

HOT IRON



Issue 1
September
1993

"Journal of the Constructors Club"

Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ

WELCOME AND CONGRATULATIONS - to you the founder members of the Constructors Club! I am very pleased that you thought the idea worth subscribing to and hope it will live up to your expectations! Thank you for your good wishes. This is intended to be a newsletter for the exchange of ideas and I positively want contributions from others with suggested topics or notes or questions etc.. To that end. I am grateful to receive initial contributions from G3GC, G4GVM and G0HDJ. My intention is to have notes each quarter on a series of themes. Apart from some sort of editorial, I expect to have something on:-

- **Construction tips,**
- **Test gear,**
- **Project application notes**
- **Question corner.**

Others can be added as demand and space allow. The main emphasis will be on ideas suitable for HF gear: not because I wish to restrict it to HF but because its much easier to make HF gear work than VHF! My own interest is in designing equipment to obtain good performance for cost, so I wont include anything associated directly with operating. I shall also be glad to have contributions on antennas although this is a topic which I regard as a black art through my ignorance! If your contribution can fit into the above categories so much the better. **Construction tips** aims to show that its possible to build things without either spending lots of money or having extensive facilities. I have started this theme with a note by G3GC on the general setting out of a project. I have kept a lengthy note by G4GVM on etching your own PCBs till next time. **Test gear** will cover items that home builders will find useful in getting their gear working. The **Project application notes** will cover the building blocks of a new kit which will eventually be available from Walford Electronics. Since I have not yet completed the design, this is a little fluid now, but the aim is a reasonably simple moderate performance direct conversion receiver/transceiver: it will be for CW and phone sideband reception but phone transmission will be by double sideband suppressed carrier. My aim is that the base rig be essentially broadband with a VFO/mixer giving coverage of 160 and 80m initially. I hope to keep the transceiver cost to around £75 but members of the Constructors Club will be able to acquire it in stages. Later additions will give other bands and extras such as digital readout.(I would love to know what sort of rig you want- cheapies, middling, or full featured superhets or phasing rigs.) **Question corner** is up to you - I am pleased to have something even for this issue! Thus there will be quite a wide range of topics and varying technical depth. Members will appreciate that unfortunately I may have to edit some contributions and that time and cost dont usually allow me to enter into individual correspondence - despite what you may have read about farmers and the EEC, we still have to work our land!

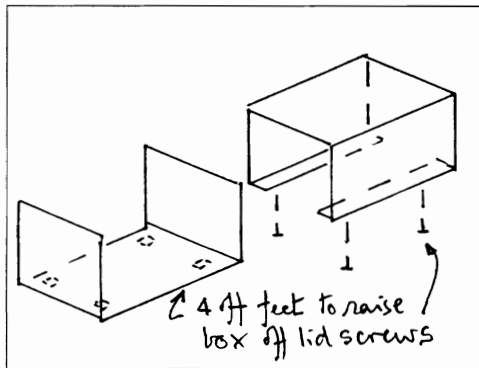
Tim Walford G3PCJ- Editor

Construction Tips

Mechanical Design. Many items of home brew equipment are often taken from a magazine and therefore will not need any basic mechanical design. Alternatively, if it is your own circuit then it will be necessary to do your own mechanical layout. in which case it is worthwhile putting something down on paper first. In doing so, be sure to think ahead to any problems that might arise in assembly and wiring. Will you be able to get at a particular part if some other part has been put in place first? Will it be possible to get at all test points with meter or oscilloscope probes? Despite your care, in practice there will probably have to be the odd change as you proceed with the construction but attention to detail at this time will pay ample dividends. Part of this layout stage will deal with the front panel. Here you should think of the appearance of the front panel and the logical arrangement of controls for ease of operation. Bear in mind that if you are left handed things might need an unconventional layout. Often some controls are put on the back panel and it is not uncommon to find a loud speaker placed in the side of the cabinet or lid. Neither is particularly satisfactory and if possible it should be on the front panel. At this stage it is also worth thinking about what finish and colour the final equipment will be. Should it blend with your current commercial gear (?homebrew house style. Ed.) or should it be different to draw attention to it?

Mechanical Construction. The type of construction will depend to a large extent on the size and type of project. As we are talking about home construction I will assume that the project has one or more printed circuit boards (PCBs). These will have to be fitted into some form of cabinet which may be either made

on the "kitchen table" or purchased from one of many suppliers. The latter will cost a lot more and probably may not be the right shape or size! The "kitchen table" version can be made to precisely your requirements, which will require some mechanical ability. (Not necessarily! In a later issue I hope to cover various less demanding mechanical techniques for projects and prototype units. Ed.) Assuming you are going for a metal box, the first thing is to decide which metal; the usual favourite is aluminium. Scrap metal merchants are a good source and it can usually be examined before purchasing. The best thickness is 18 SWG (0.048") which, while reasonably stiff, is fairly easy to bend. Bending is probably the most difficult part of home construction to amateurs. One of the best ways is to use a "workmate" as the wooden vice is of ample length and can be adjusted to hold the material firmly over the whole of any length likely to be required. One of the problems in bending is the apparent loss of material in making the bend. There are tables for the "allowance for bending" but for the amateur it is best to do a few dummy bends on offcuts of the intended material. Carefully mark out a length with precise dimensions to be bent at right angles and then check that you have bent a right angle! When bending the metal never hit the metal directly with a hammer or mallet, place a piece of wood where it



is to be hit. Using this method you should be able to obtain a good bend without blemishes. If necessary the cabinet can be stiffened with aluminium angle. The cabinet is most easily made out of two U shaped sections attached to each other at right angles. Some means of attaching the two halves is needed, either by flanges on the bottom or chassis section or by wrapping the top U slightly around the bottom U which requires the bottom U to be slid into the top one. They can be held together with self tapping screws or bolts into threaded holes tapped into thicker angle section material.

Eric Godfrey G3GC

Meter Scales

Often meters used to make test gear don't have the desired scale. On some it is possible to remove the scale plate by undoing a couple of screws. After painting the back with matt white emulsion or spraying with car matt paint it can be fitted the other way up: a new scale can then be put on with dry rub down line and number transfers to give a "semi professional" appearance. You can always revert to the original if needed!

Speaker Grills and Vent holes

Some sort of covering is needed to stop uninvited extras entering the equipment! Aluminium wire mesh which is used to repair car bodies comes in sheet sizes of 30 x 20 cms costing 60p at B & Q. It can be cut easily with scissors. Slightly larger and stiffer mesh is also a good covering for PSUs needing plenty of air.

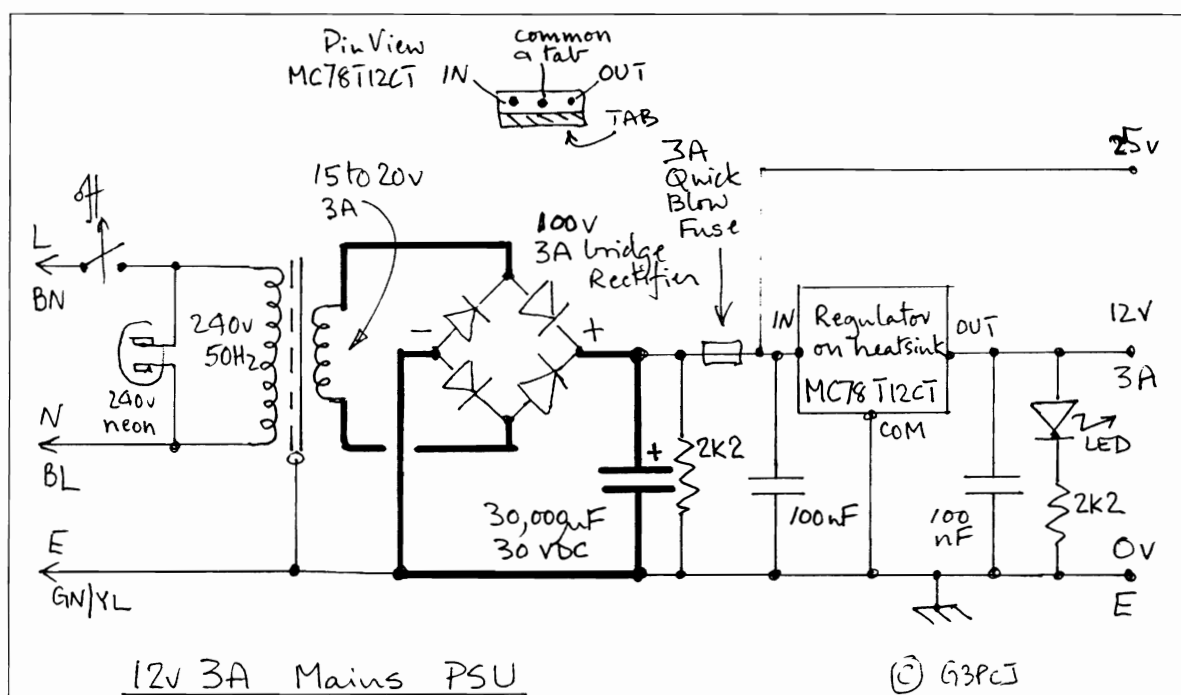
Craig Douglas G0HDJ

Test Gear

The most useful thing to have in the shack is a multi-meter. I find that an analogue one is more useful than a digital type because they are often smaller, don't have batteries that need turning on for every reading and can often be bought for a £1 or so at junk sales. (Often they can be checked before purchase by shaking to see if the needle moves at all and shorting the leads on the ohms range when it should go to full scale if the battery isn't flat.) Go for the highest sensitivity you can afford since this will reduce the loading on whatever circuit you are measuring - aim for a basic movement of 100 micro-amps or less since this will present a load of 100K on its 10v range. Most cheap instruments have AC and DC volts, DC current up to about an amp and resistance. I find that it is useful to also have a digital multi-meter as well to occasionally measure more accurately when that's important, but don't feel that they are essential; they are now available with all sorts of extra facilities such as capacitance or temperature or frequency measurement in the range £20 to £30. I suggest that it's worth going for frequency despite their limitation to around a Mhz. They invariably have continuity testers which squeak when the circuit is complete and enable you to keep your eyes on the cable etc instead of flitting to the meter.

Undoubtedly the next most important item is a general purpose power supply. Most amateur gear is designed to work off nominal 12 volt supplies and while you can do a lot with the small non-spill lead acid batteries which are sold at rallies (ex burglar alarms etc.) a mains powered unit is soon desired! It's difficult to generalise on what's needed since test gear will not require any variable voltages but if it's to power a rig there is much to be said for extra outputs up to about 25v - I try to design my gear to work with this wide range of input voltages so that the transmitter will be able to produce more output on the higher voltage; it also gives some margin of safety! Often I have lent gear to others for use with their PSUs only to have it returned with the comment that it worked fine for a few minutes then died; on investigation the PSU was not man-enough and shut itself down. Hence my suggestion to err on the large size with a 3 Amp continuous output. This ups the transformer size but it's worth while. Again be guided by what you can obtain at rallies but look for a conventional one that's about a three inch cube and it will have a rating of about 60VA. The

circuit below using a fixed 12v 3A integrated regulator (type MC78T12CT) needs a minimum of 15 volts DC input. The bridge rectifier will drop a further 1.5v so you need 16.5v on load at the bottom of any ripple on the raw DC. The maximum input to the regulator must not exceed 30v offload so the secondary RMS voltage needs to be less than 30 divided by square root of 2 (≈ 1.414) so a 20 volt secondary is the highest and 15 volts is about the lowest suitable. A good rule of thumb is that the ripple on the reservoir capacitor will be 1 volt for each amp of output current if the capacitor is 10,000 micro-farads. So look for 20,000 or 30,000 micro-farads with a voltage rating of at least 30 VDC. This can be any parallel combination of smaller capacitors with the same voltage rating. Do make certain to fit a bleed resistor across the reservoir capacitor and I like to have a mains input neon and output LED but these are optional. What are not optional are protective boxes and fuses! Be very careful of the lethal mains voltages and make certain no straying fingers can get anywhere near the mains wires. The regulator can be reduced to a 2 Amp (L78S12CV) or even a 1.5 Amp type (L7812CV) for smaller loads and you will be able to use smaller values of reservoir capacitor and a smaller transformer. The regulator must be mounted on a heatsink and will get hot when supplying the maximum current. If the case is metal, bolt the regulator in the centre of the largest face having scraped away any paint and use an extra sheet of U shaped aluminium, say about 3 inches square initially, clamped by the same device mounting bolt on the outside of the case. The mounting tab is connected to the common or 0 volt pin and will connect 0v to the chassis but it is a good idea to make a wire connection as well. You should also connect mains earth to the case and to the transformer screen if it has one. (If the transformer has unmarked windings but is known to be for 240v mains, the highest resistance winding is likely to be the mains input. Cautiously apply mains with a 1 Amp fuse to this and measure the output voltages on the other windings starting with the AC voltmeter on a 250 volt range incase there are other high voltage secondaries!) The wires between transformer secondary and bridge rectifier and reservoir capacitor carry very high peak currents so these need to be thick and the output to the regulator should be taken direct off the reservoir capacitor to avoid any volt drop in these getting into the output. (As an aside its worth noting that transformers can be a source of interference if mounted near wideband audio amplifying stages so its a good idea to space them as far away as possible at the back of equipment.) The raw DC output at up to about 25 volts can be available on a separate terminal for high power needs but this output is unregulated and will have ripple on it depending on the load. Tim Walford G3PCJ

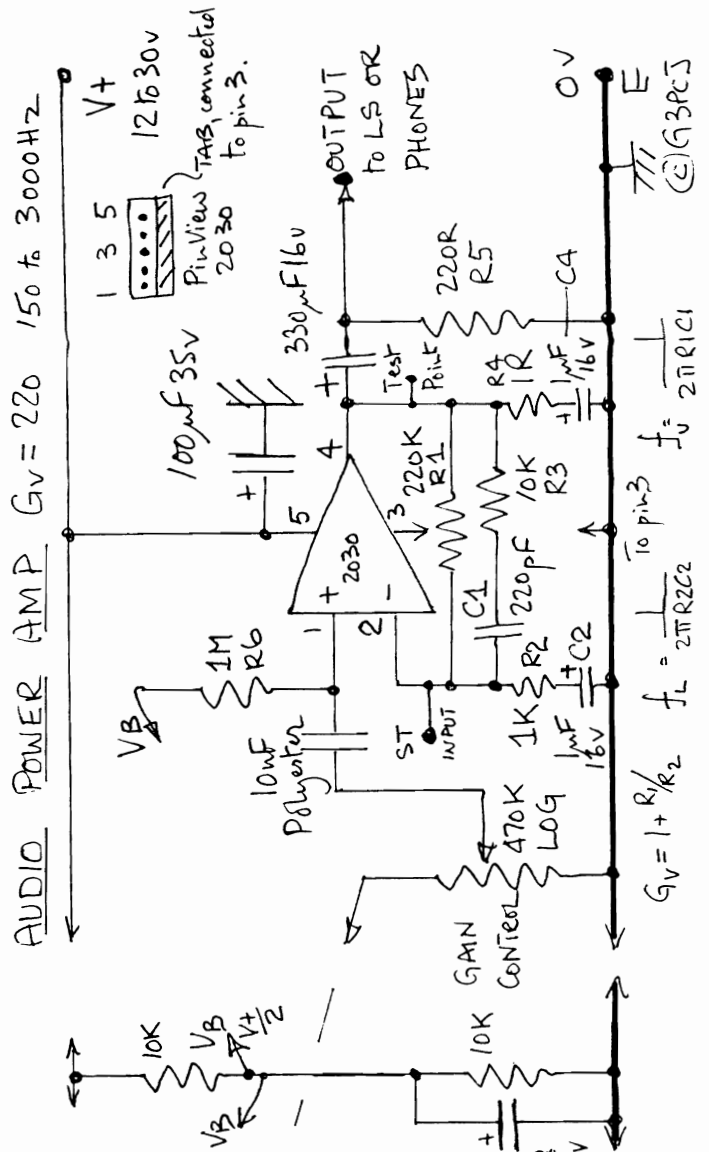


Question Corner

Ron Chisnell asks what is the best type of aerial for a short wave receiver for a flat dweller with limited space? What is a magnetic loop? The general aerial advice of get out as much wire and as high as possible maybe limited to curtain rails and balconies. Interference from mains wiring can also be a problem and loops are less susceptible to this. A loop picks up the magnetic (as opposed to the electrostatic) part of the radio wave. By placing a portable radio with a ferrite rod aerial in the middle of a tuned loop the received signal is usually enhanced, even without connections. The loop will need turning for best effect and must be tuned to the receiver's frequency. Experiment with a loop of solid copper wire wound round a cardboard box of about 50 cm cube. (Split mains twin and earth 1 mm lighting cable leaving insulation on it.) Connect the loop ends to each side of a variable capacitor of about 300 pF (ex scrap radio), try six turns for medium wave, four turns for 3 to 4 MHz and 2 or 3 turns for up to 10 Mhz or so. Keep the turns spaced at least 1 cm from each other. Tune the radio to a weak station. put in the loop. alter the loop capacitor and rotate for best effect.

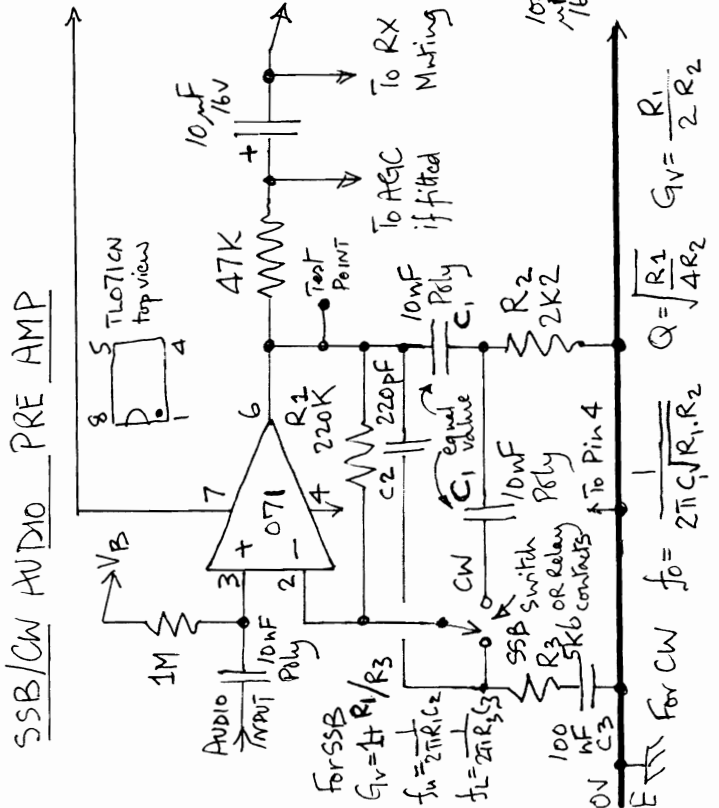
Audio Power Amplifiers

The LM380 is often used, it needs few extra parts, can use a supply of 8 - 22v and has a fixed voltage gain of 50. The TBA820 will work over 3 to 16v with a fixed voltage gain of 50 and is cheaper but usually needs more external parts. I prefer the 2030 range since they will work on 12 to 36v supplies, are almost as cheap and can have their gain set higher. They can also be preceded by a 470K gain control which makes it easier to follow an AGC stage. They are made by several manufacturers and come in vertical and horizontal versions, the latter allowing bolting to the PCB to act as a heat sink. The circuit alongside shows typical values for a stage driving a 4 ohm LS or phones having a voltage gain of 220 over the audio bandwidth 150 to 3000 Hz. The gain & bandwidth are set as for an op-amp; the gain is 1 plus R1 divided by R2. The upper bandwidth limit is when the reactance of C1 equals R1 and the lower when the reactance of C2 equals R2. R3 should be about R1 divided by 10. The network R4 and C4 help stop instabilities and R5 prevents ear shattering clicks when you plug in your phones! The bias voltage supplied through R6 to the positive input sets the output DC voltage, ideally to half the supply voltage but its often convenient to use another smooth internal rail, typically +8v. A logarithmic gain control is used to make the apparent sound level increase smoothly. The gain maybe increased to about 2000 max. by decreasing R2 to 120R but C2 will need increasing to 4.7 uF for 300 Hz cut-off. Sidetone audio for CW can be fed in at the negative input and will be unaffected by the receiver gain control provided the amp is kept live on TX! G3PCJ



Audio Pre-amplifiers

Its rather harder to generalise here but the circuit alongside is very handy. For phone it provides a voltage gain of 40 over the band 300 to 3000 Hz but can be switched to single pole audio filter for CW with a bandwidth of 145 Hz centred at 720 Hz. a Q of 5 and gain of 50. Any higher Q will tend to make the filter ring and sound funny. The switch can be front panel mounted (if the leads are short) or the contacts of a relay. The circuit also has a high input impedance and can use the same bias supply as the power amp. The design equations are on the circuit for those wishing to experiment. The 47K in series with the output is only needed for audio AGC and can usually be omitted but maybe helpful for RX muting if this is done by a short across the gain control. Do not turn off the supply to any audio stage as a means of muting. The SSB / CW switch changes over the network on the op-amp negative input and leaves both connected to the op-amp output but since this can easily drive both networks in parallel it doesn't matter. A FET input low noise op-amp is desirable, typically a TL071 or half the dual 072. Supply voltage can be up to 30v. G3PCJ



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"*Journal of the Constructors Club*" ©

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I am very pleased to be able to tell you that we now have about **50 members** of the **Constructors Club**. This is an excellent start - much better than I had hoped for and I am particularly pleased to have a small but significant number of overseas members. Please spread the word to your friends interested in electronics and amateur radio. I emphasize again that I hope many of you will contribute to the journal - even if its only a small item or idea almost certainly others will be pleased to see it - so send in your contributions please!

For this issue, the construction theme is slightly stronger than last time with very welcome contributions from a trio whose arms were more pliable than others! Thank you Gentlemen. I have included G3GC's note on soldering because good soldering is fundamental to all electronic construction and it is often the cause of problems. My own note on "Dead-bug" construction is intended to encourage experimentation without the need for etched printed circuits - the technique is very effective from an rf viewpoint and lends itself to very easy changes. Alternatively you may prefer the smart effect achieved by G4GVM, but it does require you to have sorted out the circuit and sizes - you can still change values provided the footprint on the PCB does not change. Interestingly G0HDJ has contributed a note on filters for direct conversion rigs, a topic which has occupied my spare moments quite a bit recently in connection with the new rig I am working on; I have in mind to include a tuneable switched capacitor filter with a very steep slope comparable to that achieved in the best IF filters in superhets. I need some advice on the type of filter, which is acceptable for CW without undue ringing effects (Bessel, Buterworth, Chebychev or Elliptic) - so if anyone can produce a reference I should be pleased to have it. At one stage I thought I might have to include a fancy filter in the Yeovil to get rid of interference from my latest frequency counter kit - however a fresh design using more modern chips and a change to CMOS logic has completed eliminated interference in the RX. This display kit is for direct conversion rigs or superhets or as test gear; there are two input channels which can be added or subtracted and will work to 60 MHz minimum - the prototype did 85 MHz! It suits all of my rig designs. I also now have a converter kit for the Yeovil so that it can be made into a three band transceiver covering 20, 40 and 80 metres.

Finally, following an inquiry about where to obtain parts from a member; if you do have difficulties, I can generally obtain any of the parts that get a mention in **Hot Iron**. Don't forget that membership of the **Construction Club** allows you to obtain kits in stages if this suits Father Christmas' pocket! For administrative convenience, I have decided that membership of the **Club** will always start on Sept. 1st of any year so that I have only to worry about subscriptions once a year! **Hot Iron** is 50 % bigger this time, I will try to keep it up but it needs your contributions. Tim Walford - Ed.

Soldering Techniques

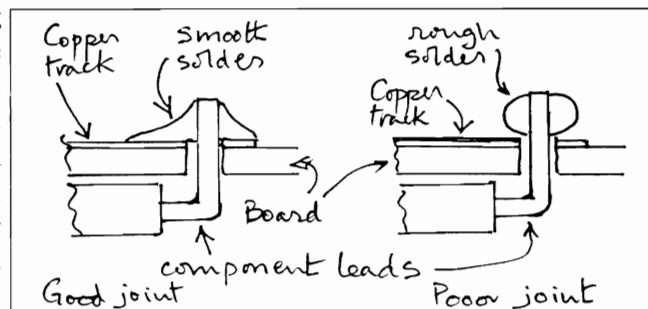
Once one has learnt to solder, then it is one of the most simple and sure ways of making a good electrical joint and may, depending upon the particular circumstances, also be a good mechanical joint. The most important thing to remember about soldering is that "cleanliness is next to Godliness". This is closely followed by having the correct size iron at the right temperature, the correct solder, tinning and keeping the work absolutely still until the joint has set.

To obtain a good joint the work must be absolutely clean. Most components will have silver plated leads which (if new) take solder easily but enamelled wire can be difficult. The insulation of modern "enamelled" wire, which has a slightly pinkish colour, will " burn off" purely with the heat of a largish iron but do NOT breath the fumes. Old style enamelled wire needs scraping with a penknife or similar, followed by cleaning with a scrap of wire wool done well away from the equipment - do not use sand paper or emery cloth. After cleaning the wire down to the bare and bright copper it should be

tinned as explained below. The copper of printed circuit boards does become tarnished in time unless it has been lacquered or roller tinned all over, again light wire wool rubbing will clean it up followed by thorough brushing. If the tracks are narrow and might peel off, rub along them. Where a board has been lacquered it is not necessary to remove the lacquer prior to soldering; it is also quite possible to solder direct to PCBs covered in freshly exposed photo resist (a greenish colour) but after a while such boards will tarnish and will need wire wool cleaning. Old components may also need cleaning and tinning prior to assembly. (See tip below.)

It is essential to have the right sized iron for the job and most irons will have a power to match their bulk and achieve the right temperature. For soldering components to PCBs, a small 2 mm pencil bit with a 18 Watt element is sensible; for more bulky jobs such as making connections to big earth tags (and burning off pink enamelling) a 3.5 mm bit in a 25 W iron is useful. For outside work on 12 SWG antenna wires a big 150 Watt iron maybe needed, particularly if its windy! A small iron would be quite useless since it has insufficient heat capacity and is quickly cooled by the work. For radio work you should use solder that is 60 % tin and 40 % lead; its melts at 188 °C and is available with internal flux cores - size 22 SWG is suitable for most work and size 18 for external jobs. Do **NOT** use either plumber's solder or their flux since it is corrosive. The purpose of the flux is to make the solder flow more easily and it is essential to keep the parts being joined still while the solder is solidifying. Tinning is the process of initially getting a film of solder to adhere to the cleaned metal which makes the eventual joining much easier. It is done by placing the iron and solder together on the cleaned part to be tinned, whereon the solder will melt with a puff of smoke as the resin flux evaporates and the solder then flows easily over the metal leaving a bright thin film. Do not breath this smoke either! Usually the copper of PCBs is very clean and the solder will flow around the joint without tinning. Tinning is often needed where the joint is likely to be difficult or the parts are large compared to the size of iron.

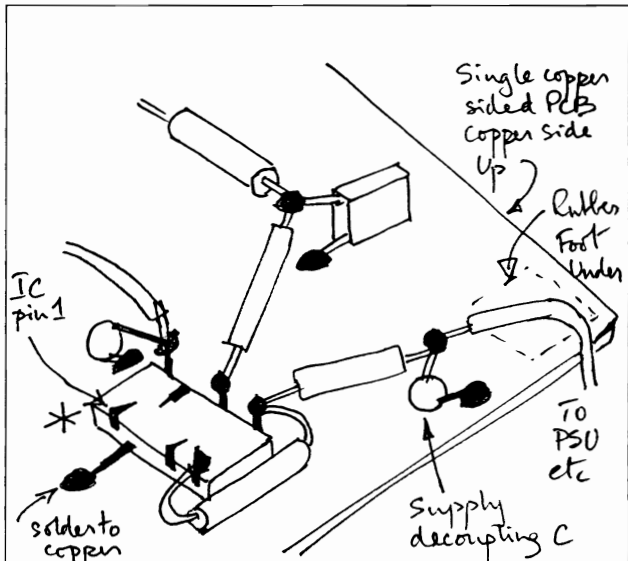
Now to making the actual joint. Assuming that the work has been properly tinned, then it is merely necessary to hold the two pieces together and apply the soldering iron and melt in a little solder. This appears to require four hands but in practice the two pieces to be soldered are often held together mechanically (such as the components mounted in a PCB) leaving your two hands free to hold the iron and solder. If necessary a small vice maybe used and there are a number of small plastic ones with a suction grip to hold it to the bench top. Crock clips and clothes pegs have also been known to be used! The joint should be allowed to cool naturally (never blow on it or drop it in water!). When cool, it should look bright, shiny and smooth. If it has a matt or pitted look then it probably moved during cooling and will have to be reheated and a little more solder/flux applied. A good joint between a component lead and a PCB track is shown in section on the left - the poor joint on the right maybe due to insufficient heat or movement during cooling or poor adhesion of the solder to the parts due to dirt. It is not easy to describe all the techniques in words but practice makes perfect. If in doubt seek advice from an experienced amateur with a practical demonstration. I will end where I started by reminding you that for soldering "Cleanliness is next to Godliness". Eric Godfrey G3GC



Dead-bug Construction

This unusual name derives from the technique of bread-boarding (or building a very early prototype) by mounting integrated circuits (the bugs) upside down with their legs sticking up in the air - thus having the appearance of dead animals. It is a very good method as it depends on a continuous sheet of copper, usually single sided printed circuit board, acting as a ground plane or continuous 0 volt line spread all over the circuit area. This is good for RF from a layout viewpoint and avoids having to worry about separate 0 volt wires for the supply. You dont have to do any drilling for component leads since they are all mounted or attached to the board by their earthy connections. As in any project, the layout of functional blocks is important and the simplest scheme is to lay the stages out in as long a straight line as is necessary and only bend round or back when space is insufficient. You must make certain that you avoid inputs and outputs being next to each other, especially when they are

working at the same frequency. All leads are kept short to increase rigidity and avoid unnecessary lead inductance; the earthy component leads are soldered directly to the copper sheet using a hot iron for the shortest time sufficient for a good joint. The other non-earthly component joints are made up in the air, again with short leads, using just sufficient solder to hold them together. By the time you have added decoupling capacitors etc for the supply leads you will find that for most circuits, practically all the components will be firmly attached and the resulting structure is quite rigid despite having the most awful appearance! If you find that some component, such as a resistor to a supply line, is rather free floating in a mechanical sense it is very easy to secure it by adding an extra decoupling capacitor across the supply line at the resistor; one end of the capacitor is soldered direct to ground, the other to the common point between resistor and supply lead. These extra decoupling capacitors are seldom a problem electrically and generally are most beneficial, furthermore they are cheap and small so you can be generous with them. Occasionally you may feel that an extra capacitor to earth is not right for the circuit at the point that needs mechanical restraint, in this case consider anchoring the component to earth with a high value resistor, use the highest value you have in the junk box and it should be at least 100 times the circuit impedance at that point - if you dont know the impedance dont use resistors of less than a few MOhm! On the whole, extra resistors are best avoided since they might cause problems whereas extra supply decoupling capacitors are very unlikely to do so; practically any type of capacitor (and value) can be used but I recommend the use of 10 nF disc ceramics as they are small and cheap when bought by the bag! If the design needs integrated circuits they are mounted upside down by their supply pins, first decide the best orientation for the chip to give you the shortest input and output connections and mark the PCB with a star where pin 1 of the IC will be located. This avoids having to unsolder all the connections when you have later forgotten which end is which. Then carefully bend the chip's 0 volt pin back so that it points out sideways (actually needing a bend of just over a right angle)



so that you can solder this pin direct to the ground plane. Then locate the supply pin(s) and solder a 10 nF decoupling capacitor direct from the pin to the ground plane, the supply lead is also soldered to this pin and run on to other supply connection points. The unused pins of the chip can be carefully bent towards each other to make more space for the other pins that have components attached to them; where there are several unused pins bend them slightly sideways as necessary to avoid them touching each other. The sketch alongside may help explain the general idea. Long interconnecting wires are best run flat in a rectangular grid pattern against the ground plane and can look quite tidy. Avoid running wires near any oscillators. If you have to make a structure, say

to mount connectors or a control it is quite easy to cut and file PCB material to the right size and attach it by soldering along the joint between the ground plane and the back of the control mounting panel - if necessary add another piece of PCB offcut at right angles to the other two to give further rigidity. Finally the base PCB can be mounted on rubber feet. You will be surprised how easy it is to get good results. You can even rip it all apart and start afresh without any difficulties! Tim Walford.

Passive CW audio filter

Craig Douglas, G0HDJ writes, "One of my QRP rigs is a Hilltopper (designed by GM4JMU); it has an audio filter using passive components with a bandwidth suitable for SSB as well as CW. It works well without any ringing etc but an article in "Sprat" suggested that a lower frequency CW note at around 500 Hz is easier to listen to and aids discrimination in a noisy background. I built the 500 Hz version of this elliptic low pass filter and it is certainly very effective with a sharp cut-off. It is intended to be fitted in the audio line just before the audio gain control. The parts are not expensive; the inductors are available in the Toko 10RB and 10RBH series, available from Circuit and others. The table shows the theoretical component values and suggests the most suitable combinations of standard value capacitors. With a theoretical attenuation of some 40 dB for an increase in pitch of 50 Hz from

500 to 550 Hz, it should be very good at removing unwanted nearby signals. If you decide to build the 500 Hz version be aware that most commercial rigs are based on an 800 Hz offset and you may have difficulty working other stations. (It is of no consequence if you are receiving only.) I have included the figures for an 800 Hz low pass filter just in case!"

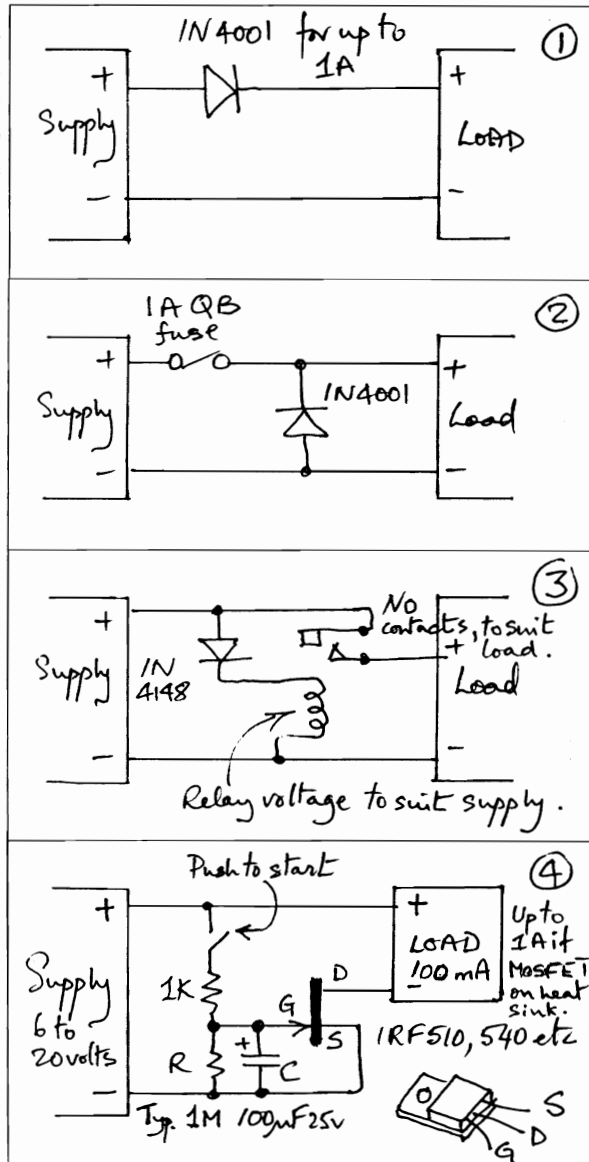
<p>Low Pass Elliptic filter.</p>		C1	C2	C3	C4	C5	L1	L2	
	"500Hz"	Theory	216 nF	40 nF	271 nF	121 nF	161 nF	708 mH	484 mH
	-40dB at 550 Hz	Actual	220 nF	39 nF	220 + 47 nF	100 + 22 nF	100 + 47/10 nF	680 mH	470 mH
	"800Hz"	Theory	135 nF	25 nF	169 nF	76 nF	100 nF	445 mH	305 mH
	Actual	100 + 33 nF	22 nF + 2.2	100 + 68 nF	68 + 6.8 nF	100 nF	390 + 56 mH	270 + 33 mH	

Construction Tip

Les Boddington G4JDC writes, "I have learned from bitter experience never to assume that the wires on components are clean and ready for soldering. I always gently clean them to clear off any oxidation by gently pulling the lead through the jaws of small pair of pliers. I know this may sound long winded and time consuming but it helps to insure a good joint." The Editor would comment that this is particularly necessary for those dreadful bags of a 1000 resistors that you get for 20 pence at rallies - they always seem to be covered in wax all over and have obscure values!

Reverse supply protection

Following my note last time on power supplies, I list some methods for protecting equipment from wrongly connected supplies. The first using a series diode, typically a 1N4001 for up to an Amp, only has the disadvantage that the supply voltage is reduced by about 0.7 volts and this figure does vary with load current. The second method of a series fuse and reverse diode does not suffer from significant volt drops but there is a very brief instant, on connection of wrong polarity supply while the fuse melts, when the load has a small reverse voltages applied to it. Only quick-blow fuses should be used. The third circuit has no performance drawbacks except that the relay does draw some extra current and it is more costly and bulky. The relay coil must match the supply voltage and its contacts must be adequate for the load current. The fourth circuit, which is intended as a timer for battery powered instruments to avoid a flat battery next time it is used, does also protect against wrong battery polarity. The time for which the load is connected to the battery varies with load and individual components but its simplicity makes up for the need for a little experimentation with C and R values to obtain the desired on time. As a very rough guide, the On time will be about CR seconds (C in microFarads and R in megOhms) but it depends considerably on the supply voltage and the characteristics of the MOSFET. A wide variety of n type MOSFETs can be used such as the IRF510, IRF540 etc. The supply can be up to about 20 volts. Tim Walford G3PCJ



Fabricating "one-off" printed circuit boards

Here is a method of making "one-off" PCBs which, with some care and attention to detail, can give a highly professional finish. For brevity I am tabulating the various steps. Read right through these notes first to help you understand what's involved. Do take care with the etching solution.

Preparation

1. You will need pencil, rubber, ruler, 0.1 inch graph paper, carbon paper, masking tape, very sharp knife such as a scalpel, 0.1 inch matrix vero-board, blank PCB, 2 or 3 small clamps or bulldog clips, ferric chloride etching solution (see later), the components, 0.8 mm drill, 2 x 3 inch lengths of 20 SWG, 2 mm ID brass shim tube, and various vessels.
2. Draw component placing and circuit layout on 0.1 inch graph paper, drawing it as viewed from the component side. The tracks will ultimately be on the other underside.
3. Try actual components on matching veroboard to check for tidy looking layout - alter as required.
4. Check and double check the circuit is correct with a sensible layout - avoid inputs near outputs etc.
5. Place carbon paper, carbon side up, underneath the drawing and trace over the pads and tracks. This will show the track layout as seen from the copper side, which will be a mirror image when viewed from the track side.
6. On the drawing, number each vertical line left to right and mark each horizontal line with letters top to bottom, a b c etc. List the numbers to be drilled to the right of each line.

Drilling

7. Cut the PCB to the required size, allowing sufficient overlap for fixing holes etc.
8. Clamp piece of veroboard to the uncoppered side of the PCB and square it up carefully.
9. Locate and drill (0.8 mm) two of the holes at each end. Thread two lengths of 20 SWG through them and twist the ends. Remove the clamps and trim the twisted wires to about 1/4 inch on top of the board.
10. Place the masking tape so that line "a" only is exposed. Number against every fifth hole on the tape.
11. Drill all holes on line "a" as indicated on the drawing. Move the tape down to expose line "b", keeping the numbering in place, and drill all holes in line "b". Continue until all holes in all lines are drilled.
12. Remove the two clamping wires. You should now have an accurately drilled, but plain PCB.

Manufacture

13. Scrub the copper side with wire wool until it shines. Remove any burrs remaining on the holes by lightly twisting a larger drill into the offending hole with your fingers.
14. Cut a 3 inch length of PVC insulating tape into 2 mm wide strips longways for the tracks. Do this very carefully with a scalpel or razor blade or Stanley knife up against the ruler, with the insulating tape laid on ex-address label backing to preserve the tape's stickiness. Drawing a 2 mm scale each end will help. Do more if required.
15. If required, circular pads can be made by sharpening the end of a 2 mm brass shim tube (obtainable from model shops) with a file, and cutting them from a strip of insulating tape.
16. Cover and join the holes on the copper side of the PCB with the tape strips as per the carbon side of your drawing. Apply the pads at the ends over the holes if required. This pattern is the circuit that will be left after etching. Press down overlaps and edges so that no etching solution can get underneath the taped areas. The rounded handle end of a scalpel is good for this. For a satisfying finish, make sure the tape strips are tidy and parallel or at right angles to each other. If there is room, "letraset" your call sign and project title, date etc, on what would otherwise be a blank area. Double check your work.
17. Find a shallow non metallic dish just large enough to take the PCB (saucer or meat dish etc.). Pour in about 3/8 inch of ferric chloride etch solution (see next paragraph) and carefully place the PCB in it. If the board is made of SRBP, which is a brownish colour, the board will float and it should be placed in the solution copper side down so that the solution is in contact with the copper. If the PCB is made of fibreglass, usually a dull greenish colour, then the board will sink and it should be placed in it copper side up so that you can see how the etching is going. Every 5 mins or so gently rock the dish to move the solution around; after about 15 to 20 mins the copper will begin to vanish, usually at the board edges first, and you should then examine it every few minutes so that you can remove it from the solution just as soon as all the unwanted copper has been removed. Use plastic or non metallic tongs to pick up the board and it is a good idea to wear rubber gloves.

18. Ferric chloride etching solution is usually made up from crystals, largish irregular yellow globules, which can be obtained from electrical suppliers such as Cirkit, Maplin etc. and maybe some chemist shops. Follow the instructions, which usually come with the crystals, on how to make up the solution. If there are none then you should use them at the rate of 250 grams of crystals dissolved into 0.5 litres of water. First asses how much etching solution is needed by filling the etching dish with water to a sufficient depth to cover the board and then pour this into a measuring jug. 0.5 litres will be more than enough for most boards and the surplus can be kept for the next board in a labelled sealed non metallic container safely stowed away from food and children etc.. For making up 0.5 litres of etchant, first place 0.25 litres of cold water into a non metallic dissolving vessel, then weigh out 250 grams of crystals in something like an old ice cream tub which can be later thrown away. Gingerly add the crystals to the cold water, NOT the other way round since heat is generated as the crystals dissolve. After a few minutes carefully add a further 0.25 litres of hot water to the dissolving vessel and stir with a plastic rod till all the crystals are dissolved. Transfer sufficient to the etching vessel and store the remainder. The solution will be warm which speeds up the etching. If you have many boards to do at once, the continued application of a little heat from something like a 60 Watt light bulb will keep the temperature up. Obviously this needs the etching vessel to be safely mounted over the heat source. If you do suffer from a splash of ferric chloride wash immediately with lots of cold water. 0.5 litres of solution will etch up to about eight boards 100 x 160 mm before the strength runs out but the last few will take longer. Generally it is best to avoid keeping part used solution.

19. When the board has been fully etched wash it thoroughly with water. Do NOT pour the spent etching solution down the drain and dont get it on stainless steel sinks, dilute it further with water and pour into a hole in waste land in your garden. Remove the PVC tape strips and pads then scrub once more with wire wool. If you can, spray the board all over with PCB lacquer (available from electrical suppliers) at this stage to stop it tarnishing. You can solder straight on to the lacquer.

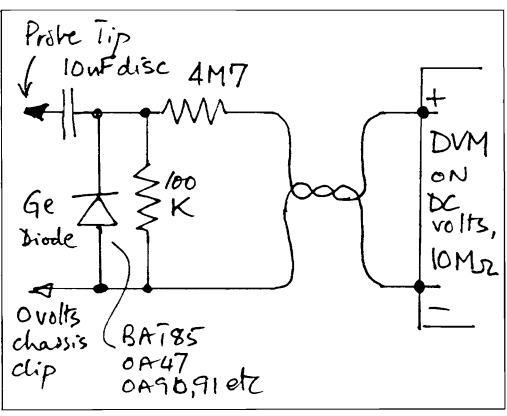
20. If the project requires a ground plane of copper all over one side, then use double sided copper clad board and fully cover the wanted ground plane copper side with wide PVC tape or selotape to prevent the etching solution coming into contact with the wanted copper. Be careful to avoid air bubbles and make sure any strips of tape overlap with no curled up edges. Use the scalpel to cut carefully round the edge of the PCB to remove the excess tape, with the board laid ground plane side down on a flat piece of wood. Press the edges down carefully. You will also need to countersink the non-earthly lead holes to prevent those leads shorting to the ground plane; this is done after etching. You will also have to give careful thought about how all earthy component connections are made to the ground plane, since it is not practical to solder the earthy leads of all the different types of parts to the ground plane underneath the part. It can however usually be done with resistors and ceramic capacitors and these make good points for soldering both sides of the board to complete the earth path.

Fitting components

21. Just a few points regarding the fitting of components. If using integrated circuits, it is a big advantage to use IC sockets or holders - note they include a pin 1 locating mark. Fit resistors so that their values can be read left to right or bottom to top. Fit capacitors so that their value can be read easily. Care in soldering components "square" and at a constant height etc will give a pleasing result. If the board has a ground plane be careful not to push in shouldered leads, such as integrated circuits, so far that their shouldered pins short to the ground plane. Derek Alexander G4GVM

RF voltmeter

None of you have submitted anything for the Question Corner so her is a space filler! It is a high impedance peak reading rf voltmeter, which when connected to a digital voltmeter with 10 MOhms input impedance will show the RMS value of the voltage providing it is sinusoidal and sufficiently large for the approx. 0.1 volt drop in the diode to be ignored. It will provide some indication for rf voltages down to tens of millivolts but the actual value shown will be way out and it can only be used as a rough indicator. It is good to VHF if the component leads are short. Tim Walford G3PCJ



HOT IRON

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Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Constructors Club**. Articles, suggested topics and questions are always welcome. Please send correspondence and membership inquiries to:-
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EDITORIAL

I am sure you will have noticed that Hot Iron has a new look - the intention is to make each issue more easily recognised by its appearance. The scene in the bottom left will change with the seasons - if anybody wishes to contribute a picture on 3.5 in floppy disc, I will be delighted to consider some alternatives. We also have several new contributors for which I am duly grateful. Three contributions are about modifications to the Yeovil. I have outlined some suggested improvements for Tiny Tim - all my own customers for Tiny Tim should already have received the details, but if there are others who you know who have built it from their own resources, they should be interested in the notes below.

I am also pleased to announce the availability of my long awaited new FET power amplifier kits. I have called them **QRP BOOSTERS** and they are suited to Tiny Tim, the Yeovil or any other QRP transmitter. Two versions are available, both capable of producing over **50 WPEP** from a maximum input of under 1 WPEP. The **MF 12 volt** Booster uses four IRF510 FETs for 160 and 80m. The **HF25 volt** Booster uses four VN88 FETs covering 160 to 10m. Both types are essentially broadband. On 25 volts the HF version produces about 35 WPEP but fitting extra capacitors related to the operating frequency enables 50 WPEP and up to 35 Volts for higher output. Both versions include relays for T/R switching & control inputs for direct control or rf sensing at the input. One control input has a delayed transmit hold facility that can also be used to provide semi break-in operation for separate TX and RX. In receive or with no power, the rf path is bi-directional. You will need low pass filters or a resonant antenna matching unit. The size is 100 x 160 x 35 mm over the heatsinks. Both prototypes produced about 70 WPEP on 80m but dont necessarily expect yours to do the same! The same PCB is used for both versions. Price is £45 - under £1 per WPEP. Send a SAE for the details.

Tim Walford

Editor

YEOVIL QRP CONVENTION

This year's convention is on May 8th at the Preston Centre, Yeovil, and has a very full programme of talks, demonstrations, QRP stations, trade stands and the like. We also have an annual construction challenge which should appeal to readers of this journal! This is the 10th convention so the theme is based on ten this year; briefly you have to design and build an 80m CW receiver using only 10 electronic components (no ICs) powered by a battery (less than 10 volts) giving an output between 10 Hz and 10KHz across a 10 KOhm load resistor. The results of your labours will be tested during lunchtime using a QRP transmitter equivalent to that used 40 years ago for the first long distance sky wave contact with a transistorised transmitter by the Yeovil ARC; the RX with the greatest output will be the winner. Contact Peter Burrige, G3CQR QTHR or phone 0935 813054, who will be pleased to send full details of the Challenge, the Convention and the CW Fun Run contest during the preceding week. Its a splendid day out, a chance to meet fellow constructors and QRPers, traders etc including Walford Electronics! Refreshments available all day. Bring the family - playing fields for kids, supermarkets and superstores within walking distance for the ladies.

Blue Tack!

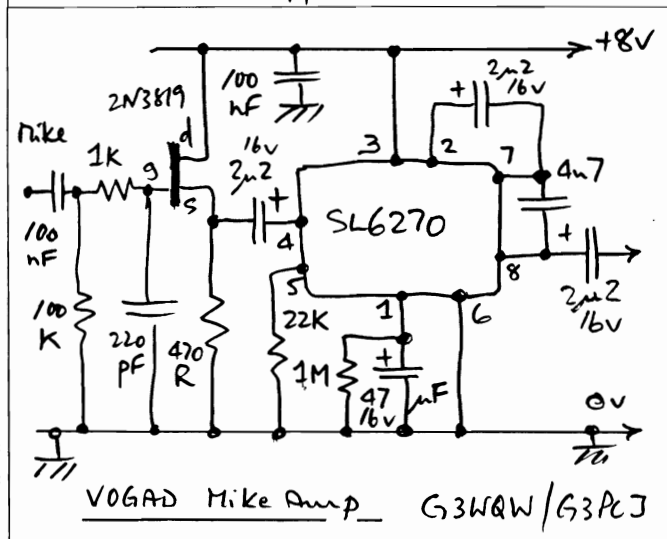
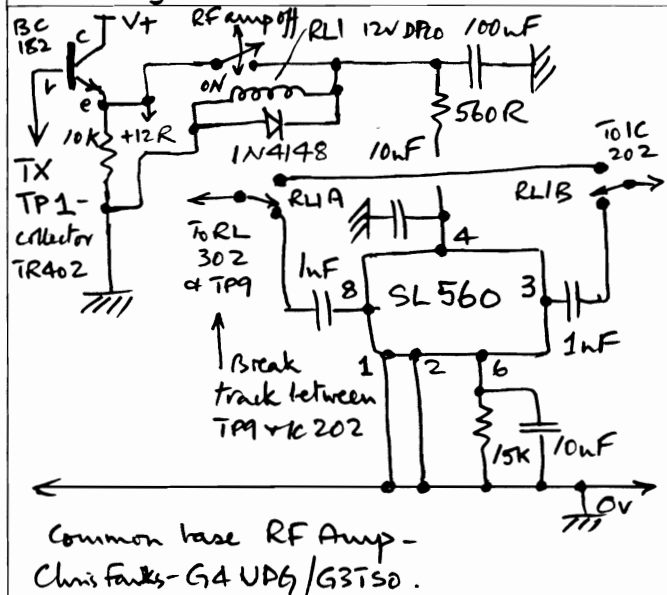
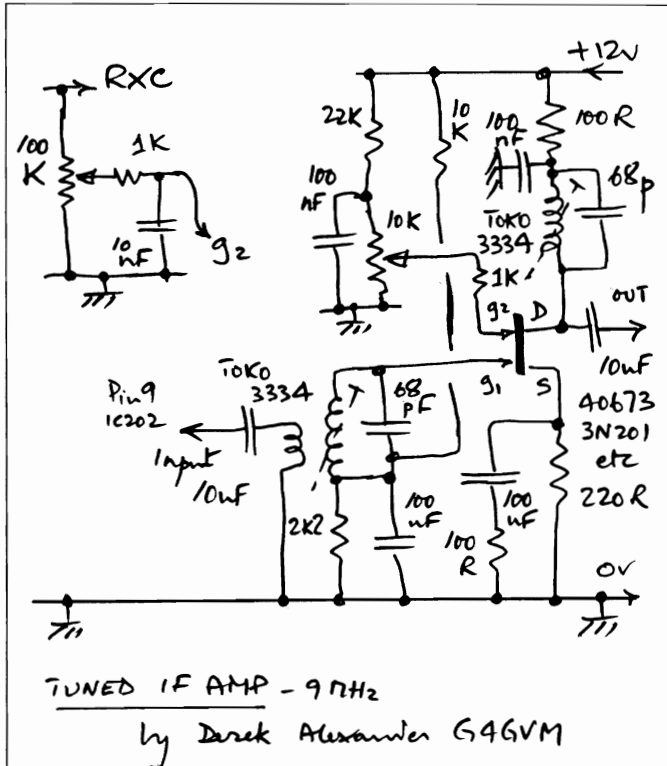
Stan Knight, G0BGI, offers a good use for a product which I regard as a decorators nuisance! "When soldering components of almost any shape or size into a PCB, if the item is held in the board with a small lump of Blue Tack, two hands are free to offer iron tip and solder to the job. Blue Tack is also a good heat sink. Removing items previously soldered this way is much easier since their leads do not have to be bent to stop the part falling out of the upturned PCB. A small tip but, I hope, a useful one."

Modifications to the Yeovil

The first two are aimed at improving the RX sensitivity. Derek Alexander, G4GVM, suggests an IF amplifier is a good solution to his need for more audio output since just advancing the audio gain control brings up the noise as well as signal. He writes " I have included the 9 MHz IF amp in the RX circuit just before the SSB filter (pin 9, IC202). The preferred position would be after the filter (pin 1, IC204) but I could not get rid of the howling which occurred! The fitting of the IF amp has not only produced a huge increase in RX sensitivity but the AF gain can be turned right down thus dramatically reducing the RX noise. The basis of the circuit is the IF amp from George Dobbs' MARLAND transmitter and is a fairly standard tuned RF amp, with a gain of about 40. I can see no reason why it shouldn't be used to improve the performance of most receivers. Ideally it should be inserted after the SSB filter, thereby amplifying only the filtered signals. Fitting to the Yeovil is easy; particularly for those who were foresighted enough to use IC holders! All that is needed is to lift pin 9, IC202, connect the amp input to the pin and connect the output to the socket and the supply to +12v; connect the RF gain control and the mounting will earth the board. I used 2 x 18 gauge wire posts between the board and the Yeovil ground plane. As will be seen, this involves the receive circuit only. (It has no effect on transmit - despite the amp's output remaining across the filter input.)" The circuit in the main part of the box is that used by Derek; I have added an alternative for the gate 2 input which will shut the amp gain down on transmit. G3PCJ

Chris Fawks, G4UDG, also tried an IF amp using a SL1612 but abandoned it in favour of an RF amp. "I built it on veroboard with a relay using a 12v supply switched off when on TX; the SL560 is about £3. The circuit is not my own but comes from the G3TSO TCVR which is also bi-directional! I have not noticed any overload problems but, just in case, I have switched it from the front panel with a toggle. Gain is about 15dB; sensitivity on 20m is greatly improved, on 80m not so profound but still useful. If you cant hear them, you cant work-em!" There is not normally a +12R supply in the Yeovil, so I have sketched in a suggested method-G3PCJ.

Stewart Sims, G3WQW, has installed a VOGAD amplifier IC on the mike input which enables him to regularly work VO1NP with only a modest antenna. This devices adjusts the audio gain so that the audio output level is reasonably constant. It enables him to adjust the mike gain to the limit so that there is no risk of splatter etc. while obtaining full output. Stewart has the distinction of building the first Yeovil outside the Yeovil club! He recommends the VOGAD kit available from Maplin using a SL6270; this kit includes a buffer amp to raise the input impedance so that it can be used with an electret mike. The circuit alongside can be used with most mikes including high impedance crystal ones. Clive Hardy, G4SLU, in his forthcoming review of the Yeovil in PW, has suggested adding a protection diode across the RIT relay coil RL303 to prevent latch-ups. Use a 1N4148 diode with its cathode end connected to V+ .



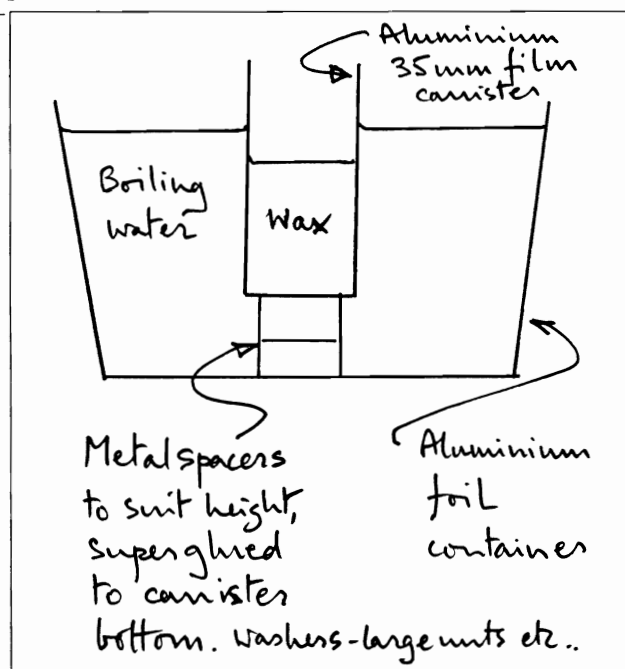
Tiny Tim and tuning voltages

Experience has shown that on some power supplies, the 8 volt regulator in Tiny Tim is not able to fully cope with the rf ripple present on the main 12 volt supply during transmission. This has the undesired effect of producing FM and very poor sounding SSB which also has a much narrower tuning frequency range over which the audio sounds reasonable. Luckily the cure is simple and cheap! Two extra 47 nF polyester capacitors should be added across the main 12 volt supply. The first should be placed directly across C33 (10uF) in the transmitter on the underside of the PCB and the second should be added from the main incoming supply pin the regulator IC5 (317T) to the nearest 0 volt point which is the earthy pin of R28 (10K). The addition of these capacitors should get the jump in VFO frequency when going to transmit with Tune on, down to around 10 Hz or less which is negligible. These two capacitors are also worth fitting to the top band version of Tiny Tim. It has also been found that some Tiny Tims are a little low on maximum rf output. If all the other possibilities have been exhausted you should increase C30 from 18 pF to 47 pF; after this change the RX rf input bandpass filters will need readjustment at the band centre.

Quite often, if a phone signal can only be read over a much narrower tuning range than normal, this is due to frequency modulation and it is unlikely to be due to rf feedback from the TX to the mike, it is usually from the TX to the oscillators invariably through the supplies. Feedback into the mike is more likely to produce a general roughness which is not resolved by tuning. I have explained this here since varactor tuned oscillators are obviously more prone to ripple on the tuning supply than those tuned by air spaced variable capacitors. In my rigs I use the 317 series of adjustable voltage regulators because their line and load regulation is appreciably better than the more common fixed regulators of the 7812/7805 type; furthermore despite needing two more resistors to set the output voltage they are not much more expensive. You can also set them to uncommon output voltages such as the +8 that I often use. This is a compromise between the highest voltage that can be obtained on a low 12 v input and the need for many chips to operate on about 6 volts. The 317 needs an input in the range 40 volts down to two volts above the desired output. The T version can source 1.5 Amps and dissipate up to 20W, but at this level it will need a large heatsink.

Boiling Wax

Craig Douglas, G0HDJ, offers the following technique for securing coils. "It works very nicely and anyone wanting to fix the coils of wire on a toroid or coil former, e.g. for an oscillator etc, will find it a good method. If you need to alter the turns, or reuse the former for something else, then you dont need to use nail varnish etc nor scrape the sealant off. Beeswax or paraffin wax can be used; there are other possible waxes but they invariably have higher melting points, are brittle and difficult to obtain without access to a chemical supplier! Beeswax congeals at 60 - 66 °C and Paraffin wax at 50 - 65 °C. The aluminium foil container can be a "take - away" type box - a largish volume will be needed to provide adequate heat. Water, which has just been boiled, will do but it may need topping up to keep the temperature up. Use a metal 35 mm film canister or similar metal pot just large enough to take the coil. Use washers etc. superglued to the bottom of the tin to keep it up and stop it floating. Using boiling water like this avoids getting the flammable waxes near naked flames and keeps the mess out of the kitchen! With toroids, a quick dunk will give a suitable coating, two dunks for a thicker coating on heavy gauge wires. Where it is important to keep the wax out of a former (e.g. for an adjusting slug), stuff a little cotton wool or newspaper into the end. If you need to remove the wax, a quick dunk into boiling water will remove it quickly and cleanly. Candle wax does not work by this method as it melts at over 100 °C. (Several years ago I had a problem with lead vibration & subsequent fracture in electronic gear on a tractor which I cured by dripping candle wax onto the wires - its still going - I think! It can be melted out by a lighted candle with care but it leaves a lot of soot - only for emergencies! G3PCJ)



Changes in AC mains supply voltage

During the next year or so, the electricity supply authorities are going to standardise on 230 volts 50 Hz as the normal domestic single phase supply voltage throughout the EEC and hopefully much of the rest of Europe in due course. Some Country's existing voltage will rise and others will fall, except for Northern Ireland which is already 230 volts so I am told. For most purposes the change will not be noticeable or have any negative effect. However it will directly affect unregulated power supply output voltages which vary in direct proportion to the mains input voltage. In principle an unregulated nominal 12 volt supply currently using 240 volts will go down to 11.5 volts. It may also be a problem with regulated supplies where the raw DC supply drops sufficiently for the regulator to run out of voltage headroom causing the regulator to partially shut down on each mains cycle leading to ripple on the output. Beware!

QRP Dummy Load Power Meter (and some notes on watts)

This instrument is a most useful thing to have in the shack for setting up low power rigs and for general development work. Apart from power supplies, this is the instrument that I use most frequently. It reads up to 5 watts RMS and presents a load resistance of 50 ohms enabling it to be used as an indicating dummy load. The meter is actually peak reading but the movement tends to average out the waveform over speech peaks etc. For convenience its calibrated in Watts RMS as I invariably use it on steady signals. Three ranges are provided using one scale with each range having a full scale deflection ten times the next lower range, thus each range adds 10 dB of power to give FSDs of +17, +27, and +37 dBm corresponding to powers of 50 mW, 0.5 W and 5 W RMS. Useful indications can be obtained down to 1 mW. It will work over all the HF band and, if the quality of construction is good, will also work in the VHF band. For calibration it has the great advantage that it can be set up with a DC voltmeter because it is a peak reading instrument. The intention is to indicate a general design concept so that readers may build one with the minimum of specially purchased parts and make good use of whatever is already available. Full construction detail is intentionally omitted because I don't know what you might have available for boxes, sockets, switches etc.!

The circuit shows the exact resistor values required for the input attenuator, they should be non-inductive - wire wound types are not suitable. R1 is best achieved with two 68 Ohm 2W resistors in parallel, R2 with 18 Ohms in parallel with 27 Ohms (both 0.5 W) and R3 can be two 10 Ohm 0.5 W resistors in parallel. Keep all leads as short as possible particularly around the input and R1,2,3, S1, D1, C1,2. Use a physically small switch for S1. While it is not essential to mount everything in a metal box, it adds style and keeps the RF where it should be! The ground connections should also be short. You can use any DC micro or milliammeter with suitable resistors R4 and 5 in series to read about 2 volts full scale and with a minimum resistance of about 2 Kohm; 1 mAmp or less will do. I happened to have a surplus 50 microAmp meter! The diode D1 should have low forward voltage drop which means it has to be either a Schottky type or germanium. A BAT85 Schottky diode will give better VHF (and HF) response than the germanium OA47 or OA90/91 which are best suited to HF.

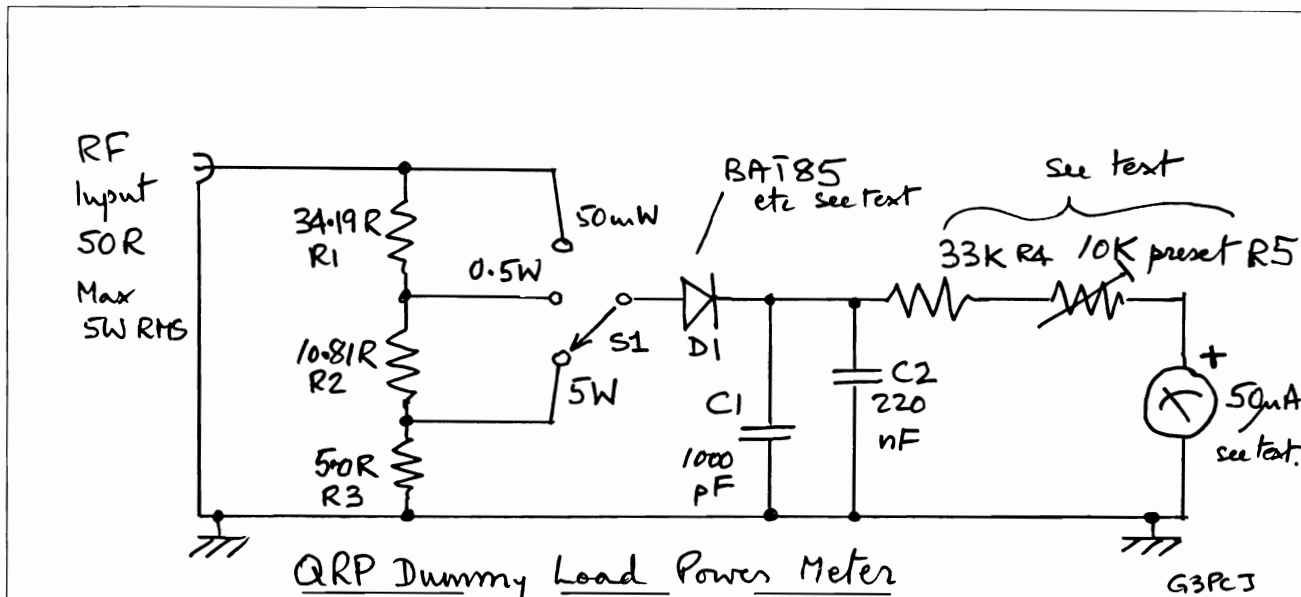
You should calibrate the instrument with a stable variable low voltage DC source capable of giving up to 50 mA into the 50 ohm load. (A 5 volt regulated PSU with a 100 ohm pot across it.) Read the applied DC voltage to the power meter as accurately as possible, preferably with a digital voltmeter. Adjust the supply/pot to give the voltages in the table and you can then mark the power meter scale, either in dB power relative to 1 mW into 50 ohm (more commonly known as 0 dBm) or in mW. You need only do it for the most sensitive range (S1 up in Fig 1). (The maths behind the table is $V_{dc} = \text{Square Root}(2RP)$ where R = 50 ohms and P equals RMS power.) Start by applying 2.240 volts on the 50 mW range and adjust your preset resistor R5 so that the meter reads full scale and label it +17.0 dBm (or 50 mW etc). Then work down through the table as the scale space permits. The meter should be used on steady RF levels; it is unreliable on SSB but will give a rough indication of signal level. Always leave the instrument on the 5 Watt range! I will leave discussion and some explanation of dBs for another occasion!

Note that I always state transmitter power output in Watts PEP because this is the correct figure to give for linear amplifiers being used for SSB (or DSB) phone transmission. When such amplifiers are used on steady tones, as for CW transmission, then the output figure in Watts RMS is half the Watts PEP figure. Power meters which are just marked "Watts" are usually calibrated in Watts RMS. This explains why many people think there is something wrong with my rigs when their power meters indicate an output of "5 Watts" instead of 10 - if they are using a steady tone the rig is producing 10 WPEP as it should. Consequently, if you were to use this meter with Tiny Tim, you might find it would produce a reading of full scale on the 5 Watt range corresponding to 10 WPEP output. You must always consider what the calibration on any power meter actually means. This power meter is calibrated in Watts RMS, despite being a peak reading device whose movement will "average out" variations in peak levels which occur more quickly than the mechanical movement can manage. Hence the importance of steady RF levels for meaningful readings. If you have a means of measuring the peak to peak RF voltage, such as an oscilloscope, then its easy to calculate the output power if you know the impedance, e.g. to check the calibration of this meter. The power in WPEP equals the peak to peak voltage times itself divided by four times the impedance. For example a steady 40 volts p-p across a 50 ohms dummy load is producing 8 WPEP or 4 WRMS. Watch out that I have used peak to peak voltages (because they are generally easier to measure than RMS voltages). There is a formula for RMS voltages but I wont give it to avoid any confusion!

Input DC volts	Power mW	dBm
2.240	50	17.0
2.000	40	16.0
1.730	30	14.8
1.410	20	13.0
1.000	10	10.0
0.837	7	8.5
0.707	5	7.0
0.548	3	4.8
0.447	2	3.0
0.316	1	0.0

$$W_{PEP} = \frac{V_{p-p} \times V_{p-p}}{4 \times R}$$

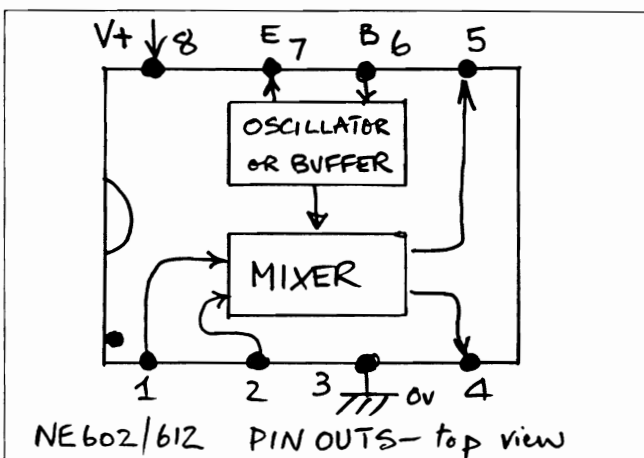
See the next page for the circuit diagram of the power meter.



The NE602/612 Mixer

These integrated circuits occur in many home built rigs because they are cheap, effective, versatile, low power and simple to use! They are used wherever the mixing function is required; for example to change frequency up or down, modulate, demodulate, or act as detector. Functionally the 602 and 612 are interchangeable - use whichever you can get hold of! They were originally intended for use in things like mobile phones but have now found their way into many types of RF equipment where the mixing function is required. The chip really contains two sections; a doubly balanced mixer and a separate section, which can be configured as an oscillator or buffer. This oscillator/buffer section

drives one of the mixer input ports. See alongside. The mixer output contains signals at both the sum and the difference frequency of the input signal and the oscillator input. Usually the output circuits will select either the sum or the difference and reject the unwanted one. The mixer section is doubly balanced meaning that the inputs and outputs are both "push-pull" in nature. This is actually achieved by a particular way of connecting several transistors in a form of tree; its known as a Gilbert cell. It also has the advantage of greatly reducing the unwanted feed through of signals from one port (input or output) to any other port. Achieving this requires a high degree of matching (or balance) between two halves of a circuit; in diode mixers, not only do the diodes have to be well matched but the transformers also require a great deal of



care which results frequently in the need to have some form of trimming adjustment to obtain the best balance. The Gilbert cell can be made with discrete components but it is necessary to have good matching between resistors and between the transistors in the "tree". With integrated circuits, the relative value or matching of both resistors and transistors can be very good and far more accurate than their absolute value; thus the process of making the integrated circuit deals with both aspects and will often mean that trimming is not required because the normal balance obtained in the integrated circuit is good enough. The Gilbert cell has other advantages; the input impedance is usually much higher - typically KOhms, the power that is required from the driving stages (and supplies) is appreciably lower, its cheap and they often have some voltage gain as opposed to the losses in diode mixers. The major drawback is their signal handling ability. There are so called "strong" Gilbert cell mixers which operate with higher currents, such as the SL6440, but there is always a trade-off between gain and signal handling performance. It is for this reason that most RF mixing circuits using IC mixers have a narrowband RF filter in front of the mixer to make certain that it receives only the low level wanted amateur radio transmissions and reject the very strong broadcast stations which can often be 100 times stronger and not many KHz away as on the 40 metre band. Mixer overload by such strong signals leads to all sorts of nasty effects where both wanted and unwanted signals can be tuned in on frequencies removed from the correct ones. Often a general buzz of broadcast station (or several station's) modulation can be heard all over a band irrespective of receiver tuning; this is the classic overload symptom. The cure nearly always is better preceding RF filtering, or in extreme cases a series tuned trap to remove some specific band - such as a 9 MHz trap at the antenna to prevent strong 9 MHz signals getting into the high gain part of the IF strip and then overloading the following product detector. The Gilbert cell mixer has been around for some time, but earlier designs such as the MC1496 tended to only have the mixer element, without the oscillator section or the biasing resistors present in the 602. These extras make the

602 a very easy chip to use. The supply voltage is nominally 6 volts but can range from 4.5 to 8 volts. A typical supply current is 2.4 mAmps. The mixer section has a 5 dB noise figure at 49 Mhz and will work to around 500 MHz. The conversion gain is typically 18 dB. The oscillator or buffer section should be limited to below 200 MHz.

Mixer inputs and outputs

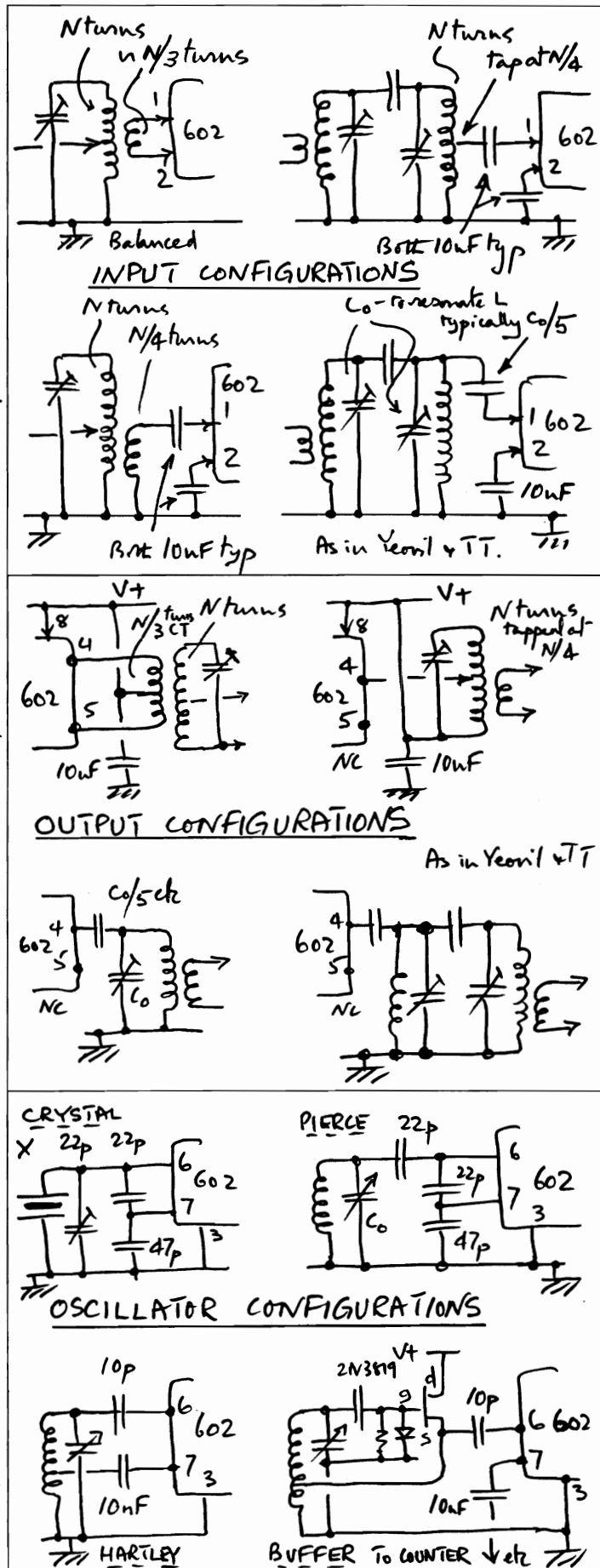
The input impedance of each input is about 1.5 KOhms, so if a balanced circuit with both inputs is being used the load impedance on the driver (filter etc.) is 3 KOhms. The chip contains biasing circuits so signals should be AC coupled and definitely not connected by DC paths to 0 volts or the supply. It is only permissible to connect one input to the other in a DC sense, as through a coil. Either single ended inputs or balanced ones can be used, the latter will have twice the voltage gain but maybe less convenient for switching etc.. Matching to 1K5 (or 3K) can be done with capacitors whose size depends on operating frequency or by inductive coupling using taps or separate windings on the RF tuned circuit. As a very crude rule of thumb these taps should be 1/4 to 1/2 way up from the earthy end of the coil, or the separate winding should have 1/4 to 1/2 the number of turns on the main winding. If only a single input is being used, the other input must be decoupled to earth with a capacitor whose reactance is 10 Ohms or less at the operating frequency. See some examples alongside.

The output impedance of each output is also 1K5 and is actually a resistor from the transistor collectors to the supply. Like the inputs, the outputs are often capacitively coupled. However the outputs can be DC connected to the supply as through a coil. They can be used either singly or in balanced form. If possible, the output circuit is arranged to reject the unwanted frequency. If the application needs to be able to select either sum or difference output, it is quite in order to have two different tuned circuits, one on each output. The fact that both input and output impedances are the same is the key to bi-directional switching (e.g.. Tiny Tim, Yeovil) since the same tuned circuit can be connected to input or output.

Oscillator/buffer section

This part of the chip can be used as an oscillator or as a buffer; when used as an oscillator most of the common configurations can be used either for VFOs or with crystal control, it should be able to oscillate at up to 200 MHz. See examples alongside. When the mixer section is working at its maximum levels, there is a risk that the oscillator section may suffer frequency pulling so in these cases its best to use a separate oscillator transistor and use the 602s devices as a buffer to isolate the oscillator from the mixer. As with the mixer section, the inputs should be AC coupled. When used as a buffer, the input should be in the range 200 to 300 mVolts peak to peak; the input impedance is unspecified but is over 1 KOhms which makes it easy to drive from an external VFO etc.. (Its also high enough to not load a low impedance RF phase shift network such as might be used in a phasing receiver.) The buffer's emitter can also drive a cable to a counter so avoiding the cable loading the oscillator and causing pulling.

G3PCJ.



HOT IRON

Issue 4

"Journal of the Constructors Club"

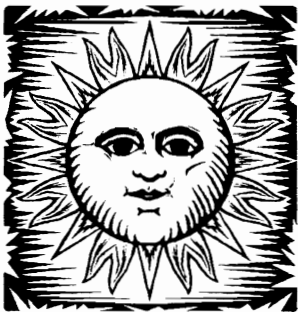
Summer 1994



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Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Constructors Club**. Articles, suggested topics and questions are always welcome. Please send correspondence and membership inquiries to:-
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EDITORIAL

Here we are on the last issue of our first year with the Construction Club. I feel very pleased since we have more members now than I thought we might have at this stage, about 80. Thank you for your support. Its continuing success is dependent on two things! Renewing your membership by Sept. 1st 1994 and a continuing supply of contributors. This time we have a few new contributors for which I am duly grateful. Many of them are snippets and I do remind you that I would welcome longer contributions - or even short ones! You may get bored with me even if I can continue to think of new material! I am acutely aware that many radio amateurs are interested in construction but are extremely hesitant to start out without very explicit instructions. What sort of things do you think people would like to know about? Its all too easy for those with experience to just throw a few bits together and have success - tell me what the stumbling block is please and I will get something on that topic. The subscription rate remains unchanged at £5 for UK and £7 for overseas members. I regret I can't send out anymore reminders so I suggest you send off now before you forget! Send either a cheque, or postal order or twenty 25p stamps. Better still, add it to an order for the Coker!

THE COKER

I am pleased to announce that this new rig will be available by the time you receive this issue of Hot Iron. The first version is for 80m but the layout should be suitable for all bands to 20m. It's a simple direct conversion receiver or transceiver primarily for CW. It is low cost and simple; has a VFO and does not use confusing integrated circuits. It should appeal to QRP operators, Novices and Clubs wanting something easy to build. The receiver is intended for use with headphones and has only a single control for the varactor diode tuning. An rf amp, oscillator/detector followed by two stages of audio gain give adequate sensitivity. Despite being intended for CW, phone SSB can be copied reasonably well. The 80m version has about 100 KHz coverage so it can be set for all the CW section or to span the QRP calling frequency and the low end of the SSB section. The CW transmitter produces about **5 watts** on a 12 volt supply and the use of a tuned output matching circuit avoids the need for low pass filters; also included are transmit frequency offset, semi break-in TR operation with a preset for hold time and a sine wave side-tone oscillator. The transceiver kit costs just **£45!** It includes an etched front panel and **all** the necessary hardware. There is provision on the PCB for adding a gain control and the use of high impedance phones. Size 4" x 4" x 2". I have included an article about its design later since it was a revelation to me how many parts had to be added to the basic scheme to make it a viable rig which I felt could be easily built with confidence.

Measuring output power

I have to come clean and admit a muck-up in my article on power meters in Hot Iron Issue 3; a reader who wishes to remain anonymous, kindly pointed out my error which is in the bottom paragraph of page 4. The power output in watts, whether it be on a steady tone or at the peak of modulation is equal to the peak to peak rf voltage times itself divided by eight times the impedance, not four times. Thus my example of 40 volts peak to peak across a 50 ohm dummy load produces 4 Watts. This highly embarrassing error did apply to all my designs and I can assure readers that my current literature now has the correct power output numbers. If any kit purchaser feels badly let down please get in touch with me. The power meter calibration table and its associated formula are correct as published.

Tim Walford G3PCJ

Editor

07/06/94

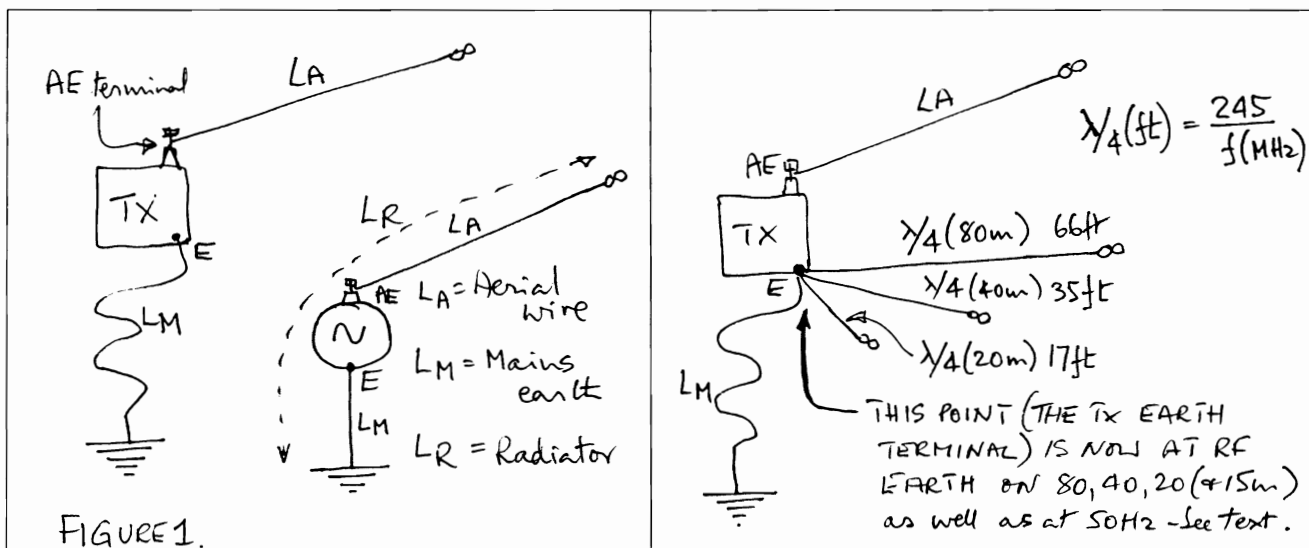
End fed aerials and transmitter earthing

Following comments from G0PCQ and G4RFU who both had trouble with the Yeovil RF PA when using end fed aerials; Eric Godfrey G3GC, who is my antenna adviser kindly produced the following notes. "End fed aerials are one of the simplest aerials for the amateur, having one end attached to the receiver and/or transmitter, and the other connected to an insulator which in turn is attached to some suitable "sky-hook" such as a tree. However there are many potential problems with using such aerials for transmitting of which transmitter earthing is probably the most important and which I will discuss in this note.

An essential requirement of end fed wires is that the transmitter should be earthed for RF. This can be a problem if like many amateurs, probably the majority, you operate from the first floor or higher in a house or block of flats. The problem is to get a good RF earth for the equipment; connecting the transmitter to the earth pin of the three pin mains plug whilst ensuring that the transmitter is at earth potential as far as the mains are concerned, does nothing towards achieving this at RF. In fact the wandering earth wire of the mains wiring effectively becomes part of the aerial system as does the transmitter itself (Fig 1). This induces RF into the mains and can be a major cause of interference with your own and neighbouring domestic equipment. It can also be the source of RF feedback, general instability problems and a "hot" key or microphone with the possibility of RF burns when using high power. Even a copper earth busbar, such as used for lightning conductors, from the shack to earth will seldom provide a good RF earth and will still operate as part of the aerial system.

So the problem is to get a good RF earth at the transmitter. How do we do this? The answer is to use what has become known as a counterpoise at HF. This is a length of wire attached to the earth terminal of the transmitter and extending down the garden often under the aerial although this is not absolutely necessary. Ideally this wire will be a quarter of a wavelength long at the operating frequency. Variants of this are a common sight at VHF where there are often three or four such wires in the form of rods forming a "ground plane" for a vertical aerial and are referred to as radials or "earth bars". The quarter wave wire or rod works on the principle that they and the ground form a transmission line and that the far end of this wire, which is not connected to anything, is open circuit with respect to earth. It is a physical fact that an open circuit transmission line an odd number of quarter waves long, in this case one, will appear to be a short circuit at its input. Thus the transmitter earth terminal at the input to the wire now appears to be short circuited to earth and therefore the transmitter is at earth potential with respect to RF. Since at the next harmonically related band (say 7 MHz with respect to 3.5 MHz) the wire is now a half wave long it will no longer provide an earth for the transmitter. In fact it will ensure that it is open circuit or very high impedance since the input impedance of a transmission line, any number of half waves long, is the same as its terminating impedance, which in this case is an open circuit. In a similar manner to nested dipoles, two or three quarter waves may be joined together in parallel to allow for multi-band working (Fig 2). There is one case where two band working with just one wire is possible and that is on 7 MHz and 21 MHz where the frequency ratio is 3:1. This means that a wire cut for a quarter wave on 7 MHz will be three quarter waves on 21 MHz and therefore still present an RF short circuit to earth at the transmitter earth terminal.

The input impedance seen by the transmitter will depend on the length of the aerial. Quite often this will have been cut to length but frequently it will be some random length dictated by the garden dimensions. This means that some form of impedance matching unit will have to be employed in the shack to match the aerial to the transmitter. It is essential that not only is this of good quality but also that it is capable of transforming a wide range of impedances to the transmitter's requirement which is usually 50 Ohms. In many cases it is better to have a home brew dedicated matching unit rather than a commercial "universal" one. However, aerial matching units is another subject! (Yes please - hint hint - Ed!) Undoubtedly, if there are problems in feeding or matching an end fed wire aerial then there is a high probability that the solution will be in providing a good RF earth for the transmitter. " Eric Godfrey G3GC



Designing the Coker

I have included these notes since I was surprised how the final parts count for a very simple idea had grown during the design, proving and testing stages. This rig had its origins in the Construction Challenge at the Yeovil Club's 1994 QRP Convention. The task was to build an 80m CW receiver using no more than 10 components! Since I was on the organising committee, I was excluded from entering but I concocted the arrangement on the right for fun and for testing the evaluation gear. It proved to have a very high gain and an output of over 100 volts for the 100 micro-volt rf input! It was definitely not suitable as a kit for all to make! It might interest the adventurous!

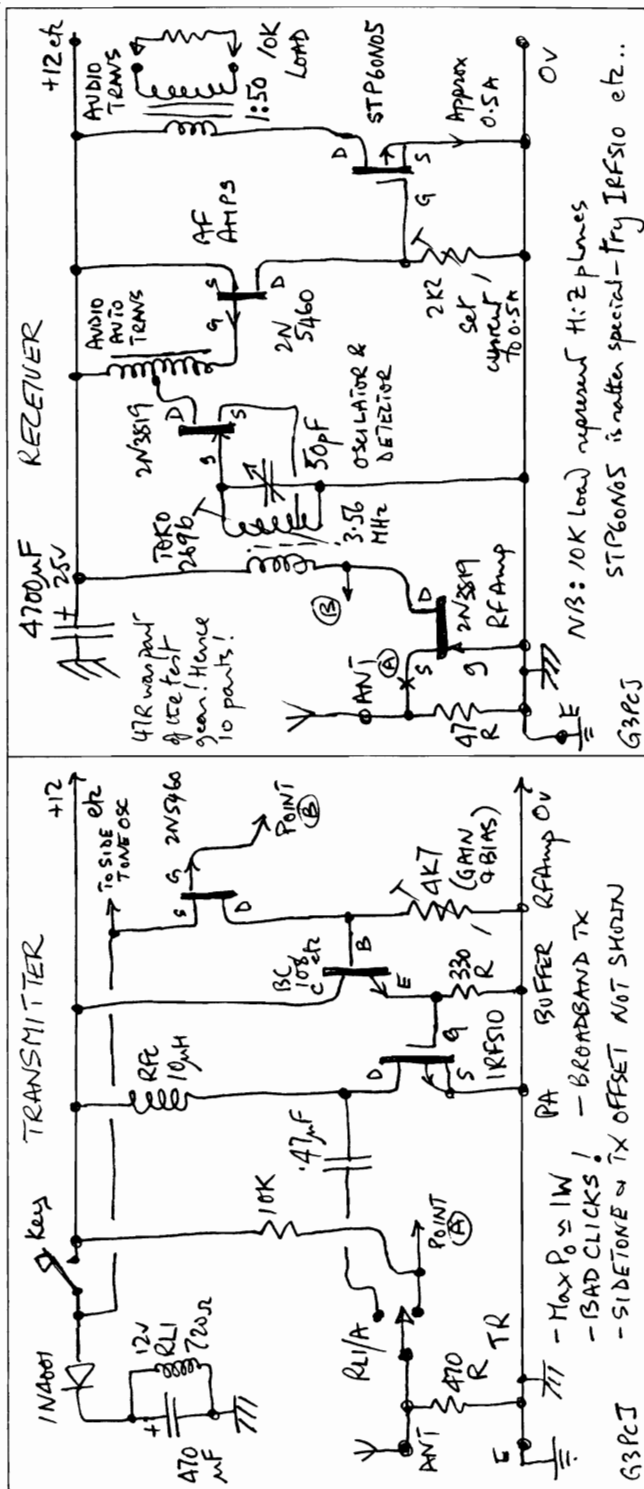
The design requirement was to avoid integrated circuits, uncommon parts and air spaced tuning capacitors but to have a reasonably sensitive receiver, using the minimum of total and different component parts to cheapen the kit, be easy to set up and a pleasure to use - i.e. no nasty clicks or thumps! Ideally the same PCB and associated etched front panel could be used for versions for all the HF bands from 20m down with only coil and capacitor changes. This is how the receiver grew!

Avoiding air variable tuning capacitor: add varactor diode, two capacitors, resistor, pot with scale linearising resistor, voltage regulator and its two resistors. (Its still worth doing this since an air variable and slow motion drive costs about £10 and makes for a much more complex and costly mechanical design.) Making VFO stable: add two fixed silver micas, trimmer for increasing sensitivity, diode and resistor. Audio filtering: change auto transformer to 0.1H choke with capacitor to resonate at 750 Hz with extra R and C for better CW filter roll-off. Driving low impedance headphones: change output transformer to readily available step down type, use standard low cost FET as for TX, and add C and R for better biasing and increased audio gain to make up for that lost in transformer. Power supply decoupling: add two electrolytics and two disc ceramics. RX RF amp: add capacitor and choke for higher gain and to allow scheme to turn it off on transmit. The RX sensitivity is such that I can just hear antenna atmospheric noises during daytime when I connect my antenna.

I have sketched on the right the original idea for the TX part, which I soon realised needed more thought! TX output matching: add two high voltage Cs with toroid coil for higher output and better harmonic filtering, add 1W resistor to dampen tendency to half frequency output, add two decoupling caps and avoid one (!) big coupling C. Increase TX amp gain to allow for higher output, low oscillator output and spread of FET characteristics: add transistor, two resistors and coupling cap. Separate gain and bias presets for best control of output stage conditions: add preset with two resistors and one capacitor. RF envelope shaping: add R and C. For the control aspects: avoiding a live key, add transistor switch with two resistors. TR relay driving: avoiding very large charging current (big clicks) and the need for big electrolytic for timing hold capacitor, add FET with preset and safety resistor for adjustable period. TX frequency offset: add two Rs and decoupling C to make dependable and free of clicks, driven from TR relay. Side tone oscillator (not shown): FET with audio filter (3 Rs and 3 Cs), preset for output level and small capacitor feed into receiver audio filter, bias resistor with diode for key control avoiding key clicks. After all this it should work well! The instructions will be written as a Club construction Project.

Experience with a MF12 QRP Booster!

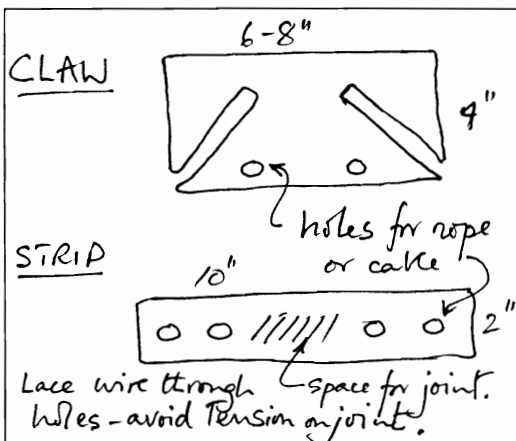
Roger Thomas GW4BCD reports that his Booster worked as soon as it was switched on but he had to get his wife to wind the output transformer! He has it working on top-band with a 160m version of Tiny Tim to which he has substituted a 10 turn main tuning pot. He would like to add AGC and an S meter. I am working on some possibilities. He found the output coil needed two less turns to get it to resonate at 1912 KHz instead of 1832 KHz.



Snippets from Members

Smart looking PCBs. Peter Dolphin offers the following idea for making a veroboard with its mass of holes look professional! Firstly fill all the holes from what will become the front side, with a thin layer of Polyfiller and smooth it off carefully. When dry, sand it very lightly to give a plain surface; then spray with an appropriate colour of car paint and allow to dry. When construction is commenced, each hole that is to have a lead through it, has its Polyfiller removed by poking it out with a sharp point such as an old compass. If this produces a rough surface a further light sanding maybe desirable. The results are surprisingly good for relatively little trouble. The component leads can be bent over and soldered to each other as required on the back, or you can use the type of perforated board that has copper strips on its back, soldering the parts to these and cutting them where necessary.

Aerial rigging etc. Rev. Tony Measures G3WUC follows the advice of John Heys (Practical Wire Antennas from the RSGB) that whenever you erect a wire antenna to the top of a pole or tree, that you should put up a continuous loop of rope around a pulley at the top. This does not directly support anything but does allow you to hoist up another rope etc to support the antenna without having to climb the tree every time you decide to cut off two inches when resonating it! He has also found the two gadgets on the right useful for holding or joining wires. Made from quarter inch thick paxolin with the edges bevelled off where they bear on cables or rope. The "claw" allows easy anchoring of wire or feeders by wrapping into the grooves. The "strip" is used to join two cables and avoid tension on the joint which is thoroughly soldered with a big iron or torch, covered in araldite and self amalgamating tape. For his big (and he does mean big, 280 ft sloping doublet and 500 ft loop!) antennas he uses electricians stranded



2.5 sq mm PVC cable. (Ref 6491X) About £20 for 100 metre drum. I went into the loop has got him into Brazil, Bombay and West Virginia. No prizes for guessing what his sky hook is! I think he has steps to his top pulley!! Despite its tendency to perish in UV light, he finds Polypropylene rope is so cheap that it can be totally replaced every four years before it gives up. A 720 ft coil cost £10 from a rope supplier - available also in most agricultural merchants.

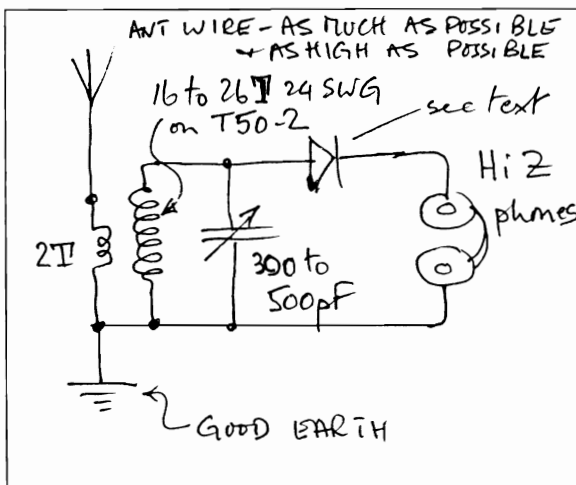
Building tips. Simon Males G0EVZ kindly sent me a long note of his experience when building the Yeovil from which I have lifted the following. He modified the tuning arrangements by substituting a 10 turn pot with a turns counting knob assembly for the main tuning and ignored the fine control. He arranged that turning the knob clockwise increased the frequency on both bands (normally they are in opposite senses) by using a bandswitch with two extra poles which reversed the end connections to the 10 turn pot. He then produced a calibration graph of frequency on the two bands versus the dial reading. (He should have a digital frequency readout instead!) To overcome the difficulty of identifying the different wires and counting turns on a multi-winding toroid, he sprayed one of the wires with grey paint before winding it onto the toroid so that the two windings were of different colour. He also found it much easier to assemble the output power FETs to their heatsinks before installing the heatsink in the PCB.

What NOT to do with a Yeovil! G3WUC's output transistors went bang when the bandswitch was inadvertently altered instead of the Tune switch being turned off. He suggests that one of the switches be changed to a rotary type or, if toggles have to be retained, one is turned so that it acts horizontally thus needing a different action.

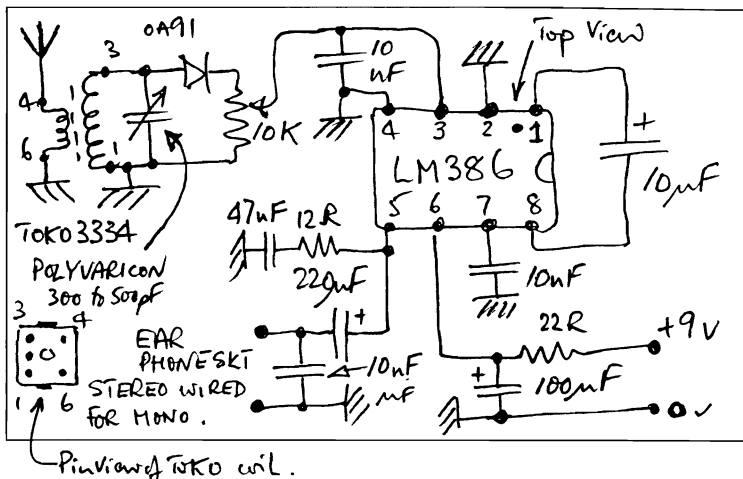
Yeovil RF amps. Noting the interest in extra RX gain, I felt that the easiest solution was to put a 50 Ohm RF amplifier in the receive path around the transmitter. A MAR1 having 20 dB gain, two 10 nF coupling caps in and out with 390 Ohms from output to + 12v suffice - cheap and easy to install. This certainly increases sensitivity but since there is no RF tuned circuit in front of this broadband amplifier, it leads to all sorts of nasty overload problems. It is usable by day but at night the powerful broadcast stations ruin all bands! I am working on an IF amp still! G3PCJ

Crystal Radios

By chance we have two contributions! Derek Alexander G4GVM commends that on the right, which first appeared in print in 1991. He made it up bird's nest fashion in seconds and connected it to his G5RV. Many international broadcast stations can be heard at different times of the day, night-time being best. A long wire aerial should give good results but do get as much height as you can with a good earth. You must use high impedance phones (2K or more) or a crystal earpiece. Use a T50-2 toroid with 16 to 26 turns of 24 SWG wire with a two turn link wound over the earthy end, any germanium diode - OA90/91/95, GD5, BAT85 etc. A 300 to 500 pF variable can be salvaged from a transistor radio. The surprising thing is the selectivity - so much better than can be obtained on the long or medium waveband. Good DX listening! G4GVM



Craig Douglas G0HDJ offers that on the right which has proved very popular with the pupils at GX0PCS as an introduction to building and SW listening. A piece of copper clad board is used, mounted near vertically on a block of wood with chocolate block connectors. The parts are kept in place by their soldered connections to each other and to the copper ground sheet. After the electronics have been assembled it's screwed to the wood. It works first time and gives good results with a 10m piece of antenna wire. Scouring the surplus adverts has enabled many to be built for under £3! Not very exciting but a good starter for pupils and grandchildren! G0HDJ



RF Output Matching

John Shaw G3ZKZ asks if I would explain the cost and impedance aspects of the output of Tiny Tim. In view of my admission on page 1, I do this with some trepidation! Once you have decided what output power the rig is to have, it is easy to decide what the load impedance presented to the output transistor should be. The required load impedance is the square of the maximum RF peak voltage divided by twice the desired output power. (This is the same formula as on page 1 since pk-pk is twice peak voltage.) The formula holds for all types of output device (bipolar or FETs) provided some allowance is made for their "On" resistance. For most FETs and bipolar output transistors this can be allowed for by saying that about 90% of the actual supply voltage is available as the maximum peak RF voltage at the drain or collector. There is some element of juggling with the numbers because it's quite often convenient to make the load impedance a convenient relationship to 50 Ohms, say half or one quarter, i.e. 25 or 12.5 Ohms. It is also important that the transistor's "On" resistance is small compared with the load resistance worked out above; if this is not so, the efficiency will be poor and the above 90% figure will be too large. The solution is to increase the supply voltage. This is why VN88AFD FETs have to be used on a high voltage supply because their "On" resistance is appreciably higher at about 4.5 Ohms compared to the 0.6 Ohms for IRF510s which can be used on 12 volts. (Unfortunately there are currently no cheap low "On" resistance FETs which will work fast enough to go above 20m with reasonable gain, owing to the high gate capacitance which requires lower driving impedance and hence low gain.)

For Tiny Tim on a 12v supply producing 5 W, the desired load impedance is sufficiently close to 12.5 Ohms to use that figure since it has a number of desirable consequences. A choice has to be made as to whether the matching is to be done on a broadband basis, such as for a multi-band rig like the Yeovil, or on a narrow band basis for a single band rig like Tiny Tim. The latter has the advantage that, if the matching network has a Q of about 12, then it's not usually necessary for low pass filters to be needed to remove RF harmonics generated in the output stage. Low pass filters, or a resonant antenna matching unit, are obligatory after a broadband transmitter output stage. There are various narrowband matching networks that can be used for this transformation from 12.5 Ohms at the FET drain to the 50 Ohm antenna. An example is the pi network commonly found in valve transmitters where quite a large impedance transformation is needed; seldom does it give easily realisable values for transistor output stages. The various three element T networks give much better results; I favoured the so called LCC configuration for Tiny Tim (and the Coker) because the capacitor values are small and also available in close tolerance types (with the necessary high voltage rating), it also needs only one inductor which builders don't like winding! It is quite often found in VHF rigs since making the capacitors variable allows matching to a wide variety of loads. I have put the circuit and theory in the box alongside. It just so happens, that for an antenna load impedance of 50 Ohms with a desired drain load of 12.5 Ohms and a Q of 12, that both capacitors have the same value; this is true of any band but on 80m it works out that 150 pF is required with an inductance of 6.5 uH. If a toroid is used, the inductance is its A_L value times the square of the number of turns. The A_L value is 5.7 nH per turn² for a T68-2 or 5.0 for a T50-2. (The first number is its width in hundredths of an inch; the second denotes the material, -2 toroids are painted red and suited to 1 to 30 Mhz). If the formula is turned around you will find that 33 turns are needed on the T68-2. The figures for these powdered iron cores (not ferrite) are pretty close tolerance so that when used with close tolerance

LCC Network

R_1 DRAIN (12.5 Ohms) R_2 ANTIENNA (50 Ohms)

Choose Q (12 typical) $R_1 \approx \frac{(0.9 V_{SUP})^2}{2 P_{OUT}}$

Let: -

$$A = \sqrt{\frac{R_1(Q^2 + 1)}{R_2} - 1} = 5.92$$

Then: -

$$X_L = Q R_1 = 150 \Omega$$

$$X_{C1} = \frac{R_1(Q^2 + 1)}{Q - A} = 298 \Omega$$

$$X_{C2} = A R_2 = 296 \Omega$$

For 80m: -

$$L = 6.4 \mu H$$

$$C_1 = C_2 = 150 pF$$

For toroids: -

$$T50-2 \quad A_L = 5 nH / \text{turn}^2$$

$$T68-2 \quad A_L = 5.7 nH / \text{turn}^2$$

$L = A_L N^2$ $N = \text{no of turns}$

$$\therefore N = \sqrt{\frac{L}{A_L}} = \sqrt{\frac{6.4 \times 1000}{5.7}} = 33 \text{ turns for T68-2}$$

capacitors, there is a good chance that tuning to suit will not be required - if it is necessary it can be done by adding or subtracting a turn on the toroid.

Another useful output matching circuit is the LCL, which I have used on my own rigs not intended as kits. Interestingly John Cronk GW3MEO, has tried this in his Tiny Tim. He used a lower drain load resistance in the quest for more power but could not easily accommodate the parts on the board and I suspect the driver stage also began to run out of gain. It has excellent harmonic rejection but the capacitor is large and difficult to obtain as a variable trimmer so the coils have to be variable. Because there are two, it is also less attractive to builders which is why I stuck to the LCC version. He built his with Aladdin 7/16" formers with cores. See the theory alongside. G3PCJ

Output Low Pass Filters

Where a broadband transmitter is used, such as in the Yeovil or the Boosters, then these filters are needed to get rid of harmonics generated in the output stages. A very useful design is the half wave filter, so called because it behaves like a half wave of transmission line. The numbers are very easy because for each section of three elements in the pi configuration, the reactances near the operating frequency are made to be those of the line in which it is to be placed. This is normally 50 Ohms so the capacitors and inductances should have a reactance of 50 Ohms at a frequency just above the desired operating frequency; for example at 4 MHz for 80m and 18 MHz for 20m bands. The fundamental will be attenuated by 3 dB at the frequency where the reactances equal that of the line so you want these to be just above the upper band edge. Usually to get sufficient attenuation of the second harmonic, it is advisable to have two three element sections in series. When this is done the two middle capacitors can be combined in one with its value double that of the end ones. Unfortunately since all lower frequencies go through without attenuation it is necessary to have a filter for each band. Use powdered iron cores. G3PCJ

Construction Tips

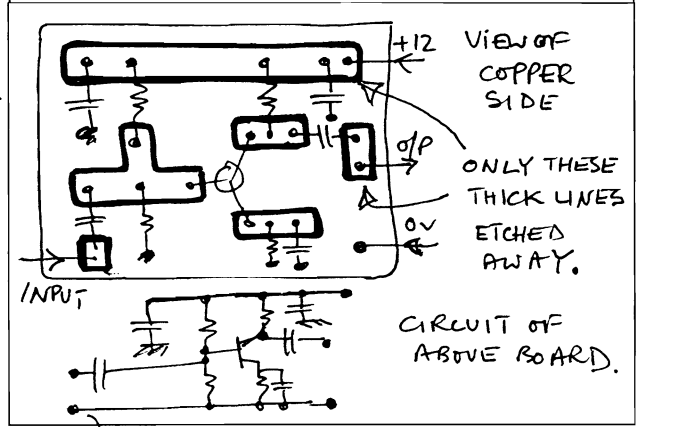
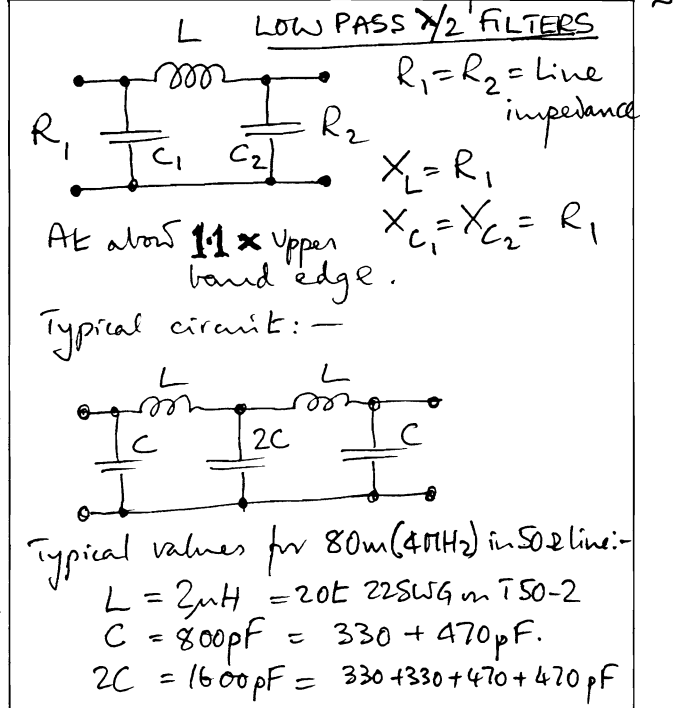
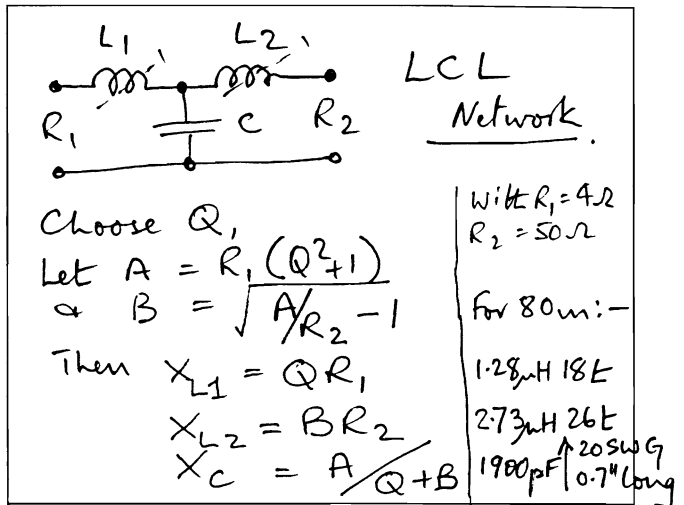
John Shaw G3ZKZ suggests that where you need to mount components with awkward pin spacings on a board needing to be drilled, that you first smear a layer of plasticine about 1.5 mm thick over the board around the component location. Then carefully press the leads into the plasticine, remove and drill through the holes. He likes to use small sections of board so that he can keep his ferric chloride in a large mouthed screw top jar (out in the shed!) into which he can dangle his boards for etching. This avoids pouring the nasty stuff out and he arranges his track patterns to remove the minimum of copper so that the etchant lasts longer. He leaves lots of copper for earth and joining patches and etches away only the isolating strips. (I wonder how? G3PCJ.)

The Somerset Range of Kits

Herewith a brief reminder of whats available. Please send a SSAE for full details.

- The Yeovil 20 and 80m CW and SSB well specified TCVR, optional converter for 40m.
- Tiny Tim 80m SSB phone simple superhet TCVR, mod kit available for 160m.
- Novice 160m Double sideband suppressed carrier direct conversion phone TCVR. Low cost.
- Counter Five digit KHz and MHz two channel counter to 60+ MHz. For superhets or DC rigs.
- QRP Boosters Two versions; 12 volt for 160 & 80m, 25/35 volt for 160 to 10m. 25W for under 1 W in.
- Coker **NEW.** Simple DC CW TCVR for 80m. No ICs! Suit Club construction project.

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HOT IRON

Issue 5

"Journal of the Constructors Club"

Autumn 1994



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- Fault finding
- RF limiting
- Accessories

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Constructors Club**. Articles, suggested topics and questions are always welcome. Please send correspondence and membership inquiries to:- Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 0458 241224 The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £5 per year for the UK (£7 overseas) from Sept 1st in each year. Jan 1st 1994.



EDITORIAL

I am pleased to be able to welcome some new contributors for the start of our second year with Hot Iron; David Sugden, G4CGS, offers a note on measuring inductance which I suspect is one of those things that many of us would like to do but can never remember an easy way - here it is! Incidentally, David does much of my PCB drilling for me and has to have some major surgery soon - we wish you well. We even have a letter to the Editor, (not invited by me!), with a most helpful suggestion on finding where to put parts into boards. Please keep the material coming - my material file is getting rather empty now! Alex Robertson, GM4IAO, has pointed out that my words on the copyright of material published in Hot Iron maybe putting off contributors - I hope that this is not the case because I certainly have no desire to make any commercial gain out of other peoples ideas. It is there to give some cover, albeit rather thin I think in reality, from others trying to make something of my own ideas. In fact you will find that the publisher, practically without exception, will retain the copyright for all material in his journal irrespective of whether he paid a fee for the article or not. For example, the contributions to RadComm's Technical Topics, are covered by the general copyright for the whole magazine. Please tell me if you feel inhibited by this copyright aspect.

At last I am able to tell you about my IF amp for the Yeovil, it should also be useful for Tiny Tim but to date I have not tried it out with TT. I do find that the MF Booster does go very well with Tiny Tim; I had some very good reports when working with an 80m dipole clear of all buildings in a field with the rig under a fertiliser bag due to a downpour just prior to our Wessex Clubs BBQ on July 30th.! The rain neither put out our spirits or our fire!

Tim Walford Editor 30/08/94

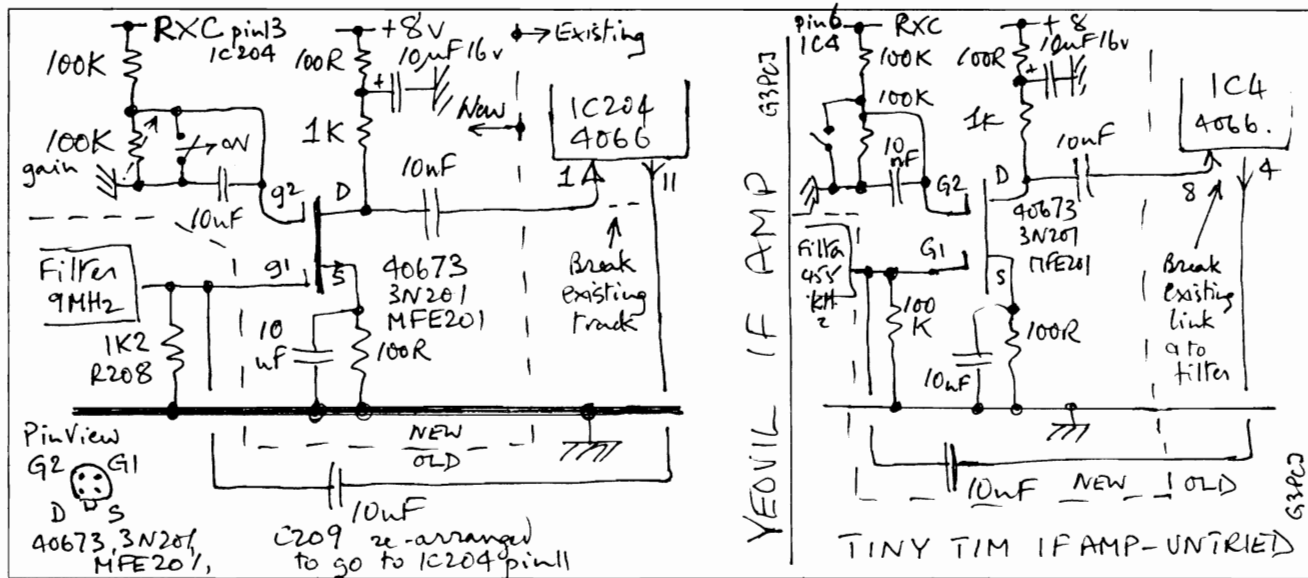
Snippets

Craig Douglas, G0HDJ, has sent in a couple of snippets. Firstly that SMITH KENDON travel sweet tins have many uses in the shack! Apart from storing spare parts, they make excellent cases for small items of test equipment and are also suitable for supporting a PCB when soldering the underside connections. The tin has sufficient dept for the parts to not hit the bottom, the width gives it stability and there is enough room for a damp sponge for cleaning the soldering iron tip! He has also solved the problem of where to find plastic knitting needles which are a vital tool for adjusting the ferrite cores of Toko coils and the like. Visit your local shop specialising in second hand furniture and house clearance - a good rummage around and you might find some without the steel cores of the plastic coated variety - see if you think you can snap them before buying! These shops also have old radios with large air spaced variable capacitors.

Stan Knight, G0BGI, has asked for advice on static precautions in regard to FETs and CMOS devices. Its a big subject but the best advice is to assume that all active devices maybe subject to damage and thus treat all equally carefully. Some may have protective zeners but dont rely on it! As I live in an old damp farmhouse, there is usually sufficient moisture about for there to be a leakage path practically anywhere! You should keep parts for as long as possible in static discharging black carbon loaded plastic bags, or in similar carbon loaded foam plastic or with their leads rammed through kitchen foil wrapped around a polystyrene block. If your shack has a very dry atmosphere which might cause problems, you should earth yourself, your iron and the item being assembled, frequently to mains earth. You can regularly touch the exposed metalwork of some piece of mains earthed equipment, or better still, wear an earthing wrist strap. A stripped flexible lead wrapped twice around your wrist and connected to a suitable mains earth point should help and do also earth the PCB. Do be CAREFUL to get mains earth and not the live line. Do not connect to an RF earth. Never insert parts into live circuitry.

IF Amplifier for the Yeovil

The correct place for a receiver IF amp is after the IF filter and before the second (product) detector. When Derek Alexander, G4GVM, tried his IF amp in this location he was unable to control the ensuing hooting so he moved it to before the IF filter - see Hot Iron 2. My own efforts were equally useless until I realised that the feedback was audio from the rig output stage, through the 12 volt supply to the extra IF amp and into the product detector and hence round again etc. It needed about 10,000 μF on the +12 volt line to stop this! Luckily it is quite in order to use the +8 volt line where the feedback path is broken by the regulator. The basic circuit uses one device with a few resistors and capacitors which can be mounted ugly style with short leads so I don't think a PCB is necessary. It does require that a track be cut between pins 1 and 11 of IC204 and I would suggest that you drill four small mounting holes for the dual gate FET in the space between R208, R205, C211 and C209 which has to be removed/rerouted to pin 11 of IC204. The device leads are pushed through these holes with all the other parts mounted by their leads between the transistor and other rigid connection points on the underside of the PCB. It is important for the filter pin connections to be short as it is very prone to picking up BCI. Only use the earthy ends of R208 and C213 for making earth connections. Any of the three transistors listed should be suitable. The amplifier gives about 10 dB gain and it will slightly increase the apparent RX noise level when no signals are present as it amplifies front end noise, however the AGC action comes into effect at lower levels when signals are present and this depresses the noise. The 100K shown as a variable can be used as an IF gain control or replaced by a fixed resistor, with or without the switch to reduce the gain. In practice most people would leave it on full gain the whole time. Increasing the IF gain decreases the threshold of AGC action and you may find that the S meter reads continuously even without a signal present. The cure, if required on your rig, is to reduce the AGC loop gain by reducing the value of R110. This is most easily done by tacking say 100K in parallel with R110 under the PCB. (It is possible to replace the 1K drain load resistor of the IF amp with a 9 MHz parallel resonant circuit; this will give greater gain but you will definitely have to reduce R110 and the recommended 1K is much easier to install and will suit most people.) In principle this circuit can be added to TINY TIM since it will work equally well on 455 KHz; however the pin numbering is different and parts are needed for the DC biasing of gate 1. G3PCJ



Yeovil tuning controls

G4GVM tells me that he is working on a scheme to make the main tuning of the Yeovil always give increasing frequency with the same rotation and at the same time limit the coverage to just the appropriate band segments, rather than the normal 500 KHz. This uses presets and a potentiometer with slow motion drive - details in the next issue. G3PCJ

Frequency Counter as an instrument

One counter, returned for investigation of random readings with no input, showed symptoms of instability and noise on its +5 volt line caused by the input logic gates not having any signal to switch them fully to their normal digital output levels. By applying DC feedback around the CMOS gate, its output is forced sit at mid supply level and in doing so draws rather more current from the supply than is normal for a CMOS gate. This in turn causes the supply to droop a little and the gate to oscillate at around 100 KHz. This oscillation does not occur if there is an input signal since this drives the output to the supply limits in the normal manner for a logic gate; hence if the counter is installed permanently in a rig, it always has the oscillator signals driving it and the fault does not show up. Only when its used as test gear and there are no signals does it show - the cure is easy; add a 100 μF 16v decoupling capacitor to the +5 volt line. The same unit also had another fault; a regular beating of the display between two values when the input was in a certain frequency band. This was located to a missing earth point connection for one of the counter chips! G3PCJ

Measuring Inductance

Most amateurs own a multimeter which will enable them to measure resistance. A few will own either a capacitance bridge or one of the newer digital multimeters which has a facility for measuring capacitance. Not many have anything for inductance but with simple gear and ingenuity it can be done. The methods described require some simple calculations and will give an accuracy of around 10% which is good enough for most purposes. For inductances up to about 2 milliHenries, the simplest method is to connect a known capacitor in parallel with the unknown inductor and determine their resonant frequency. Its worth remembering that all inductors have some self capacitance so a fairly large value should be used to swamp the unknown self capacity. Having determined the resonant frequency the value is determined from the standard formula:-

$$f = \frac{1}{2\pi\sqrt{LC}} \quad \begin{array}{l} f \text{ in Hertz for} \\ L \text{ in Henries and} \\ C \text{ in Farads} \end{array} \quad \text{OR} \quad f(\text{Mhz}) = \frac{159}{\sqrt{L_{\mu\text{H}} \times C_{\text{pF}}}} \quad \begin{array}{l} f \text{ in Mhz for} \\ L \text{ in } \mu\text{H and} \\ C \text{ in pF} \end{array}$$

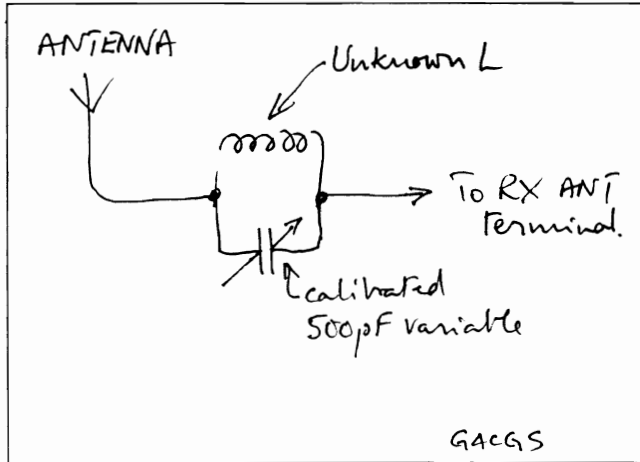
There are at least two other methods.

1. Using a Grid Dip Oscillator

Connect a known close tolerance capacitor across the coil and search for the dip which indicates the resonant frequency. If you always use a 250 pF fixed capacitor, calculation is simple. Take the frequency in Mhz, multiply it by itself (square it) and divide the result into 100. The answer is the inductance in μ Henries. If this produces an abnormally low frequency, try repeating the test with a fixed 25 pF capacitor, but this time divide the square of the frequency in Mhz into 1000. Again the answer is in microHenries. Easy isn't it? What no GDO! Then use your RX.

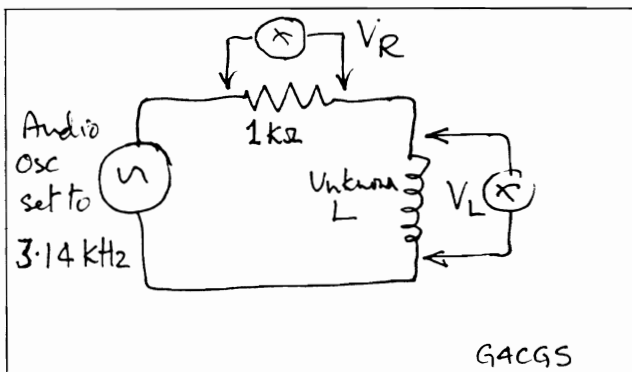
2. Using a Receiver

This method makes use of the fact that a parallel connected coil and capacitor combination connected in series with the antenna lead of the receiver will act as a rejector circuit. At its resonant frequency, the rejector circuit exhibits a high impedance and rejects signals of that frequency. Here we use a 500 pF variable capacitor fitted with a pointer knob and scale calibrated at 50 pF intervals using a capacitance bridge. The variable has short leads with crocodile clips to attach it to the unknown which is placed in series with the receiver antenna lead. Simply tune in any steady signal on the receiver and rotate the variable capacitor until there is a sudden loss of signal. Note the frequency and value of capacitance; find the inductance by inserting them in the above formula or using charts which are available. With the capacitor variable between 50 and 500 pF giving a 3 to 1 frequency range on any coil, an HF receiver with coverage of 500 KHz to 30 Mhz will cover inductances from 0.1 μ H to 2 mH. This will cover most coils used in RF work but what about those for audio work?



Measuring Reactance

For coils of relatively large value, the above resonance methods become impractical; instead we measure the impedance of the coil at a known frequency. We need an AF oscillator capable of a volt or more output and some sort of voltmeter suitable for measuring the audio frequency voltages. Simply connect the coil in series with a known non inductive resistor across the output of the oscillator. Since the same current flows through the coil and resistor, we can use a voltage measurement across the resistor to measure the current in the coil, which can be used with the voltage across the coil to obtain its reactance and from that, its inductance. The maths is a little tiresome but we can simplify it by always using a 1000 Ohm resistor and using a fixed frequency of 3.14 KHz for the audio oscillator. Connect up as shown and measure the voltage across the resistor, call it V_R then measure the voltage across the coil, call it V_L . Note that if these two numbers are simply added together they will not equal the voltage applied from the oscillator since the voltages have different phase relationships. For this reason the voltmeter used must be isolated from the audio signal generator. Insert the measured values into this formula and the result is in milliHenries:-



$$L(\text{mH}) = \frac{50 \times V_L}{V_R}$$

Measuring inductance is certainly not as easy as measuring resistance or capacitance but with a little ingenuity quite good results can be obtained.

David Sugden

G4CGS

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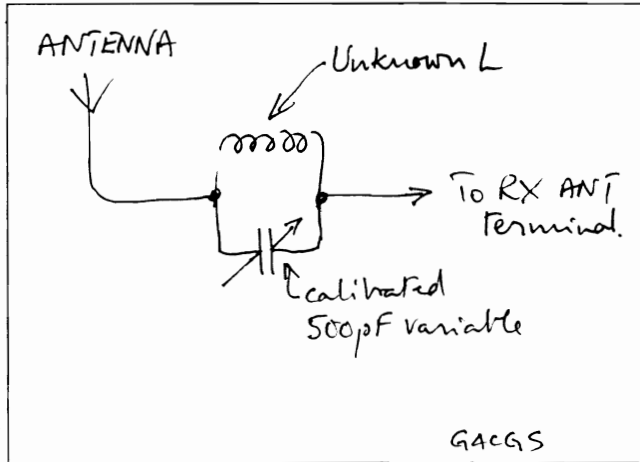
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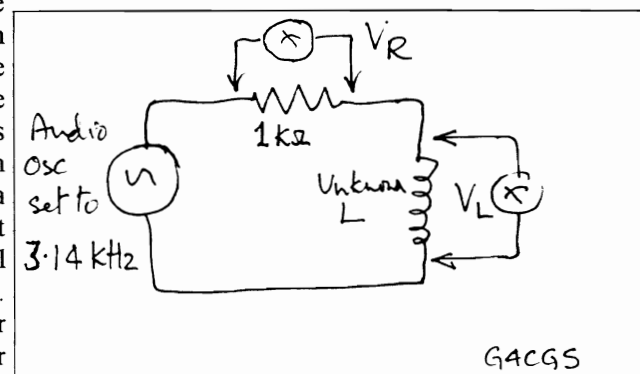
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Fault finding

Quite often I find people unsure what one ought to do when confronted with a dead electronic beast. (Please excuse my farming background!) Herewith some suggestions written as though you are examining something built by somebody else. If you have built it, the principles are just the same. If it has worked in the past, then damage physical or electrical (blown devices) is most likely. If it is a kit that has never worked go back and reread the instructions doubly carefully for things you failed to do; incorrect parts placement is quite common. The sort of fault where parts go out of tolerance with age or where the design was marginal in the first place are likely to be pretty rare and cause much sweat even if you have good test gear! There are three main stages in fault finding; a good physical examination, followed by tests you can do easily and finally, less easy tests with measuring equipment. The basic principle of fault finding (with the device switched on) is to assess the output responses to any form of input. The further the input is from the output, the more uncertainty there is which makes it necessary to keep on dividing the section being tested in two until you have found the fault. If there is no response to your first test, either move the input signal halfway towards the output or the output halfway towards the input. If the enclosed stages now work you know the fault was in the other half. Transfer the input and output evaluation points to the non-working section, check its not working and divide into two as before. Keep on doing this (within the convenient possibilities that you have for injecting test signals and evaluating the response) until you are down to just a small group of parts.

The physical examination involves looking for signs of mechanical or electrical damage inside and out - broken and bent parts, loose and poorly insulated wires, melted or lifted tracks, swarf and solder splashes etc. Pay particular note to the points where there should be ground plane solder connections on the top side of the PCB as well as on the underside. Unless there have been board drilling mistakes, there should be no countersinking for these points on the ground plane side. Failure to make these top side solderings, because it fails to link underside ground connections to the ground plane, is the most common cause of malfunction in my kits. Also examine carefully the quality of soldering; are the joints well shaped, bright and well adhered to the component wires? Again ground plane solderings are prime candidates - notably disc ceramic capacitors which don't always tin very well close to their body and may need their leads scraping. At this stage look for parts that are bent over, or inserted too far, that might be shorting to the ground plane; worst offenders are ICs pressed in too far before soldering, Toko coils that have pins with shoulders, and preset resistors. Any wiring to the front panel should have short leads laid away from sensitive areas such as VFOs and high impedance low level signal stages (audio pre-amps). I prefer to lay wires tidily but NOT laced on the topside against the ground plane since this helps to screen them from the tracks underneath. Front panel earths should also be short and thick - particularly for gain control earths - they should connect direct to the front panel ground plane if fitted, which should be soldered every inch or so to the main PCB ground plane.

After passing, and maybe rectifying any defects of the physical examination, make the external connections and apply power of the right polarity. Watch out for unreasonably high supply currents. Examples of easy tests which you might do first are to listen to the output of a RX or to measure the output of a TX. If there is nothing at all, not even at a very low level, the output stage is likely to be dead but if there is a hiss or any very low level RF output, then its likely the trouble is earlier. See if it works on any other bands or in any other modes - do any of the controls have any effect - as expected or otherwise? Carrying on with the easy tests, you might see if it responds to the application of a finger to the hot end of the audio gain control. This is a crude test of the following audio stages and you should find your finger causes a hum - unless of course there is a nasty narrow CW filter in between which would reject the 50 Hz! That tells you that you should have made certain the controls were set correctly for the sort of test you are performing. (Be very careful when doing any tests with valved rigs having high voltages and the finger test is best avoided just in case a coupling capacitor is leaky.) Probably the most valuable thing to do next is to check all the supply voltages and particularly any internally derived general supplies - do they have the right levels and do they change in an unexpected manner when the controls are operated? After this its worth seeing if the oscillators are working because that can often be done easily. Use a RF probing voltmeter, scope, counter or a general coverage receiver with its aerial lead draped over the suspect oscillator. Tune the test RX around the expected frequency and remember to alter the oscillator's tuning (on a VFO) just in case the vanes are bent and touching etc. If it is a crystal oscillator you should know exactly where to look.

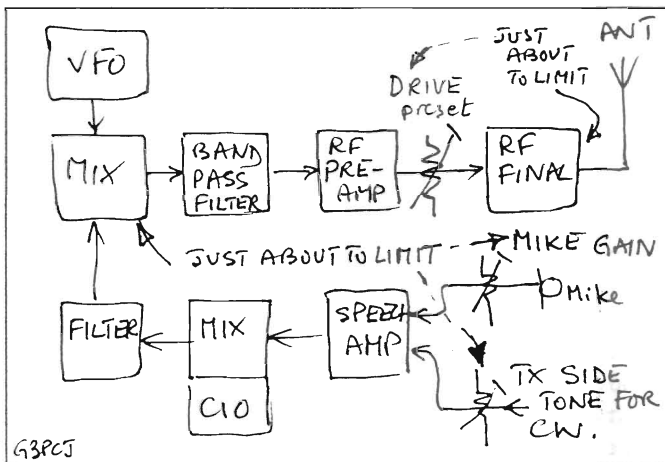
If these relatively easy tests fail to identify the problem area you will have to inject known carefully controlled signals, audio, RF or whatever, and measure the output with appropriate voltmeter, scope etc. Since we havn't yet had much in Hot Iron on items of such test gear, I cant go much further in this article. I hope later to have something on test oscillators, broadband amps and attenuators etc to compliment the RF power meter described in Hot Iron 3. Similarly for audio test gear. However by far and away the most useful piece of commercially made test gear is a scope if you are thinking of spending some money - they are now very good value for money and its not practical to build you own. (I would rather spend £300 on a scope than on a new rig!) If you can, go for one with a bandwidth of 20 Mhz or more. Most nowadays have two channels but its not essential. Surplus sales and rallies are good sources for your first, but once you have had one, you will soon realise their value and want a better one! New dual channel 20 Mhz scopes start at about £300 including probes. Assuming that you have various oscillators and measuring instruments you will soon find you want a counter. Don't forget the Walford Electronics counter which works to 60+ Mhz and will soon be complimented by a kit to give it instrument style facilities using Radio 4 for the reference. Details out soon. G3PCJ

RF Output Limiting

Tony Measures, G3WUC, asks what are the signs of output limiting. He felt that he might have increased the drive preset in his Yeovil too far leading to a poor QSO. I think that most receiving stations, certainly at a distance, are unlikely to be able to tell whether the transmitter is limiting in its RF output stage; to the distant station, when correctly tuned to the nominal carrier frequency, it just sounds normal. To a nearby receiving station, the symptoms would be splatter on both sides of the transmitter's frequency. The width of such splatter is dependent on the degree of limiting, the radiated power level of the unwanted signals, distance etc.. In bad cases it can extend 50 or more kiloHertz either side of the nominal frequency and be detectable tens of miles away even from moderate power transmitters. The splatter sounds like poorly tuned SSB but it cannot be resolved away from the nominal carrier frequency and it gets stronger as you tune towards the nominal frequency. I have heard it said that very strong good signals can cause a weak receiver front end (unable to cope with large signals) to produce similar effects although I am not sure it sounds the same. It certainly does not produce the type of effect that strong broadcast stations do when present in a weak front end - they produce a type of mushy signal that is uniform across all the band whereas splatter is centred on the offending transmitter's carrier frequency. The usual forms of transmitter output low pass filtering are useless at removing the unwanted output signals that cause splatter and it can occur in broadband or tuned output stages.

Limiting is actually caused when the RF output devices try to produce a larger instantaneous RF voltage than the DC supply will permit; caused by an excessively large input signal, it is usually the negative swing which is most troublesome. The device output voltage suddenly has to stop going negative when the device is turned fully or hard on thus clamping the output to the zero volt or ground line - this process is also known as "bottoming" and can occur in class A, B or C output stages. With a class A output stage, a similar effect can occur on positive swings, caused by the DC standing current being less than the instantaneous RF current preventing the RF voltage from rising any further - so called "current limiting" as opposed to the voltage limiting which occurs when bottoming.

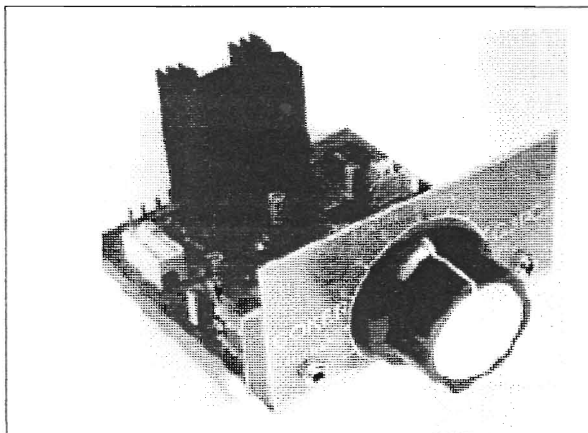
The following comments on setting up apply to both the Yeovil and Tiny Tim since their general block diagram is similar - see the sketch above for a typical superhet transmitter. The important thing to remember, when setting up, is not to overdrive the output stage. You should start by turning back the drive control or preset to make certain there is no possibility of the output stage limiting; this setting can be confirmed by checking that the output power is well below, perhaps a quarter of the rated power output. You then need to set the audio presets so that the final mixer stage is just about to limit. For the Yeovil there are two, one for the CW TX sidetone and one for the mike gain. For Tiny Tim there is only the mike gain preset. Monitor the rig output and wind these presets up to just below the point of maximum output. You can whistle or say Aaaaah. If you



have a scope then use a long timebase and you can see when the output ceases to go up but there will be sections in between the peaks when the RF output is much lower. If you have to use a mechanical power output meter, it averages out these periods of low output making the reading appear significantly lower; you should adjust the speech presets so the output is about 75 to 80% of the maximum for that drive setting, for the CW TX sidetone preset go for 90 to 95% of max. output since there is no averaging effect on a continuous steady output. Increasing the speech presets beyond the points indicated will give a degree of speech processing by allowing the mixer to limit on speech peaks thus raising the average level of output - it should be done with caution however. The harmonics this produces are removed by the following bandpass RF filters. After you have done the audio presets you can now increase the drive preset to get the transmitter output up to its rated level. Again observe the output and increase the drive preset to just below the point of maximum output - say 90%. On the Yeovil there is some interaction with the trimmer capacitor which attenuates the drive on 80m so you must check on both bands. After the tests, get a nearby amateur to listen carefully to your signal and report critically on what he hopefully doesn't hear (hoping his front end does not overload!). Tim Walford G3PCJ

The Coker

Finally, and to fill a hole, I thought you might like to see what the Coker looks like. Versions are available for 80 and 160m. The RX for the other bands are fine but the TX suffered too much chirp on 40m upwards. If you have a photo that might be suitable for inclusion with a note then I should be able to scan it with my new computing toy! G3PCJ



HOT IRON

Issue 6

"Journal of the Constructors Club"

Winter 1994



Contents

- Yeovil tuning & IF amps
- RF amp for small antenna
- More on end fed antennas
- Variable output PSUs
- Offset voltmeters
- VFO capacitors

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Constructors Club**. Articles, suggested topics and questions are always welcome. Please send correspondence and membership inquiries to:-
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Editorial

First of all may I wish you a slightly early happy Christmas and an excellent New Year building electronic gadgets! I suspect that never before has there been such a selection of projects and equipment that can be built by amateurs; the range widens every year and the performance of things that can be home built steadily increases as integrated circuits are more widely used in equipment. While this may make it slightly harder to understand how a rig works; we have not got to the stage yet in home built gear, where everything is done in a microprocessor with incomprehensible software. The modern technology does undoubtedly produce high performance for cost.

On a sad note, I have to report that David Sugden G4CGS, who contributed an article last time on measuring inductance, never made it to the major operation that he thought he might have to undergo. He suffered a major heart attack and collapsed just outside his own front gate. He will be badly missed by us all since he had already written several notes and had hopes to write more; his wife has kindly agreed that I should print those already completed. I shall particularly miss him as someone who I could bounce technical questions onto and who was also very dependable as my PCB driller. I am pleased to have another new contributor this time with Jim Chick, G4NWJ, adding his experience with a Yeovil. There are also further ideas on IF amps and tuning for the Yeovil. I do urge any of you who have any interesting experience or ideas to share it with others by writing a note for me. It need not concern my kits. Get writing please.

I also pleased to announce that the off air REFERENCE kit is now available with its two optional INPUT kits. The reference part provides highly accurate digital frequencies in the range 1 KHz down to 0.2 Hz with useful intermediate frequencies. It works by phase locking an oscillator to the Radio 4 transmission on 198 KHz and applying this to decade dividers. It can be used on its own or with the normal Walford Electronics counter to achieve very high accuracy and a resolution down to 1 Hz. The optional HF INPUT parts, fitted on the REF PCB, provide a high input impedance amplifier with a voltage gain of x10 and a bandwidth of about 60 Mhz so that the basic counter's input sensitivity can be maintained while using a scope type divide by 10 probe. The other optional INPUT DIVIDER kit is a divide by 10 frequency prescaler which will work to at least 575 MHz. When these four kits are used together, a very high performance counter instrument can be constructed for a fraction of the commercially made cost. The basic REFERENCE kit costs £37 with the two INPUT kits costing £9 for the HF amp and £24 for the UHF prescaler. The basic counter is £49. Further details are available from me.

For those of you still searching for small items that might be added to Santa's present list, may I remind Santa of the Coker - a CW transceiver that can easily be packed into large socks hung on the end of the bed. Versions for 80 or 160m, cost £45. Very full instructions and no integrated circuits. 5W output on a 12v sledge supply!

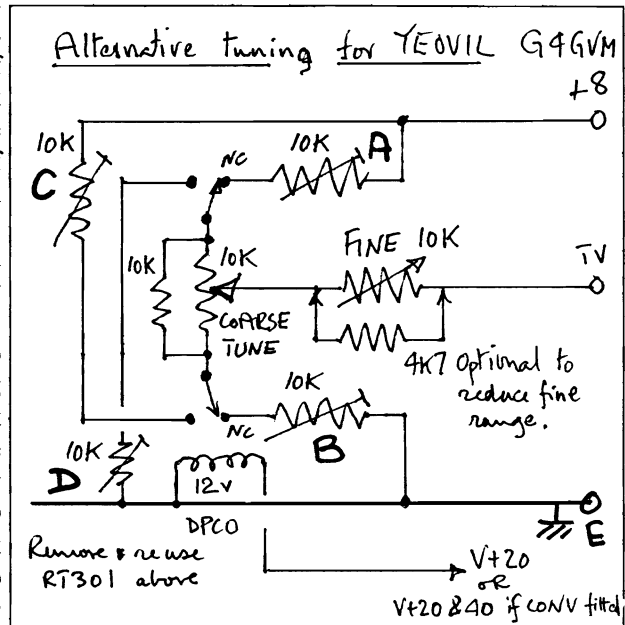
Snippets

I am reminded in a note from South Western Electricity that the 50 Hz mains supply is to go down to a nominal voltage of 230 volts on Jan 1st next. They explain that most domestic equipment should be unaffected by this change since it is within the existing allowed tolerance to which most equipment should be designed. Certainly most commercial electronics or appliances, which are likely to have switch mode power supplies, are not likely to be effected. Apart from slightly dimmer incandescent lamps, the main items where performance will be degraded are unregulated power supplies, whose output will drop by 4.3%, and regulated linear power supplies where the decrease in their internal unregulated supply falls below the required input level for the regulator.

Yeovil Transceiver Topics

VFO Tuning Modifications

Derek Alexander G4GVM writes " I have been playing around with the tuning arrangements and you may find this circuit of interest. With the addition of a DPCO relay, 3 extra 10K presets and a couple of resistors it is possible to arrange 1) the frequency will always increase with clockwise rotation of the tuning pot, 2) full rotation of the pot can be adjusted for 320 KHz on 80 and 370 KHz on 20m. (40m still covers the bottom 100 KHz of the 20m scale.) If you can obtain a 10 or 12:1 reduction gear for the main tuning pot, you can dispense with the fine tuning pot by replacing it with a short. See the circuit alongside. Setting up. Set coarse and fine tuning pots and all four presets to mid-position. Adjust Toko slug of L301 to give a VFO reading of 5260 KHz, switch to 80m, then with coarse tuning pot turned fully clockwise set preset A to give 5190 KHz on the VFO (RX frequency 3810 KHz). Set coarse tuning pot fully anticlockwise, & adjust preset B for 5510 KHz on the VFO (RX 3490 KHz); the presets interact so you need to repeat these adjustments till they are both nearly correct. Switch to 20m; set preset C for 5360 KHz at the VFO (RX at 14,360 KHz) with the tuning fully clockwise and then adjust preset D for a VFO frequency of 4990 KHz (RX at 13,990 KHz) with the tuning fully anticlockwise. Repeat the checks and adjustments remembering that if you have to adjust the TOKO slug then all will be affected. Eventually you can obtain the desired full swing on the two main bands and have them both tuning in the same direction.



Mobile Perambulations with the Yeovil by Jim Chick G4NWJ

"Travel, it is said, broadens the mind and expands understanding. This may indeed be true, however, in my case it also means long periods of time in remote and sometimes desolate parts of the world. At such times, having a mobile rig available is a real pleasure and for a while I used my 757GX2 for this purpose and it performed very well although I was always aware of the danger of it being "confiscated" by over zealous custom officials. The turning point came after a trip to Turkey which culminated in my exit visa being withheld for fourteen days and only granted after payment of a large sum of money. I realised that the only equipment which attracted the attention and envious looks were those items in smart cases with lots of knobs, dials and lights and I decided that a home made rig might escape all this unwanted attention. The first approach was to consider a single band design but this was quickly dismissed due to limitations it imposed and after much deliberation I decided to try a Yeovil. The construction was straightforward and I added the 40m converter and the digital frequency readout which in my rig I found necessary to house in a screened box. The completed rig was built into a rugged case suitable for mounting in my Landrover. The antenna I favour is the conventional G whip mounted on the rear of the vehicle with its base about 5 ft from the ground. This is fed via an ATU and SWR meter and I have found this arrangement most successful.

Once the initial trials were underway, a couple of problems became apparent; the audio level was low for use in my type of vehicle and the RF output made life difficult for the receiving station under normal band conditions. The addition of the IF amplifier in the last edition of Hot Iron solved most of the audio problems producing greater signal strength on all bands and I have now built a 120 Watt PA which cured the second difficulty. When using the rig with a conventional wire antenna system or a long wire, the standard version performed very well and I was only aware of the problems I mentioned when using the mobile whip. It can be very difficult to find anything to attach a length of wire to in the middle of the Empty Quarter and most of the time I have to use my vehicle antenna.

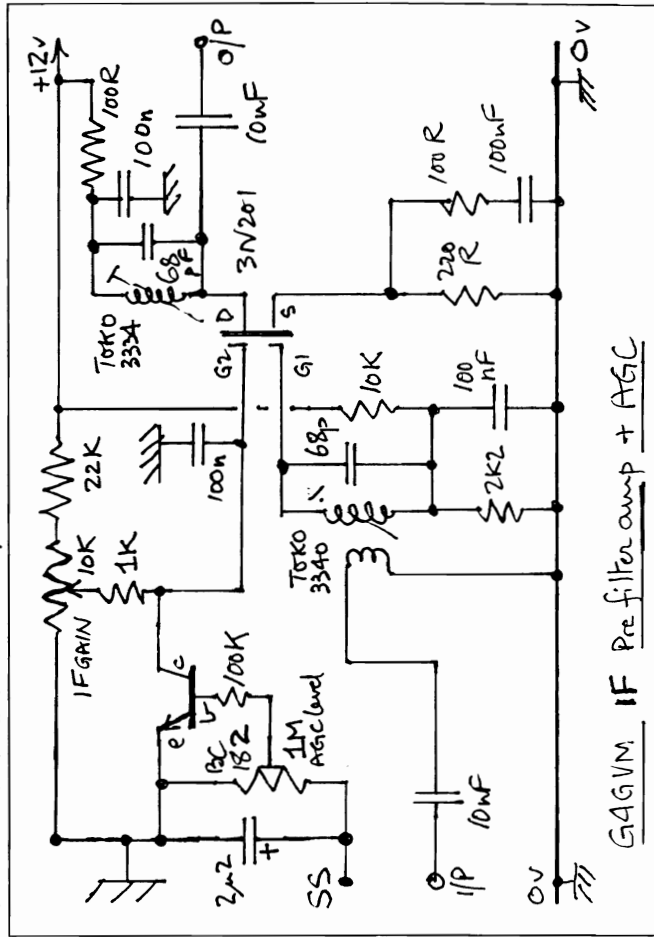
In conclusion, I would like to recommend this grand little rig as a reliable mobile unit which has already proven a worthy companion on my travels."

Thank you Jim; in another note he remarks that he found it very stable even under the most arduous conditions and would like to hear of the experiences of any other mobile users. Another has also been used in the Gambia. G3PCJ Technical matters. I had one Yeovil returned for examination with complaints that it was smelling! It transpired that with mid settings of the audio gain control, the audio output 2030 chip was getting hot and the power supply current was about three times that at low gain control settings. The output chip was oscillating just beyond the audible range with mid gain settings due to feedback from the loudspeaker leads to the gain control leads. Re-routing of these leads so that they were no longer next to each other for a few inches cured it. The same sort of problems can happen at any frequency and is more likely the higher the operating frequency of the stages in between the input and output leads.

The second topic is a little conundrum that I haven't yet solved! Two Yeovil owners observe that while their digital frequency readouts are exactly correct on 20 and 80m, when they switch to 40m they are out by 3 to 5 KHz despite the 11 MHz crystal being set exactly. I think this has to be something to do with a sideband inversion when the 40m converter is in circuit but I am unsure about it. Can anybody offer an explanation? G3PCJ

Further thoughts on IF amps and AGC for the Yeovil

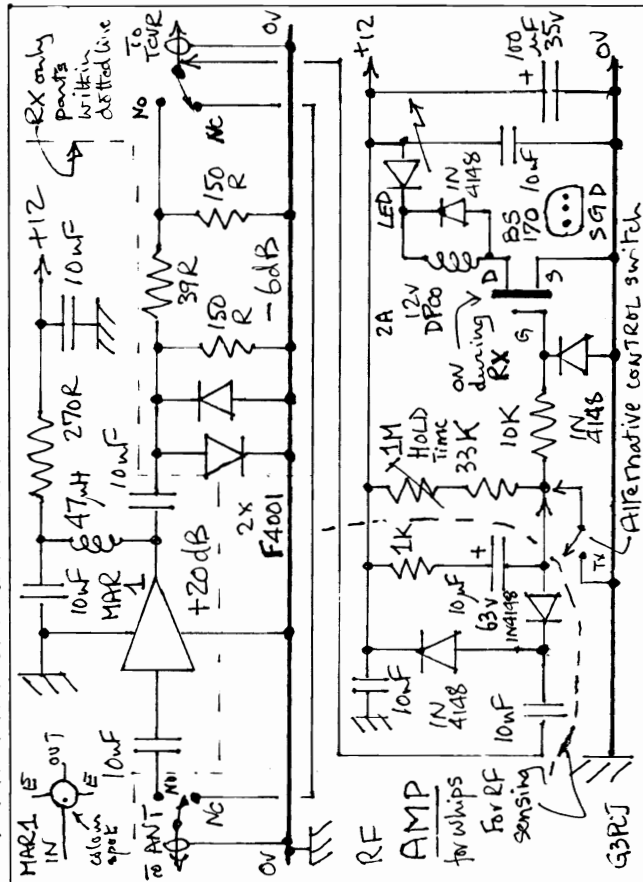
Derek, G4GVM, has sent along more on his experiences and comments that he finds his IF amp scheme rather better than that which I suggested in the last Hot Iron! He has made extensive trials on at least three versions and, while I think most builders will find that the circuit in Hot Iron 5 is the best balance between complexity and performance, I include his final version for the more adventurous since it has a second level of AGC. He finds that it gives a marked increase in signal to noise/hiss ratio allowing the gain control to be kept low and the AGC parts can be adjusted to give further attenuation of really strong signals. This circuit is intended to be placed in the receive path after the first mixer IC201/202 and before the 9 MHz IF filter. Although this is not the ideal position he finds it best and it is ignored on transmit. To connect it to the rig, cut track to isolate pin 9 IC202. IF amp input goes to pin 9 IC202 and the amp output to pin 10 IC202. SS is connected to the drain of TR101 and 12 volts is found from any convenient point. His circuit was on a small board which was mounted by the earth connections. The BC182 is needed to invert the AGC signal for control of the 3N201 and the extra 2µ2 on the point SS restores the hang time which would be decreased by the addition of the 1M preset. He found that R110 needed to be reduced to 47K to prevent the main AGC operating on noise and, with a little advice from me, improved the strong signal handling of the main audio amplifier by adding 2M2 from pin 1 of IC103 to earth which shifts the DC output level to 6 volts which is better for 12 volt operation.



IF Amp for Tiny Tim. I am pleased to report the circuit that I sketched out in the last Hot Iron, which was untried at that time, does indeed work well and gives a useful improvement in sensitivity. Care is needed to fit it in! G3PCJ

RF Amps for small antennas

Readers may recall an earlier comment that an additional wideband RF amp for the Yeovil was not recommended when it is used with normal sized antennas due to overloading by out of band broadcast stations; however I have found it to be a most useful addition when giving demonstrations with my 0.5m square portable loop antenna made of 15 mm copper pipe and which can also be used for transmission. It will also be suitable for those using whips like G4NWJ where overloading is unlikely. If its to be only used with a short antenna, then the amplifier part of the circuit can be inserted in the receive path around the transmit amplifier. The circuit is broadband with 14 dB gain. It is important that there be some good selectivity in the antenna matching unit to reject the broadcast stations just outside the 40m band. I have the full circuit shown alongside mounted in a separate box which can be left in circuit continuously as its bypassed with no power applied. The attenuator/diodes on the amplifier output protect it when the rig transmits during the short time that the RF sensed relay takes to turn off on transmit. It can be controlled with a hard wired transmit contact switch as shown which avoids the hold time delay associated with RF sensing (needed to avoid it dropping out between words). This circuit can be used in any low powered 50 Ohm antenna line and is a handy "extra" for more sensitivity - fast power diodes must be used. G3PCJ



More on End Fed Aerials by Eric Godfrey G3GC

My aerial system for HF is a half wave dipole on 80 metres (132 ft overall) centre fed with home brew 600 Ohm open wire feeder. The centre is supported by a pole in a sycamore tree lopped off to stop it growing further and each Spring it is pruned back to the trunk to avoid the new growth interfering with either the dipole elements or the 600 Ohm feeders. This also has the advantage that there are no flowers and hence no helicopter seed pods to germinate all over the garden. On 40m and the lower harmonically related bands, the 600 Ohm feeder sees a high impedance at the centre of the dipole but on 80m, where the length is a half wave, it is low impedance. In the shack, the open wire feeders are connected to a KW (E-ZEE) MATCH which in turn connects to a Drake TR7 transceiver via a 50 Ohm coaxial feeder. This all works satisfactorily on all bands (including the WARC bands) from 80m to 10m but the KW (E-ZEE) MATCH is not designed for use on 160m.

I needed to use the aerial in the Edgware and District Radio Society's Activity Period last October and decided to strap the feeders together in the shack and connect them to the TR7 via a simple LC matching unit comprising a variable capacitance to earth from the aerial and a variable inductance in series with the inner of the coaxial feeder to the TR7 (see sketch). I then tried to match the system on a frequency of 1.950 KHz and found that although I could get an apparently good match by adjusting the inductance and capacity, I could not wind the power up properly on the TR7. I was at a loss to understand this at first; it was not until I discussed it with our Editor and he suggested that I read my own article in Issue 4 of Hot Iron that I realised that it was of course due to the problems which I discussed in that Issue. Here was I, caught with my own RF trying to go into places that it should not have been and not practising what I preach!

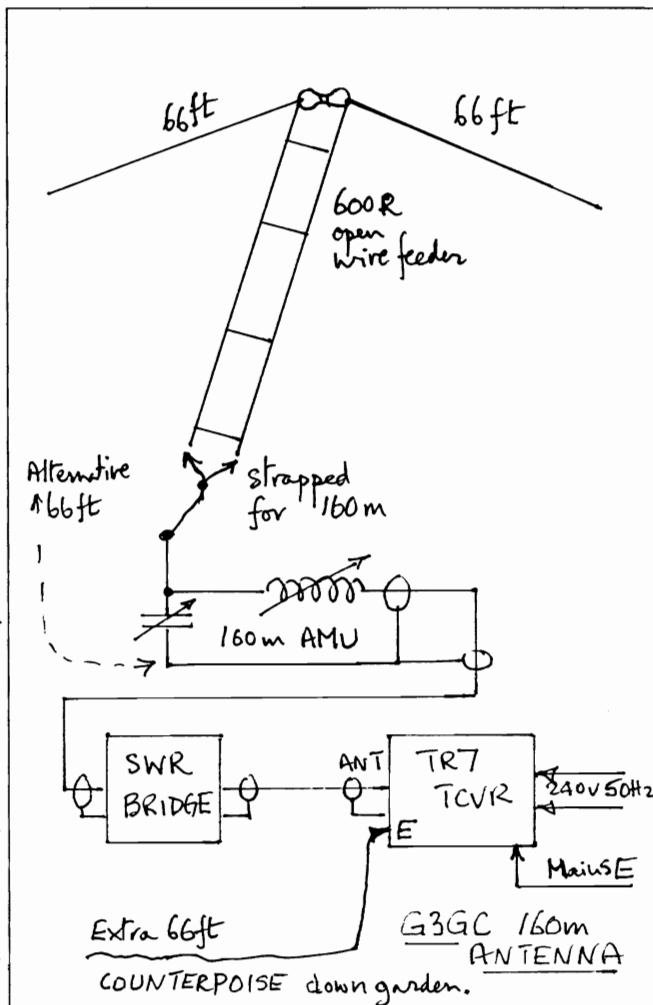
The obvious thing to do was to add a quarter wave counterpoise to the earth terminal of the TR7. This I did using 66 ft of ordinary connecting wire thrown out of the window and just tied to a garden cane down the bottom of the garden somewhere nearly underneath one leg of the aerial. The LC matching unit was again adjusted for minimum SWR and this time I could get full power into the system. I think that what was happening in the first case, was that although I had a reasonable SWR in the coax from the TR7 into the elevated wires which formed one leg of the whole aerial system, the other leg was formed by the mains earth wire, and this was causing the transceiver as a whole to receive a lot of return (backward) power and its self preservation circuits were limiting its power output.

This, I think, goes to confirm that no end fed aerial system should ever be contemplated without some form of earthing system. It might be worth adding that, if you ever have the transmitter near ground such as on a table at field days, then a low impedance earth wire (thick coax with inner and outer joined is very satisfactory) connected to a good long earth rod driven well into the ground may replace the counterpoise provided the earth is moist (water if necessary). If in any doubt have an earth rod and a counterpoise!

Comment if allowed! Eric first advised me of this problem in some rather boring part of a Committee meeting with a cryptic diagram saying "what's going on?" Answer-RF shooting down the mains earth wire! My own preference would be to connect the counterpoise to the coax screen at the matching unit but Eric comments that his SWR bridge would not be affected by any RF on the outside of the coax cables going in & out of the bridge. The full evidence also suggested the possibility that his mains earth system might be resonant (with the quite high Q of 8) at 1.95 MHz since tuning to 1.83 MHz cured the problem completely. I wonder if it is OK to live in the middle of a 160m loop?! G3PCJ

Variable Output Linear Power Supplies

I apologise for returning to the subject of power supplies but they are a frequent source of inquiry! There are two common variable types, those based on the 317 chip and the very similar 338K type. The 317 can provide outputs up to 37 volts; it is available in the 100 mA L version and the 1.5 Amp T version which needs a heatsink. The TO-5 338K can handle 5 Amps and needs lots of metalwork! The output of the 317s can be from 3 to 37 volts and the 338



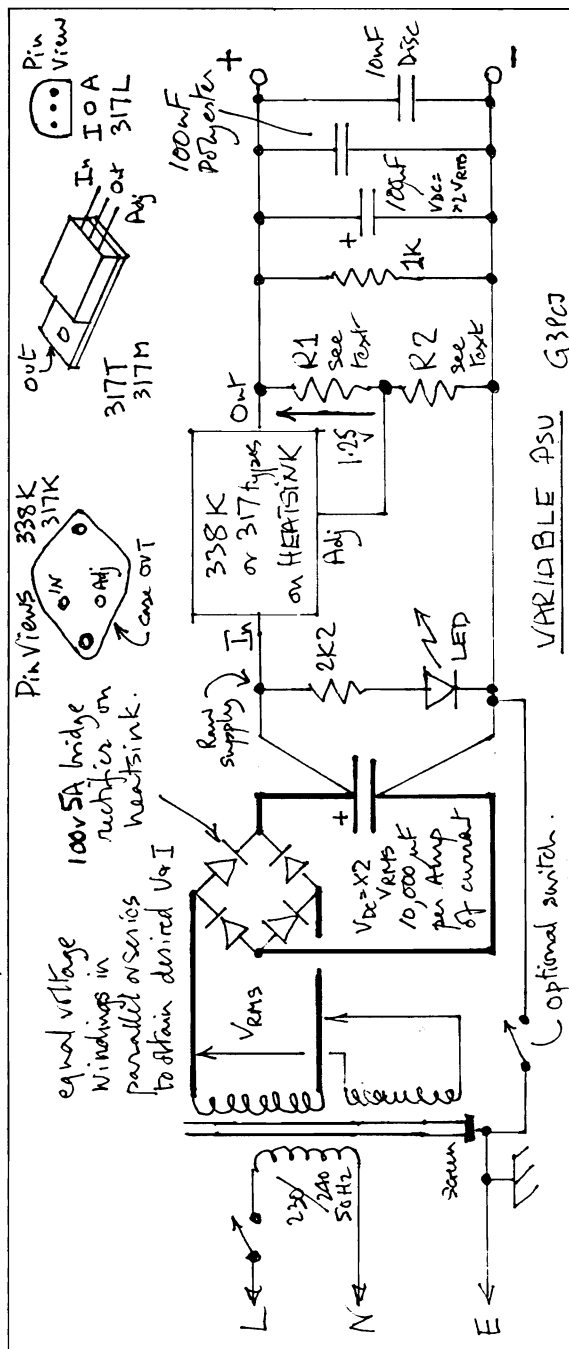
from 3 to 32 volt. The input voltage must be at least 2 volts more than the maximum output but beware that the device dissipation will be highest on low output voltage at high current. Devising a power supply to give say 5 Amps continuously over the range 3 to 32 volts is a severe electrical challenge and also a mechanical one as it might have to dissipate nearly 150 watts and will need a transformer weighing about 3 Kg. The first problem is that the input to these regulators must not exceed 35 volts for the 338 and 40 volts for the 317s; the transformer on load secondary AC peak voltage needs to be a minimum of about 5 volts higher than the desired maximum DC output (2 for the bridge rectifier, 1 for ripple and 2 volts for the regulator) - this usually means a nominal transformer secondary RMS voltage of at least the maximum DC output voltage. The off load raw DC voltage will at least 1.4 times the nominal RMS secondary voltage and perhaps up to 8% higher if the mains is high. For our notional 32 v PSU, a simple arrangement of transformer, bridge rectifier and smoothing capacitor combination might generate a no load voltage of perhaps 50 volts - none of these regulators will tolerate this! Either the regulator has to have a permanent load, or some form of pre-regulation, or the secondary RMS voltage be lowered to about 25 volts in order to keep within the permitted off load maximum input voltage. The probable upper full load output DC voltage will then be around 24 . At high output currents, even the bridge rectifier will get warm and need bolting to the metalwork since it might dissipate 8 Watts. The smoothing capacitors should have a working voltage about twice the transformer open circuit RMS voltage and as a guide, their value should be about 10,000 μ F for every Amp of output current, if the ripple on the raw supply is to be below 1 volt at full output. The smoothing capacitors should always be fitted with a bleed resistor which can also be used for a LED Power ON indicator. The notional 32 volt 5 Amp continuous supply would need a 150 VA transformer and capacitors of 50,000 μ F rated at about 60 volts DC - they will be BIG and EXPENSIVE if bought new! All of this points to an impractical design requirement! A further practical point is that for a 5 Amp supply, the peak current in the rectifier will be around 50 Amps so you need to use thick wires in the transformer, rectifier and smoothing capacitor part of the circuit. Incidentally, soon all commercially made supplies whose power output is over 50 Watts will have to meet difficult requirements about not reflecting harmonics back into the mains due to these very large and spiky rectifier currents. The above list of snags explains why switch mode power supplies are so attractive as all these problems are much reduced and nowadays the problem of electrical switching noise is well under control. Many of these problems can be much reduced by designing for as small a range of output voltage and low current as is possible. I have sketched in some suggestions alongside.

Both the 338 and 317 series of regulators work by developing a controlled 1.25 volts across a resistor R1 placed between the output and the adjust pin. The current, which this causes in R1, then flows on through a second resistor R2 from the adjust pin down to zero volts developing the control voltage. The maths of this is:-

$$V_{out} = 1.25 + (1.25 \times R2 / R1)$$

The current which flows in the adjust pin is around 50 μ Amps and can usually be ignored. Typical values are 220R for R1 with R2 to suit the desired voltage if the output is fixed. Alternatively R2 maybe variable but if it goes open circuit (with a noisy pot) then the output will rise to the raw supply probably wrecking connected circuits. A better approach is to make R1 variable and fix R2 at about 2K2. If R1 is a variable of 1K in series with 82R the output range should be about 4 to 35 volts if the raw supply will allow it. The current in R1 and R2 should really be at least 0.5 mAmp but this is difficult to arrange with a wide single output range. It is quite a good thing to put a load resistor of 1K or so permanently across the output and to decouple the output with 100 μ F (V DC same as smoothing caps) in parallel with a 100 nF polyester and 10 nF disc ceramic on the output terminals. It is also worth noting that the line and load regulation of these regulators is appreciably better than the common fixed voltage types; this is why I use them for internal stabilised supplies for varactor diode tuning voltages.

ALWAYS fully try out a PSU on a dummy load first! G3PCJ



Offset Zero DC voltmeter by David Sugden, G4CGS

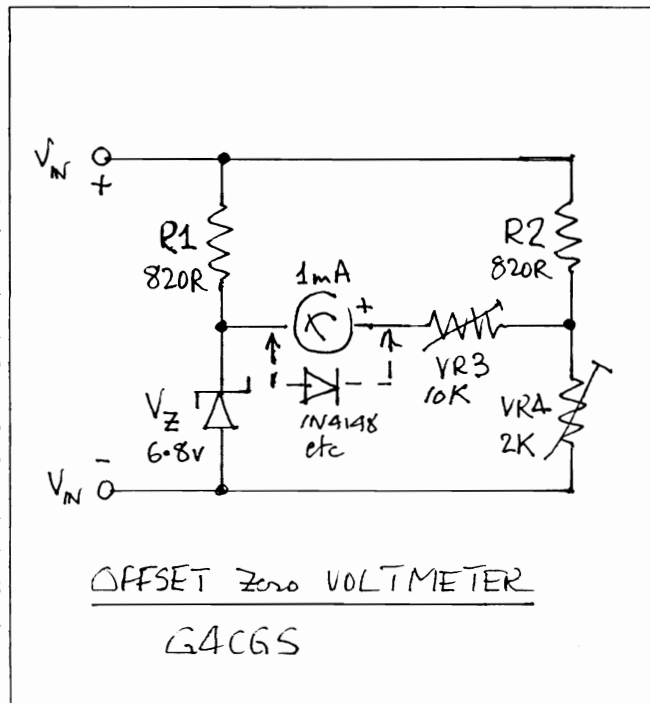
There are times when it may be desired to more or less permanently monitor a DC power source without tying up the shack multimeter all the time. Usually the voltage range required is restricted and so a form of scale expansion by using an offset zero will enable accurate readings to be made. A typical example might be to monitor the terminal voltage of your car battery whilst working DX from the top of a hill. The battery voltage may, dependent on charge state, be between 10.8 volts fully discharged and 14.5 when fully charged on float. Since for this purpose we are not interested in readings outside this range, it would be appropriate for it to be scaled 10 to 15 volts. With care, readings to plus or minus 0.1 volts are possible. The circuit can be easily adapted to other voltages and meter sensitivities. It is essentially a bridge arranged so that, at the minimum input voltage, the bridge is balanced and no current flows in the meter. As higher voltages are applied it becomes unbalanced and the meter reads up the scale. It will read backwards for inputs below the minimum and you might wish to add the diode to protect the movement if this is likely. Select a zener whose voltage V_z is about 60 to 80% of the V_{min} .

$$\text{The } R1 = R2 = (V_{max} - V_z) / 10 \times I_m \quad \text{KOhm}$$

$$\text{and } VR3 = (V_{max} / V_{min} - 1) \times 1.5 \times V_z / I_m \quad \text{KOhm}$$

$$\text{and } VR4 = V_z / (7 \times I_m) \quad \text{KOhm}$$

These theoretical values for VR3 and VR4 are the minimum and you should use the next available higher value. The circuit gives some typical values. The setting up procedure is to set VR3 to maximum resistance and apply V_{min} from a variable PSU - 10 volts in this case. Adjust VR4 till the meter reads 10 volts at its normal zero position. Then apply V_{max} and adjust VR3 for full scale indication - 15 volts in this example. Repeat these two adjustments as there is interaction between the presets. To complete the job, assuming you can dismantle the meter, remove the old scale calibration numbers carefully by scrapping or snowpake etc., then carefully add the new numbers with a fine tipped pen; the intermediate values should be reasonably linear but its worth checking them with your variable PSU.



Tail enders

Further to my note about Blu-Tack, Peter Barville G3XJS, writes "It is useful for a wide variety of jobs including temporary (or not so temporary!) mounting of finished PCBs in confined spaces (e.g. mounting a small extra board above or on an existing panel). I even admit to using it as quick and easy method of securing a battery, without having to drill holes for securing a battery clip. It is also ideal for sealing connectors and soldered joints exposed to the elements. In my experience, copper cable, chrome nuts and bolts etc stay shiny and bright so long as they are protected within Blu-Tack used as a sealant. There appears to be no problem of corrosive action, as is the case with normal bathroom (and exterior) type sealants. Blu-Tack doesn't harden, can be easily removed, and then replaced if necessary, and is cheap and readily available. Every shack should have some!" To think I have been chucking it away! G3PCJ

Pat King, G4GFY, who I frequently hear using his Tiny Tim, found that he had a bit of a problem with audio breakthrough on transmit. He cured this by an extra relay operated by the PTT switch which disconnected the LS.

Some while back, Stewart Sims G3WQW, suggested a note on temperature compensating capacitors for VFOs etc. This is big topic but I think there are some general observations that can be useful. I find that when the inductor of a HF VFO is a TOKO style coil and it is used in conjunction with a combination of NP0 and N150 capacitors, then drift is seldom a problem. The characteristic of the N150 roughly matches that of the inductance so that with increasing temperature, as the inductance goes up, the capacity goes down. Both the NP0 and N150 capacitors are low K ceramic discs which usually have small rectangular grey bodies and coloured tips; the NP0 sort have black tips and the N150 types have orange tips. The NP0 (black tip) ones have a nominal zero temp coefficient and are supposed not to change as temperature alters; the orange tipped have a -150 parts per million per degree Centigrade characteristic. The other violet tipped disc ceramics (- 750 ppm) should not be used in VFOs. Medium and high K disc ceramic types (often with round yellow bodies) are not suitable for VFOs either since their temperature coefficients are even larger and more unpredictable. As it is difficult for most people to tell the difference between the low K and other ceramic types with certainty when they are presented unlabelled at a rally; my advice is don't use them for a VFO unless you have confidence that the supplier is certain of what they are and write the details down at the time. Chance it if you wish, but at least silver mica (if you can find them) and polystyrene types are far less confusing and nearly as good for VFOs!

And finally, I thought you might be amused to know that one of my Booster linear amplifiers is doing service at Malin Head Radio Station ! I have to admit it is with EI0CF and not with the Irish Authorities! G3PCJ

HOT IRON

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"Journal of the Constructors Club"

Spring 1995



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Editorial

I thought that as this is the first issue in 1995, I would transpose a new happy figure into the box on the left that my son has drawn elsewhere on this computer. I see it every time I turn the beast on but I have now been trying for over an hour to get it here with no success! I was going to go on and be rather negative about computers in general but I have just seen the article in the March RadCom about single chip micro controllers; it leads me to wonder what most builders would think about some form of micro control in their own home built rigs, for example to control a synthesizer? Some feedback on this would be most interesting please.

This issue has a strong theme of antennas with a very practical contribution from Derek Alexander G4GVM and several interesting ideas from Stewart Sims G3WQW. My thanks to them & other contributors. I also felt that members, who do not have Yeovils, might like to see one of my favourite antenna matching bridge circuits; my apologies if you have seen it before. Keep up the contributions please!

Craig Douglas, G0HDJ, has made the helpful suggestion that owners of Somerset Range rigs might like to have some printed "rig name" stickers that could be placed on your QSL cards in the space where you give details of your equipment. I have in mind the small stickers that are about 1 x 1.5 inches which are sometimes used as address label stickers; these could have the rig name and or other simple details. For example:-

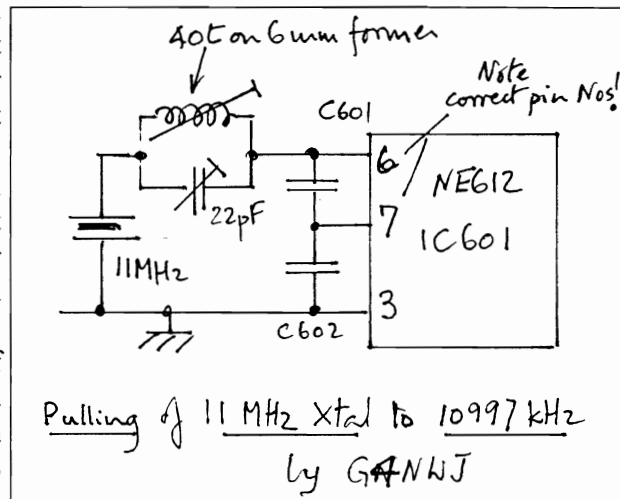
Yeovil TCVR
20 & 80m, 5 W
Walford Electronics

I would be happy to organise these, the cost would appear to be about £15 for 250 labels (post paid) or £20 for 1000, possibly significantly less if a lot of you are interested in one common label or rig etc. Please let me have your suggestions.

Some members have been inquiring about how the **Taunton** is progressing; I am pleased to answer "well". I have been working on it, amongst other things, for over a year now; the very first prototype is now working well and the design has now gelled sufficiently for the next stage of testing. Three members have kindly agreed to take on the onerous task of building and evaluating my instructions to get rid of the mistakes that I will have missed! I am hoping that it will be available for general release at the Yeovil QRP Convention on May 21st this year - see later. The Taunton is a superhet rig which can operate on any single HF band, including the WARC bands, by means of plug-in band cards. These cards contain all the parts that have to change with each band and are the only thing that will need changing to switch for one band to another. Initially, all bands will be available up to 15m; the higher ones are possible but need non standard crystals so will have to wait! At a later date, I hope to have a second band plug-in unit that will allow the fitting of parts for any two bands selected by a front panel switch. The rig will be available as RX, or TCVR, with an Optional Extras kit comprising receiver S meter & IF amplifier, transmitter matching bridge & power output indicator etc. The whole is based on one 100 x 160 mm PCB which is drilled for all the extras. Base TCVR about £90 + £15 per band. The standard frequency counter kit can be used and the matching CW kit with a very high performance tuneable switched capacitor filter is also in the late stages of design. Tim Walford Editor.

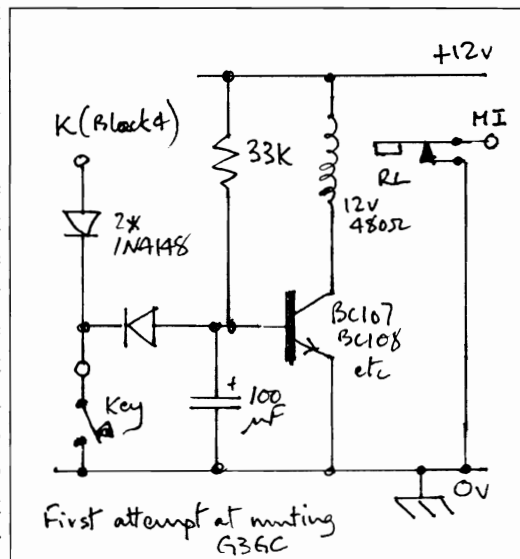
Yeovil Updates

40m converters. Both Geoff Gregor, G4OWH, and Jim Chick G4NWJ, found that their digital readouts were in error by about 3 KHz only when they operated on 40m. The rigs works perfectly normally but you would have to have a very good tuning and pointer mechanism to notice the 3 KHz dial calibration error on 40m compared to the calibration for 20 & 80m. This is why it has only been spotted by those with a digital readout. A certain amount of head scratching by all lead to the conclusion that it is due to sideband inversion as the signals pass through the 40m converter. The solution is to offset the crystal in the converter to 10997 KHz instead of the nominal figure of 11000 KHz. Regrettably this shift is beyond the adjustment range of the normal trimmer. Jim kindly tried substituting a ceramic resonator for me; this can easily be pulled down more than enough with the trimmer capacitor but it failed the stability tests. Both temperature effects and its repeatability from cold were not good enough. (Those of you contemplating ceramic resonators as high frequency VXOs for simple direct conversion transceivers beware!) The nice solution would be 10997 KHz crystals but these are non standard and prohibitively expensive in small numbers. Luckily the amount of pull that is needed is possible with standard 11000 KHz crystals but it needs extra parts. Jim Chick has used the following circuit with complete success - I have not tried it but other work on pulling a 6 MHz crystal for the Taunton suggests it should be fine. Only those members who have a digital readout and 40m need contemplate this modification. It needs a rearrangement of the tracks around the trimmer and crystal. I have given the details that Jim sent me. At 6 MHz, I needed 10 μ H & about 30 pF to swing 3KHz; so perhaps a fixed 5 μ H should do at 11 MHz with adjustment being solely by the trimmer capacitor. Try it out for yourself! Jim also pointed out the numbering error on pin 6 & 7 of IC601. In addition he has also tried several alternative FETs in the driver and output stages. His suggestion is an IRF621 as driver and a pair of IRF630s for the final. I do not know who manufactured these FETs and I do note significant differences with alternative IRF510 suppliers. His output increased to 18 W for 80 & 40 with slightly less on 20m. G3PCJ



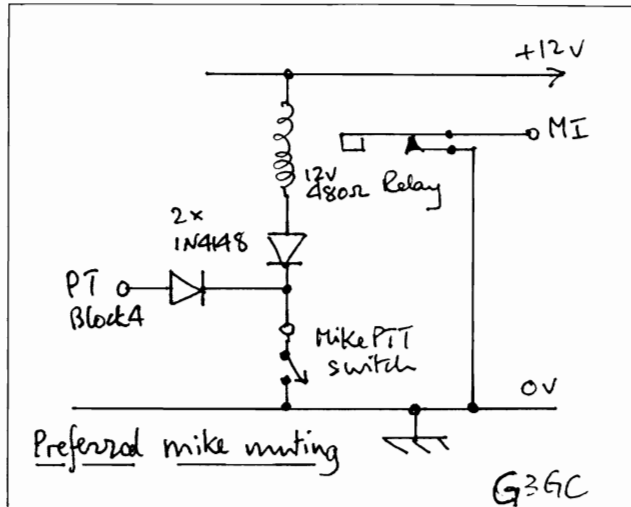
Using the CW filter on SSB. Eric Godfrey, G3GC, contributes the following which may well be of interest for other rigs apart from the Yeovil. "I fell into a trap the other day when working Howard, G4HMD in Northwood, Hertfordshire on 80m using the Yeovil on SSB in heavy QRM. I decided to put the CW filter in circuit to improve selectivity at the expense of SSB speech quality. This was satisfactory, bringing up what was a difficult signal to readability R5. However, at the end of my next over, I found that G4HMD had not copied me at all. I then remembered that the CW filter switch places a short across the microphone input. This has been included quite rightly to ensure that when on CW there are no random transmissions from the microphone which would otherwise be live until the T/R relays drop out. It was therefore necessary to change the filter switch to SSB when transmitting on SSB. This was inconvenient and some form of automatic arrangement was obviously required.

I decided the solution was to use a small relay operated by the key to provide a pair of normally open contacts (relay unenergised) in series with the earthy end of the CW filter switch. This would then ensure that the microphone would not normally be short circuited on SSB transmit. This worked except that the short circuit was only in place while the key was down. Obviously some hold delay was required and this was achieved by driving the relay from the transistor as shown on the right. In this circuit the transistor is normally conducting and the relay is energised except when the key is down, earthing the base of the transistor and cutting it off. Since the relay is now energised in the key up position, the normally open contacts (open unless the key is down) are now used to short the microphone to ground. The time constant of the resistor/capacitor combination on the base of the transistor



provides a hold delay a little longer than the maximum T/R delay, thus ensuring the microphone remains dead on CW transmit.

After a little more thought, I decided that a simpler and more elegant way to achieve this objective was to control the relay from the microphone press to talk switch. This would require that the microphone was always shorted to ground except when the PTT switched was operated during SSB transmission. This way there are no requirements for any hold delay and the final circuit which comprises one relay and two isolating diodes is shown on the right. These three components can be assembled on a piece of veroboard less than a square inch in area and mounted close to the microphone socket. This circuit is in effect inserted in the PT line from the

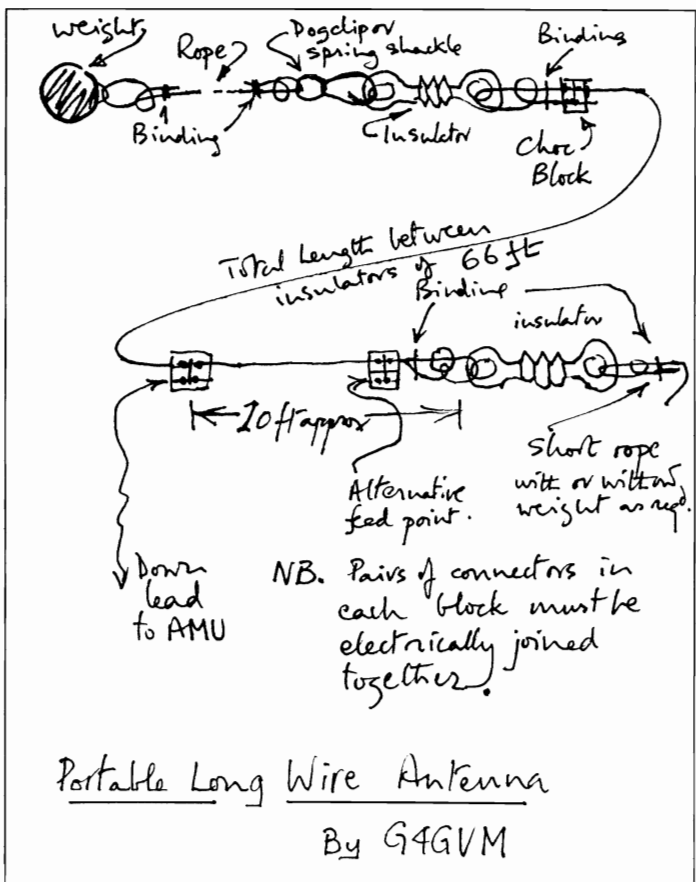


transmitter to the microphone socket. If you do incorporate this circuit in your Yeovil, then do not forget to remove the earth lead from the CW filter switch if the PT line is still connected to it. G3ICO has also pointed out that some CB microphones have a two way push to talk switch, which shorts the microphone on receive. If one of these is used, then no additional circuit is needed and you only need remove the lead from the CW filter switch to the mike socket." Eric Godfrey G3GC

A Versatile Portable Aerial by G4GVM

I do a fair amount of /P operating visiting friends and relatives - mostly on 80m. I have, in the past, often used a portable trap dipole, G whip and so on but I have been impressed by the signal reports when using an end fed or long wire aerial. The end fed aerial is perhaps the easiest to erect - the total length is not critical (with a good AMU and earth! - Ed) but I have found that the 80m 66 ft length is convenient. A weight on the end of a supporting rope tossed into a good tree (or a suitable climbing Grandchild!) can give sufficient height at the far end. The other operating end can be fixed to a window hinge for example. It doesn't even have to be fed from the end of the main wire! As a variation, I have mine 1/7 th (harmonic?) from the operating end (about 9 ft 6 in) to allow operation from a ground floor extension with the end of the aerial fixed to an upstairs window above the extension. Here is a practical way to cover most situations and give good results.

1. Prepare three pairs of 2 A block connectors. Make two cuts about 3/16 th inch apart with a hacksaw into the polythene underneath across the two inserts. Solder a short stub of thick wire to join the two brass inserts. Use a heavy duty iron to avoid melting the polythene!
2. Obtain a 70 ft length of good flexible PVC covered wire (Henry Westlake - 8p per metre). Cut to 66 ft 6 ins and remove 1/2 in insulation from each end 6 inches in from each end and 10 feet from one end.
3. Slide all three connecting block pairs onto the wire. Tighten up the middle block on the bared 1/2 inch which is 10 ft in from the end.
4. Loop each end through an insulator with one turn around the wire. Secure the bared end, and the 6 inches in, into the same insert of a block pair, leaving the other insert for the down lead. Bind with strong thread.
5. Similarly loop and bind suitable nylon cord or rope to the insulator (or via a dogclip) with a suitable weight on the other end of the rope.

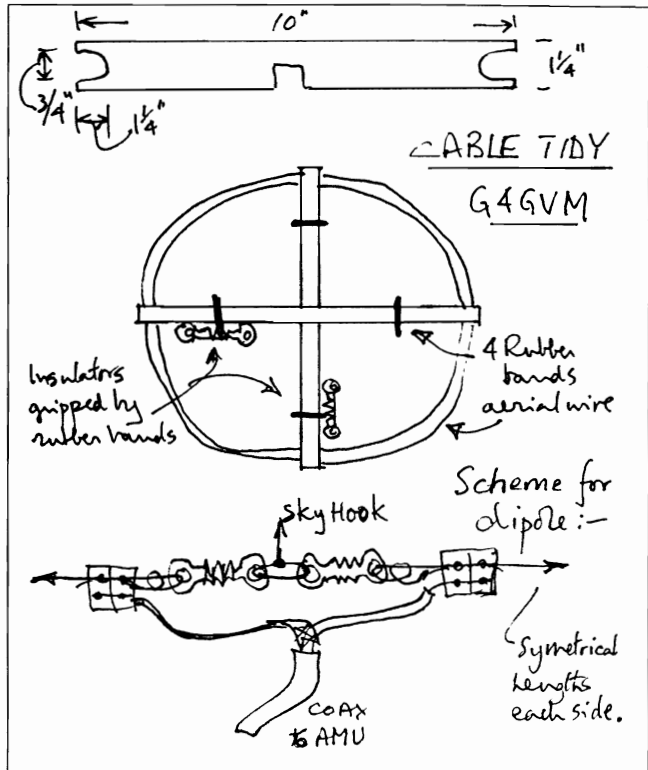


6. Use the 13 ft 6 in (or thereabouts) offcut as a down lead from one end or the 9 ft 6 in point.

7. A cable tidy can be made from standard wood lathe obtainable from most DIY stores. It is about 5/16 in by 1 1/4 in wide. Cut two 10 in lengths and form a "U" at each end 3/4 in wide and 1 1/4 in deep. Cut a slot the thickness of the piece wide and half the width deep, so that each length fits into the other, forming a cross. Make this a tight fit and glue up. Place a strong rubber band around each of the four arms. The idea is to trap the weight (or insulator if you are only winding on the aerial) under a rubber band and then turn the cable tidy to wind on the wire. This will avoid kinking the wire; finally trap the other weight or insulator when you reach the other end.

8. Although intended as along wire aerial for use with an AMU, two such arrangements could easily be used as a centre fed 80m dipole. Just tie the two centre insulators together and attach the coax inner and outer to each half. The block connectors make connecting up a simple matter and extra support can be provided in the centre on the linked insulators if there is a suitable sky hook!

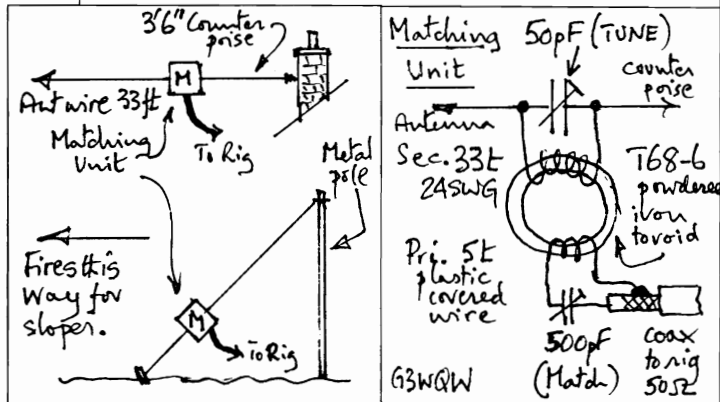
Derek Alexander G4GVM



End fed half wave antenna for 20m

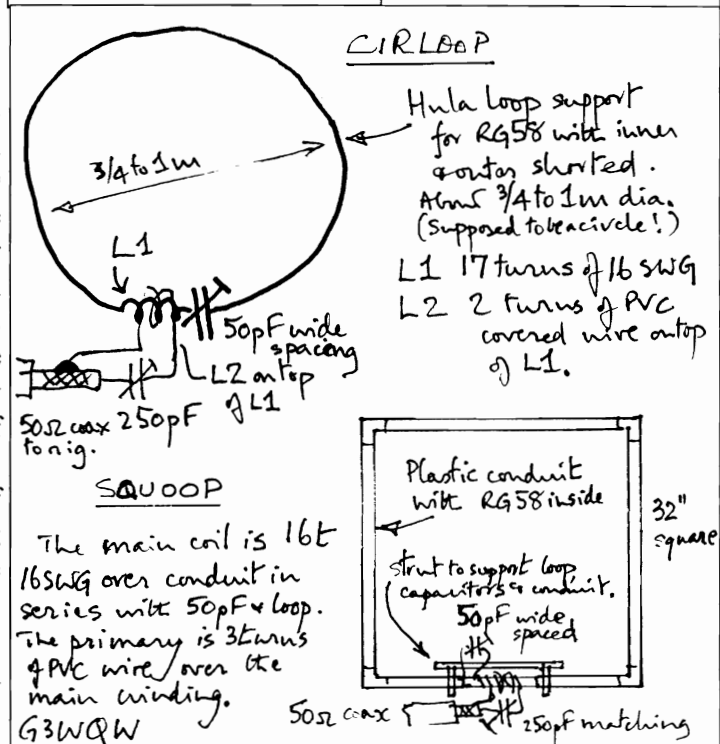
This antenna can be rigged as a sloper or as an ordinary horizontal one; it uses a small counterpoise and a matching unit at the feed point. Used as a sloper supported by a metal pole typical reports with my Yeovil are:-

IK6QRD	59	9K2ZZ	59
DL3KDH	58-9	4N7NN	57
UX0LT	57	VO1NP	52-6
Stewart Sims	G3WQW		



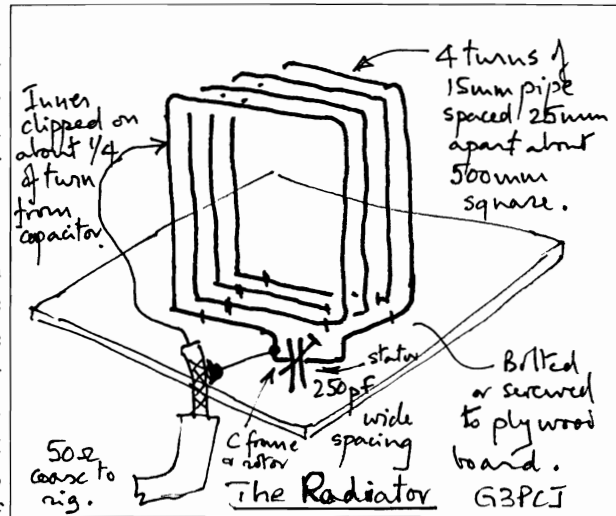
"Cirloop" and "Squoop" Antennas

Herewith two basically similar antennas but with different physical shapes and mechanical construction. Both are loaded loops for 30, 20 and 17m bands with inductive coupling. The main loop tuning capacitor needs to have wide air spacing of the plates and is placed in series with the loading coil and the radiating loop. Outputs up to 25 W should be all right but do NOT place yourself nearer than about 10 feet when actually transmitting as there is the possibility of dangerous field strengths. Both these designs operate with a high Q and have a bandwidth of about 180 KHz on 20m, making retuning necessary if you wish to operate over the whole band. G0CRZ & G3WQW (Tune the loop capacitor on receive for max. signal and then adjust the coupling capacitor with a few Watts for best match to 50R. G3PCJ)



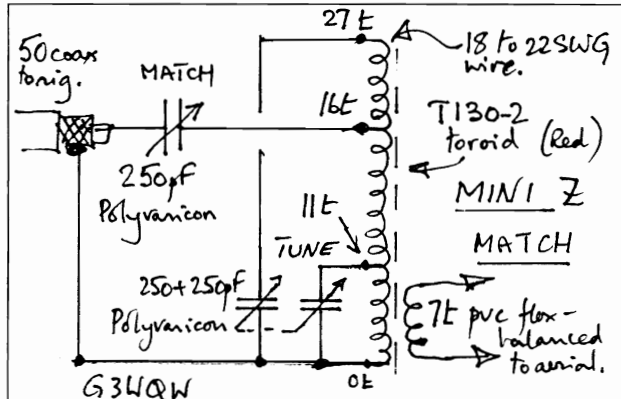
"The (central heating) Radiator"

This portable loop antenna had its origins in a QRP Convention Construction Challenge some years back. Part of the task was to make the most efficient 80m antenna within a 0.5m cube. I now use it for demonstration purposes and have used it for QRP QSOs over a few tens of miles. It is made of soft or malleable 15 mm copper tube bent into an approximate square. It can be obtained in good plumbers merchants. Its very effective because although the performance is dependent on the loop area, it is also dependent on the square of the number of turns. 22 mm pipe would be even better! The task was to get on as many turns as possible, with sufficient spacing to minimise self capacity, as can be made to resonate on 80m with about 1-200 pF. In fact I ran out of pipe first! Mine is bolted onto a sheet of plywood for stability and to keep the turns in place. Matching is simply a question of adjusting the crop clip until your matching indicator indicates nothing reflected. Move the tap nearer to the capacitor frame for low impedances and further away for higher Z outputs. Although not a balanced or symmetrical design, I have never found it to be sufficiently directional for this to matter. G3PCJ



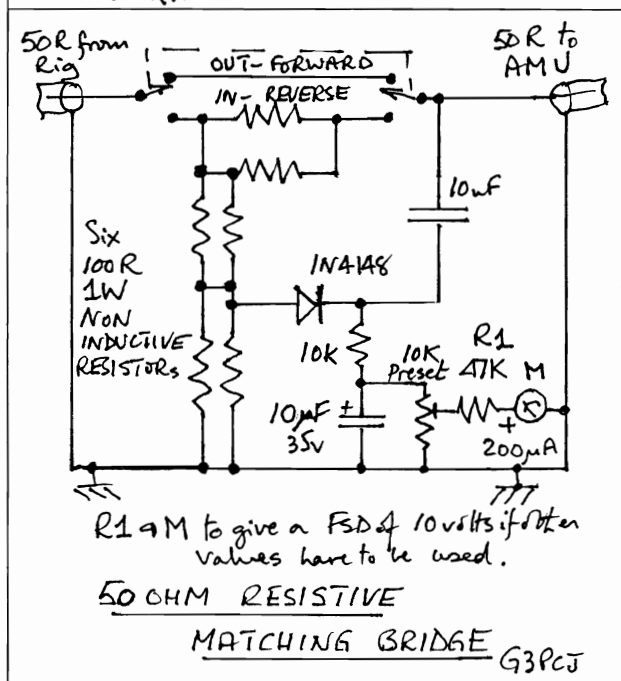
A single coil Mini Z match AMU for 80 - 15m

This AMU is intended for QRP up to a max. power of 15 Watts; being fully balanced it works well with 300R slotted feeder. Polyvaricon mini variable capacitors are used (from Birketts of Lincoln or from scrap domestic portables). T130-2 toroids are available from Cirkit and copper wire can be obtained from electric motor repairers possibly - see Yellow Pages. It tunes my delta loop on any frequency I choose and is hardly bigger than a packet of cigarettes! It goes very well with my Yeovil. Stewart Sims G3WQW



A Resistive Antenna Matching Bridge

The circuit on the right is basically that used in the Yeovil's bridge but can be used on any frequency up to VHF with careful layout and a small switch or relay. It has the advantage that when it is in circuit, it will always present a safe load to the transmitter, even if there is a short or open circuit on the aerial terminals. The three arms of the bridge need values of 50R for use in a 50R antenna line. A good compromise is to use two 1 Watt 100R non-inductive resistors in parallel for each arm. This will enable safe use with a 5 Watt transmitter. The use of a 2 pole switch, or a relay if remote control is desired, means that there is not another contact available to alter the meter sensitivity between forward and reverse. The reverse reading is not normally more than half full scale unless the rigs output impedance (not it's desired load impedance which is the usual 50R) is more than a few ohms. The preset is adjusted for full scale when the bridge is out, operating into a 50R dummy load. In use, since the antenna matching controls are adjusted for the lowest reading when the bridge is in circuit, the fact that the upper limit is only half scale doesn't matter too much. When the bridge is out, the meter actually indicates output voltage but since the AMU is now known to be presenting a 50R load, it can also be calibrated in output power (with a square law). G3PCJ



The Eleventh Yeovil QRP Convention

This year the event has been put back a little to May 21st 1995 so as to avoid clashing with others. Doors open at 10 am and an even more diverse programme has been devised; all the usual things are planned with a series of talks, traders and demonstrations related to QRP construction and operation. The QRP Fun Run contest, which takes place in the preceding two weeks, has a slightly different format this year to make it more diverse. There will be a display of pre 1930 equipment and an advice clinic for anyone seeking technical assistance with their gear. Simple test equipment will be on hand but if anybody has a particularly knotty problem it would be best to warn the organisers in advance so that extra brain power or special test gear can be organised! This years Construction Challenge is to design and build an audio CW filter, using not more than 10 passive components, which will be evaluated on the day to see whose has the best interference rejecting properties. The event will be opened by the **President of the RSGB**, Clive Trotman GW4YKL, who will be in attendance all day; it will be an excellent opportunity for anybody to meet him and discuss any amateur radio and RSGB matters. Full details of this and other aspects of the event can be obtained from Peter Burridge, G3CQR who is QTHR or on 01935 813054. It should be a good event - hope to see you there. G3PCJ

The Coker's Sidetone

One instance has come to light of the sidetone oscillator on the Coker transmitter not keying on and off cleanly or even staying on continuously. It is due to component tolerances around the transistor TR6; if yours exhibits this symptom the solution is very easy, just add a 1K resistor from TX test point 2 (collector of TR25) to 0 volts which should turn TR26 off when the key is up. I am not bothering to alter the PCB because I doubt whether more than another one or two are likely to be effected; I have now put a warning note in the transmitter instructions. G3PCJ

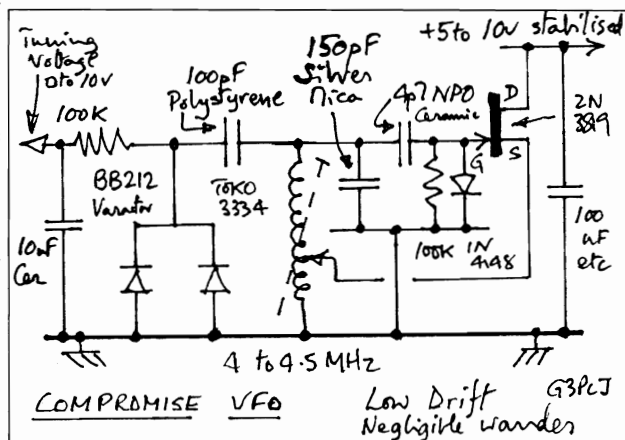
Construction Club Membership

I recently found that not all members of the Club, were in my current name and address file. I believe this is now correct but there is the faint possibility that some of you may not have received the last Hot Iron Issue number 6 - if this is so, I apologise; please let me know and I will send it. Tim Walford G3PCJ

VFO Design

During development of the Coker, and recently when doing long term testing of the Taunton's VFO, I became aware that there is much more to this topic than meets the eye! The considerations for a VFO are complex:-

1. Nominal frequency - this is dictated by the rig's band structure for a superhet and will attempt to avoid undesired harmonics and unwanted mixer products being within any working band. For DC rigs there is little choice except perhaps that the VFO operate at a multiple of the output frequency.
2. Tuning range - often dictated by the rig's band structure leading to a typical 500 KHz swing; it is also influenced by the cost of different varactor diode types; in a simple rig a compromise is needed between resolution and single knob tuning which usually limits coverage to about 100 to 150 KHz for a 270° rotation pot.
3. Configuration - many different oscillator schemes are possible. They seldom dominate frequency stability considerations because the effect of coil and capacitors is more significant. I like Hartley VFOs as they use less parts. Amplitude stabilisation is necessary; with FETs it is easily done by gate capacitive coupling and a diode which decreases the FET bias as oscillation voltage increases. The gate coupling to the RF tank should be as low as permits reliable starting of the oscillator in order to preserve tank Q. The FET supply voltage needs to be stable and lowish to minimise power dissipation and hence heating effects in the FET and in the RF tank.
4. Choice of Inductor - kit builders are notoriously keen to avoid winding their own and there is little choice but to use commercially made ones. I find the TOKO range admirable, there is a wide range of screened coils with many choices of inductance, taps and extra windings for RF transformers where commonality of parts is important. Generally their temperature coefficient is +150 parts per million per degree centigrade (ppm/°c).
5. Choice of capacitors - herewith the fun! To avoid long term drift, ideally the temperature coefficient of the RF tank capacitors should be the opposite of the coil's i.e. -150 ppm/°c. Low K ceramic plate capacitors have this characteristic for 22 pF to 150 pF; smaller ones with a nominal zero tempco are fine for the gate coupling capacitor. They are both often used for the RF tank. The snag is that sometimes they seem to cause significant short term wanderings in frequency. Silver mica types used to have a bad reputation for being inconsistent, but my experience is that modern ones do not exhibit this wandering effect. Their tempco of +39 ppm/°c for typical values means that drift will remain unless something else is done. My suggestion is to then use polystyrene types with their -150 ppm/°c characteristic for coupling to the varactor diode. Polystyrene capacitors do also have a slight tendency for this wandering effect but not as much as some ceramics. Because the varactor coupling capacitor is usually smaller than the main tank C, the slight wandering effect is reduced to an acceptable level and drift from the coil is partly compensated. See circuit. Varactor supply stability is also crucial! The problem free cheap VFO continues to elude us! G3PCJ



HOT IRON

Issue 8

"Journal of the Constructors Club"

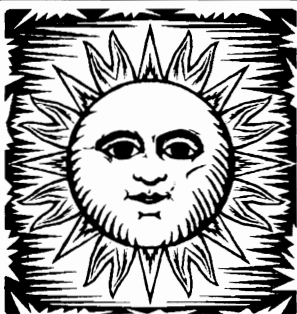
Summer 1995



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Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Constructors Club**. Articles, suggested topics and questions are always welcome. Please send correspondence and membership inquiries to:- Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224. The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £5 per year for the UK (£7 overseas) from Sept 1st in each year. Jan 1st 1994.

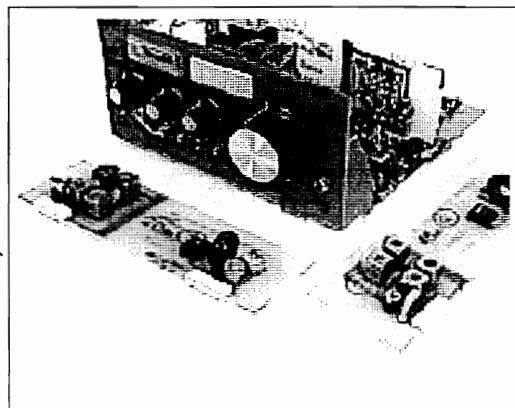


Editorial

In my last Editorial I asked whether anybody thought they would like some form of micro-controller or other type of computer in their rigs, perhaps to control a synthesiser or DDS (Direct Digital Synthesiser) chip. I have to report that I have had a nil response, from which I gather that all readers who do bother to write are analogue people who would be uncomfortable with the digital world of micro controllers. I have much sympathy with this viewpoint because I think the fun of amateur radio building, is to do something over which you have complete control and hopefully a pretty good understanding of how the gadget works; sadly this is generally not the case where computers are concerned - no matter how simple their design. Many years ago I used to design specialist computers for use on warships but modern PCs are very different. We used to produce machines that had three address fields so that the sum $a+b=c$ could be done in one instruction with the data being fetched from and sent to three different locations in memory. Modern processors do not allow this and the consequence is that programs are much longer than they used to be! This is acceptable because memory has become very cheap! The first machine I worked on, had the complete program for the handling of air traffic control flight data strips shoehorned into 4096 words of 24 bit memory or 12 Kbytes in modern compuspeak! The point of all this is that, although I understand the general language of modern computing, I wouldn't have the faintest idea of how to fault find on this 486 computer if it let me down; unfortunately the same would be true of most devices that one might use in a micro controller buried in a radio. Fine if its works first time but useless to those who have made some trivial mistake that prevents it ever doing anything useful. I shall try to avoid using them in my designs; however, future commercially built rigs are quite likely to be direct conversion phasing rigs where most of the signal processing is done digitally!

The Taunton

At long last, I am able to tell you the Taunton is **now available!** It has taken 18 months from serious start to launch. If anyone wants full details let me know; basically it is a 5 Watt TCVR capable of working on any single HF band by means of plug-in cards. All bands to 15m are available now. It starts as a phone superhet, CW is added with either a simple fixed or a very high spec. **variable CW filter**. The PCB is drilled for a range of optional extras which can be fitted initially or later. The phone rig, with optional extras, is all on one PCB 100 x 160 mm. The very full manual is available seperately at £5. The TCVR + any one HF band + membership of the Construction Club for 95/6 is discounted to £99. Extra bands at £14, optional extras at £24, fixed CW kit £17 or variable CW kit £37 and counter £47 if ordered together. P and P £1. Fantastic value! Tim



Small Board Construction by Tony Measures G3WUC

I wanted to build a Yeovil VFO for use with a synthesiser. A piece of double sided PCB was to hand. I put a good wad of blutak where I wished the Toko coil to be, and made a good footprint through the blutak. I then, using my mini drill stand, drilled through all the pin prints made by the coil pins, but not those made by the case lugs, and then removed the precious blutak to store! Carefully rule lines to run in between the drill holes lengthways and breadthways so as to cover the whole of the board area on which parts are to be mounted. My piece happened to be 40 x 65 mm. Put the board in a vice so that the line to be cut is up against the outside edge of the vice jaws; saw gently with blade firmly against the jaw sides, acting as a guide, being careful to go only sufficiently deep to cut through the copper (and NOT right through the board!). Continue until all lines have been given this treatment. Clean all saw cuts carefully. Put board in mini drill stand and drill holes through all the rectangular islands. The other intact side is a ground plane and holes have to be countersunk as required to prevent leads touching the ground plane. I had plenty of room to fit regulator, VFO, buffer amp, controls for coarse and fine tuning varactor tuning, and could have added RIT if wanted! Components for most parts can be mounted either side of the PCB and surplus lead clippings are useful for make extra connections through the board. A late streetwise suggestion is to leave a row of blank spaces all down one edge for edgewise soldering to, say, the back of the front panel. (Note also that in TT of Radcom April 1995, there is a more sophisticated version of this for multipin ICs etc. if you insist on having a nervous breakdown! I think mine is more KISS!)

Coil Construction for ATUs and QRP Use by Roy Boldock G0FFQ

Polystyrene cement suitable for securing coils can be made easily by obtaining a small jar, ex mustard pot etc. which is used as a vessel for dissolving polystyrene packaging or tiles into genuine turpentine. This can be obtained from an art or paint shop. While dissolving the polystyrene small bubbles may appear - this is normal. Add polystyrene until the mix is sufficiently thick.

Coils can be made using small plastic bottles, or spice bottles, as formers. Keep a selection of sizes on hand to suit different bands etc. Many people leave these bottles inside to act as a permanent former but losses will be lower if the plastic former can be removed! Having found a suitable former, wind on a tight layer of thin string all over the former. Cover this with two layers of plastic film such as used for carrier bags and secure in place at the ends. Now wind the coil over the plastic film, either closewound or side by side with another piece of string acting as spacer if the wire is bare. Tie the start and finish of the wire tightly so the turns cannot slip. Carefully remove the string spacer turns if fitted. Apply the above cement, or Araldite, in thin strips across the outside of the coil turns along the length of the former - put about 4 strips around the former circumference. Wait 2 days for the cement to harden fully, if OK, remove the string underneath the plastic film on top of the former. This will release the former which can now be slid out. Apply more cement in strips on the inside of the now self supporting coil to increase its strength. You now have a low loss inductor. If you need a coupling coil, this can be made by the same technique with a smaller former so that the coupling coil will slide inside the main winding. If left as an adjustable sliding coil this can be used to adjust coupling for best match conditions in an ATU. Taps can easily be made on the outer coil for band changing; either by making doubled back "nibs" (carefully soldered) in the wire as the coil is wound. If the turns were spaced without insulation, then taps can be made with wire hooks which are carefully soldered around the coil wire in suitable positions.

Mounting PCBs in Diecast Boxes

PCBs can be mounted inside boxes on suitable length bolts without the heads showing outside by gluing the bolts to the inside of the box as follows. Before you load the PCB with parts, find a suitable number of long mounting bolts with two nuts for each bolt. Put one nut on each bolt and place through the PCB in its mounting holes so that the bolt can be secured to the PCB by the second nut. Adjust the nuts on all mounting bolts so that the board is level when placed with the bolt heads down on a flat surface - do the nuts up lightly. Place the assembly into the diecast box in the desired position so that the bolt head positions can be marked or noted. Thoroughly clean the inside of the diecast box with emery cloth to remove any tarnish on the surface. (It is aluminium oxide which prevents good adhesion and is the reason it is practically impossible to glue to plain aluminium since the oxide forms very quickly on plain sheet aluminium - Ed.) Apply a little Araldite cement to both the bolt heads and the intended positions of the bolts where you have cleaned the box. Offer up the PCB with its sticky mounting bolts, wriggle it sideways to fuse the cement and settle it down. Leave for a couple of days if ordinary Araldite or 12 hours if the quick setting version has been used. Undo the exposed nuts, remove the PCB and load with parts. Properly tighten the nuts when finally fitting. You now have a neat job with no external nuts or bolts! Internal cables can also be secured to the inside of the box using Araldite to keep them laid neatly in the folds of the box. This also gives a measure of screening. Again remember to clean the surfaces before applying glue!

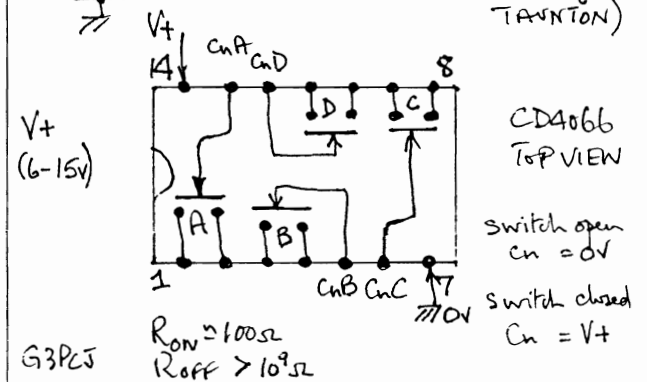
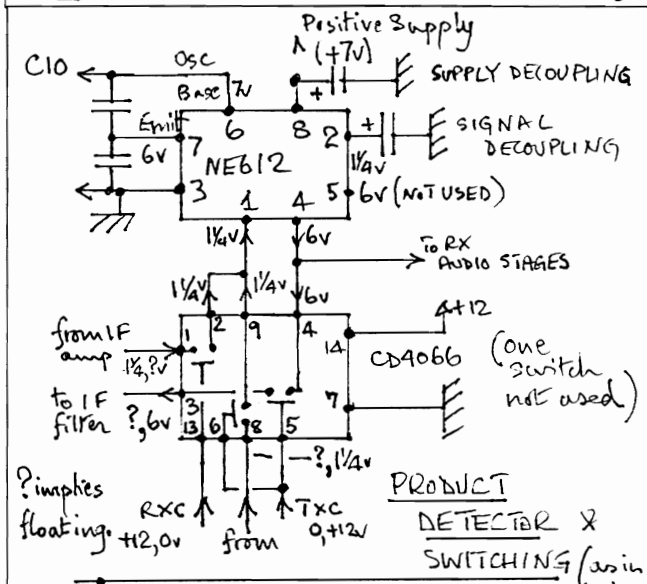
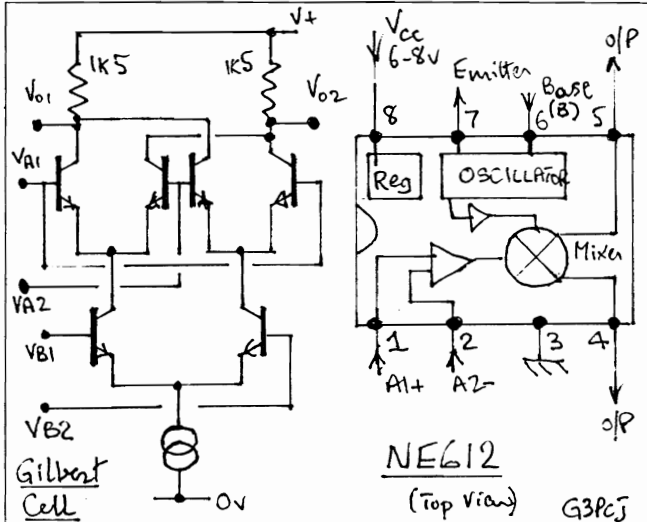
Roy Boldock G0FFQ

Fault Finding on Active Mixer Chips

Following my general note on fault finding in Hot Iron Issue 6, I did promise to return to the subject with more definitive advice where the obvious things are OK. Active mixer chips of the NE602 or 612 type are now very common so must be good candidates for failures in comparison to other less common devices! (This is not to imply that 612s are prone to failure - just that there are lots of them so many may get damaged etc.) Other active mixer chips such as the older MC1496 and SL6440 have much in common with the 612 so these notes may also help with those devices. The 612 and 602 are electrically interchangeable and have the same internal circuit so I shall refer to the 612 as it is usually cheaper! All these types have a Gilbert Cell as the mixer element which I have sketched alongside.

Modern semiconductor processes have very good matching between devices on the same chip which gives a high degree of balance between the two halves of the chip, which is why their external circuits seldom have balance presets to improve on the natural matching of the two halves. With the 612 and 6440, internal biasing resistors are incorporated on chip but not for the 1496. In addition the 612 also has a separate section that can be used as an oscillator or buffer and which always feeds into one signal input of the mixer. All three types have balanced inputs and outputs with provision for push-pull or anti-phase connection; frequently only single ended drive (in or out) is used with the other side being decoupled for signal or ignored. **The important thing is that under normal conditions the DC voltage levels in the two halves should be the same.** I have sketched in the second box a typical circuit for a 612 when connected as a product detector linked with a CD4066 switching chip to make it act as a balanced modulator during transmit. I have listed typical DC voltages against the 612 pins; it is usual for the circuits connected to the 612, either directly or through a 4066 switch, to be AC coupled so that the 612's DC voltages are not altered by the external circuits. In the circuit on the right, the 4066 is literally connecting alternative input and output signals to the mixer chip in much the same way as a 2 pole changeover relay would work. Thus any DC voltages that are present on the 612 get transferred through the 4066 depending on which way its switches are made. The DC voltages shown against the 4066 pins are firstly those on receive when the control signal RXC is high (or at the 4066 positive supply voltage) and TXC low at 0 volts; these are followed by the DC voltages on transmit when TXC is high and RXC low. The switch "contacts" are closed when the control signal is high and are open circuit when the control is low. Signals can pass in either direction through the closed switch but their instantaneous voltage (DC plus superimposed AC) must be between 0 volts and the positive supply to the 4066. Normally this is no problem as the input and output levels to a 612 are seldom over a volt p-p on top of the DC voltage of about 1.25 at the input or about 5 to 6 volts DC at the outputs. To help explain the switch connections in the 4066 I have drawn out its pin connections separately.

Each switch in a 4066 has a resistance of about 100 Ohms when on suggesting that it should only be used where the circuit impedances are significantly above this figure - hence its use with the 1K5 in and out



impedances of the 612. When **off**, the switch resistance is thousands of MOhms! Thus if you have a suspect 612, first check that pins 1 and 2 are equal and about 1.25 to 1.5 volts. Secondly, check these are properly transferred through any 4066 switches. The DC output voltages are not always equal since the outputs can be DC connected to the positive supply instead of relying solely on the internal 1K5 resistors between each output and the supply pin. If there is no external DC connection, the two output pins 4 and 5 should be equal and about 1 volt below the supply on pin 8; this is typically 6 to 7 volts leading to output voltages of 5 to 6 volts. If connected to a 4066 switch these should be transferred to the other side of the switch. If the voltages on pins 1 and 2 are higher than on 4 and 5, it is definitely faulty. The 612's oscillator section has internal biasing so that the base input pin 6 is usually at the device's supply voltage on pin 8. The DC voltage on the oscillator emitter, pin 7, is one V_{be} drop or 0.65 volts below that of the base input pin 6. So typical voltages would be 6 to 7 on pin 6 and 5.35 to 6.35 volts on pin 7 - these are seldom connected to switching type circuits using 4066s and are normally DC isolated by capacitors in the associated circuits. The conclusion of all of this is that a good high impedance DC voltmeter is all that is required to tell if your 612 and its associated 4066 is OK.

VFO Building and Design

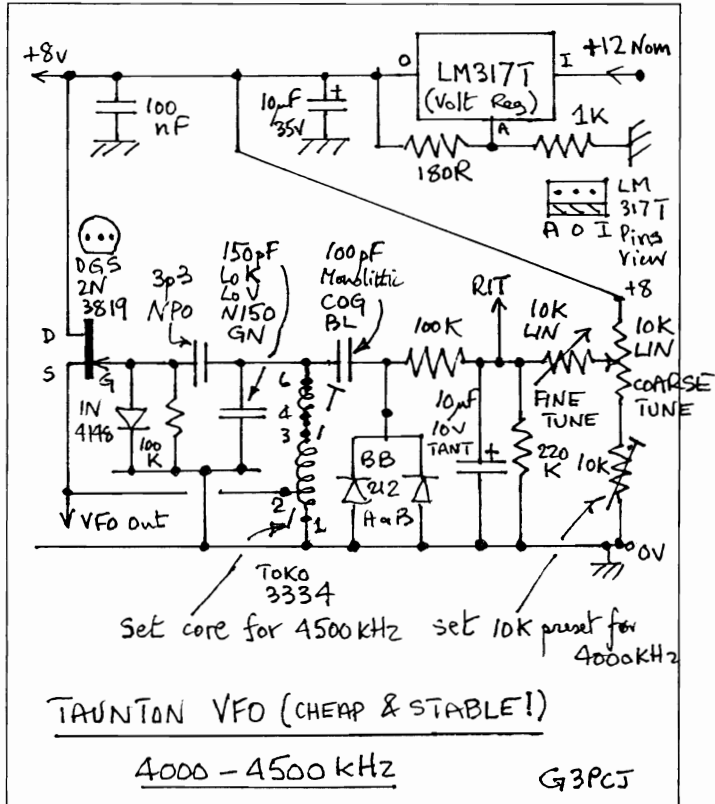
I ended the last issue 7 of Hot Iron with the comment that the cheap problem free VFO continues to elude us! I very pleased to have a contribution from Peter Barville G3XJS about building super stable VFOs which fits neatly with further work of my own. Peter relays some notes from Steven Wilson and Mike Czuhajewski which I have combined. "The principles of building good stable VFOs have been known for many years, however many amateurs and some QRP equipment manufacturers seem to ignore them. (Due to cost compromises -Ed!). Stability is the usual problem; mechanically and electrically it must be built like a rock. Herewith some tips which should make it possible to get drift down to 100 Hz or less in 24 hours!

1. Use double ball bearing capacitors. The more common types with just a single control shaft bearing will not be as good. The sliding contact (if fitted) for the rotor should be carefully squirted with contact lubricant.
2. Once the coil is tuned, either by removing turns and/or squeezing or expanding, use Q-dope to secure it in place. (See notes about cement previously.) Best to add extra turns, remove if necessary later and finally squeeze.
3. Use the white or yellow **powdered iron** toroids, they have 2 or 3 times better temperature stability than red ones. Yellow ones will work down to 3.5 MHz. Do NOT use Ferrite cores. If in doubt about a core do not use it. Black cores maybe powdered iron or ferrite, so avoid them!
4. Fasten the coil down. Hardware stores have cone shaped rubber washers for fixing dripping taps that work well when you add a plastic nut and bolt. Do NOT use brass or steel bolts - they will alter the inductance.
5. Use 18, 20, or 24 gauge wire. Nylon coated types can be stripped with a really hot iron.
6. Use polystyrene capacitors for best temperature stability. NPOs help to trim some of the core drift. I prefer several caps in parallel rather than just one fixed tuning capacitor. Some silver mica types drift badly. You can also remove plates from the tuning capacitor if frequency is too low. (See later on capacitor types - Ed).
7. One sided PC boards are better for VFOs than double sided or multi-layer types.
8. Use a Vackar circuit if you can. Differences in drift over those of the more common configurations will only be noticeable when the mechanics and thermal characteristics of the tuning components are already excellent.
9. Use a good FET such as the 2N5484 and make certain its output is buffered."

Problem Free Cheap VFOs

My quest for good performance and simplicity in a 4.0 - 4.5 MHz varactor controlled VFO for the Taunton continued after the work mentioned in HI7, as the stability actually achieved with that circuit was not good enough. None of the capacitors were really suitable and the orange tipped N150 ceramics were inconsistent; they were not dependable, some being good and others poor, (causing the VFO to wander quite quickly), rather like the reputation of silver mica capacitors. Eventually I started again and ordered samples of every cheap supposedly stable capacitor that I could obtain! My best compromise for the main tuning capacitor, is to use low K low voltage cement coated N150 disc ceramic types from RS which are made in Japan; these happen to be coloured green and are 8 mm diameter. I suspect the similar ones sold by Farnell are made by the same source but they are coloured buff! For the coupling to the tuning diodes I recommend a monolithic ceramic COG type having a nominal zero tempco (from Maplin) which happens to be coloured blue! This combination has removed all trace of short term wandering which was present with the orange tipped N150s. A further improvement in short term stability was obtained by decoupling the varactor tuning voltage with a solid tantalum electrolytic instead of an aluminium type. Many hours later I am able to report that this VFO moves less than 150 Hz (down) from cold after several hours when built with my open style of construction (on double

sided PCB) in conjunction with a TOKO coil; I reckon this is good enough for most people and avoids having to spend several pounds on each quality fixed capacitor. I hate to think what they and a double bearing air variable would do to kit prices! In use it is more than good enough; for example, immediately after turning on, I tuned to some long running net; one and a half hours later when the net controller packed it in I had not had to retune. (I know what you will be saying about his VFO!) I also investigated the effect of power supply changes since varactor supply voltage stability is crucial. After trying many different regulators I recommend using the LM317T; although the current rating of this device was not needed, its regulation and thermal properties were much better than others. An abrupt change from 12 to 18 volts produces a 300 Hz change which falls to a 100 Hz difference after several minutes; when the supply change was spread out over 2 minutes the change in frequency was nearer 60 Hz! This is appreciably better than my other designs so I have now ceased VFO development! The full circuit is on the right. G3PCJ



PCB Production from Magazines by Simon Males G0EVZ

I often see projects in magazines that include a full size PCB layout; these boards purchased from a supplier can cost quite a bit, so I usually make my own using the following method:-

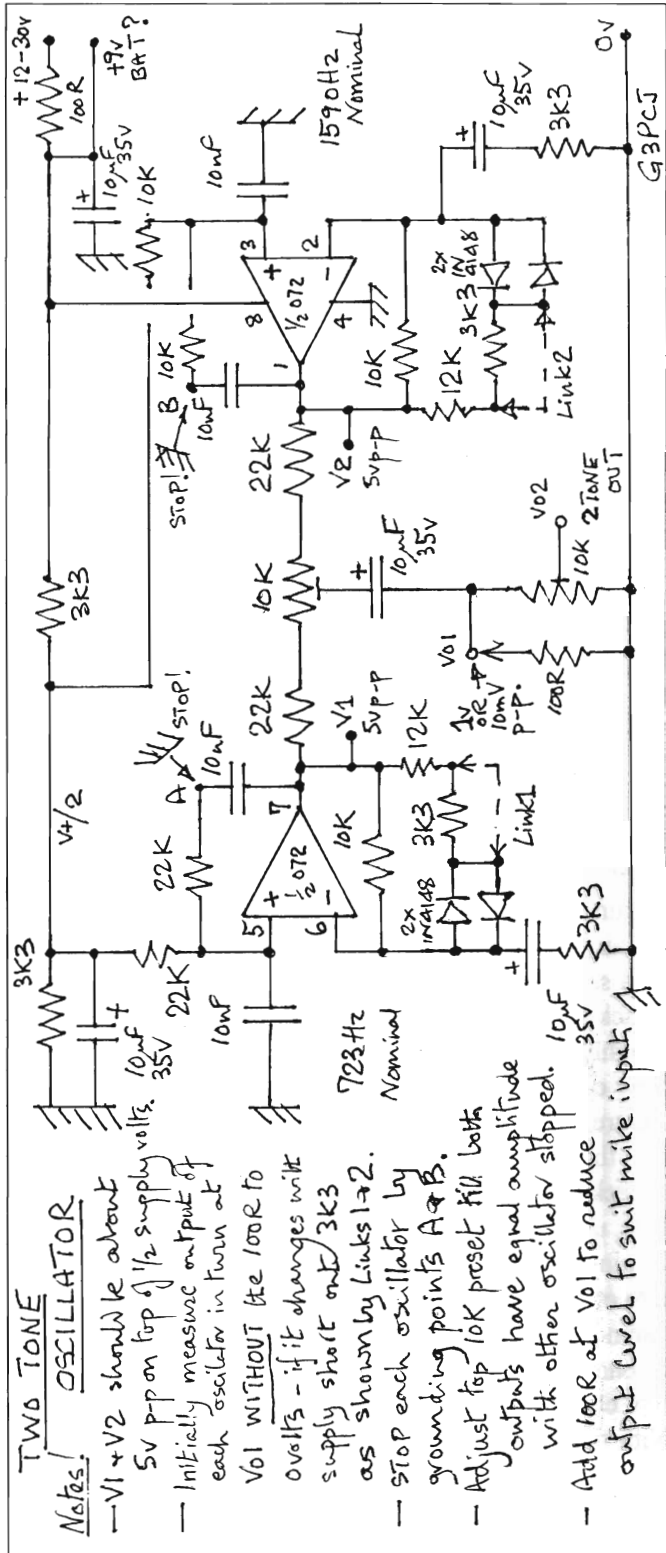
1. Obtain a piece of good quality PCB (preferably glass-fibre) roughly the required size.
2. Obtain a photocopy of the PCB layout. Cut out and "sellotape" it onto the copper side of the PCB. Then using a small centre punch (or even a hardened nail), centre pot as accurately as possible each hole marked on the track layout. Check that no holes are missed and then remove the paper layout. The board must be thoroughly cleaned to ensure the copper is shiny and free from grease.
3. Now comes the "fun bit". Using a special etch resist pen (available from component suppliers etc), join up the centre pot marks as in the track layout diagram. With care, even IC pads can be marked on to the copper. Ensure that no copper shows through the resist where you wish to retain the copper. Allow your board to dry and check very thoroughly for mistakes, omissions, etc., if necessary tidying up and scraping away any track bridges, using a scalpel or modellers knife.
4. Obtain a supply of ferric chloride either as a liquid or granules, water having to be added to the latter. This is used to etch the unwanted (uncovered) copper away by pouring some of the solution into a shallow plastic tray, and immersing the board until all unwanted copper is etched away. Etching is speeded up if the tray is rocked occasionally. Rinse the board thoroughly under water and then dry. Note. Ferric chloride is corrosive and must be kept clear of skin and eyes. Do not allow the ferric chloride to get onto a stainless steel sink!
5. With the aid of drills of sizes to suit the component leads (generally 0.8 to 1.2 mm) drill out all the centre potted holes. Finally, clean off the etch-resist with solvent and your board is ready to use.
6. The ferric chloride can be used many times so it should be stored in a sealed container in a safe place.
7. I have made many boards satisfactorily by this technique, including double sided ones.

A Caution!

Reg Pattinson GW3KVB warns that you should be careful to make tidy and small topside connections when soldering earthy component leads to the ground plane of a double sided board. In a kit he recently purchased (I wonder where?) there was a missing hole; when he came to drill through the offending pad, the other side had a large blob of solder on it as he had been too generous with an earth connection. The general advice must be to have a good look at the PCB before you start loading it; if there any missing holes which you cannot drill out sensibly yourself, then send it back to the supplier. It is no excuse, but I can tell you from hard experience, that it is very difficult to be certain that you have drilled all holes in a dense board when doing it without numerically controlled drilling machines - your eyes get mesmerised by holes! Ed!

Two Tone Audio Oscillators for SSB rigs

Derek Alexander, G4GVM, asked me long ago to produce a design to assist in the proper setting up of a phone SSB rig. The important thing is to have two equal amplitude non harmonically related pretty pure audio sine wave oscillators; the outputs from these are added together and input into the mike input of the rig being set up. The resulting RF waveform output from the transmitter is a sinewave envelope whose frequency is the difference of the two audio frequencies. Normally this has to be observed with an oscilloscope (see later though) and will appear as two sinewave envelopes, 180 degrees out of phase, filled with RF in between. The test signal is used to check firstly that the rig output (or earlier) stages are not limiting with all the nasty splatter that this causes. Limiting is apparent as a flattening of the top and bottom of the RF envelope - it is usually caused by some stage, invariably the output one, not being able to generate any higher peak to peak RF voltage due to a variety of possible reasons. The transmitter's drive and modulation controls should be adjusted so that under normal conditions, the maximum output is just less than the level where flat topping begins. The other use for a two tone oscillator, is to set the carrier oscillator frequency to give the least residual carrier. As before, modulation is applied and the RF envelope observed on the 'scope. When the carrier oscillator is correctly set, the cross over of the two sine envelopes near 0 volts will be clean and sharply defined. Hence you should adjust the carrier oscillator frequency for the cleanest cross-over of the two envelopes. Remember to do it for both sidebands if the rig has facilities for both sidebands. I have put the circuit alongside for the two tone generator and resistive adder - this is acceptable because the output needs to be low level to feed into the rig's mike input. To set up the balance control, first measure the audio output level with only one audio oscillator working; then measure the level of the other oscillator with the first one stopped. Adjust the preset until they are equal. I shall be making this circuit available as a kit and I intend to add a simple detector circuit so that measurements can be made with a DC voltmeter instead of a 'scope. I will include rather fuller notes about how to use these gadgets with the kit! G3PCJ



SUBSCRIPTIONS!

Since this is the last issue of our second year of Hot Iron, I am sorry to have to remind you to send me your subs if you wish to continue receiving Hot Iron. The rate remains unchanged at £5 for UK and £7 for overseas members. I regret that I shall NOT be sending out any reminders; this is the last warning you will get! I suggest you send off now before you forget. Many thanks for your continued support. Please don't forget that I am always after material for Hot Iron - your tips will certainly be of interest to others. Tim Walford G3PCJ

Hot Iron

Issue 9

"Journal of the Constructors Club"

Autumn 1995



Editorial

As this is the start of our third year for the Constructors Club I thought we ought to have a small facelift; I even managed to find and retrieve from the depths of the hard drive, the logo on the left that my son Charles drew some months ago after he complained about the original builder being rather po-faced! I am always pleased to have contributions and even those in pictorial form. We have a graphical progress report from GW3COI on his Yeovil and a frequent question to! Thank you John.

Kit developments

Some of you will know that I am a farmer, when not buried in my electronics bench! The splendid weather in August has allowed us to complete the harvest in record time and progress on new kits has been good. The high performance **Tuneable CW Filter** that I mentioned some while back is now out at £37. The low pass corner frequency, above which you will not hear interference, is tuneable by a pot or preset. It also provides all the functions to convert a phone only SSB transceiver into a CW rig; it can be used with most of the Somerset Range rigs or on its own with other makes. I have also decided to introduce a range of low cost simple instruments; the three items mentioned below are available now and I hope also to have a signal generator and simple counter in due course. The **Two Tone Audio Oscillator** has a separate section with diode detectors. As I hinted in the last Hot Iron, the detector part enables you to set up a rig using its two tone audio signals but **WITHOUT** a scope. Apart from this major advantage, the diode detector part incorporates a low power dummy load and acts as power meter with your DC voltmeter! The second item is a **Marker Generator**, which provides harmonic markers right up into the VHF region, with the spacing (or base frequency) being set by a PCB mounted rotary switch giving options of 10, 1 MHz, 100, 10, 1 KHz derived from a crystal. There are both wideband and rectangular 5 volt CMOS logic outputs with the facility for alternative outputs at 2 MHz, 200, 20, 2 KHz. The size is 50 x 80 mm with mounting by the switch bush or nuts and bolts. The third item is a **50 Ohm Dummy Load**, rated at 30 Watts continuous. It is supplied as the two non-inductive resistors with a 1.6 °C/W heatsink. The cost of all three items is the same £16 for each or £45 for all three. Full details are available. Post and packing £1 please.

Win a kit!!!!!!!

To help me decide what to offer, all complete responses received by Dec 1st to the following questions will go into a **DRAW**. The prize is any one of the above three instrument kits, (indicate which you would like):-

1. What bands and modes do your current homebrew rigs cover?
2. What other bands and modes would you like to see kits available for?
3. What would you consider a realistic price for such rigs?
4. What is the most sophisticated piece of test equipment that you own or have access to?
5. Do you consider it important for the kit to have a box as an optional extra?
6. Do you rate yourself as experienced, typical or beginner at electronic construction?

Tim Walford G3PCJ

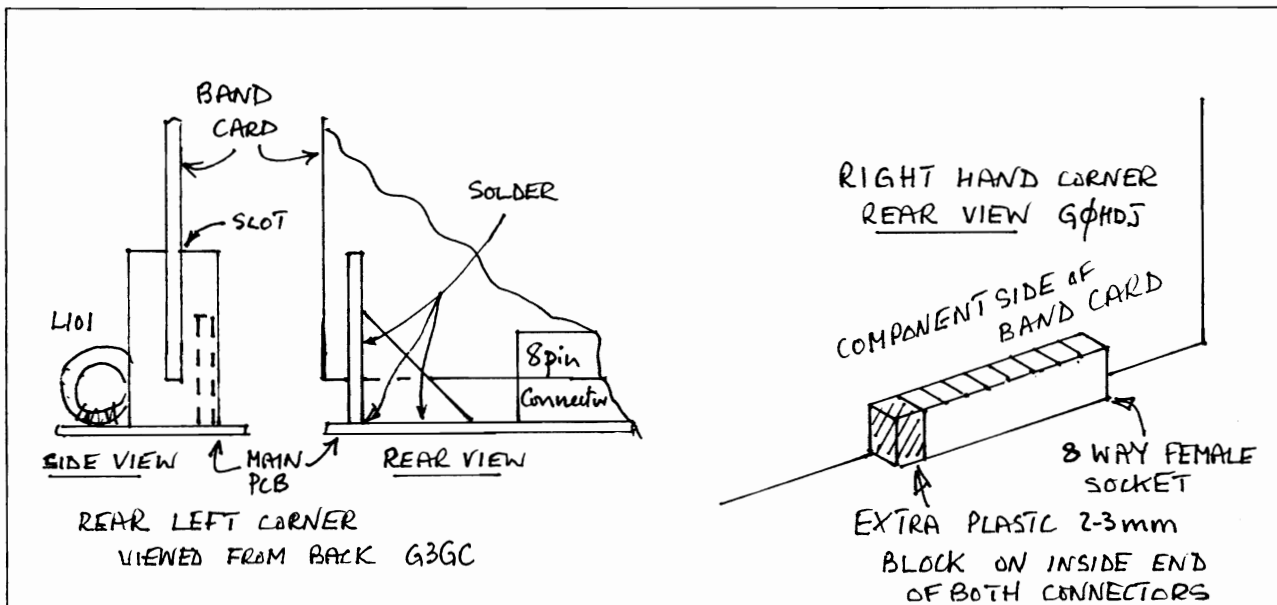
Editor

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224 The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £5 per year for the UK (£7 overseas) from Sept 1st in each year. Sept 1st 1995.



Updates on the Taunton

Band Cards. A number of suggestions have come in from G0HDJ, G3GC and G3WUC. Firstly, it is advisable to apply insulating tape to the back of the heatsink as there is a risk that the band card can be bent forward with the risk of a +12 volt short onto the heatsink. Partly to prevent this and to avoid possible damage to the band card's edge connectors, it is suggested that two guides be made out of PCB material to keep the card vertical - two rectangular pieces about 10 x 25 mm are cut out (perhaps from the front panel PCB side cheeks if not required). Into each of these, a slot is cut wide enough to accept the thickness of the band card. They are then soldered vertically in a front to back direction onto the top of the main PCB near the outside rear edges so as to hold the band card vertical. Two more smaller triangular pieces of PCB material are then soldered at right angles so as to brace the new slotted guides. G3GC suggests "tac" soldering the extra PCB material into position with a band card fitted and then completing the soldering after removing the band card. The band card edge connectors can also benefit from a very small dab of Araldite under their body to secure it to the band card but do not allow it to get into the innards of the connector. Another suggestion is to glue two extra small blocks of rectangular plastic etc. to the band card just inside both edge connectors. G0HDJ no longer has a complete toothbrush as he found the handle of his to be just the right size! Another possibility is the shaft off-cut from a plastic pot shaft. These blocks should prevent the band card being inserted left or right of the correct alignment for the connector pins and thus avoiding potential damage to circuits. See the diagrams below.



Parts List. Derek Perrey G3WUE, has kindly notified me of some errors which I had not picked up. C127 appears twice - it is 68 pF N150 and not 10 nF. R110 is 1K not 180R. R111, not on the list, is 180R.

Circuit diagram. I think I have notified all builders about an error on L103 - it should be shown with the centre tap connected to pin 6 of the band card and the top high impedance end connected to C111. C304 should be a 10 μ F Tantalum type - everyone building the TX should have had one from me, if not let me know. Pat King G4GFY also points out that the meter is 200 μ Amp FSD not 20 μ Amp.

Update on the Coker

Experience with some Cokers suggests that the regulator circuit is sometimes struggling to produce a nominal stabilised 10 volts from an actual 12 volt supply. The cure is to reduce the 10 to about 9.5 volts by adding a 15K in parallel with R7. This will affect the tuning calibration but little else. The general frequency stability and ease of setting the transmitter offset capacitor should be improved if the rig was sensitive to low supply voltages. It has not effected all Cokers. Gerrard PA3EKK had his on 160m from the Benelux QRP Club Family day field event with a 40m wire, it caused quite a pile-up! It took about 6 hours to build.

Update on the counter

Fred Maddison, VK6GE, found that when he fitted a counter to his multiband phasing transceiver, the G3TDZ design in Radcom 1993, there were some specific sprogs with the sound of a motor boat due to the 5 Hz update rate of the displays. While not being able to replicate this effect directly, I suspect that the layout and physical arrangement of the control wiring is important. The two signals Cntl A and Cntl B are rather important and switch at the 5 Hz rate. They need to have as low a capacity as possible to maintain accuracy but from a radiation viewpoint they are best laid close on the ground plane. This recommendation is a general one and quite

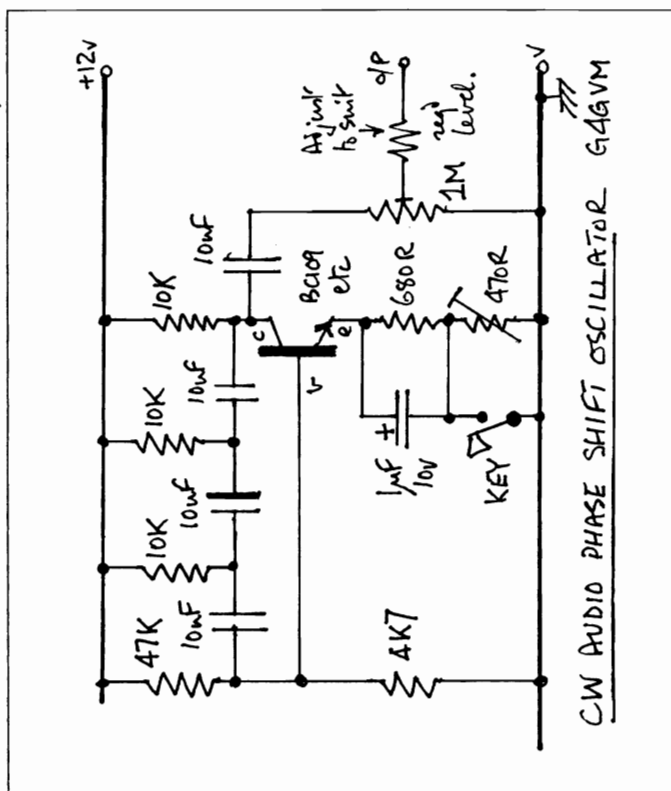
often can account for peculiar symptoms, instability etc. I don't think I have ever used screened wires for connections to front panels and around a PCB. I do however always lay wires tight against the ground plane or back of the front panel. Laying them in lines parallel to the edges of the PCB will also look neat. Most of the control signals in my designs are DC or low impedance audio, so the risk of cross-talk is small.

Sprogs and rig complexity!!

Simon Males, G0EVZ, reports finding very weak sprogs on his Yeovil at 14.29 MHz and the image of 3.71 MHz; those of you with Tauntons will also know that there one or two quite strong ones listed in the Manual. Sadly it is almost impossible to avoid them in simple rigs, particularly where there are multiple conversions. I don't have a ready explanation of the above sprogs but the usual source is a harmonic of the VFO, or some other oscillator, perhaps mixing with the harmonics of some other oscillator (either adding or subtracting) to produce the intended receive frequency or the IF. Getting rid of the harmonics is quite hard, particularly where the rig is multiband with an oscillator whose frequency changes with band. Sinusoidal oscillation is a jolly good starting point! The use of narrow band filtering wherever possible helps; this is why the Taunton has double tuned circuits at the oscillator mixer output. Narrow band front end tuning to reject signals outside the intended listening bands is a very good thing for many reasons; it helps with these unwanted harmonics, broadband noise, and unwanted very strong broadcast stations that can often cause overload. I find that double tuning in RF and mixer filters is usually the best compromise between complexity and cost. During 1994 and 1995, QST and Radcom have had some very interesting articles by Ulrich Rohde, KA2WEU, with further comments in Technical Topics, about the deficiencies of some black box front ends with diode switched octave filters etc. Achieving a simple and low cost multiband rig for kit builders almost certainly has to have oscillators dotted in among the wanted RF bands with the inevitable consequence of sprogs! Double conversion, high first IFs, Direct Digital Synthesizers with microprocessor for dual VFOs, multiple reed relay narrow band switching with super strong front ends, adjustable IF pass band and digital audio signal processing are not the stuff of low cost value for money kits, much as I would like to design them (and have the time to do so)!

A Phase Shift Oscillator - by Derek Alexander G4GVM

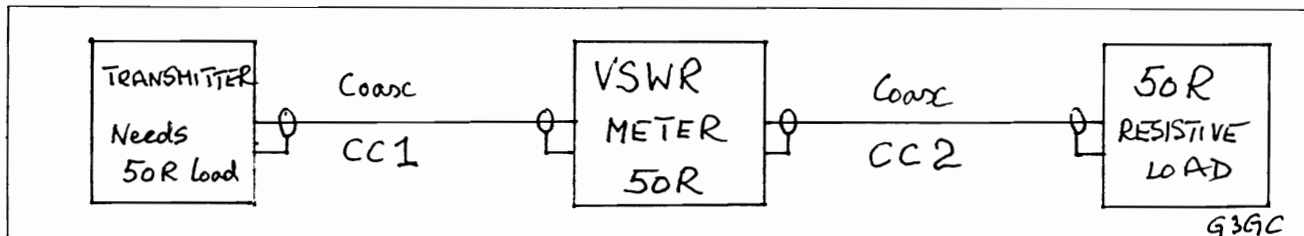
Here is a 800 Hz phase shift oscillator which could be used to add a CW capability to an SSB phone rig through the mike circuit, or as I had hoped, as a sidetone oscillator. The advantage of this type of oscillator is that it (usually! - Ed) produces a pure sine wave and therefore sounds good to the ear! I found the basic circuit in the QRP circuit handbook (page 58) when seeking a suitable sidetone oscillator but could not get it to work. However after some advice, I added the 1 μ F capacitor in the emitter lead - this increased the gain and it burst into life! Further problems were encountered when I tried the suggested keying circuit. Putting a key in the emitter lead was no good as it was very slow starting due to the time taken for the DC levels to adjust to the running values. John, G4TRN, suggested that the key be paralleled by a small pot adjusted to just avoid oscillation which would maintain the DC conditions (nearly). This works well but I still have not satisfactorily sorted out how to key it, drive the TR control circuit, and key the transmitter! Interaction between these functions is the problem. Can anybody come up with a simple solution please? (Replies via the Editor please.)



Technical comment. Derek has suffered the classic problem of sidetone oscillators, that of stopping the oscillation without disturbing the DC conditions. The latter can cause the most obnoxious thumps, particularly when headphones are used. The frequency of oscillation with this arrangement is dependent on many actual component values. Not even an audio oscillator is simple! G3PCJ

Voltage Standing Wave Ratio Meters The first of two related notes by Eric Godfrey, G3GC

From my experience as the "Doctor" at the last Yeovil ARC's QRP Convention, it was obvious that there is widespread misunderstanding about Voltage Standing Wave Ratios, its measurement and meaning. (My apologies to those of you who are also members of YARC since you will be seeing this note twice - Ed.) I do not intend to go into the design or operation of VSWR meters here but only to say that they are always designed for a particular impedance, which for the amateur is 50 Ohms. As such it measures the VSWR with respect to that impedance and nothing else. The quality of the meter depends on the accuracy of its internal coaxial line and the ability of its coupler(s) to differentiate between forward and backward power.



The above figure shows a transmitter, designed to work into a resistive load of 50 Ohms, connected through a coaxial cable (CC1) to a VSWR meter designed for 50 Ohms which in turn is connected by another coaxial cable (CC2) to a pure resistance of 50 Ohms. What VSWR will the meter show? Well it all depends upon the impedance of CC2. If its impedance is 50 Ohms then the impedance at the input to CC2 where the VSWR meter is connected will also be 50 Ohms and the meter will read 1:1. However supposing that length of coax that you bought at some rally was not 50 Ohms as you thought but instead was actually video cable of 75 Ohms impedance, what effect would this have on the VSWR? This will depend on the length of the cable. If it is an electrical half wave long at the measuring frequency, then its input impedance will be the same as its terminating impedance, namely 50 Ohms and the meter will still read 1:1. On the other hand, if CC2 is a quarter wave long, then it will behave like a quarter wave impedance transformer, the input impedance being given by the formula $Z_{in} = Z_r^2 / Z_{out}$. Thus the 50 Ohm terminating impedance will be transformed into a 112.5 Ohm input impedance to CC2! The VSWR at this point is still referred to 50 Ohms by the 50 Ohm VSWR meter which will now indicate a VSWR of 2.25:1. Intermediate lengths will vary between a VSWR of 1:1 when the cable is a number of half waves long to 2.25:1 when it is an odd number of quarter waves long. At low frequencies cables are only likely to be a small portion of a wavelength long and the mismatch will be small and progressively less at the frequency is lowered. However at 28 MHz, the physical length of an electrical quarter wave in a solid polythene cable is only just over five feet and at 144 MHz even less at around fourteen inches, lengths which could well be used for interconnecting cables.

Now let us consider what happens if the cable CC2 is the correct impedance of 50 Ohms and the 75 Ohm rogue cable is used instead for CC1. The VSWR meter, since it is working into a 50 Ohm cable terminated in a 50 Ohm load, will read 1:1 indicating that the impedance at the meter is 50 Ohms. However since the cable CC1 is now 75 Ohms, then if it is an electrical quarter wave long it will again act as a quarter wave transformer and its input impedance will again be 112.5 Ohms which will be directly connected to the transmitter. Thus the transmitter will be working into a system whose VSWR is now 2.25:1 with respect to the 50 Ohm impedance it expects. It is most likely that the transmitter will not like it, and if it has protection circuits these will limit the power to a safe value, but without such circuits it is possible that the final transistor(s) may give up the ghost even though your VSWR meter shows 1:1. Of course the actual input impedance at the transmitter depends upon the effective electrical length of cable and again if it is a half wave long then its input impedance will be 50 Ohms and there will be no problem. Something that may intrigue you is that if CC1 and CC2 are both 75 Ohm cable each a quarter wave long, then the VSWR meter will read 2.25:1 but the transmitter will actually be working into a load with a VSWR of 1:1 with respect to its 50 Ohms. CC2 transforms the 50 Ohms resistive load up to 112.5 Ohms at the meter (hence the 2.25:1) and CC1 transforms it back down again to 50 Ohms at the transmitter. So all is well despite the meter showing 2.25:1! Summing up:-

1. A VSWR meter measures the VSWR with respect to its own internal impedance and nothing else.
2. If the meter reads 1:1 then all cables on the transmitter side of the meter must be of the correct impedance. Those on the terminating side maybe of any impedance provided that a VSWR of 1:1 is achieved. (See part 2.)
3. Keep all interconnecting cables as short as conveniently possible.

Note. You can check the impedance of a coaxial cable by measuring its capacity per unit length. For solid polythene cables it is 30 pF per foot for 50 Ohms and 20 pF per foot for 75 Ohms.

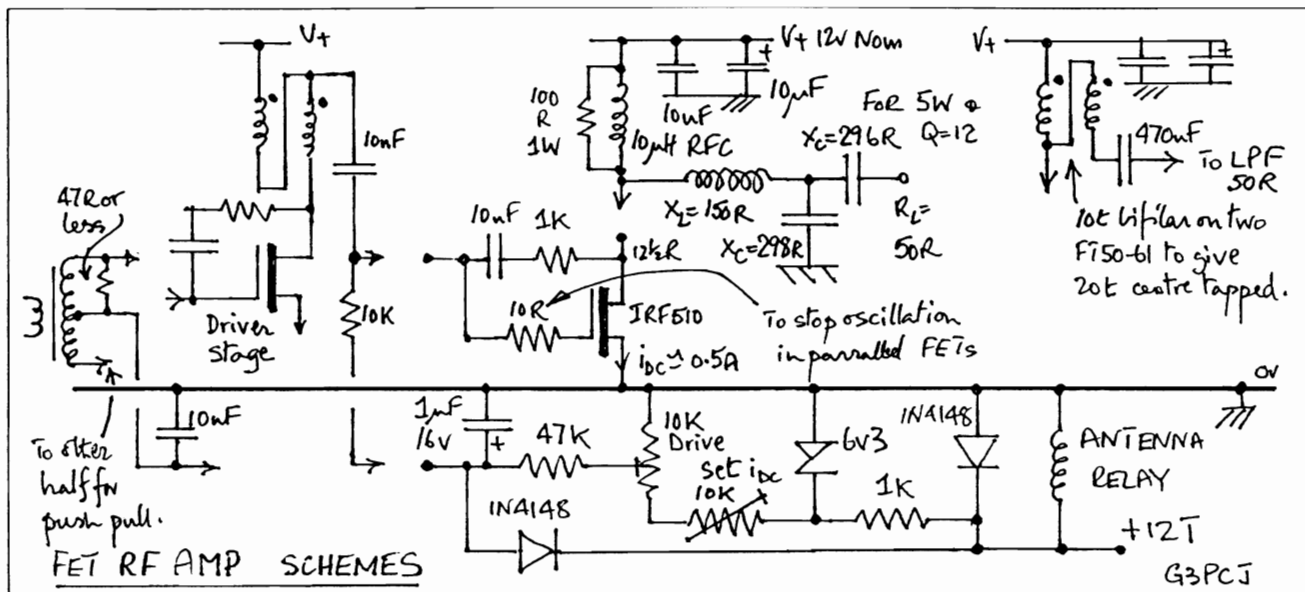
In the next part I will discuss impedance matching units, their uses and limitations.

FET RF Power Amplifiers

Over the last few months, I have been helping Joseph Bell, G3DII, with his experiments using power FETs as RF amplifiers. Although he has been using VN88AFDs, it has prompted this note which is rather more general although expressed in terms of my favourite device, the Siliconex IRF510. This N type device has a drain voltage rating of 100 volts allowing supplies up to potentially 50 volts but more importantly, its On resistance is 0.6 Ohms meaning that, at a typical peak operating current of 1 Amp, the On voltage is only 0.6 volts; this is a small proportion of a 12 volt supply and means it can be sensibly be used on this voltage or higher. (The VN88AFD has an On resistance of 4.5 Ohms which means that 12 volt operation is very inefficient hence its usual use on 25 to 35 volts.) For any device, the maximum RF output power is given by the formula $P_{out} = V_{pk}^2/2R_L$ where V_{pk} is the maximum RF voltage that can be generated. A working figure for V_{pk} is the supply voltage less the On voltage at typical maximum current. A little mental arithmetic soon tells you that a typical QRP rig intended to run 5 Watts, needs a load on the device of 12.5 Ohms with a nominal 12 volt supply. The peak current will be 12 volts divided by the 12.5 Ohm load hence my Amp of current above and assertion that the 0.6 volts for On voltage can be almost ignored! Although the IRF510 is rated at 20 Watts dissipation, this is at a temperature of 25 °C which cannot usually be attained with practical heatsinks and a measure of derating is desirable for reliability and wide operating bandwidth. Use on a supply significantly below half the drain voltage rating will also markedly increase its ability to withstand unintentional abuse such as open or short circuit loads. The drain load of 12.5 Ohms for 5 Watts can be matched to the normal 50 Ohm feed line by two main techniques; firstly a broadband centre tapped toroidal transformer giving the desired 4:1 impedance ratio but this must be followed by suitable low pass filters to remove the unwanted harmonics that all output devices generate - particularly if it is working in class C conditions. The Yeovil employs this broadband basis, with a push-pull pair of IRF510s which has the advantage of reducing even harmonics and potentially higher output power. The other technique is to use some form of tuned matching network such as in Tiny Tim and the Taunton. This restricts the range of frequencies over which it can be used but has the advantage of getting rid of harmonics at their source and is often preferred by builders since the inductors are easier to wind! Such networks often work with a Q of about 10 to 12 meaning the rig output automatically falls off just outside most amateur bands. There are many available matching networks but the L network has the most practical component values for semiconductor amplifiers running on low voltage supplies. The capacitors can sometimes be made variable for tuning and obtaining the best match but RF voltages are high. Issue 4 of Hot Iron has some brief notes on these networks with formulas.

The input side of FETs is a little more distinctive! Their gates only require a DC bias of about 4 volts (down to 2 volts for small low power MOSFETs) to turn them on, and since they draw no DC current, it is very easy to arrange a suitable bias supply based on a Zener diode with extra capacitors and diodes to turn them on slowly and off quickly as the rig changes from receive to transmit and vice-versa. A convenient way is to power a Zener from the TR relay. These timing aspects are to ensure that the device is off whenever the load is not connected. It is customary to leave the main drain supply on the whole time and switch off the bias during receive so that their standing current (and dissipation) is reduced to zero. For class C service (CW and FM etc.) they can be biased just below the point at which significant drain current begins to flow leaving the RF voltage to drive them into full conduction. For SSB phone, linear service (class A or AB) is necessary which implies at least some standing current. There is no magic figure but I find that about 0.5 Amp per device (for the IRF510) is a reasonable compromise between gain and low harmonic output. The gain can be reduced by lowering the standing current with a simple DC pot acting as a drive control. (The extremely high gate resistance means any unwanted charge on the gate does not leak away hence they are static sensitive devices.)

The AC aspects of the gate are much trickier! It looks like a capacitor, roughly 150 pF for an IRF510. This has to be charged up and down at the RF frequency which means an unusually low driving impedance. Impedances of around 47 Ohms are adequate for 80m use but to get up to 30 MHz requires nearer 10 Ohms. Some designs use a plain resistor of these values in the gate RF circuit but this is a lossy arrangement since the RF drive is wasted in these resistors. An alternative is to use a driving stage with a low output impedance and reduce it even further with a transformer between stages, as used in the Taunton. Inevitably the gain is lower with the low impedance drive but still useful. FETs of the IRF510 type are inherently very wideband devices (VHF) if you can get the gate to move that quickly but usually the drain output capacitance will become a problem at low VHF. I suspect that 30 MHz is a good practical upper limit for IRF510s. I also like to fit a little negative feedback from drain to gate, not really to have much effect on RF gain but I do find it helps to keep them alive under adverse conditions (no load)! If this feedback increases at low frequency it can reduce the LF gain and help even it across a wide operating band. I have sketched out some circuit ideas overleaf.



Snippets

PCB Production. Tony Measures G3WUC recently caused a certain amount of amusement by demanding instant trial samples of various ladies hairsprays; after careful evaluation he is now able to report that hardsetting Sun Silk Hairspray, at 99p from his local market, makes an excellent lacquer for sealing PCBs! He also draws our attention to a product called TEC 200 which is a form of iron-on etching resist that enables single copies of a track layout to be made by photocopying from magazine articles. He has not tried it yet.

Somerset Home Brew Contest. I am pleased to announce that WE is sponsoring a QRP contest on March 30th 1996 specifically for users of *homebuilt* gear. Details in next Hot Iron and SPRAT. The draw prize, for all entrants who complete a small questionnaire, is a tuneable CW filter; first prize is a Taunton RX.

And to end this issue, John Worthington's progress report. Happy building. Tim Walford G3PCJ



Hot Iron

Issue 10

"Journal of the Constructors Club"

Winter 1995



Editorial

I thought I might have quite a lot of people wanting to win something in the draw which I announced in the last issue of Hot Iron - five of you sent in responses and I would like to thank you all for your most interesting answers. There were hardly any common themes but this in itself is most interesting. It shows that radio amateurs have very broad interests; some wanted only CW rigs while others wanted only SSB. Bands of interest ranged from 160 to 2 metres! Some wanted cases as options and others thought this unimportant. Nearly all claimed to be inexperienced but I think this is modesty! Slightly to my surprise, two respondees implied that Somerset Range kits were the only complete rigs that they had built. I put the names into a hat and was about to ask my wife to pull one out, but by chance one of our neighbouring farmers was here with some splendid locally produced real Cheddar cheese and he seemed to be rather more impartial! **Pat King G4GFY is the winner.** Well done Pat, a two tone oscillator is on the way to you. I was tempted to offer some cheese for a prize!

Tim Walford G3PCJ

Editor

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- Amps for phones

Kit Developments

I am pleased to announce that the **Pitney** is now available. It is a simple regenerative tuned radio frequency receiver intended as a first serious radio construction project for **novice** electronic builders. It is able to receive all the normal modes (AM, CW or SSB) used by broadcast and amateur stations in its basic frequency coverage of 1 to 5 MHz. It uses five transistors and a voltage regulator for the varactor diode tuning, without integrated circuits, so is very easy to understand and get working on the strong stations in the medium waveband. It is able to run off 9 or 12 volt supplies and is intended for use with "walkman" type phones. A small modification gives better coverage of the amateur 160 and 80m bands and adds 40m. No test gear is required as there is nothing to set up! It is supplied complete with all hardware and detailed instructions so all the builder needs is tools, a battery, phones and a moderate length of wire for an antenna! It is an excellent project to compliment Novice radio examination courses. See later note. The one off price is £27 plus £1 P&P.

The **Bruton** is also very nearly available, Geoff G4OWH is kindly building a pre-production model now. There is a high confidence in the circuitry as much is common with other rigs; this project also has a smart and comprehensive manual. The Bruton is a superhet phone TCVR that can work on any single band between 20 and 160 metres. Band changes are done by fitting different coil and capacitor packs so once fitted you cannot change easily to another band! CW can be added with either CW kit. This project is not as complex or dense as the Taunton. It also has provision for channelised operation which can also be on groups of frequencies outside the normal amateur bands such as those used by the Air Training Corps. The Manual will be available for £5, the RX will be £58, the TX £25 or £84 for the TCVR with Construction Club membership.

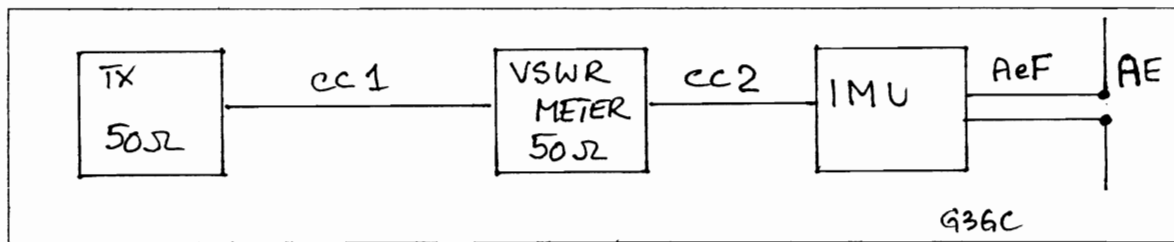
Meanwhile work continues on a two band plug-in card for the Taunton which I hope to try out shortly, a 3 digit counter, a signal generator, and separate simple DC RX and CW TXs to work with each other and the Pitney. No shortage of projects and your ideas are always very welcome!

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224. The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £5 per year for the UK (£7 overseas) from Sept 1st in each year. Sept 1st 1995.



Impedance Matching Units The second of two related noted by Eric Godfrey, G3GC

An impedance matching unit is a device for transforming an impedance of one value to that of another value. The most common use by amateurs is for transforming the impedance at the input to the aerial feeders to the 50 Ohms required by the transmitter. Amateurs, more often than not, quite incorrectly call it an "Aerial Tuning Unit". One thing such a unit does not do is to tune the aerial. G5RV a few years ago commented on this and suggested that it should be called an "Aerial Systems Matching Unit" (ASMU) which is descriptive of its use although I prefer the simpler "Impedance Matching Unit" (IMU) since the impedance being transformed does not necessarily have to be an aerial system. There is no reason why, if you wanted to, you should not match your transmitter to a bowl of goldfish but pity the poor goldfish. Matching units may take on many different forms but the common configuration used by amateurs is the Z-Match so called because it matches the impedances i.e. the "Z". There are a number of commercial forms of this arrangement including the KW E-Zee Match. Such units often also perform the change from a nominal balanced aerial system to the unbalanced coaxial system required by the transmitter.



The above figure is similar to that on my previous article on VSWR meters in Hot Iron 9 but now the 50 Ohm termination has been replaced by an IMU connected to the aerial feeder (AeF) at the far end of which is the aerial (AE). For the moment we will assume the aerial is a full wave dipole cut to resonance with a centre impedance of 700 Ohms resistive and that AeF is a twin 300 Ohm feeder. There will be a VSWR of 2.33:1 on the feeder due to the mismatch of the 700 Ohms to the feeder's 300 Ohm impedance. Let us assume the feeder is an odd number of quarter waves long when it will behave as a quarter wave transformer and its input impedance at the output of the Matching Unit will be 128.6 Ohms ($300^2 / 700$). The VSWR meter will now indicate a VSWR, with respect to 50 Ohms, at the input to CC2 of the combined effects of the aerial, the aerial feeder, the IMU and the cable CC2. Supposing that with some random setting of the IMU, this combination gives a VSWR of 2:1. The Matching unit is now adjusted (some say tuned) to give a VSWR of 1:1 at the input to CC2 with respect to 50 Ohms. This operation has not altered anything on the aerial side of the IMU with the feeder AeF still 300 Ohms and the aerial impedance is still 700 Ohms; it has not been "tuned" as it was already at resonance and therefore there is still a VSWR of 2.33:1 on the twin feeder. Thus it is quite clear that an IMU does not effect the impedance or VSWR of anything beyond itself other than to allow all the power to be transferred to the aerial rather than some power being reflected. What was said in the last article about interconnecting feeders applies when going back from the VSWR meter towards the transmitter.

Theoretically it must be possible to get a VSWR of 1:1 with some combination of the values of the IMU components. However in practical units there are limitations on the range of impedances which can be matched due to limited range of the variable components. An external capacity across the input to AeF may help or an additional length of feeder between AeF and the IMU may move the impedance into an area with which the IMU can cope. Both of these have to be "suck it and see" operations since the VSWR itself does not indicate what the actual impedance is. However if you cannot get a VSWR of 1:1 and you are not running out of the range of the controls, then this indicates that there is more than one frequency present in your transmitter output. The most likely cause of this is harmonics and a low pass filter in the transmitter output will usually provide a solution. This effect is often noticed when having set up the IMU with a QRO commercial transmitter and then, on using a simple QRP TX (probably homebrew), the IMU settings have to be changed. The fact is that VSWR is not dependent on power. Summing up, the important points concerning IMUs are:-

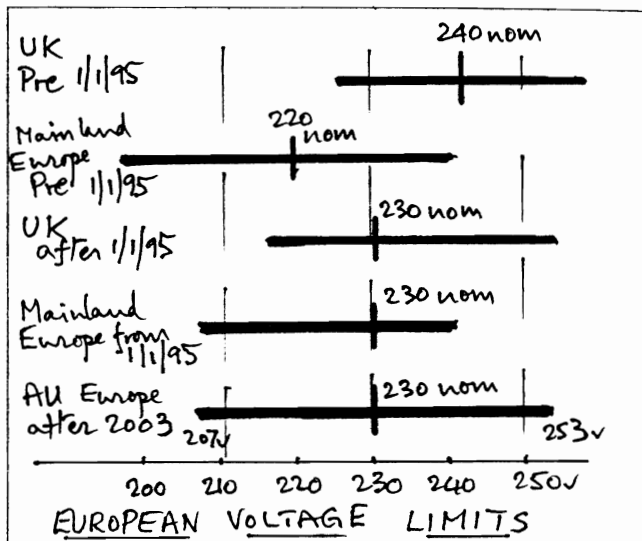
- 1) The IMU does not tune the aerial.
- 2) The VSWR on the feeder connecting IMU to aerial remains unchanged with adjustment of the IMU.
- 3) If you cannot obtain a 1:1 VSWR, without running out of control range, then your TX has an impure output which is probably due to harmonics.
- 4) VSWR is not dependent on power levels.

I hope that these notes will have helped to clarify some of the often misunderstood aspects of VSWR measurement and adjustment.

Eric Godfrey G3GC

Mains Voltage Harmonisation

An interesting diagram has recently been brought to my attention showing how the main electricity supply voltages are scheduled to "change" over the next few years in Europe. Interestingly, the change which occurred on Jan 1st last was a non-event since in the UK our supply was already compliant with that required from 1995 and no actual change had to be made! The change was that of name only. The difference is that equipment should eventually be able to take the much lower limits implied with a nominal 230 volts which can legally go down to 207 volts (and up to the present 253 volts!). I guess that at some stage after 2003, the actual nominal voltage in the UK will be changed to 230 volts instead of just being called 230 volts! I am not sure what this does for conventional incandescent light bulbs!
G3PCJ



100 Watt HF MOSFET Amplifier

Builders of the Tiny Tim and the Taunton may not be aware of a RadCom construction article by G0MRF (Feb/Mar 1993) which described a 100 Watt HF MOSFET amplifier suitable for use with low power excitors. After several months of lost QSOs on 80m, about a year ago I decided to tackle the construction of an amplifier to assist my Tiny Tim.

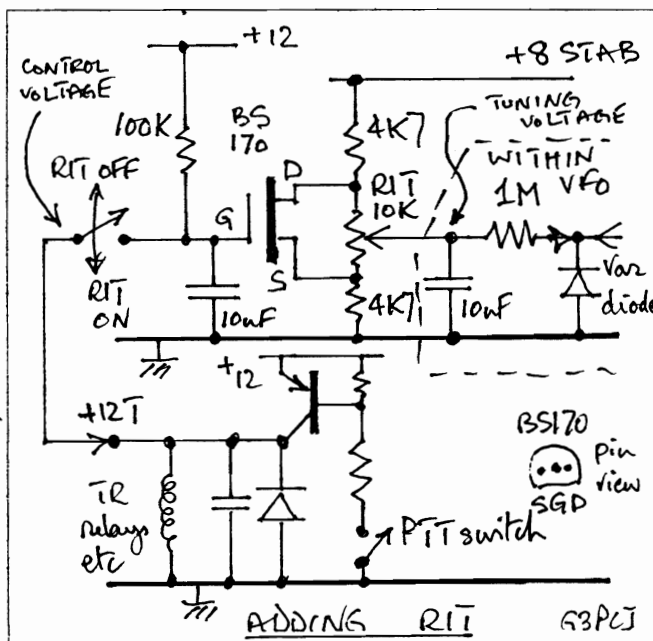
I have found the G0MRF design to be ideal. At the time I constructed the amp, a reasonably priced kit was available. The extra's required were a case and most difficult (for me) to source, a 48-50 volt 5 Amp peak supply. The design is capable of 100 W RF output 1.8 to 14 Mhz with less up to 21 MHz. The feature was well written and easily understood. My amplifier has now been in almost daily use on 80m and although my power supply (unstabilised) is low on volts, I find that I can work around Europe and I've even had a couple of contacts with W/VE. Not bad for a Tiny Tim!

I am sure that anyone requiring details can find someone with appropriate RadComs or contact G0MRF direct.
Pat King G4GFY

Comment from G3PCJ! I am pleasantly surprised that Tiny Tim's receiver was good enough for the real DX. At some time in the future, I hope to revisit my design of QRP Booster linear amplifier so that a single design using four IRF510 FETs will work over the 2 to 30 MHz on a nominal 12 volt supply producing 20 to 25 Watts. Having got them up to 30 Mhz during development of the Taunton transmitter, I am quite hopeful.

Adding RIT to a varactor tuned rig

Simpler rigs such as Tiny Tim and the Bruton, not having Receiver Incremental Tuning, can easily have it added. Often a switch/transmit operated relay is used to "disconnect" the RIT control when the small offsetting tuning voltage is not required. In this circuit, a low power MOSFET is used instead of the relay and the control remains connected but inactive by placing a short across it. When shorted, the voltage at the RIT control slider is half that of the stabilised tuning supply irrespective of control position and is thus the same as the mid-position value. The actual DC RIT voltage is applied through a 1 MOhm resistor which must be decoupled at the VFO. The MOSFET is switched off only when the control voltage is near 0 volts with the switch closed. Using a control voltage which is high at 12 volts during transmit gives RIT; using a control voltage which is at 12 volts during receive will give Transmitter Incremental Tuning.
G3PCJ



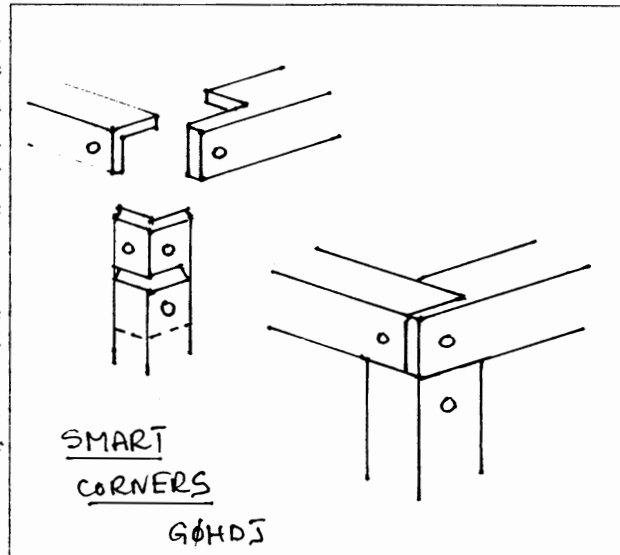
Bespoke Boxes

Building your own equipment often causes the constructor a problem to find a suitable box. "Standard" boxes from the usual suppliers are never the right size or don't have removable panels, etc. (Murphy's 4th Law of inappropriate dimensions!) The answer is to make your own. Bending aluminium to make a tidy box is an art form and a skilled task even with proper folding bars but without them almost impossible. For the "kitchen tablist" the following is offered as a suggestion and any size or shape is possible with the minimum amount of cutting and filing. Angle/corner pieces of aluminium can be cut and joined as shown. (Use counter sunk-head nuts and bolts about 6 BA or metric equivalent plus a drop of Rapid Araldite). Panels can then be fixed permanently with pop rivets or nuts and bolts. Sheet metal can be fixed with self tapping screws allowing the panels to be removed for access etc.

Additional sections of angle (equal or unequal sides) can then be added to provide the supports for the PCB or whatever. If single or double sided PCB is used for the panels, then brass corner pieces (if you don't mind the expense) can be cut and tack soldered to each other and/or to the boards. Screws are then used for the removable panels.

A variety of sizes (equal sides or unequal sides) of aluminium corner pieces and brass corner pieces are available in 1 metre lengths from B & Q (£2.10 for aluminium and £3.29 for brass or thereabouts). Aluminium stockist and scrap metal merchants (Yellow Pages) may have some off-cuts but they may take a bit of finding. The diagram shows how to make a corner.

Craig Douglas GØHDJ



Update on RF amp for Yeovil RX

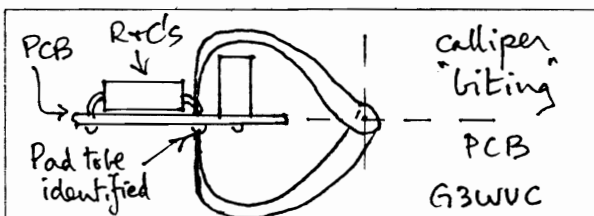
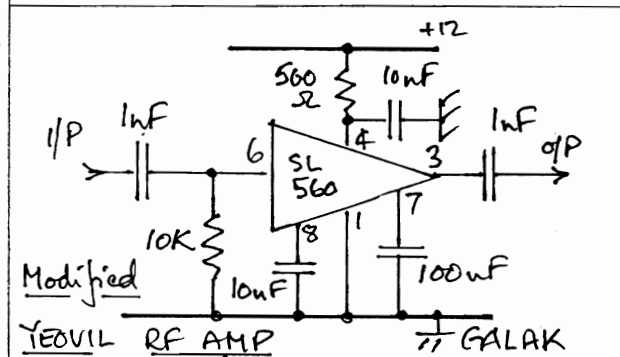
Reg Proctor G4LAK failed to get his IF amp for the Yeovil working and reverted to a RF amp; he tried the circuit in the Spring 1994 Hot Iron but that did not work satisfactorily either so he altered it to that shown on the right. This has made a marked improvement on 20m with some benefit also on 80m.

(Reg is now tackling a Taunton and we hope for a satisfactory report in due course! - G3PCJ)

Finding parts locations on PCBs

Nick Collis-Bird recently returned his Taunton to me for a "tweak", (all it needed was removal of a misplaced solder blob), but he had done something to it which was far more interesting! To assist with finding the parts locations, he had lightly scribed a one centimetre grid onto the ground plane side to match up with the grid references given in the construction sequence which are counted off in centimetres. While not being any help on rigs already started, it is an excellent idea for those PCBs about to be loaded which have instructions with grid locations. I have put this suggestion in my text for the Bruton - thank you Nick.

Tony Measures G3WUC has some help for those trying to identify the correct pads on the underside when trying to desolder and remove some component. He finds that a calliper biting on the board right close to the component on the topside will remove all ambiguity about the underside pad as long as the calliper hinge is in the plane of the PCB - see diagram.



Waterproofing

Joseph Bell G3DII thoroughly recommends Finnigan's Waxoyl for sealing and water repelling in all sorts of cable junctions and antenna connectors. It can be used on wood, metal and plastic and protection can be built up with several layers. It does not crack and is presumably flexible. It is made by the same firm that makes the range of Hammerite paint.

Decoupling, ground planes and ground bounce!

This has nothing to do with earthquakes! Some builders may have noticed that my kits seem to have rather more 10 nF disc ceramic decoupling capacitors than may really be necessary. They are there as an insurance policy because trying to eliminate unwanted feedback due to poor bypassing is very tricky for most people with limited test equipment. It is far safer to add these extra capacitors which cost about 4 pence each on all points that might be prone to pick up of unwanted signals than to attempt a phone call cure of some disgruntled customer's marginal rig. However it is important to use suitable capacitors connected to a really low impedance point. Most types of capacitor have a limited frequency range over which they perform best - quite often this will not be as large as the full operating range of the rig. When this occurs you must fit something else in parallel on the same point. In extreme cases you may find that the designer has specified something along the lines of a 10 microfarad electrolytic for LF, paralleled by say a 100 nF polyester and 10 nF disc ceramic for HF. This combination will have a low impedance over a much wider range than any one in isolation provided the ground point is rock solid. Sometimes a tantalum capacitor is used instead of the electrolytic and polyester but they are more costly.

Surprisingly the ground planes that I use on all my transmitter designs are not as "solid" as one would expect. A 5 Watt transmitter operating with an output stage drain impedance of 12.5 Ohms has a peak current of just under an amp so it does not take much impedance to generate a few millivolts. If these millivolts get in the wrong place they can cause all sorts of problems including unwanted oscillation. Using ground planes is the best that one can do cheaply but it still means that you must lay out the functional blocks so that the high currents do not flow in sensitive areas. This is why the classic layout of a transmitter is a straight line with a steady progression giving maximum separation between the sensitive low power stages and the high current output. It is notoriously difficult to make sensible measurements of signals in ground systems but it is not unusual to observe 100 mVolts across a ground plane. These observations emphasise that all high current signals should have their return lead taken to an earth point as close as possible to the device or circuit (matching network) generating the current and not necessarily to the point of the PCB nearest the antenna connector!

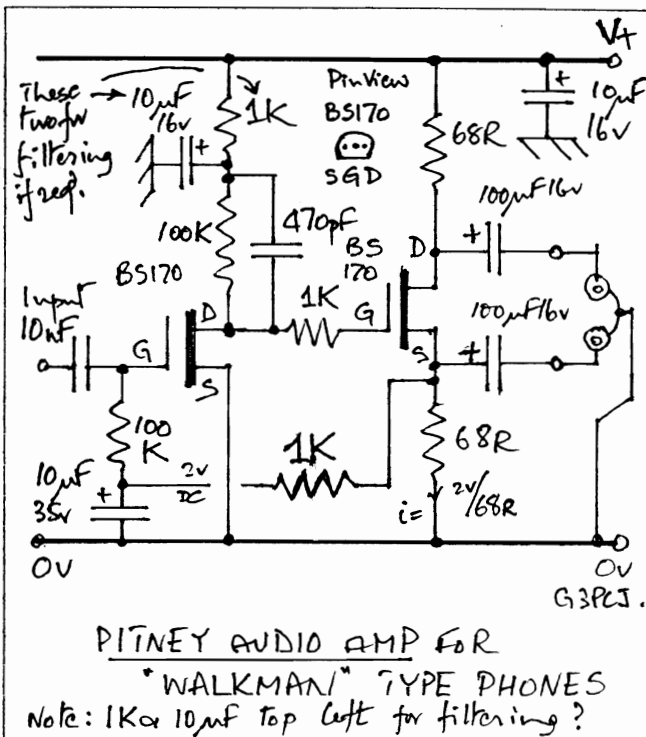
Ground bounce is another effect which is more often observed in digital systems where a whole bus (8 or more signals) all change in the same direction very quickly. The sum of the currents discharging the capacity of several bus signal lines flows through the driving IC's earth pin and its internal thin wires connecting to the actual die. To a heavy current signal edge, with sub-nanosecond fall times, these leads look like inductors. It can lead to the 0 volt point on the die actually departing by large fractions of a volt from the earth plane directly underneath the chip! This eats into the noise immunity of the digital signal and may eventually lead to the signal being misread at the receiving gate. It is extremely difficult to replicate and makes fault finding awful! Similarly, rising edges can significantly reduce the supply voltage on the die. Decoupling must be at the chip!

Here are some examples of earthing problems; I remember an early Yeovil that was showing signs of RF instability. It transpired that RF was getting back from the output lowpass filters into the low level TX stage via a heavily decoupled relay control signal. The decoupling was not effective because there was no series impedance to form an attenuator with the lowish impedance of the decoupling capacitors; the answer was to reroute the signal with a longer lead giving added series RF impedance and taking the unwanted output RF current in this lead away from the sensitive low level stage. Owners of Cokers may have noted that the key down frequency alters slightly as you adjust the antenna matching unit. This rig has a VFO operating at the transmit frequency and only separated by about 75 mm from the TX output stage. There is a very small amount of TX current flowing in the ground plane in the VFO area and when this alters, as the AMU is adjusted, it changes the effective value of the VFO resonator components. This is what is actually happening when a rig "chirps". I had intended that the Coker work up to 20m but chirp gets worse with increasing frequency; and the VFO was shifting 8 KHz on 20m which was obviously no good! This is why the rig is only available for 160 and 80m where the actual shift is insignificant. When connecting measuring instruments, you must be sure that the return or earth lead is sensibly located. Generally a probe's earth lead is best connected to 0 volts as near as possible to the point being measured (unless you are investigating ground plane signals!). You also must consider what effect the capacitance of the measuring system will have on the circuit under test. If you are investigating an oscillator, it is hopeless connecting it to a counter with an ordinary screened lead such as miniature coax. That has a capacity of at least tens of pF per foot which will pull it way off frequency. You must use scope type divide by ten probes which have a capacity of about 2 to 3 pF max.! Admittedly they attenuate the signal by a factor of ten but usually this is not important as the sensitivity of the test instrument can be increased to compensate. Avoid coax test leads at all times!

Tim Walford G3PCJ

Audio Amplifier for phones

When designing the Pitney's audio stages, I was keen to avoid using integrated circuits so as to make the rig more understandable; unfortunately this makes driving a loud speaker impractical. Luckily modern "walkman" type phones are cheap (£3 upwards) and have a higher nominal impedance of around 30 Ohms for each earpiece which is much easier if a transformer is to be avoided. It makes a class A output stage possible but since the phones are usually sold as stereo types, I had to think of driving both earpieces separately. This suggested a phase splitter arrangement running at high current to drive each earpiece. Its yet another application for the BS170 low power MOSFET where its maximum dissipation of around 200 mW is the overriding consideration - this limits either its standing current, and hence audio output for the 30 Ohm load, or the overall supply voltage. Using a MOSFET does not require high current drive so the preceding stage can have a high impedance load to give gain. Since the output stage can look like a capacitively loaded source follower, a gate stopper resistor is necessary to prevent output stage oscillation. Interestingly, by grounding the output connected to the source, the gain of the other output is much increased as it becomes a common source amplifier. Even when driving both earpieces connected in parallel to the drain output, there is a gain increase by grounding the source output. The input stage can also be a BS170 in a common source configuration to provide most of the gain. The DC conditions in the two stages are easily controlled with a DC feedback loop which is dependent on the BS170 needing about 2 volts positive between gate and source to turn it on. The input impedance is about 100K and provides a voltage gain of about 50 into stereo phones across both outputs or about 200 if connected with both earpieces in parallel on the drain output with the other output grounded. Supply voltage is 9 to 15 volts. The maximum output is more than enough for phones and it will drive a 15R speaker but don't expect to be deafened! G3PCJ



Dates for your diaries!

Firstly, the **Somerset Homebrew Contest**, which is taking place on **March 30/31st 1996**. It is a multiband QRP contest being organised by the G - QRP Club and is open to all operators using homebrew equipment with sponsorship provided by Walford Electronics. Full details are in the Autumn 95 Sprat; first prize is a Taunton receiver for the band of the entrant's choice. All fully completed entries will go into a draw for a second prize which is a high performance Variable CW filter - this can be used with Somerset Range kits or on its own following some other brand of receiver.

Dates for your diaries!

The other date to note is that of the **1996 Yeovil ARC's twelfth QRP Convention on May 19th**; it is being held at a new location in the Digby Hall in Sherborne which is a few miles East of Yeovil and is easy to find. There will also be an informal programme of events on the Saturday afternoon of the 18th with a dinner in the evening which is open to all. Activities for spouses are being planned so that those coming from afar can make it into an overnight break. Full details and assistance with bookings can be obtained from Peter Burrige on 01935 813054.

The **Construction Challenge**, at the QRP Convention, is to build a 80m antenna and receiver within a cube of 0.5 metre side. No more than 12 components are to be used and it has to operate without any DC power source, relying solely on electromagnetic radiation. The winner is the receiver producing the highest DC voltage into a 10 KOhm load when excited by a test transmitter putting 1 Watt CW into a short vertical antenna about 12 metres from the RX under test. Full details from Mike Smith on 01963 250594 in the evenings.

Finally, best wishes for Christmas and the New Year, and please do keep up your contributions for this journal - thank you. Tim Walford G3PCJ

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Hot Iron

Issue 11

"Journal of the Constructors Club"

Spring 1996



Editorial

Earlier this afternoon, as I was pointing one of our stone walls on the farm, I was wondering what to put in this issue of Hot Iron as I didn't remember there being very much in the file of contributions. I am pleased to report that in fact the file contained several contributions and this issue should be somewhat more interesting for not having been all my own material! It really is very important for you to continue with these offerings as I already have to think uncomfortably hard for my own topics! It makes it so much more interesting if there are many contributors so please do continue sending me in your articles, snippets and questions etc.. It is intended to be *your* Club with me doing most of the work! For each issue, I try to have a note on some design type topic and I would love some feedback on what aspects of construction etc. you find troublesome and needing more explanation. I purposely try to avoid the maths of the subject since it is boring and, anyway, I have forgotten that little bit that I did know years ago! By way of example, a later note describes some of the trade-offs in the design of a signal generator - an item that has long been on my project list but which makes slow progress. I would love some comment on priorities.

Tim Walford G3PCJ

Editor

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- Taunton Updates
- Diary Dates
- Twin VFOs
- Workshop practice
- Sig Gen Design

Kit Developments

I have already mentioned a **Three Digit Counter** which I am pleased to report is now available. It uses the same counters and displays as the 5 digit one and can also count from DC to over 60 MHz with a typical input sensitivity of about 50 mVolts RMS at 20 MHz. Depending on the setting of a link (or switch), the three digits can either show the KiloHertz value of the input signal or the hundreds of KHz. The former mode is intended for use with rigs where it would show the KHz part of the tuned frequency (the MHz part having overflowed out of sight). This can be used with direct conversion rigs or with superhets having an IF which is a whole number of MHz. The other mode is intended for general use such as measuring a rig or signal generator output frequency with a 'display' upper limit of 99.9 MHz - the circuits are very unlikely to work that fast though! In addition, when used with a superhet, the counter can count either up or down for additive or subtractive mixers; also, a preset of + or - 1 can be applied to approximate for the usual CIO offset of 1.5 KHz from the nominal IF. The 3 displays and segment resistors are all mounted with the logic on the 100 x 80 mm PCB; the display section (25 x 80 mm) can also be cut off remote mounting if required. Price is £37 + £1 P&P.

Experience with the earlier variable CW filter kit showed that it was too sensitive to individual rig layout so I have redesigned it as the **Adjustable CW filter** kit. The good news is that it has the same very high performance elliptic switched capacitor tuneable lowpass filter, with presets for CW and SSB bandwidth. The response is down 79 dB at 1.5 times its set -3 dB frequency corner frequency bandwidth - this makes it almost a brick wall filter!! It now has a separate preset for the frequency of the tone used to modulate the transmitter. This considerably simplifies both the circuits and its method of use. It has semi break-in operation and a Tune facility. Size is down to 50 x 80 mm. It can drive walkman type phones. Price is down to £27 + £1 P&P.

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224. The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £5 per year for the UK (£7 overseas) from Sept 1st in each year. Sept 1st 1995.



Taunton Updates

Those of you with Taunton receivers should already be aware that the CD4066 used for IC105 had a spare unused switch section which was originally connected to the positive supply in Issue 4 and earlier PCBs. It transpires this was a bad design decision because it can lead to damaging supply currents at switch on which in turn applied an unwanted high voltage to the associated NE612 IC104 which then also expired! It is advisable to connect the pins 10, 11 and 12 of IC105 to the adjacent pin 13 (RXC) and lead the 12 volt track around this group. Ray Donno G3YBK advises replacing the 4066 when doing this modification as his rig produced some queer results after the mod due to internal damage to the 4066 which was not showing up in normal use. If any of you are having difficulty with this aspect please contact me.

There a couple of other errors in early Manuals; on page 8, C101 needs moving into the table higher up the page to join C102 to make the oscillator work. On page 19, Figure 9, the 30m receiver bandpass filter coils L201 and L202 should be TOKO types 3334 instead of 3335 - customers with these bands have been told. Also C137 appears twice in some early RX parts lists - it should be 10 nF as in the circuit diagram and not 1 μ F.

I am please to announce that the **TWO** band plug-in card for the Taunton is now available. It can take **any** two bands in the range 15 to 160m with selection by a front panel switch. I am grateful to Tony G3WUC for assistance with proving this design. He has also been experimenting (using his old single band cards) on getting the rig running on 12 and 10 metres. He has overcome the snag of needing unusual crystal frequencies for 12m by extending the VFO coverage. More details on his progress in a future Hot Iron. The fully equipped 2 band card is £37 or, if you can salvage the parts from two single band cards, the PCB and five relays are £20.

Coker VFO Capacitors

With a little nudging from G3WAL, I tried using the same types of capacitors in the Coker VFO as I use in the Taunton's VFO hoping that this would improve the stability. It did! It is worth changing the two silver mica types to the round ceramic type coloured green or buff and also changing the capacitor linking to the varactor to a COG type. I can supply these three capacitors for £1 in stamps to include the postage.

Pitney experiences

As part of the Yeovil Club's activities to commemorate the 75th anniversary of the first amateur trans. Atlantic experiments in Feb. 1921 on 160m, Joe G3KSK, has heard several different US stations using his Pitney and a relatively simple antenna. I had thought it pretty unlikely that one would hear US stations in the UK with such a simple rig but I am glad to be proved wrong! It is surprising what one regenerative tuned circuit and an audio amp can achieve! Craig Douglas G0HDJ has also found that, when used with a normal transmitting type wire antenna, an antenna attenuator makes a great improvement to breakthrough problems from broadcast stations when trying to sniff out weak amateur stations.

Dates for your diaries!

There is just time to brush off your homebrew gear and get ready for the **Somerset Home-brew Contest**, which takes place on **March 30/31st 1996**. It is a multiband QRP contest being organised by the G - QRP Club and is open to all operators using any brand of homebrew equipment. Full details are in the Autumn 95 Sprat; first prize is a Taunton receiver for the band of the entrant's choice. All fully completed entries will go into a draw for a second prize which is a high performance Adjustable CW filter - this can be used with Somerset Range kits or with some other brand of receiver.

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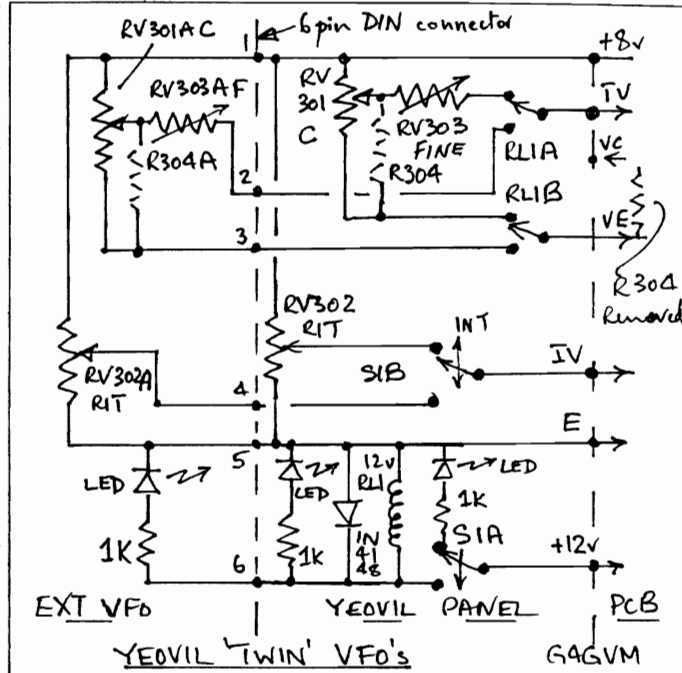
The **Construction Challenge**, at the QRP Convention, is always a jolly interesting event for anybody interested in construction. Plenty of opportunity for ingenuity! The task is to build a 80m antenna and receiver within a cube of 0.5 metre side. No more than 12 components are to be used and it has to operate without any DC power source, relying solely on electromagnetic radiation. The winner is the receiver producing the highest DC voltage into a 10 KOhm load when excited by a test transmitter putting 1 Watt CW into a short vertical antenna about 12 metres from the RX under test. Full details from Mike Smith on 01963 250594.

Computers!

I read in a recent article in an IEE Journal that one third of households in the UK have a computer in them already! It suggests that there must be many amateurs having PCs who might be interested in using the computer to control a rig or some item of test equipment. Any comments or suggestions most welcome!

'Twin VFOs'

Derek Alexander G4GVM has made a most interesting suggestion about rigs with varactor diode tuning. He says 'Of all the extra gimmicks (or what have you!) on the modern commercial rig, I think the second VFO is very useful. I usually use home brew equipment (more fun!) but when I do use my Icom 735 I often use the facility to find a clear channel whilst maintaining a QSO so that I can make a quick return. All of the Somerset Range kits use varactor tuning and it would seem to be an easy matter to switch from one set of tuning pots to another. I am particularly thinking of my Yeovil and the circuit illustration refers to this rig. In mine, I have added a 6 pin DIN socket on the rig's rear for connection to the second set of pots, with a control switch and relay added behind the rig's front panel. You can add LEDs to show which VFO is in use if you wish. The extra leads should be kept as short as practical, despite their only carrying DC, since small voltage drops in the leads can occur.'



In principle this approach can easily be applied to any rig with varactor tuning. The switching could also be controlled with a bandswitch if desired enabling cross band working for multi band rigs such as the Yeovil and Taunton! There is a small caveat to this in that the variable tuning voltage to the varactor usually has a 10 μ F decoupling capacitor on it which does take a finite time to charge up to 99.999% of the tuning

Workshop Practice by G7SDD

(This is a heavily 'Edited' piece derived from notes accompanying a very practical talk by Mike to YARC.)

Start with the tools you need!

Many people have the idea that to build anything, one needs a full blown workshop complete with every imaginable tool. **Wrong!** As long as you have an old table, and a few basic tools, you should be able to tackle most things. (Some aspects of metal bashing may prove somewhat difficult under these conditions, though!). So what is the minimum needed? The following list should enable construction of most kits or DIY development.

ESSENTIAL ITEMS

- Drill and drill stand with bits 0.5 mm to 6.5 mm and a pin chuck
- Soldering Iron, selection of bits, solder sucker, 60-40 solder,
- Flush-cut wire cutters, fine point pliers, medium pliers,
- Knife (not razor sharp), scribe (or 'pointy' tool), small centre punch,
- Misc. screwdrivers
- Tuning tools
- Magnifier
- Permanent marker pen

It is worth mentioning at this point, that it is false economy to buy cheap cutters, pliers and drill bits, so spend the most you can on these items. The reasons should be obvious. £4.00 cutters will last five minutes! Also, there's no need to buy purpose built wire strippers.... Its not too difficult to develop the knack of holding the wire cutters gently, and they will do the job just as well. Remember too, a very sharp knife, (such as a Stanley knife) will probably cut through more than you bargain for! Particularly the braid of coax or audio screened cable. Use an ordinary pocket knife instead. Besides, this can also double up as a means of de-burring holes you have drilled in boxes or panels.

USEFUL ITEMS (Particularly if DIY jobs intended to be done.)

Spot face cutter	(easier to handle than a drill bit)
Small G clamp	(holds laminate etc. to table whilst drilling and cutting)
Hacksaw	(full size one has more control)
Small vice	(drill bench vice best, but other options avail)
6" file	(de-burrs edge of laminate or chassis)
Nut drivers	(better than using pliers!)

Drilling.

Most DIY projects undertaken involve drilling holes in a die cast box or chassis and maybe in PCB's. The former usually presents few problems, as long as the drills are sharp and the drill position has been centre punched. (Just see where a 4 mm hole ends up if you don't centre pop the aluminium panel or die cast box first!) When drilling PCB's why is it that many people think that its better to run the very small drill slowly and carefully? Carefully, YES. Slowly, NO! If the drill is running at 3000 rpm (preferably faster), it is reluctant to bend, and zaps through the laminate without any problem. Don't use the small battery portable drills, as they tend to run slowly in order to increase the torque. As with any cutting operation, let the drill bit do the work. Don't force it to go through the board like a gimlet! Very few domestic drills will hold drill bits of the size used for PCB work. So use a pin chuck, which in turn goes into the main drill chuck. Don't even contemplate drilling whilst holding the drill freehand.... unless you have an unlimited stock of drills! A drill stand is essential, and can usually be picked up second hand at rallies or car boot sales. Finally, don't try drilling a PCB in near darkness. Steal the bedside lamp, or similar device, and get as much illumination on the work as possible.

Assembly

This may seem a somewhat obvious process, i.e. stick components in the holes and solder it all up. Well, its more or less done like that, but there are a few useful tips that may be considered worthwhile. Resistors and diodes are the easiest components to insert once the leads have been preformed to the appropriate pitch to suit the PCB holes. (Typically 0.4" or 0.5"). Once inserted, there's no need to bend the leads back along the track. A few degrees of bend will hold it in place whilst soldering, then once soldered, crop the excess wire at the limit of the solder fillet. Cropping AFTER soldering is good practice, as it minimises the shock on the component imparted by the cutters. This is particularly important when cutting transistor, diode or crystal leads. Capacitors are more of a problem, in that they vary so much in lead-out style. Axial lead capacitors can be treated like resistors, but radial lead types usually have to be lead-formed with more care to avoid stressing the lead-to-ceramic junction, or to avoid shorts to the ground plane. Lead-forming is simple

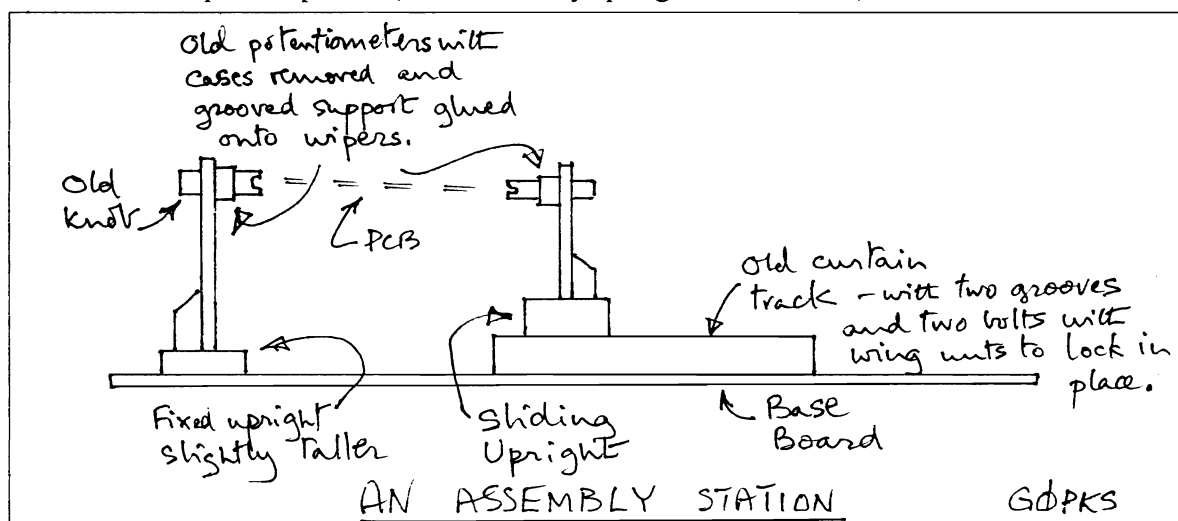
enough, but DOES require a good pair of fine point pliers and a bit of care. But once you've developed the knack, you'll wonder why building equipment ever seemed difficult. Finally, If the equipment is intended to be portable, e.g. RDF RX, where it may be bashed around a bit, it is worth anchoring larger components to the PCB with a small amount of contact adhesive.

De-soldering

Another black art..... so it seems. But one that can save many pennies by reclaiming components. Don't waste time trying to carefully melt the component-to-circuit board joint whilst trying to pull the component out of the board! All that happens is that the component overheats, the leads break, or you get burnt fingers! Some pundits advocate the use of Solder Wick, which soaks up the excess solder from the melted joint. I favour the fast attack approach, using a Solder Sucker. With a medium or fine point nozzle, this will suck up virtually all of the melted solder from the joint, leaving clear holes in the PCB. The component then drops out! (Assuming it hasn't had the leads bent over during assembly, of course. Again, plenty of heat and the right shaped bit, (particularly one that will hold a pool of solder), and the appropriate fast response on the trigger, is necessary, otherwise overheating will occur and negate your outlay for the solder sucker! Mike Smith G7SDD

An Assembly Station

Pete Norman, G0PKS, finds that the gadget sketched below to be very useful for holding and turning a PCB while it is being assembled. Old curtain track and old pots are the essential ingredients! The mounting board serves as a removable work bench with a soldering iron stand and a peg to restrain the solder reel. Prior to starting assembly, he recommends laying out capacitors, which are perhaps not so easily identified as resistors on a sheet of paper marked with their values; the capacitors are then held next to their 'label' with Sellotape or masking tape - it makes finding them again much easier and enables you to check that the kit supplier has sent all the parts required! (He had not! My apologies Pete. G3PCJ)



Smart Panels

Peter Barville G3XJS passes on his experience that a very good finish can be obtained on front panels by the use of 'Scotch 3M Spray Fix'. After spray painting the drilled control panel, and allowing it to dry thoroughly, he carefully applies the rub down lettering of the 'lettraset' type. He then sprays the whole panel with a couple of coats of the above product which gives a high degree of protection all over. Its available in artist shops.

He has also recently taken up sailboarding and has realised that the sailboard masts, being made of fibreglass, would make very nice aerial supports. He does recommend buying a new one, but his local club had some old (and out of fashion) one piece masts about 4.5 metres long at a nominal price. Most people now use a two piece mast. You might even operate maritime mobile at the same time!

My Bench!

I would add a pair of surgical tweezers to Mike's essential list above. Apart from these, the tools always on my bench are side cutters, two small screwdrivers, scalpel, smooth faced thin nosed pliers, small round and flat files, an indelible marker pen, a solder sucker and various plastic component trimming tools. As I do a fair amount of circuit building without any PCB, I keep several pieces of copper clad PCB on rubber feet with permanently connected supply and decoupling components. I build up circuits by soldering the earthy ends of grounded components direct to the PCB, with plenty of extra 10 nF decoupling capacitors for supply line anchorage points and other parts strung in free air between the earthed parts! Its simple & effective! G3PCJ

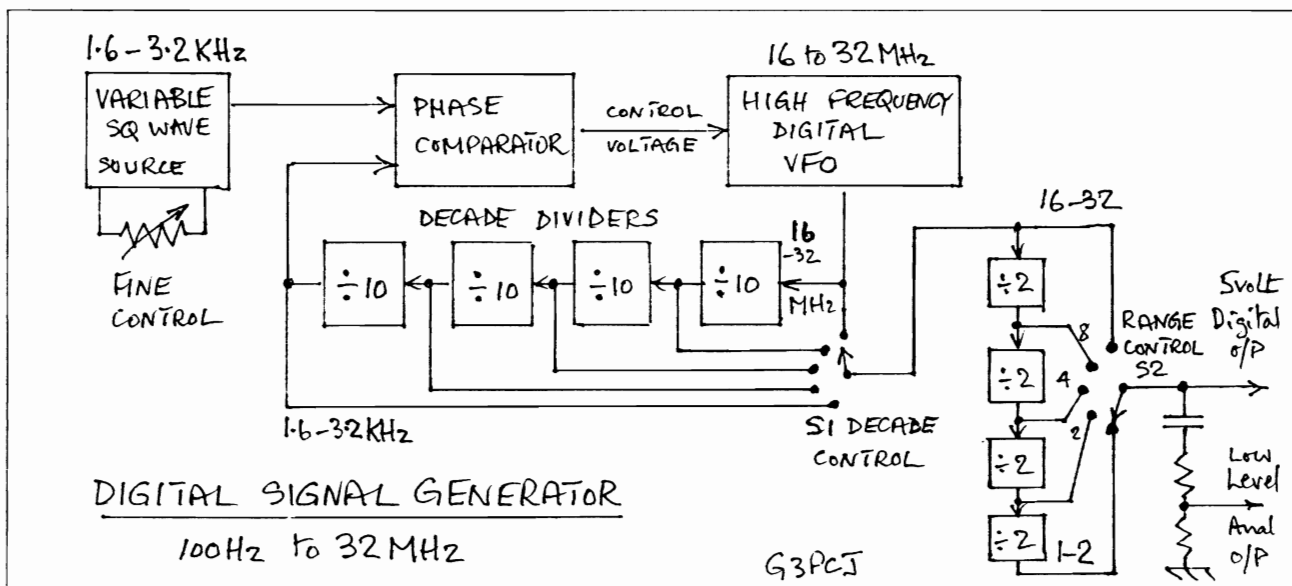
Evolution of a Signal Generator Design

The original brief was to design a simple signal generator covering about 1 to 30 MHz having a sinusoidal output and being easy to set up. Target price was under £50 since commercially made instruments are available for about £150. I had already decided that it was not to be cased and would not have a complicated mechanical dial assembly; the 3 digit counter is sufficiently cheap at £37 for this to be more attractive for those needing an accurate indication of frequency. Thus far it was easy going! Achieving stability, and adequate resolution without too many frequency ranges are where it becomes tricky! Within any one tuning range of a conventional oscillator, it is hard to achieve more than a 3:1 frequency coverage so conventional oscillators would need four ranges involving a lot of switching and probably markedly different output levels. Not attractive. Scheme two is a mixing scheme between a VFO running 10 to 20 MHz and a 10 MHz crystal oscillator providing three bands 10 MHz wide. Needs two fairly sharp filters and suffers badly from unwanted mixer high order products. Scheme three is for a VFO covering say 40 to 70 MHz and a 40 MHz crystal source to avoid the high order mixer products; only one filter needed but awful stability unless a phase locked loop with a low frequency variable master oscillator is used to stabilise the high frequency VFO. This needs to have the main range broken up into sections, using a variable division ratio but then the coverage on each frequency range would alter with changes in the division ratio. Scheme four is similar to three but with the HF VFO going in say 5 MHz steps and the 40 MHz signal being varied over 5 MHz to obtain the continuous coverage - again poor stability unless a second low frequency oscillator is used and multiplied up - getting awfully complex! Scheme five is solution three with a 'fractional N' variable divider - getting really very complex and might need a micro controller! Clearly it has got out of hand!

Start afresh with the thought that a sinusoidal output is not essential. Output signals from a digital VFO would probably have a 5 volt amplitude but this can easily be attenuated and the harmonics which make the fundamental into a square wave would all be at least twice the fundamental's frequency. Only if it was being used with a really wide band rig would the second and higher harmonics be within the receiver (or other band limiting circuit) passband. At first sight then this is not a problem and quite often low frequency audio amp tests are now done with square wave test signals anyway! It is also useful to have a source of square wave digital signals. The output frequency ranges can now easily be obtained with digital dividers, probably a mix of decade stages and smaller steps being easy. The HF digital VFO is easily made, operating to 40+ MHz, but can only easily achieve 2:1 frequency range so the output dividers need to be in 2:1 steps - this is very easy! If the HF VFO is locked to a low frequency digital VFO (actually a square wave variable clock source) using decade dividers in the feedback path to the phase locked loop's phase comparator, then these same dividers provide a convenient pick off point for further output range dividers. Output frequency coverage can now be down to very low frequencies limited only by how many decade dividers it is sensible to install for most people's needs and would actually be determined by what comes in standard ICs. The general block diagram then looks something like that shown below. This is about scheme number ten! The only snag that I can see, is that the variable dial calibration would be in terms of a multiplying factor from the bottom edge rather than an actual frequency or decade range etc. I think this is outweighed by the circuit simplicity and easy of setting up. I would love to have your thoughts please.

Tim Walford

G3PCJ



Hot Iron

Issue 12

"Journal of the Constructors Club"

Summer 1996



Editorial

Many of you who know that farming is my main activity, might expect me to say something about those three dreaded letters standing for Blame Someone Else. In order to leave just a little space for electronic topics, the only sensible comment I can make is 'if you have not done so already, fill your deep freeze now because it will never be so cheap again'. I must say I am glad to have amateur radio as a diversion!

I was pleased to see many of you at the Yeovil ARC's QRP Convention which was held this year in a new location in Sherborne. The Digby Hall had a much more friendly atmosphere and there was a good attendance by amateurs and their traders which led to a jolly good event. As usual there was keen interest in how the entries for this year's Construction Challenge performed. The task was to make a 80m antenna and RX with only 12 components and no active devices. Excited by 1 Watt into a whip about 50 feet away, the highest DC output signals were in the order of 40 mVolts. Most were tuned loops with diode voltage multipliers. The Convention was one of the best that YARC has organised and most of that is due to the hard work of G3CQR. I hope that more of you in Southern England will be attending next year.

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- Power Measurement
- Book Review
- Taunton 10 & 12m
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Products News

I pleased to receive several favourable comments from those building Brutons and Pitneys. After having two for evaluation, British Telecom ordered a large quantity of Pitneys for a Novice course which they are sponsoring in East Anglia. I was initially somewhat nervous about their reasons for wanting them since at that time, the good news about kits intended for amateur radio builders not needing CE certification for EMC, had not been announced. Luckily my concerns were ill founded! To go with the Pitney, I have designed a simple broadband CW crystal controlled 1.5 Watt TX called the **Drayton**. It can also be used with any other brand of RX. It is supplied with a ceramic resonator for 3.58 MHz; the on board trimmer allows about + or - 20 KHz swing. Simply by changing the crystal you can use it anywhere in the range 1.5 to 10 MHz. Since it is broadband, it must be used with low pass filters or a resonant antenna matching unit. It has a sidetone oscillator and control can be semi or full break-in and it has a netting facility. Price is £24 plus £1 P and P.

Progress on the Frome, which is the any-band CW rig, is a little slow due to pressure of other things. This will have a crystal mixing VFO scheme to give stability and avoid chirp. It will also have a very sharp adjustable switched capacitor low pass audio filter and some other frills not yet fit for announcing! I do also wonder if there is a demand for a crystal controlled receiver to go with the Drayton. Another job for the bath! Last time I wrote about the development of a signal generator and some of you kindly expressed an interest. Sadly this has proved to be a lot more difficult to get right than I imagined! Digital oscillators are nothing like sufficiently noise free and I have had to add a switched capacitor filter for the audio outputs since their third harmonic would unfortunately be in band. Although I was able to make the HF VFO give the desired coverage with a dead-bug version, when implemented with copper tracks there was too much stray capacity! The tuning diode voltage had to be raised to 30 volts needing an extra voltage boosting circuit. It has required several revisions and more proving which is not yet complete. My apologies! Tim Walford G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224. The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year. June 1st 1996.



Peak Envelope Power

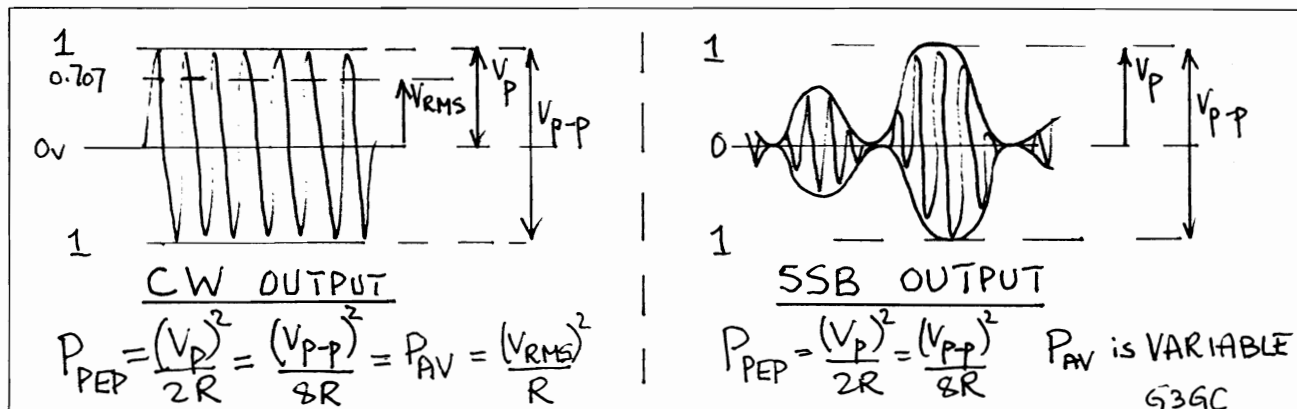
(This note follows a question from Stephen Melling G0WAF about the measurement of power; and for various reasons I thought I had better get Eric to explain!)

Peak Envelope Power (PEP) and its measurement always seems to cause some confusion among amateurs. According to the licence, PEP is the average power supplied to the load during *one RF cycle* at the crest of the modulation envelope. The lefthand diagram below shows a transmitter with a constant output (CW) and the righthand shows a typical modulation envelope from a SSB transmitter with the same peak output. In the left diagram, since the peak voltage is constant, the crest of the envelope is constant and the average power of each RF cycle is the same and equal to the square of the RMS voltage divided by the load resistance. Since the envelope contains a constant amplitude sine wave, the RMS voltage is the peak voltage multiplied by 0.707 (the square root of 2). The peak voltage can be measured with a peak reading voltmeter or an oscilloscope having a bandwidth well in excess of the signal frequency. (With a scope it is actually easier to measure the peak to peak voltage which is twice the peak voltage.)

When we come to an SSB TX output portrayed in the righthand diagram, the envelope is no longer constant but follows the modulation in both amplitude and frequency. This means that although the two example waveforms have the *same* maximum peak voltage, and therefore *the same PEP* because PEP measurement is defined as being averaged as over only *one* RF cycle; the actual average power dissipated in the load (considered over many cycles of the modulation envelope) is very much less and will be heavily dependent on the actual modulation. Any normal power meter will average the reading over several cycles of the envelope due to its mechanical inertia and thus give a reading much lower than is the case for the constant CW conditions despite the PEP of both waveforms being the same. It is for this reason that speech compressors are often used which, whilst not increasing the PEP, do increase the average power (sometimes loosely referred to as the 'talk' power) giving better readability at the receiver. A speech compressor usually reduces the peaks of the modulation envelope which allows the average modulation level to be increased to bring the peaks back to the same peak power level as before, thus uplifting the average power.

The formulae for the calculation of the powers associated with a load resistor R for the two waveforms are shown below them.

Eric Godfrey G3GC



The 'times two' confusion! People often mistakenly think that the PEP figure for an SSB TX is twice the CW maximum power output figure - it is not! In fact they are usually the same! The origin of this misunderstanding is that the proper way to adjust an SSB transmitter is to use two audio oscillators having equal amplitude outputs feeding together in place of the microphone. (This gadget is called a two tone oscillator). A single steady audio input tone only produces a steady CW output in an SSB TX making it harder to detect output limiting. The two tone input produces an RF output whose envelope is defined by two antiphase sine waves of the same frequency; this waveform allows easy observation of limiting effects, usually in the output stage, with a scope. Provided the TX is operating linearly, on the peaks of this modulating envelope, the power (averaged over one RF cycle as above) *is* twice the power that the TX produces from either of the tones on their own. The transmitter output is then increased so that the peaks of this modulation envelope are just beginning to limit or clip. Then either tone is switched off and the RF power meter is used to measure the power in what is now a steady carrier due to the remaining single tone. The PEP figure *is* then twice this single tone figure and the PEP figure represents the maximum power that the rig can produce averaged over one RF cycle. I expect this is as clear as mud by now! It all leads up to a sales plug for the Walford Electronics two tone oscillator kit. This has a special diode detector section enabling proper CIO frequency adjustment without the need for a scope! It senses clean cross-overs in the modulation envelope with a DC voltmeter. G3PCJ

Introduction to Radio Frequency Design by Wes Haywood W7ZOI

A review by Mike Smith G7SDD who asks 'Is this a new Radio Designers Bible?'

The first time I saw Wes Haywood's book, *Introduction to Radio Frequency Design*, I knew I had to get a copy if I was going to do any serious radio design work. For the majority of us Radio Amateurs who construct equipment that can be considered as conventional, rather than pursuing the frontiers of radio technology, this book is an absolute MUST.

At first sight, it may appear a bit daunting, as it covers the fundamental theory of many aspects of radio design, and is liberally spread with attendant equations. Don't be put off by this if you are not mathematically minded, as there are plenty of practical examples which stimulates one into thinking more about the underlying principles rather than just copying the circuit. Even for those amongst the amateur fraternity who are at home with a bit of mathematics, the treatment of fundamental methods and models does not use any heavy maths, but keeps everything as simple as possible. (It does show how rusty we can get, though!)

Of particular value in my opinion, is Wes Haywood's treatment of oscillator design, filter design and network matching. These topics are absolutely fundamental to everything we do in RF design, and the way in which the subjects are presented is excellent. Even topics that we care not to think about, such as noise, noise models and noise matching, are all superbly covered. The book does not stop at models and simple treatment of the basic building blocks, but goes on to present an analysis of an overall receiver, covering front end and IF design, together with ways in which performance can be measured and evaluated,----- without recourse to sophisticated laboratory equipment.

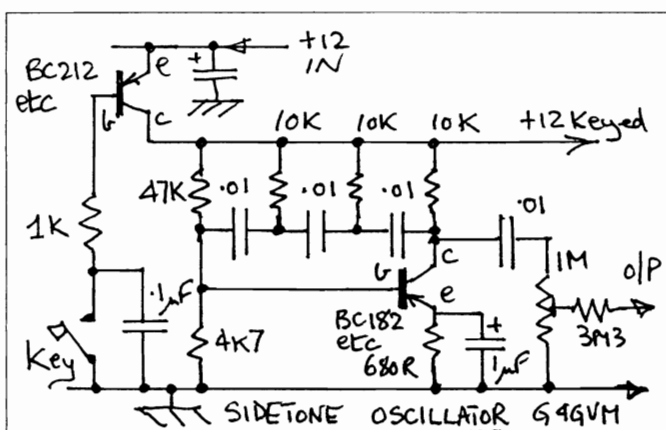
Naturally, it would be almost impossible to cover every possible topic and application in radio frequency design, and one area that is not covered in depth is large signal analysis, as would be applied to power amplifiers and driver stages. But there are plenty of references made to other literature that covers these specific topics. For those fortunate enough to have an IBM compatible computer, the book also comes with a 3.5 inch disk which has a host of extremely useful design tools, enabling one to devise filters, matching networks, attenuators, coils ----- and more. And what's more, the computer generated designs when translated into real hardware, work EXACTLY as designed. Magic!

The book is an ARRL publication and is available from the RSGB for £20.74 for members and £24.40 non-members. ISBN:0-87258-492-0 The disk alone is worth every penny! Mike Smith G7SDD

Phase Shift Oscillator Update

Referring back to Hot Iron Issue 9, further work has shown that keying the positive supply line with a p-n-p transistor is the simplest and least costly solution to the problem of how to key the oscillator. The circuit shown right still allows 'negative' keying which parallels up nicely with controlling the delay and changeover relay. This circuit avoids the need for any trimmers. Derek Alexander G4GVM

(Given the 3M3 in the output, it does need either a high impedance load and/or to be fed into an audio stage with significant gain such as a LM386 etc. G3PCJ)



Snippets

Nick Collis-Bird reports on the wonders of Hot Glue Guns available for about £8 from DIY shops. They are apparently perfect for tacking wires to chassis and it even sticks to aluminium which is notoriously unwilling to take glue. They are also useful for mounting S meters. The joints can be undone again if necessary.

Ray Donno reports a sad experience at the hands of a DTI radio inspector who called on a newly licensed amateur in the West Country. The poor fellow was put off the air, and his log suitably incised, for:-

- having a TX that could operate outside the relevant amateur bands,
- having a TCVR with a faulty display that read 5 KHz off frequency,
- incorrect recording in his log, noting the band and not actual operating frequency,
- not having any frequency counter or means of monitoring spurious radiation.

This all sounds pretty draconian and possibly debatable. It is important to be able to demonstrate that your rig does not produce spurious transmissions and to know your actual frequency - get your counters now!!

Ten and Twelve metres with the Taunton

Tony Measures G3WUC has spent a great deal of time working on these bands and assisting me with the development of circuits to provide the last two 'missing' bands in the Taunton's armoury. Originally I did not include 10 and 12m because they needed what appeared to be obscure crystals to obtain the correct local oscillator frequencies. With a 4 - 4.5 MHz VFO & 6 MHz IF, integer MHz crystals are needed to retain the same common VFO calibration for each 500 KHz segment as used on other bands. The easiest implementation requires 23 MHz for 12m and 10m needs 18, 27, 19, 28 MHz crystals. A 14.5 MHz crystal can be used for 12m but the band will start at 24.5 MHz at the VFO dial position where the normal bands start at X.00 MHz; similarly 18.5 and 19.5 MHz crystals would give the 28.5 - 29 and 29.5 - 30 MHz segments all tuning the same way as the other two segments of 10m. Subsequently I have located a source of 18 MHz crystals and Tony realised that 12m could be done with a 14.91 MHz crystal if the VFO calibration was completely different from other bands. This does not matter to him as he has a digital readout and could therefore use non integer crystals.

Having already changed all his single band plug-in cards for two band cards he had plenty of single band PCBs to experiment with! It did not take him long to get some action on 12m but only with rather reduced power. Feeding in signals from a signal generator had shown that the transmitter strip would work up to 10m provided there was enough drive. I was somewhat relieved to obtain this confirmation of my early development work which had 30 MHz as the intended upper limit for the IRF510 output stage. It was clear that an extra amplifier was needed in the transmit path; other experiments had shown that when the IF amp is fitted no extra receive gain was desirable so the challenge is to find a way of bringing this amplifier into circuit only on transmit for these higher bands and without needing any extra connector pins! His suggestion so far is to use the spare pin, normally used for controlling the choice of band A or B, as a means of getting +12T onto the band card when not being used with two band cards. The +12T then controls a relay and the extra amplifier.

Despite being a bit of a rat's nest, Tony has already managed several DLs and F5RRS near Geneva on 12m phone with the basic 5 Watt output of his Taunton from Warrington. As soon as this work is complete, I shall inform readers. I am very nervous of requiring expensive non standard crystals and do ponder about a special card with a phase locked loop to get the full coverage of 10m. The pragmatic alternative maybe non integer crystals and mandatory digital readouts - particularly in view of the experience reported on the previous page! Both Tony and I would welcome any comments. Tim G3PCJ

The 1996 Somerset Homebrew Contest

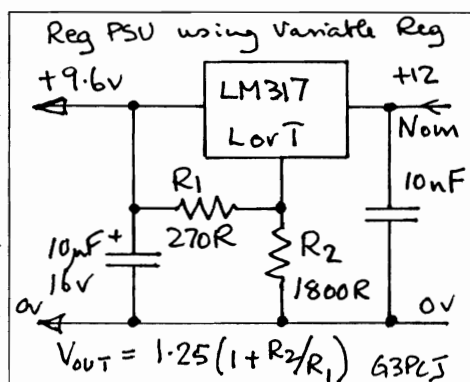
This was kindly organised by the G-QRP Club during March and I am pleased to be able to report the overall winner as VU2NGB; he operated only on 40m with an AM transmitter! The draw prize, available for all properly completed entries was won by our own Construction Club member Keith Edwards G3XUO using his Yeovil to good effect. Construction Club member Peter Burrige G3CQR also did well. I am discussing with Gerald Stancey G3MCK how we can ease the rules to encourage more entries next year. Star prizes in 1997!

The Pitney's Voltage Regulator

Just in case I have failed to notify all builders likely to be effected, the last batch of voltage regulators used in the Pitney proved to be rather more susceptible to insufficient capacity on their output compared to earlier batches. The LM2930T8 low drop out regulator actually needs 10 μ F on its output to stop it oscillating. With insufficient capacity the output tends to apparently follow about a volt below the input when measured with a voltmeter. A scope shows a most unsteady output voltage instead of the desired straight line! Unfortunately the tolerance on many types of electrolytic capacitors can be -20% to perhaps +50% or more! For a few actual specimens C11 was insufficient to prevent oscillation. The cure is to replace C11 with a 22 μ F part. If any body with a Pitney is suffering this problem and needs a capacitor let me know. G3PCJ

Comparison of voltage regulators

The standard 78XX regulators (where XX = output voltage) have line regulation of about 0.1% V_{out} against input voltage changes. The variable types based on the LM317 chip (suffix L is a 100 mA part, suffix T is 1.5 Amp) are much better with line regulation of about 0.01% V_{out} . Load regulation is also better at 0.1% V_{out} . This is why they are used for varactor diode tuning voltages. Low Drop Out (LDO) regulators are worse. The circuit for the variable types is shown right with the equation for output voltage. The values shown give 9.6 volt out - the practical maximum for a low nominal 12 volt input. Use plenty of output decoupling. G3PCJ

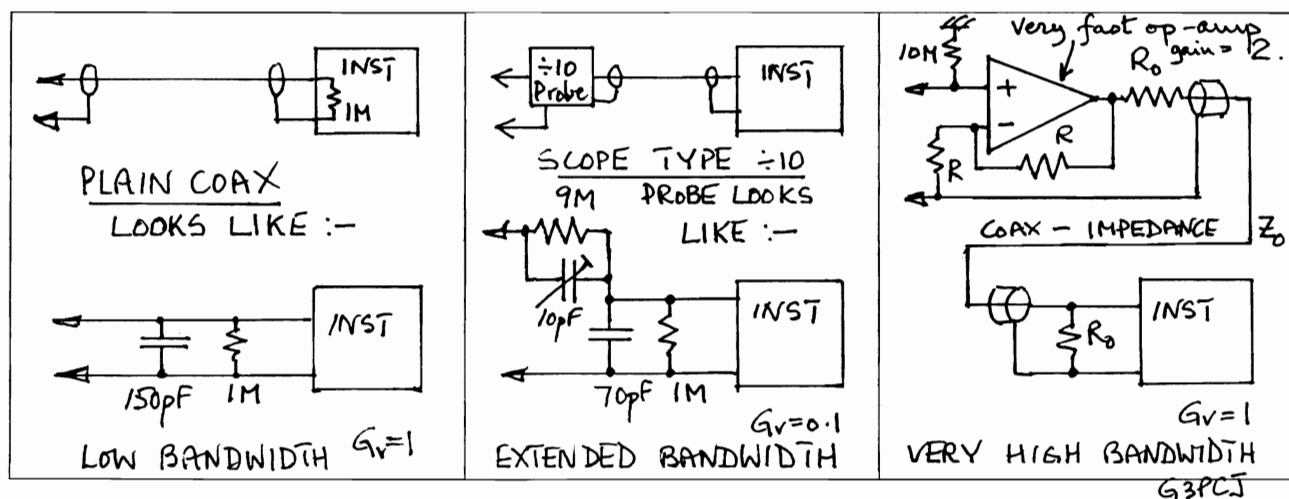


Test Leads and Probes

Quite often kit builders who are experiencing setting up problems with oscillators, ring me up saying that it doesn't oscillate or that it seems to be way off the intended frequency. Invariably these troubles are due to the leads to the test equipment! Questioning often reveals that the builder is using a plain piece of coax to connect between the oscillator and the instrument; perhaps a counter, RF voltmeter or sometimes a scope. At low frequencies, perhaps to a few KHz, this is all right but from 100 KHz upwards it causes severe problems. The reasons are that the piece of coax looks just like a capacitor, see left below. (A different situation exists if it is terminated in its characteristic impedance but this is seldom the case.) A typical test lead length of coax might have a capacity of 150 pF with a reactance of just over 1 KOhm at 1 MHz. Put across a 4 MHz VFO, the effect is even worse! Put this across some sensitive part of an oscillator, or almost any other RF circuit and it will cause havoc! It does not matter that the instrument may have a 1 MOhm input since when connected together, they are in parallel and still look like 150 pF or 1 K! It may sound odd, but it is actually better to connect the circuit to the instrument with the shortest possible single insulated wire. Do the same for both the signal and ground leads while keeping them apart; this will minimise the capacity and it might just work or give a reading!

A better solution is to use what are known as 'divide by 10' scope type probes. Here the probe is actually made up of a resistive attenuator arranged to divide the input signal by ten and provide a much higher DC load impedance than the basic 1 MOhm of the instrument. This is done with a 9 MOhm resistor in series with the probe tip - because this resistor is at the probe tip it isolates the cable capacity from the circuit under test. However the cable capacity is still there, and with the tip resistor, will act as an attenuator as frequency is increased. This effect is partially overcome by placing a small capacitor across the high value series resistor as shown in the middle below. In the ideal situation when $C1R1 = C2R2$ where $C2$ is the cable capacity and $R2$ is the instrument's input resistance, the range of frequencies over which the factor of 10 division applies is very much increased. As a guide $C1$ will be roughly one tenth of the cable capacity but to allow for manufacturing tolerances, it is usually made as a trimmer in the probe tip. (This trimmer is adjusted for the flattest top and bottom of a square wave signal applied to the probe tip and viewed with the probe attached to a scope. A suitable square wave is often available on the scope front panel.) To the circuit under test, the probe now looks like a few pF in parallel with several MOhms which is a great improvement and will be good enough for most HF applications. Occasionally the trimmer is fitted at the scope end of the probe cable.

At even higher frequencies, or where impedances are high, it is necessary to go to an 'active' probe to fully isolate the cable capacity from the circuit under test. A very high speed op-amp is placed right at the probe tip and drives the cable as a transmission line terminated at both ends. The op-amp is usually an FET type with a gain bandwidth product near 1 GHz and an input that looks like a couple of pF in parallel with many MOhms; it is arranged to have a voltage gain of 2 to allow for the signal loss across the driving end termination. The arrangement is sketched on the right below. This could be a kit if anyone is interested. G3PCJ



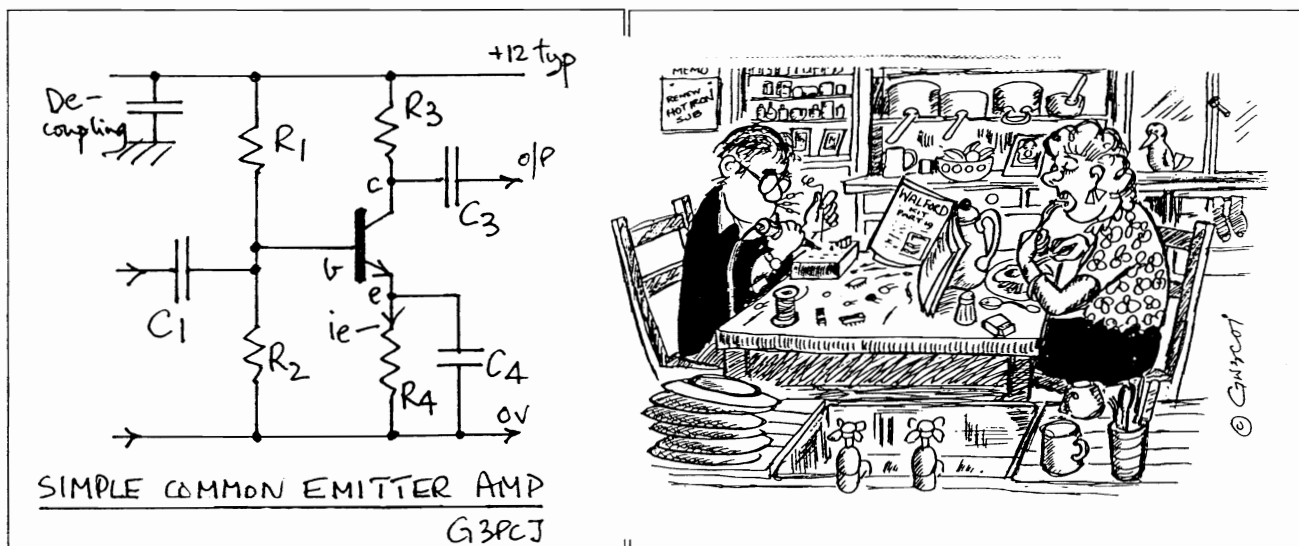
Lightning Protection

It is crashing away outside! Grounding the antenna system during a storm is reckoned to significantly decrease the chance of a strike on the antenna. I have a large 240 volt relay switch the feeders away from the AMU to a good RF ground (NOT mains earth) whenever the main shack 50 Hz supply is switched OFF. However, if it does strike the antenna, you will certainly suffer badly damaged gear!

The Common Emitter Amplifier

The box below shows a typical circuit. Given the lack of space, this assessment has to be rather simplified and without any feedback to make things easy! For convenience, it is assumed that the output is feeding a load impedance which is at least 10 times R_3 . (If not, substitute the value of R_3 in parallel with the load for R_3 .) In this circuit, the purpose of R_1 and R_2 is to set the DC conditions in conjunction with R_4 . As the emitter current is almost equal to the collector current, the DC voltage across R_4 needs to be a fraction of the supply voltage so that the available voltage swing at the collector is as large as possible. One quarter of the supply is a good starting point, which will mean that R_3 is 3 times R_4 . If the supply is 12 volts then the emitter voltage needs to be 3 volts, and remembering that the base voltage will be 0.65 volts above emitter for a common bipolar type of transistor, gives a desired DC base voltage of 3.65 volts. R_1 and R_2 act as a potential divider to give this. The small signal voltage gain of the stage (collector AC voltage divided by base AC voltage) will be roughly R_3 divided by the effective emitter resistance R_e . If C_4 were absent, R_e would be nearly equal to R_4 and the voltage gain would be R_3 divided by R_4 or a gain of 3 for the DC conditions suggested. If C_4 is fully effective and decouples the emitter at the signal frequency then the effective emitter resistance in Ohms is approximately 25 divided by the emitter current in mAmps and the gain is much higher. The input capacitor C_1 needs to be sufficiently large so that its reactance at the lowest frequency of interest is smaller than the parallel combination of R_1 , R_2 and (20 times the effective emitter resistance as derived above). The output capacitor C_3 needs to have a reactance smaller than the load impedance at the lowest frequency. The DC collector current needs to be at least a bit larger than the peak output signal current, (desired peak voltage divided by load impedance). Since this DC current also flows in the emitter, that allows R_4 to be derived from the suggested 3 volts at the emitter. Output signal level will be limited by the lower of a) maximum available collector voltage swing, b) inadequate DC current for the collector swing and c) voltage gain times about 0.1 volts (due to non-linearity at the emitter) ^{when C_4 present}. The upper frequency at which gain begins to decrease, will be determined either by the transistor running out of gain as its gain bandwidth product is approached or when the reactance of the capacity at the collector (strays and device) is less than R_3 . This simple type of analysis is a useful guide for most small signal bipolar transistors of either n-p-n or p-n-p type. In selecting a transistor you must also make certain it has a sufficiently high collector voltage rating (at least 1.5x the supply voltage), sufficient maximum power dissipation for the collector current times voltage between collector and emitter, and adequate gain bandwidth product (known as F_T) for the application. A current gain or h_{fe} above 20 also is desirable. Since this is rather heavy stuff, a cartoon is in order!

G3PCJ



Subscriptions

Sadly, it is that time of the year again! Unfortunately, the increase in the cost of postage and copying mean that I have to raise the subscription - it is however the first increase since we started the Construction Club three years ago and I trust that you find it good value. Feedback and articles are always very welcome.

From Sept. 1st 1996 I shall have to charge £6 but as a discount to existing members, I shall be pleased to renew your membership for the next year at £5 for UK members (£7 overseas) provided payment reaches my by Sept. 1st. Where membership was included with a rig, payment will be needed for next year.

Hot Iron

Issue 13

"Journal of the Constructors Club"

Autumn 1996



Editorial

As the weather is doing its usual best to disrupt my harvesting activities, I think I had better make a start on this issue of Hot Iron! Much as one would like to be able to think up suitable electronic topics while driving the combine, the best I can do, is to wonder if there is some sort of smoke detector that will react to burning rubber from slipping belts and burning chaff on the exhaust manifold! It took much of yesterday to change one belt! Access for repairs was not a high design priority!

Just recently I have sent follow-up questionnaires to those inquiring about kits who have not actually ordered anything; one answer was noteworthy as the author said he never bought kits where he thought the kit price was higher than the sum of the cost of the individual parts. In my experience, this is nearly always the case because the economies of scale are not great and overheads have to be recovered. A supplier of quality kits has to buy his parts from reputable and repeatable suppliers so that the vagaries of customer's demands can be met without huge unsold stocks of parts costing 8% per annum. While an individual can go to a rally and buy air variable capacitors for 50 pence and a slow motion drive with knob for a £1, they will cost me over £10 even at the 25 off rate. (This is why I stick to varactor diodes and pots!)

Costing most parts at the 25 off rate and adding the PCB material, etching and drilling charges, instructions and then those dreaded overheads, means that the kit price is significantly higher than the 'rally' part's costs. What overheads? Advertising (1/16th page in Radcom £75), sales leaflets, phone, stationary and postage not paid by customers, photos of new products, development parts for new product circuit design, PCBs and at least one prototype model, share of capital item costs, (test gear, computer, reference books) etc..! My time - free for fun!

Product News

Readers may recall my mentioning the Drayton CW transmitter as a companion to the Pitney RX; now the *Martock* RX is available for those wanting a dedicated amateur band RX to go with the Drayton. Experience has shown that the Drayton will work up to 15 MHz simply by changing the 'crystal' - it is actually supplied with a ceramic resonator for 80m which allows a far wider pulling range (40 KHz) than can be obtained with a crystal. It is almost a VFO!! The *Martock* is a direct conversion RX for any single band 20 to 160m by selection of coil/capacitor combinations at ordering. It is equipped with double tuned RF filters, a sharp SSB audio filter and a narrow humped low pass filter for CW centred on 750 Hz. The output stage drives walkman type phones or a small speaker. The VFO has special temperature compensating capacitors to ensure adequate stability at up to 20m but since it is operating at the received frequency, if it were to be used for driving a CW transmitter, there would be severe chirp problems! This is why the companion TX to the Martock is the crystal controlled Drayton TX. For CW on the higher bands with a VFO, you need the *Frome*!

Design work on the *Frome* is progressing well; it is multi-band by single or two band plug-in cards like the Taunton for up to 15m with full VFO coverage on all bands. 5 Watts RF output on CW. Double tuned RF filters and sharp audio filters like those in the Martock. This rig will complete the line of HF TCVRs. The signal generator kit makes slow progress as it has proved very difficult to eliminate the close-in harmonics. I think this is now solved and it only needs the PCB to be laid out again! Tim Walford G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224 The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year. June 1st 1996.



Pitney Tuning and RF Gain Control

Here are a few optional modifications which make the Pitney more suitable for dedicated amateur band use. The Pitney's frequency coverage can be reduced so that your chosen band(s) fills a larger part of the coarse tuning knob swing, possibly making the fine control unnecessary so that it can be re-used as an RF gain control. Because the Pitney has very little provision for tuning presets, the following alternative capacitor values must be taken as guidance only and may need some adjustment for your particular rig. Obtain these parts at rallies etc.. You may find that switching L2 in and out of circuit, enables you to retain coverage of some parts of 80 and 160m with the same setting for L1 - but generally L1, and maybe C20, will need adjusting for each band if coverage is to be spread over the full pot rotation. If you wish to retain it as a three band rig covering specific segments, you will definitely have to have extra trimmers and switching which are beyond these notes! Extra RX capacitor(s) C20/21 are required for each band to provided the fixed part of the tuning capacity. These are installed on the underside of the PCB between the track leading to RX pad B and the nearest suitable ground track having a chassis symbol, so as to connect them across the main coil of L1 of the RX. The Pitney's original C5 (10 nF disc) should be removed and the RX pad A should be linked to the ground plane.

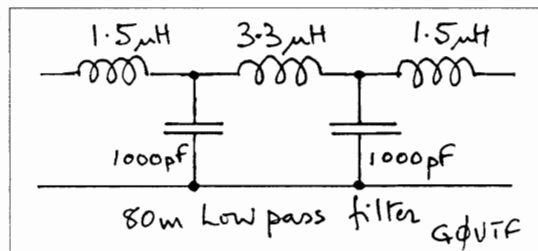
Band	New approx tuning range - KHz	Links to replace original switch connections	New C20	New C21	New C5	New C6
160m	1810 - 1860		100 pF	100 pF	100 pF	56 pF
80m	3540 - 3630	RX pads B to C - perhaps via switch.	100 pF	100 pF	100 pF	56 pF
40m	7000 - 7150	RX pads B to C.	22 pF trimmer		100 pF	15 pF

After making these changes, decide if the fine tuning control is really needed. If not, remove the wires to RV3 and reconnect the slider of RV2 to the RX point TV. The RX track between C2B and the hot end of L3 should be cut in its middle so that the RF gain control can be connected between C2B and L3. The anti clockwise end of RV3 should be connected to the ground plane. The clockwise end of RV3 should be connected to L3. The slider of RV3 should be connected to C2B. RV3 should now act as an RF gain control and will allow the Regeneration control to be left just either side of the point of oscillation for maximum selectivity. Using RV3 as an RF gain control will also help reduce cross modulation from strong unwanted signals. G3PCJ

Coker Modifications

David Proctor, G0UTF, found the following useful:-

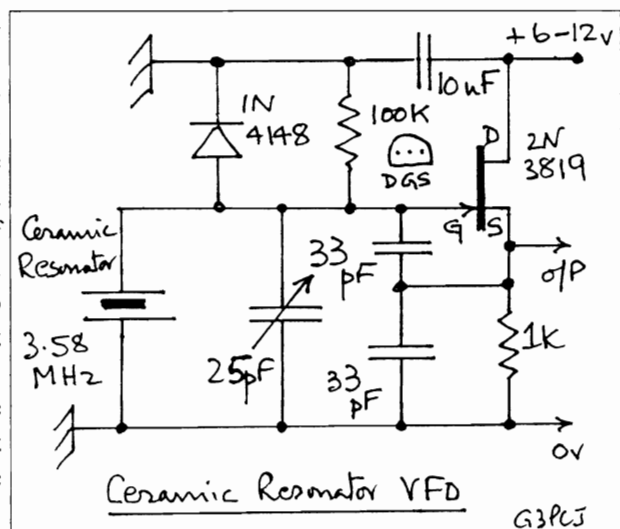
1. Add a low pass filter (circuit right) on the output to reduce TVI when using his unbalanced antenna system.
 2. Reduced VFO drift by using a silver mica cap for C1.
- (I have a set of alternative capacitor types which cure the drift tendency - please send £1 in stamps if wanted. G3PCJ)
3. Add 1K pot in series with the tuning pot for bandspread.
 4. Optional SSB audio response by switching 1K across L3.
 5. Use relay contacts to switch in RIT control voltage on receive.



Ceramic Resonator VFO for 80m

The circuit right is that in the Drayton. It is a Collpits oscillator with the resonator instead of a crystal or parallel coil/capacitor combination. The ceramic resonator requires a nominal 30 pF capacity in parallel but by making part of this variable, the frequency can be varied appreciably. A trimmer or air variable can be used (or even a varactor and pot!). The relatively high Q of ceramic resonators means that chirp, due to RF feedback from the transmitter output is unlikely to be so large as to be troublesome. The commonly available 3.58 MHz ceramic resonators can be swung over 40 KHz with a 22 pF trimmer which is just over 1%. The same technique would swing a crystal nearer 0.05%! Although 10 MHz ceramic resonators are available, I could not make mine reach the 30m amateur band!

G3PCJ



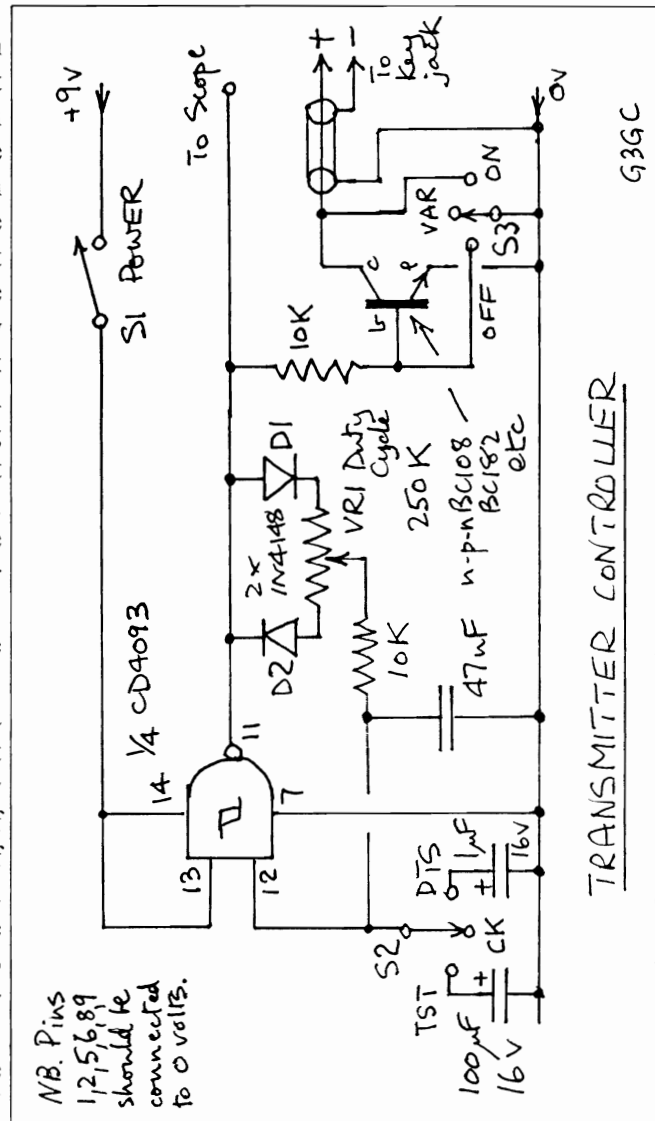
Transmitter Controller by Eric Godfrey G3GC

This device has two main uses with a CW transmitter and saves a lot of hand key operation!

1. Keying the TX with varying duty cycles for soak testing, etc.
2. Generating continuous dots for assessing unwanted effects.

The circuit can be built in a small plastic or metal box using veroboard etc. with its own internal 9 volt battery. The output lead has a jack suited to the key socket of the transmitter under test. The transmitter must be of the type where the key normally switches only low currents with low open circuit voltages. The transmitter RF output should of course be connected to a dummy load or antenna system depending on what is being investigated.

The circuit shown right simply comprises an astable NAND Schmitt trigger connected to an output switching transistor. The jack plug output is taken from the transistor's open collector and 0 volts. The transmitter's key control line should have an open circuit voltage below about 15 volts positive. The repetition frequency (RPF) of the astable is dependent upon the position of S2 which selects one of three capacitors. The position labelled TST gives a low RPF, about 15 Hz, suited to prolonged duty cycle soak testing; the middle position labelled CK gives a high RPF (100 Hz) suited to scope observation of keying characteristics while DTS is used to provide dots at about 17 wpm for identifying transmitter harmonics, intermodulation products and other nasties. The selected capacitor is charged through the 10K resistor and that part of duty cycle pot VR1 connected by D1. It is discharged by the 10K and the other part of the pot connected by D2. When the pot is in mid-position, the charge and discharge times are the same giving a 1:1 mark to space ratio or a 50% duty cycle. The pot alters the charge and discharge times to give duty cycles of up to 5/95% in either direction. The output of the NAND gate (pin 11) is a square edged wave, of amplitude equal to the supply voltage and repetition rate dependent on the setting of S2, with a duty cycle controlled by VR1. This output, which can be used to trigger a scope, drives the output switching transistor which can be practically any n-p-n type. The switch S3 has positions for OFF (no keying action), VARIable with key 'down' duration set by the pot VR1, and ON where the transmitter is producing continuous RF.



Part Location and Screen Printing

Potential builders often express caution about being able to find the correct holes in a PCB, particularly if their eyesight is not as good as they would wish. I have to admit that I now use a magnifying glass far more often than I would like! I find the markings on certain types of capacitor particularly hard to read. The very large illuminated bench mounted magnifying lenses are highly recommended; with care, one of these lenses should enable most builders to find the correct holes for parts. I do not include screen printing on the PCBs because it is another process that would add to PCB cost and would reduce design flexibility notably on dense boards where often it is essential to mount resistors vertically. While this may require more care by the builder, that is in your time which is free to you! Studying the track layout, checking as parts are inserted, followed by testing in stages greatly helps circuit understanding. The alternative approach of inserting all items from a parts list, applying power and praying it will work is not suited to moderately complex circuits! I try to start construction with the larger parts that can only be put in one way and whose location should be obvious, such as presets and TOKO coils. Another approach is to scribe the top ground plane with fine lines on a 1 cm square grid. On more complex projects I now include a grid reference for all parts based on such a grid. G3PCJ

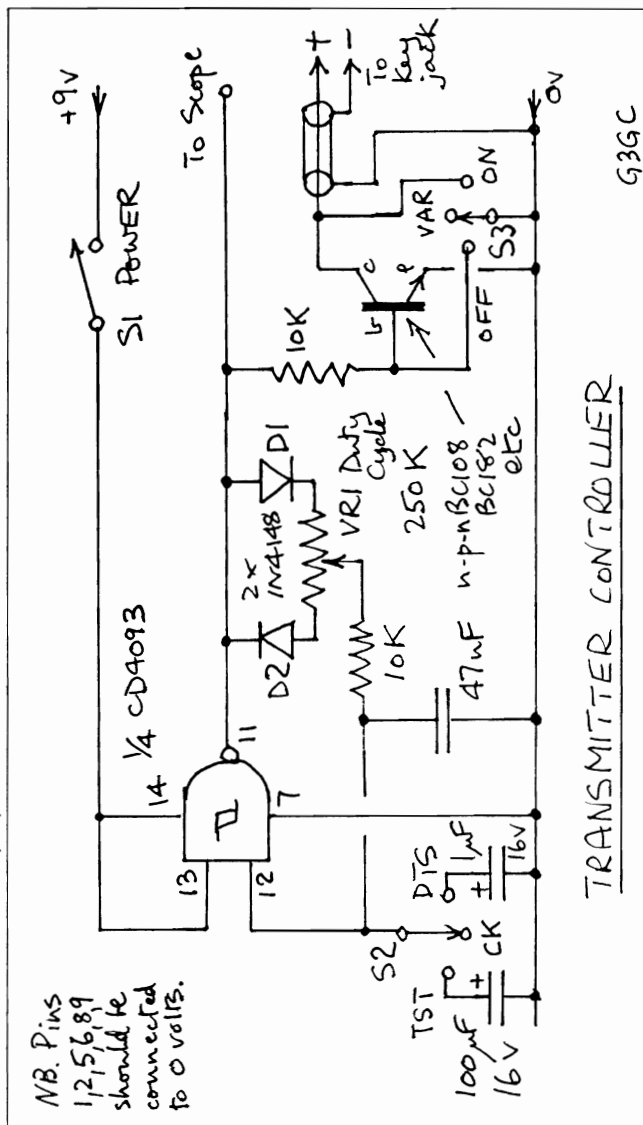
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RF Bandpass Filters

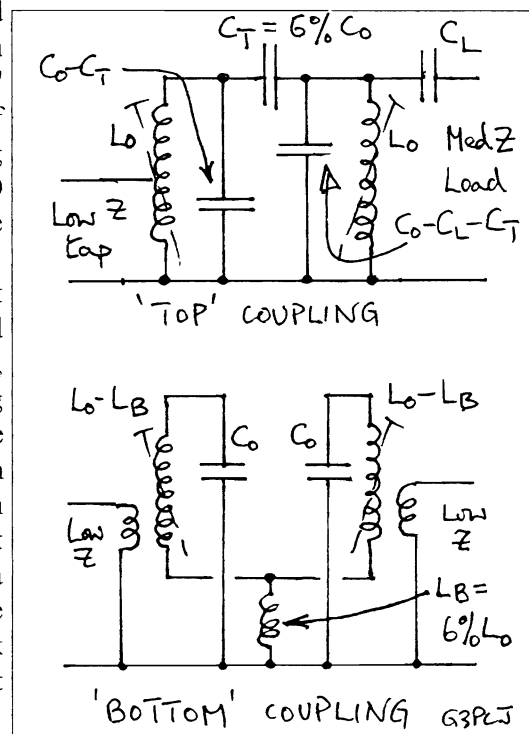
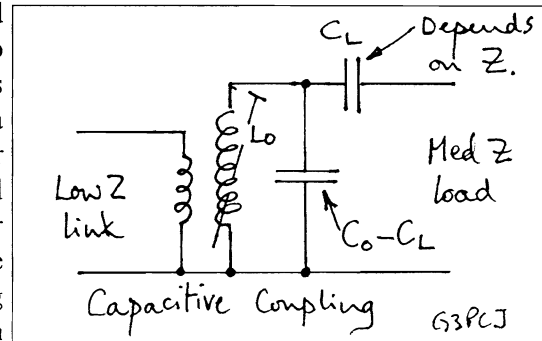
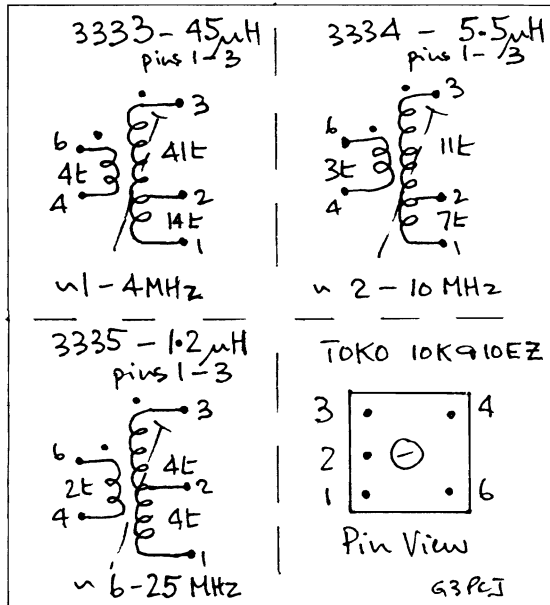
The more common filters are based on parallel tuned circuits, either 'single' tuned with one resonant circuit or 'double' tuned with two coupled resonant circuits. Coupling in and out maybe by transformer coupled link windings or by capacitors. Since people don't like winding any coils, invariably design starts by selection of a standard coil from the TOKO range whose more common parts are shown right. Knowing its inductance, the desired resonating capacitor C_0 is calculated from:-

$$C_0 = \frac{10^6}{(2\pi f)^2 L_0} = \frac{25,330}{L_0 \times f^2}$$

C_0 in pF, f in MHz, L_0 in μ H.

This capacity maybe any combination of fixed and variable types. The parallel part of the circuit operates at high impedance and Q will be reduced if low or medium impedance loads are connected directly across the main L and C. In practical terms, only the high impedance of FET gates should be connected directly across the main resonant windings. Where link windings are used for input/output, the load impedance is multiplied up by the square of the turns ratio between primary and secondary. Generally it is unwise to load the resonant circuit with less than a few KOhms due to these multiplied up in and out impedances. Quite often 50 R in/out impedances, typical of antenna feeders or some interstage couplings, can be connected direct to the link winding. Where capacitive coupling is used to link to the 'hot' end of the resonant circuit, then small capacitors being a fraction of the resonating capacitor C_0 are needed. It is a complex calculation! As a very rough guide, use 10% of C_0 for linking to 50 R, about 25 to 33% C_0 for linking to 300 R and perhaps up to 50 % C_0 for 1K. The actual capacitor required for the main resonating capacitor will have to be reduced by the linking capacitor value. It is unwise to use capacitive coupling for both input and output coupling as this degenerates into a high pass circuit rather than the desired bandpass response.

Where two (or more) resonant circuits are coupled together with the objective of giving higher attenuation away from the passband, then either a small capacitor between the *top* 'hot' ends of the resonant circuits, or small inductors at the *bottom* of the main inductors can be used. See right. The small top coupling capacitors should be about 6% of C_0 for a typical overall Q of 10 which is commonly needed. This value will also have to be deducted from the main resonating capacitors of both inductors. Reducing the linking capacitor will raise Q, while increasing it will lead to a double humped response and a dip at the passband centre frequency. Where the coupling is done by small inductors, the coupling inductor should be about 6% of the main resonating inductance. In an ideal world bottom coupling is preferred since the coupling inductance looks like a short at low frequency which helps preserve the desired bandpass characteristic. However, in practice, top coupling is far more convenient and is the most common technique. The same methods can be used for adding a third resonant circuit for even better stop band rejection. The guidance here is necessarily very approximate; for serious work the best treatise that I have found is in the ARRL Circuit Designers Handbook..

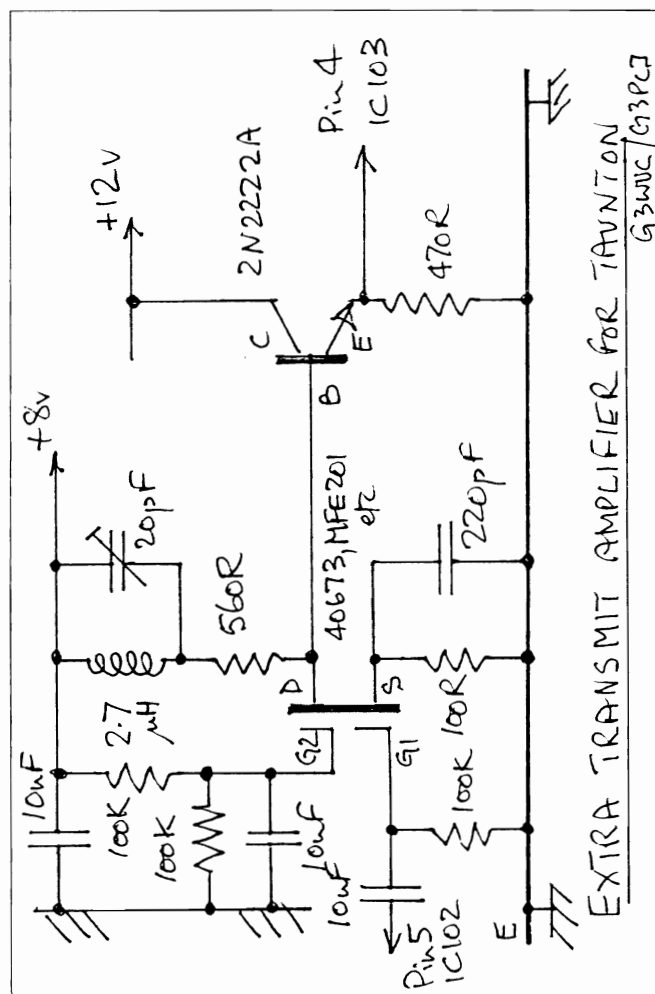


Taunton TCVR on 10 and 12 metres by Rev Tony Measures, G3WUC

Having changed my single band cards to double ones, I have been able to experiment with the singles for 12m and the first section of 10m to 28.5 MHz. The table shows the bandcard parts required - note the change of TOKO coil type for 10m RF BPF and the use of yellow T68-6 cores for the TX matching coil. With the crystals that I had available (14.910 for 12m and 18.0 MHz for 10m), the VFO had to go down to 3.98 MHz and I raised the upper end to 4.515 MHz for extra coverage with my single crystal on 10m. The wider VFO range only needed adjustment of L102 and RT101; although this upsets the normal tuning calibration, it is immaterial if you have a digital readout. (See earlier notes in Hot Iron Issue 12 about crystals for these bands.) Later I hope to fit an extra slide switch and an 18.5 MHz crystal to obtain all of 28.0 to 29.0 MHz. These two cards tune pretty well but more drive is needed to obtain full output, especially on 10m; nevertheless I4KDR did give me 5 & 3 when I was only up to 1 Watt! My earlier efforts with an on-card RF amplifier became unnecessary with Tim's suggestion of an extra transmit only amplifier between Mixer and switch (IC102 and IC103). The circuit is essentially a broadband common source amplifier with a gain of 5 followed by an emitter follower to isolate the amplifier drain load from high the capacitance of the following 4066 and longish tracks to the RF filter. The main drain load is the 560R resistor but the 2.7 μ H & 20 pF trimmer can be peaked for a little extra output on 10m. The 220 pF bypassing the source resistor also lifts the gain at the HF end. Since it is in the transmit path it does not have to be controlled. It should be installed with short leads etc. on the underside of the main board with the track between pin 5 IC102 and pin 4 IC103 being cut at each end. Because it is in circuit for all bands, it will require a reduction in the drive preset for all existing bands and possibly a tweak to the RF BPFs for the higher frequency bands. As part of my earlier efforts, I had already changed TR303 to a 2N2369A but this may not be necessary and if a 2N2222A is not available for the extra amplifier, it is well worth trying a BC182, BC108 or BC109. After adding these circuits I was able to attain 5 Watts on 12m & 4.4 Watts on 10m using a 13.8 volt supply with a standing current of 0.9 Amps in TR301. Raising the supply to 15 volts produced the target 5 Watts on 10m! (Well done Tony! I hesitate to offer this as a formal kit because I suspect the actual performance may vary appreciably from rig to rig, however it is indicative of what should be possible; if anybody wants assistance with parts etc. please let me know. G3PCJ)

Part No	12m	10m
RF freq	24.94 MHz	28.25 MHz
L201	3335	4613
L202	3335	4613
C201B	10 nF	10 nF
C202	18 pF	6p8
C203	4p7	1p8
C204	22 pF	6p8
C205B	10 nF	10 nF
LO freq	18.94 MHz	22.25 MHz
L203	3335	3335
L204	3335	3335
C206A	15 pF	15 pF
C207	33 pF	33 pF
C208	2p7	1p8
C209	33 pF	33 pF
C210B	10 nF	10 nF
LO xtal	14.91 MHz	18 MHz
C251	65 pF trim	65 pF trim
C252	65 pF trim	65 pF trim
L251	12 t - T68-6	11 t - T68-6
Link 202	Yes -add	Yes -add

C201A, C205A, C206B & C210A not required.

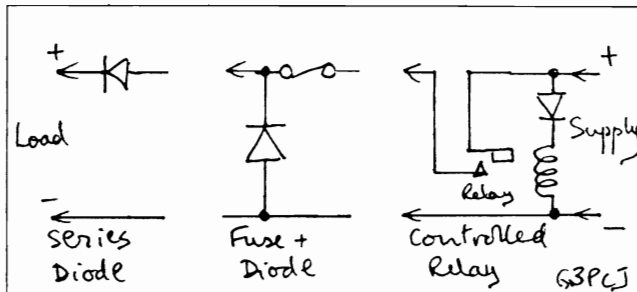


Power Supply Protection

One of our members recently had a cheap CB type commercial PSU fail, resulting in high DC volts on his Taunton plus counter, which burnt out some of the chips supplied direct from the 12 volt line. Hence these notes! These are not complete circuits since you may be able to use what is already in your junk box. It is necessary to keep protection circuits simple so that their reliability will be appreciably higher than the item which might fail, causing damage. However simple circuits often have poorly defined operating points so it is vital to try them out with care on dummy loads first!

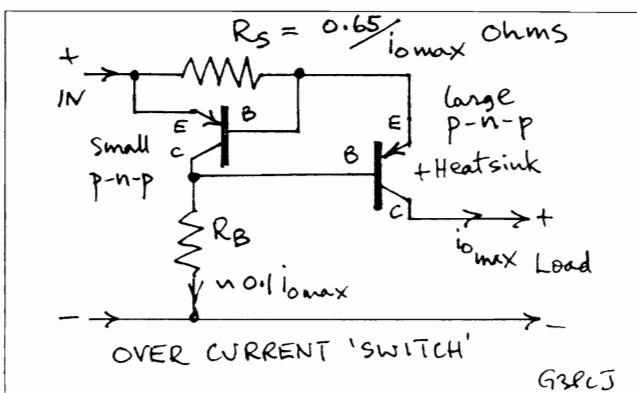
Reverse polarity - protects against operator failure!

The easiest is a series watty diode, better is a series fuse followed by watty diode across the supply. Note that a correctly connected RF output stage FET such as an IRF510 acts just like this power diode (assuming its drain is always connected to the supply). This has saved my Yeovil once with the supply wires acting as fuse! Even better still is a relay with a diode in series with the coil - see right.



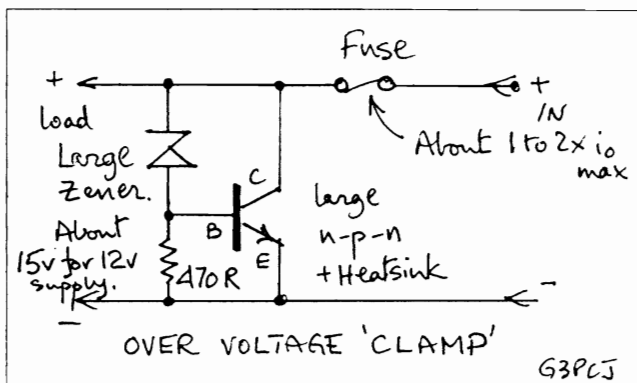
Over-current sensing - protects against load failure!

The load current is sensed and, when above some threshold, shuts down the regulator by removing the control voltage. Most schemes depend on the load current flowing through a resistor which turns on a transistor, hence there is nearly always a voltage drop of about 0.7 volts. The 'switch' scheme outlined right can be added to an existing supply but will have a variable loss across it up to about 1 volt. This can be avoided if it is placed in the raw DC line feeding the regulator. The current through R_B needs to be about 10% of I_O max. - also consider R_B dissipation. The sense resistor should be about 0.65 volts divided by I_O max. Use a watty transistor + heatsink for the output.



Over-voltage sensing - protects against PSU failure!

Here a fast acting circuit is needed to avoid damage to the load. Usually the excessive voltage triggers a 'crow-bar' across the supply - often done with an SCR which stays on till the PSU is shut down. The scheme on the right is a compromise between simplicity and precise trip voltage. Again use a watty transistor with heatsink and also a relatively watty zener. Don't forget the fuse or you may lose the protection devices as well! It is well worth trying this out first with a variable power supply to assess the actual voltage at which the transistor turns on hard.



Metalwork!

Yet another case recently of inadequate metalwork acting as heatsink in a PSU; this time with a LM317T regulator which warmed up after a few minutes and began to shutdown by reducing the supply voltage. The consequence was a slow change in VFO frequency as the PSU warmed up. If the regulating device feels hot to touch add more metal! It may be able to handle a high current but only if it is kept cool! G3PCJ

A PLEA!

Help! I am running out of ideas. Please let me know what you want to have covered in Hot Iron. Even better still, write me a few notes. Do not worry about the style etc. as I am quite happy to put it into shape. I can scan in a photo of something interesting if you have one. You won't want my rumblings for ever!

As implied elsewhere, the HF line of rigs in the Somerset Range is nearly complete, so I am thinking about further construction projects; if you do drop me a line, tell me what you would like to build next. Would you like something for 50 or 70 MHz or more test gear, grid-dippers, Hi Z Hi freq probes etc.??? G3PCJ

Hot Iron

Issue 14

"Journal of the Constructors Club"

Winter 1996



Editorial

I am a little later than usual compiling this issue of Hot Iron (Dec. 7th), so it is quite timely to wish you all a very Happy Christmas and prosperous New Year! May you also enjoy good health and an excellent year in your radio activities. Looking back over this year, it has been about the busiest that I can remember, both around the farm and in the 'Laboratory'. One of the pleasures of living in an old farmhouse, apart from not having to worry too much about damage to MOS devices from static electricity, is that I can sit in front of a log fire typing away in the half of the room that is my farm office. (Incidentally, the wood is fallen willow trees which have to be cleared up and so benefits everybody!) It feels very 'Christmassy' and, given the freezing fog outside, there is little to draw me away! The other half of the room is 'The Laboratory'; this is instantly recognisable as a typical radio amateurs shack piled high in literature, components, wire and home-made bits and pieces. Under considerable pressure from Madam, who also has a desk somewhere in here I

understand, I rearranged the computer table so that it now faces the Laboratory - in consequence I find it much harder to concentrate on the text when some half finished project is in view on the bench opposite! Soon, I expect there will be pressures from my daughters to erect some Christmas decorations, the snag is what to attach them to! Everything is always in constant use and/or fragile! (It sounds like a scene for our cartoonist member GW3COI.) I am sure that you all have impeccable shacks - at least modern equipment is much more spouse friendly than the 19" racks of yesteryear! Whatever your domestic arrangements, have a very good year in 1997.

Tim Walford G3PCJ Editor

Kit developments

The *Frome* CW TCVR is now available. It is a 5 Watt any single, or any pair of bands, by plug-in cards for 15 to 160m. It has a DC receiver with switch selectable sharp phone or CW filters. Double tuned RF filters and a varactor tuned VFO with crystal mixing scheme to give stability and avoid chirp. The Manual (£5) is available separately if you wish to assess the project first. Single band TCVR £85, or any two band TCVR £115 + £1 P&P. There is also the possibility of double sideband suppressed carrier phone operation.

By the time you read this, the January 1997 Practical Wireless will be out, with an article by Rob Manion G3XFD about the *PW CADET*. This is a collaborative project between us for a beginners project which should be quite within the abilities of 10 year olds upwards. It is an AM broadcast station receiver for the medium wave band, and short wave from about 3 to 6.5 MHz. It has three stages using only FETs for simplicity, ease of understanding and building. You only need a 9 volt PP3, walkman type phones, solder, soldering iron and cutters. £24 + 1 P&P from PW or WE. The *CADET PLUS* will add a BFO and RF amp.

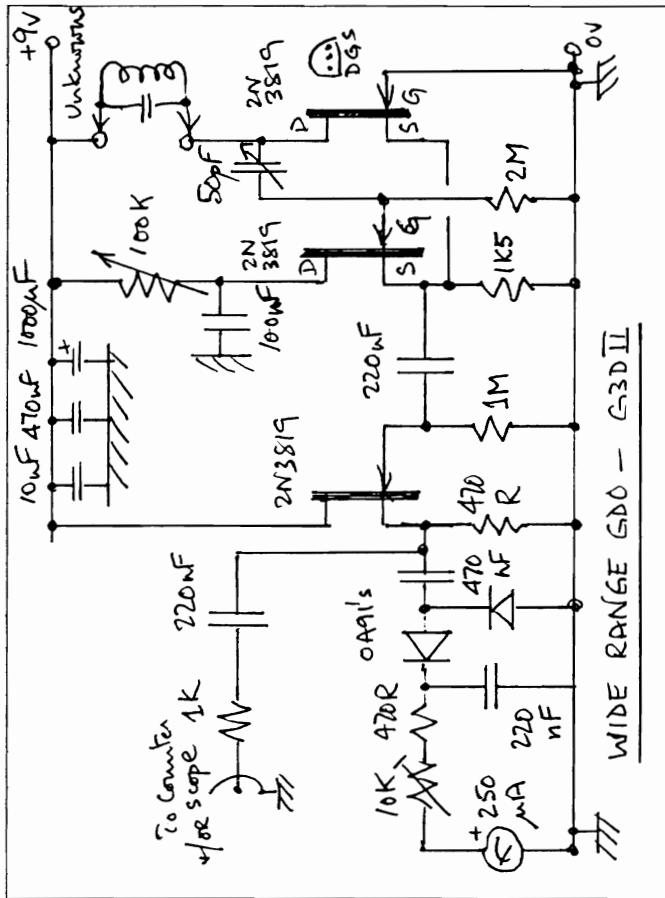
The re-designed *Signal Generator* should be available soon; if you are interested and you haven't heard from me recently - give me a call. The revised 12 volt 10/15m to 160m 25 Watt *Booster* is also imminent!

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224 The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year. June 1st 1996.



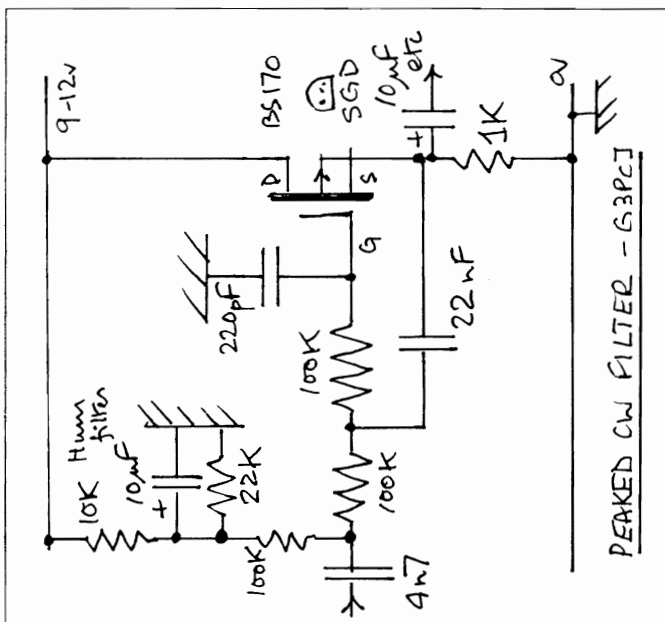
Wide Range Grid Dip Oscillator by G3DII

Joseph Bell, who is a frequent correspondent about FET amplifiers and has an IRF510 operating on 10m, has sent along some notes about his search for a gadget that would allow him to measure the resonant frequency of parallel tuned circuits down into the kiloHertz region. "I tried driving digital dividers from an ordinary HF GDO but without much success. Following on-air discussions with GD3FXN, I was introduced to the circuit shown alongside. It is based on our old friend the multivibrator; I had to use extra decoupling for the low frequencies and increased feedback. Now you can place a parallel tuned circuit between the 'test' points and it will oscillate from low LF up to VHF! For instance, I stuck 2200 nF across a pot core and the counter indicated 2 KHz. If you have a counter, it is easy to calculate the inductance of any coil with the aid of a tolerably close tolerance capacitor (silver mica for instance). The formula for L or C unknowns, is that the LC product (L in microHenries, C in picoFards) is equal to 25330 divided by the square of the resonant frequency in MHz, so work out the LC product and then divide it by the value of the known L or C. I used a variable feedback capacity so that its value could be kept to the minimum for a reasonable waveform. A 9 volt supply is sufficient."



CW audio filter

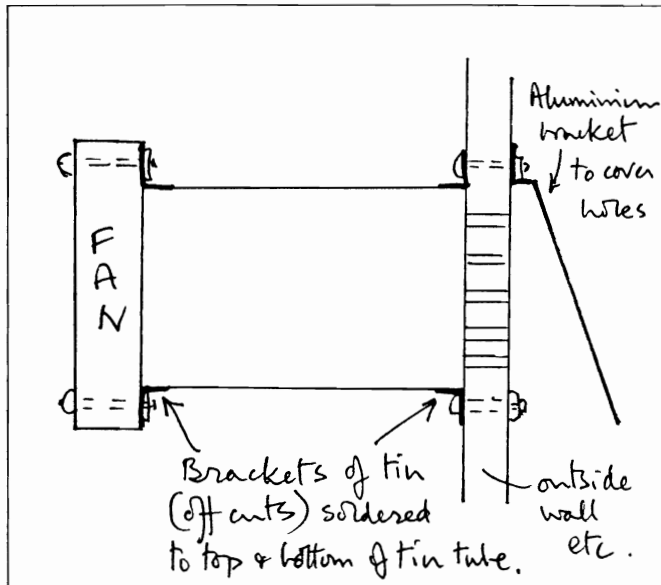
Direct conversion receivers need to have narrow audio bandwidths since it is the audio filter characteristics which determine the selectivity of the receiver. Quite often the audio filter is sufficiently wide (about 2.5 KHz) to pass phone signals without degrading voice quality but this means that several different CW stations can be copied at the same time! Hence the need for a much narrower audio filter for CW. Ideally this would be a bandpass filter so as to reject signals both above and below the desired beat tone. Since most people use a beat tone near 800 Hz there is more scope for unwanted signals coming through within the 800 to 2500 Hz range, hence the common simple solution to use a low pass filter which is 3 dB down at about 800 Hz with increasing attenuation above 800 Hz. This still allows lower tones through between the RX's low frequency pass band (typically 300 Hz) and 800 Hz. Hence the ideal is a bandpass filter centred on 800 Hz. They are not



often provided because they are complex if the filter slope is to be reasonable. The circuit above is a reasonable compromise though and can make a great improvement if the audio passband is wide. It is basically a humped low pass filter with much better attenuation on the HF side where it is most needed. The 22 nF feedback capacitor is larger than normal giving a slight (but controlled) tendency towards oscillation - it does not actually oscillate but the filter sharpness is much increased. The circuit consumes only a few milliAmps and can be fed from a hum free 9 or 12 volt supply. In the *Martock* receiver, the filter output feeds the 4K7 AF gain control so using a 68 nF output coupling capacitor gives attenuation to signals below 500 Hz; hence the overall effect is a bandpass filter with sharper attenuation on the all important HF side. G3PCJ

Soldering Extractor Fan by Dick Turpin G0BFU

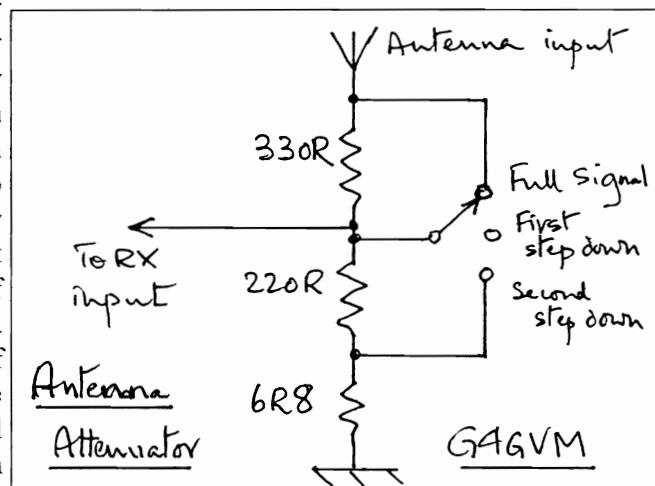
A recent visit to my surgery, where there was a notice saying "Fresh air is not free", made me think others might be interested in my fume extractor. I have long been aware of the dangers of breathing soldering fumes, particularly from the 'enamel' on modern copper inductor wire. Many amateurs do their construction in small rooms, or in wooden sheds, and in cold weather with closed doors and windows. Good ventilation, without getting cold, is however essential. I use a small 5 volt fan (sold cheaply at rallies) which is permanently connected to the incoming mains supply of my soldering station. The fan needs DC so a small bridge rectifier fed from the 6 volt heater winding of an old receiver mains transformer is all that is needed to keep it going whenever the soldering station is turned on. The fan exhausts through a metal tunnel out through the shack wall. An empty cat food tin, less top and bottom makes a tube to bring the fan intake nearer the source of fumes. A grill is desirable on the outside of the wall to prevent draughts when not in use; if the 'wall' is wooden as in a shed, then drilling multiple holes is an alternative. The holes or grill should be covered with a metal shade or cover to shed water and add to draught prevention. Sealing of the various joints can be done with bluetack, mastic or putty. If necessary, a longer tube can be made with wood or 3 inch sewer PVC ventilation pipe. In Summer, it can also boost air flow through a hot shack!



A grill is desirable on the outside of the wall to prevent draughts when not in use; if the 'wall' is wooden as in a shed, then drilling multiple holes is an alternative. The holes or grill should be covered with a metal shade or cover to shed water and add to draught prevention. Sealing of the various joints can be done with bluetack, mastic or putty. If necessary, a longer tube can be made with wood or 3 inch sewer PVC ventilation pipe. In Summer, it can also boost air flow through a hot shack!

Switched Antenna Attenuator by Derek Alexander G4GVM

Anyone operating a Direct Conversion receiver in the evening will know that an RF/Aerial attenuator is a must. I had no room on the front panel of my transceiver for the usual potentiometer control so an alternative had to be found. The three position miniature ON - OFF - ON toggle switches came to mind. This switch and associated resistors take up very little room and fit easily onto an already crowded front panel. The resistor values shown give two steps of attenuation satisfactory to my needs but would form a good starting point from which to experiment if different levels of a signal reduction are required. The fact that impedances in and out are no longer a nominal 50 Ohms is less of a problem than the breakthrough without the attenuator!



Soldering coaxial leads

Peter Barville, G3XJS, has sent me some notes gleaned from the Internet about soldering jumpers on PCBs where the cable has to be bent sharply adjacent to the PCB for it to look smart. However the methods suggested have more general applicability. The key is to prepare the braid before making any connection to the coaxial cable inner conductor. After stripping back the outside cover perhaps 3/4 of an inch, the braid can be carefully unwoven with the aid of a small spike. The mass of single strands of the screen can then be twisted into a single 'core' on one side of the coax. Cut off the surplus leaving a tail of about 3/8th of an inch long into which a stiff wire can be inserted. The offcuts of some component having fairly thick leads is best. This single wire is then soldered into the middle of the bundle being quick with the soldering iron in order to avoid heating the insulation between inner and the braid. Make certain there is no mechanical strain on the coaxial cable or inner when doing this. Before making the screen connection to the PCB, prepare the inner conductor by stripping the insulation and tinning. The screen connection is made to the PCB by inserting the single ex-component lead into the PCB screen hole and soldering. Finally make the inner connection. (An alternative approach with small flexible cables, is to pull the inner out through a hole in the screen without unravelling it.)

PCB Artwork

Craig Douglas, G0HDJ, writes that he experiences frequent problems with hairline fractures in his own self laid out PCBs. I can assure Craig that he is not the only one! In the case where the tracks are being laid on transparent film, such that multiple copies can be made by exposure with ultra-violet light onto photo-resist coated PCBs, the answer is to examine the artwork very closely with a magnifying glass after it is complete. This is often helped by doing it over a light box with an ordinary white light source. You may even be able to fit an extra ordinary bulb inside the same light box that is used for ultra-violet exposure. For single projects where the artwork forms the etching resist, it is much harder to see the breaks as they are against the darkish background of the copper. My only suggestion is to do the whole layout twice over because the chance of two breaks occurring right on top of one another is extremely remote. This may seem like a waste of effort but it is often trivial compared to the time spent hunting for faults, or supposed design errors, only to find a broken lead! Many home 'etchers' will be aware that the gap on the copper arising from a hairline crack is much wider than the break in the artwork because the ferric chloride tends to etch away the copper just under the edge of the resist material. Craig asks about shelf life and materials. In my experience, the special rub-on transfers intended for PCB work do have a finite shelf life, after which they are prone to cracking or failing to peel cleanly from the backing paper after being rubbed down. I suspect this is measured in terms of a small number of months. For ultra-violet work, a very dense black material is necessary to stop penetration of the light rays. The special rub-on transfers are made of suitably dark material but often it is difficult to obtain all the line widths and shapes, or letter sizes that you require. 'Lettraset' type transfers can be used with care, I use a range made by a firm called Graffik. I have not used them as an etch resist though. I have also tried copying a pattern with a photo copier but it is a complete waste of time! The deepest shade of black that any of my local machines will print is still slightly transparent! At one stage I required an image inversion for a track patterned ground plane and the only satisfactory method that I found was to have it done photographically; this was terribly expensive and inflexible since every hole change required the ground plane artwork to be re-photographed! That is why my circuit board ground planes do not have any etching on them at all. I have not had much joy finding pens with very fine points with a very black ink either; if they are really black, they seldom dry on transparent film which is non absorbent. Occasionally I have to touch up the resist on a UV exposed board, I use a Dalo pen which produces a blue thickish varnish - it works very well provided you let it dry before putting the PCB in the ferric chloride. I am told that nail varnish and various brands of hair spray are also very effective but I am not quite sure how one gets a track pattern with a spray on lacquer. I have also considered exposing the output from my HP deskjet printer with ultra-violet light; even after two passes through the printer (which did align very well) on ordinary paper, the image was still not dense enough for the ultra-violet. Do any members have experience of using CAD programs with low cost printing techniques to make PCB artwork? G3PCJ

Taunton matters

Gerrit ten Veen PA3FOY has sent me some photos of his splendid Taunton; unfortunately the photocopier does not do justice to his handiwork (like the PCB artwork!) but I was able to note the use of Meccano (I still have the remnants of my childhood sets!) and also a piece of folded aluminium as a temporary front panel with the PCB sitting on a small cardboard box prior to ultimate boxing. This had kept lead lengths reasonable and still allowed access to the underside. Poor Gerrit suffered a heart attack and now has more time for radio as he is off work - we all wish you well for 1997 and beyond. He mentions unwanted markers at 500 KHz intervals, these are free calibration markers which are a by-product of filtering compromises! They arise from the VFO having a 500 KHz swing with crystals which are a whole number of MHz. Ray Donno also reports that he has had his Taunton going on 10m producing 0.5 Watts without the extra transmit amplifier mentioned by Tony Measures. He used TOKO 4612s instead of 4613 without ill effects. He wonders if 10 and 12m would work on the same two band card; I have my doubts owing to the extra lead lengths and resulting capacitance. G3PCJ

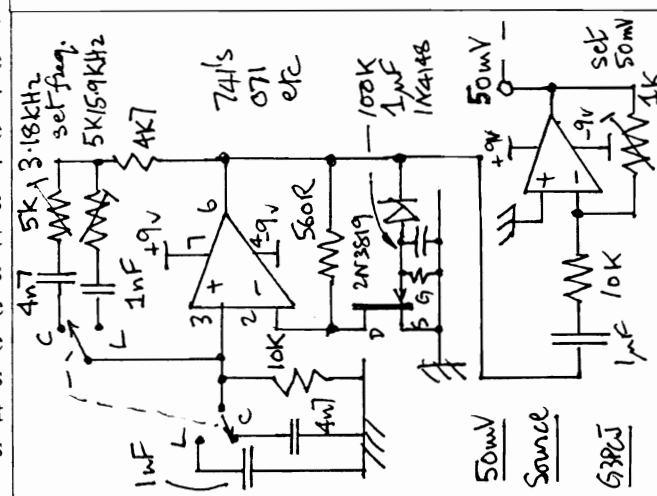
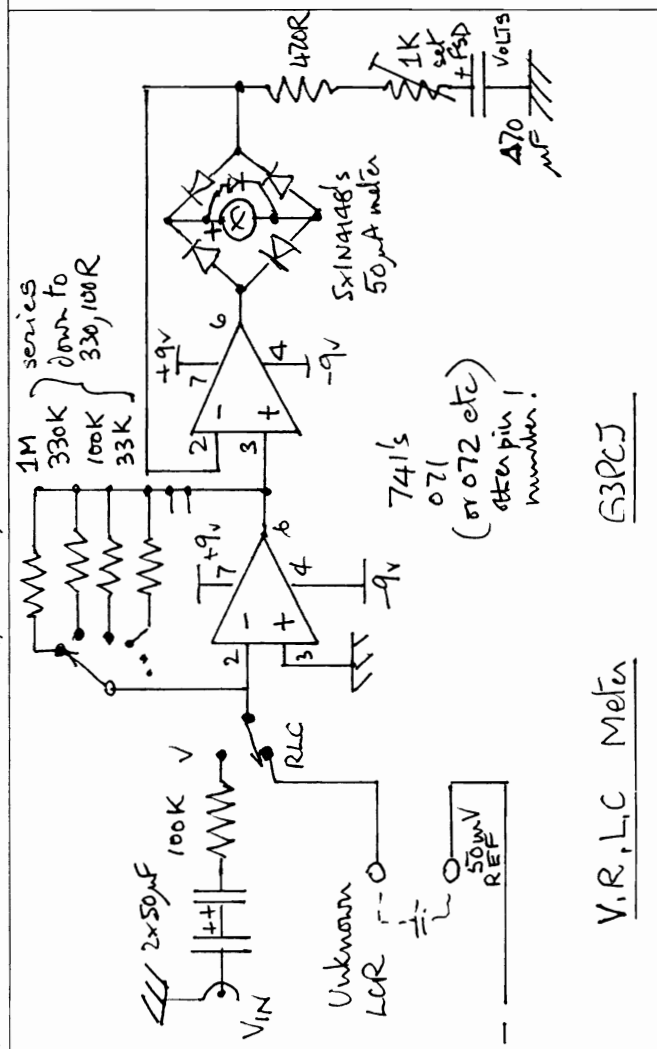
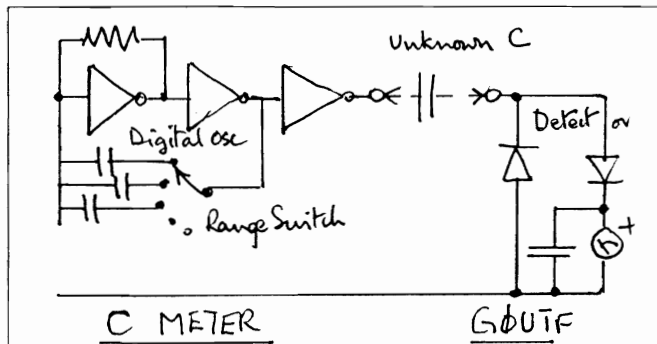


Measuring Components

David Proctor, G0UTF, suggests we should all have instruments to measure parts bought at rallies etc. and points out that for most purposes a 10% tolerance is quite close enough. He suggests the scheme indicated right for measuring capacitance, or alternatively, a bridge circuit comparing unknowns against standard components. I suppose that I am spoilt in that I have to buy new parts from repeatable sources for kits and I therefore use these for development work. However many years ago I made up an instrument which was a combined AC voltmeter and RLC meter. The basis is a sensitive AC voltmeter able to read from 5 mVolts to 50 volts RMS FSD. Components are measured by using them to determine the gain of an op-amp, to which is applied a known constant 50 mVolts and then measuring the output voltage. The voltmeter part of the circuit actually responds to the average value of the waveform but for sinusoidal signals this is of no consequence provided it is calibrated with a sine wave signal. The voltage, or component value, is read off the meter scale directly (when set to a suitable range). The V and C scales work forward but the R and L scales read backwards which is not quite so easy but as they are used less often it hardly matters. The use of the following frequencies allows the component values to be read off the same scale as is used for voltage/resistance. Capacitance is measured with a frequency of 3.18 KHz while inductance is measured with a frequency of 15.9 KHz. The following table gives the impedances and FSDs. R_f is the switch selected feedback resistor.

R_f	$V_{in\ FSD}$	R or X_{IN}	C_{FSD} 3.18K	L_{FSD} 15.9K
1M	5 mV	1M	50 pF	10 H
100K	50 mV	100K	500 pF	1 H
10K	500 mV	10K	5 nF	100 mH
1K	5 volts	1K	50 nF	10 mH
100R	50 volts	100R	500 nF	1 mH

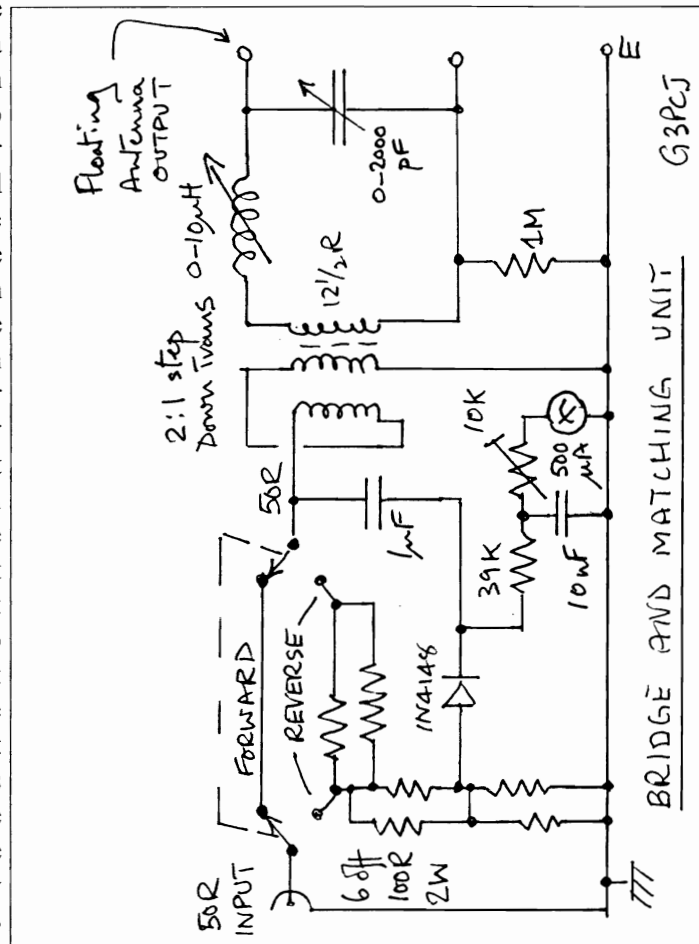
The table is based on a R_{in} for voltage of 100K and a reference voltage of 50 mVolts. I used a 1 pole 12 way switch which made it possible to use the intermediate values with a FSD based on 15 for voltage. The meter part of the circuit is shown in the middle right. The meter movement is within a full wave bridge rectifier inside the op-amps feedback path so that the diodes effectively become perfect! I used 741 op-amps but more modern types such as the TL071 or dual 072s could be used. 9 volt supplies (of both polarities) are the minimum but up to + or - 15 volts is allright. The circuit that I used to provide the 50 mVolt reference is shown in the lower box. I used OA10 diodes but probably 1N4148s will be OK. Please write if this is not clear enough for building yourself. G3PCJ



Antenna Matching Units and other matters

Stephen Melling writes that he still has difficulties with power measurement and the words in our licences. He points out that power is normally measured in terms of the RMS heating effect whereas the licence talks about the mean power and there is a small but significant difference. I passed this onto my technical consultant Eric G3GC but he apologises as he has been heavily occupied producing the newsletter for the Yeovil ARC; he intends to cover this as part of an article that I have asked him to write on decibels. Like several others, Stephen suggested 50/70 MHz rig kits and an antenna matching unit. These have been on my mind for a while, but neither is easy. The rig would be a single band phone superhet (with the standard optional CW kit) but doing the TR switching around the IF strip is not possible with 4066 switches so an alternative way has to be found to keep the price reasonable. The 'VFO' will have to be an overtone crystal mixed with a low frequency actual VFO for stability. I hope to use NE612 mixers with a dual gate MOSFET IF amp as standard. For the RF output, it will not be possible to use the IRF510 on 50 or 70 MHz so, on cost grounds, I think the output stage is likely to be a 2N3866 producing about 1 Watt. I have an open mind as to whether it should have extras like AGC, S meter etc.. Any thoughts would be most welcome.

The circuits for AMUs are easy but I have failed so far to come up with what I regard as a cost effective kit owing to the difficulties with inductors and variable capacitors suited to up to 25 Watts. I have not yet seen small roller inductors, so it has to be equal spacing tapped inductors with a rotary switch perhaps in a coarse and fine arrangement; the alternative is multiple inductors increasing in binary steps and a switch for each. Neither is elegant! I had hoped to use small binary coded rotary switches but the switch elements are commoned which is a snag. Air variables are terribly expensive, particularly for large values with adequate plate spacing for about 500 volts which might be generated into a high impedance feeder. I plan to incorporate a resistive matching bridge which will also indicate output power. This is the easy part. The intended circuit is shown right but for the present you will have to go part hunting at rallies (with the component checker)! Another interesting point concerns the mechanical style; I envisage a Pitney style unit but it hardly needs an etched PCB as most of the parts are likely to be mounted on the back of the switches etc.. I hesitate to put any particular style of input/output connectors on it because so many different types are in use - screw terminal PCB blocks again I think! G3PCJ



New projects!

In the light of a customer's request, I spent much of last Sunday doodling new designs. Several interesting ideas are beginning to germinate! A 5 Watt 80m CW TCVR using just a couple of chips and a few FETs with a ceramic resonator which seems to give 60 KHz coverage in the top half of the CW section. The next item was a simple regenerative TRF RX for 20, 40 and 80m having tuning limited to just wider than the bands. The last item is a 5 Watt CW crystal mixing transmitter for any single band 20 (maybe 15m) to 160m to go with the Martock. This would use much of the Frome's circuitry. I will let you know how these develop.

The Somerset Contest

Don't forget to have your rigs ready for this contest organised by the G-QRP Club over any four hours of March 27th 1997 on the 80m band only. Full details in the Autumn 1996 SPRAT Iss number 88. First prize is a *Frome* receiver for the band of your choice; all properly completed entries also go into a draw for a *Pitney*.

Happy Christmas to you all from Tim G3PCJ

Hot Iron

Issue 15

"Journal of the Constructors Club"

Spring 1997



Editorial

We have a slight change in format as I am now preparing this on the toy which I obtained earlier this year. Just at the moment I am still fuming since it has taken me over an hour to get the headings etc. correct for this new format. I do wish that everything didn't change so much from one product of a family to another! But where would we be without them! I know it is really a case of lack of practice and one could easily spend many hours a day at one just learning how to use the latest gimmick! My son is constantly urging me to make an Internet connection and many letters contain their author's E-mail address. I just can't bring myself to spend more time every day on it and to increase BT's bill. (No cable out here in the sticks yet!) Many of you readers have experience in this field and I would love to have some comment from you - am I being old fashioned, lazy, or missing out on a splendid opportunity? For publication or not as you wish.

Contents

- Decibels
- Using scopes
- Rig Updates
- Simple AMU
- Power 'values'
- Ceramic Resonators
- Snippets

The onset of Spring, at long last, reminds me that the Yeovil ARC is actively preparing for the QRP Convention on May 18th; to be held in Sherborne at the Digby Hall. The festivities start with an open Dinner on Saturday night (booking essential) attended by this year's VIP

who is Ian Keyser G3ROO and his wife. Sunday has a full program of lectures, competitions and demonstrations etc., together with on-demand morse tests for those equipped with photos etc.. The Construction Challenge is open to anyone and the task is to produce a 'useful piece of gear'. This gives a very wide scope! For serious entries, I suggest you contact Peter G3CQR (whose is QTHR) about the actual rules and other Convention details. The judges will certainly have a difficult task comparing vastly different entries but their decision will be final! A must for keen constructors.

Kit Developments

It has been a busy quarter; these are now available! The Wedmore is a specialist 5 Watt CW DC TCVR for 80m using a pullable ceramic resonator VFO; it has 9th order bandpass filtering and can be used on either RX sideband at will. It is especially easy to set up! Just £49. The Lopen is a 1.5 Watt CW TX to go with the Martock; it can be used on any of the Martock's bands and gives VFO coverage over the whole CW section - again either RX sideband at will. Alternatively it can be used with another RX, either on 80m with the ceramic resonator supplied, or your own crystal up to 15 MHz. £29. The Coxley is a regenerative TRF RX for 20, 40 and 80m derived from the Pitney but with tuning limited to the amateur bands. The companion CW TX is the 1.5 Watt Godney; this can work on any 3 frequencies to 15 MHz. A pullable 80m ceramic resonator is supplied for one with space for your crystals for the others - normally for 20 and 40m, but all 3 can be in any band. Coxley & Godney £29 each or £55 for both. The signal generator design is now much simpler. 400 Khz to 50 MHz approximately for £29. Do not forget the **Somerset Homebrew Contest** on Mar 28th - see Sprat issues 89 & 88 for details.

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224 The Copyright of all material published in *Hot Iron* is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year. 1/9/96.

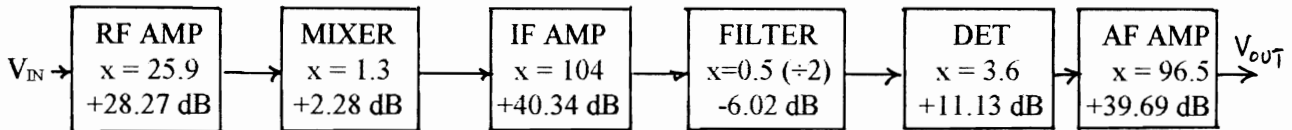


Decibels - by Eric Godfrey G3GC

The one thing that seems to cause more confusion to Amateurs than anything else is the decibel. This has no doubt been made worse by the indiscriminate use by the media of decibels when talking about the loudness of sound. Who has not seen or heard a remark such as "The noise from the aircraft was 140 dB(s)". This is quite meaningless as the decibel is a ratio expressed in a logarithmic form and ratios do not have any dimensions of their own. When expressing a quantity it is essential that the value in decibels is always expressed relative to some specific value of the unit to which the decibels apply. For instance to say that a transmitter has an output power of 20 dB is quite meaningless. However it could have a power gain of 20 dB which would be meaningful being equal to a power gain of 100 times. However if the output power is stated to be 20 dBW, then this is meaningful since the "W" means relative to 1 Watt. Since positive dBs represent gains, and negative figures represent losses, the 20 dBW is a gain of 100 and the output power is $100 \times 1 = 100$ Watts. A power of 20 dBmW would be with respect to 1 milliwatt and equal to a power of 100 mW. (20 dBmW may be written just as 20 dBm as the "W" is implied in the use of power. The same applies when referring to voltages, the "V" of dBmV may be dropped when referring to voltages with respect to 1 millivolt). Before going any further perhaps we should state the formula for calculating dBs:-

POWER GAIN dBs = $10 \times \log(P_1 / P_2)$ VOLTAGE GAIN dBs = $20 \times \log(V_1 / V_2)$

The calculation for power and voltage differ because P is proportional to V^2 ($P = V^2 / R$) and to square a logarithm one multiplies the value by 2, i.e. $10\log(x^2) = 2 \times 10\log(x) = 20\log(x)$. Why do we bother to use dBs, why not just use the ratios? Well the answer is that dBs are much more convenient as will be illustrated by the following example.



This represents the block diagram of the signal path in a receiver but the values given for the voltage gain (x) of each block are for illustration purposes only and may not be those that would pertain in a practical receiver. The third line are the gains / losses converted to dBs. A gain factor less than one, or negative dBs, indicate a loss in the block.

Overall voltage gain (using gain figures) = $25.9 \times 1.3 \times 104 \div 2 \times 3.6 \times 96.5 = 608,241.8$

Overall voltage gain (using dB figures) = $28.27 + 2.28 + 40.34 - 6.02 + 11.13 + 39.69 = 115.7$ dB

The first calculation involves multiplication and division finishing up with a very large number whereas the use of dBs only involves addition and subtraction and uses figures which are easier to handle. The gain figure above of 608,241.8 to 1 when converted to dBs is, as expected, also 115.7 dB, a less clumsy figure.

An amplifier with a power input of 3 Watts and an output of 12 Watts has a power gain of $12/3 = 4:1$. Expressed in decibels this, in common parlance, is 6 dB but more precisely 6.0206 dB. If both the input and output impedances of this amplifier are the same at say 50 Ω then:-

The input voltage (3 Watts) $V_{IN} = \sqrt{P_{IN} \times R} = \sqrt{3 \times 50} = 12.25$ Volts

The output voltage (12 Watts) $V_{OUT} = \sqrt{P_{OUT} \times R} = \sqrt{12 \times 50} = 24.49$ Volts

Ratio of output voltage to input voltage is $24.49 / 12.25 = 2:1$.

Expressed in dBs this is $20\log 2 = 6$ dB or to be more precise 6.0206 dB.

Provided that the input and output impedances are the same then this voltage ratio will be maintained irrespective of the value "R". From this it can be seen that a four to one increase in power leads to only a two to one increase in the output voltage. This is why that an increase of four to one in transmitter power is required to get an increase of one "S" point (6dB - 2 x Volts) at the receiving end.

For an amplifier, power and voltage gains, expressed in dBs, are only the same if the input and output impedances are the same. However, even in a passive circuit, voltage gain is possible without there being a power gain. This is illustrated in Figs 2 and 3 which show two ideal lossless transformers.

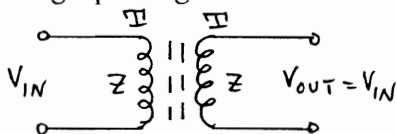


FIG. 2

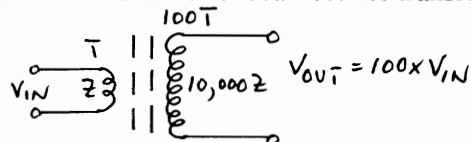


FIG. 3

In Fig 2 the transformer has equal turns on the primary and secondary and therefore both the output voltage and impedance must be the same as the input voltage and impedance. Since the transformer is lossless the input power must be equal to the output power. Therefore both the power and voltage gains are equal at unity. Since the logarithm of 1 is zero both $10\log 1$ (power) and $20\log 1$ (voltage) are zero, i.e. 0dB. In Fig 3 however the lossless transformer now has one hundred times as many turns on the secondary as on the primary. This means that the output voltage will also be 100 times the input voltage and the voltage gain is 40 dBs ($20\log 100$). However since the transformer is a passive component the output power must still be equal to the input power. This accounted for by the fact that the output impedance has also increased but by the turns ratio squared $(T_2 / T_1)^2$ which in this case is $100^2 = 10,000$. Therefore the output impedance across which the output voltage is developed is ten thousand times the input impedance. Expressing this mathematically in Fig 2, $P = V^2/Z$. In Fig 3, $P = (100V)^2/10,000Z = 10,000V^2/10,000Z = V^2/Z$, which is the same power as in the one to one transformer of Fig 2. Therefore the voltage gain in Fig 3 is 40 dB whereas the power gain is 0 dB.

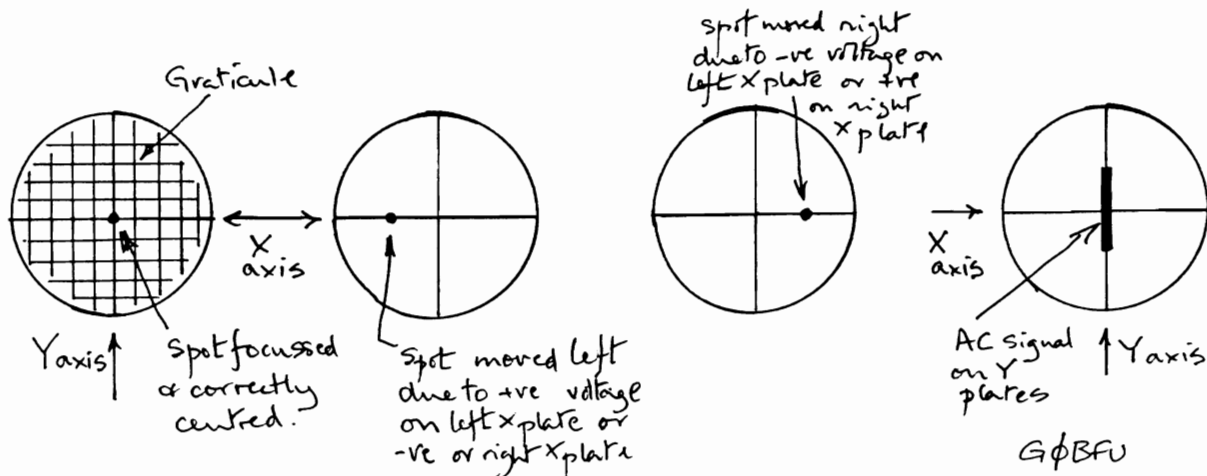
Thus when one is dealing with dBs one must be very clear about what the impedance is and whether the dB values used are for power or voltage.

Using an Oscilloscope by Dick Turpin G0BFU - Part 1

The oscilloscope is one of the most interesting instruments available to the radio amateur/constructor but its real value is only determined by the operator's skill. Most amateurs fail to obtain this skill due to a lack of understanding in its mode of operation and controls. So, if you have one but have not yet used the instrument:-

1. Check that it is set to the correct line voltage and frequency to suit your supply.
2. Before switching 'on' be sure you have made yourself familiar with the positions of all controls, even to the extent of drawing a copy of the control panel with all controls clearly marked, then test your knowledge.
3. Turn the 'Intensifier' or 'Brilliance' control fully anti-clockwise so as to prevent a trace or spot from burning the fluorescent screen inside the tube face. Develop a good habit of doing this after each observation.
4. Before making any observations, allow it to reach normal operating temperature; this is more important for older scopes whose circuitry is more prone to temperature effects.
5. To make 'observations' on any item, a 'probe' will be necessary, plugged into the input.
6. Advance the 'brilliance' control to about halfway (hopefully), when a spot (or line if the timebase is working) should appear near the screen centre. If the spot is badly focused or fuzzy, try adjusting the 'focus' control. It may need resetting for different brightness settings. Make certain that you can centre the spot using the 'X shift' and 'Y shift' controls- sometimes called 'X and Y position' controls.

Now one must review the basic operation of the scope to enable the operator to make primary observations. The spot is formed by a beam of electrons which pass between two pairs of deflector plates - one pair are vertical and these are the X plates. If either plate is charged positively by a positive voltage, the negatively charged electron beam will be attracted towards it. If the other plate is made negative, it will repel the electron beam. So the spot will move from its central position to a position which will depend upon the applied voltage on the plates. See diagrams below.



Similarly, if the two Y plates are charged instead of the X plates, the spot will either move up along the Y axis or, on a change of polarity, down the Y axis. Now one has a simile with a centre-zero meter, single range and no calibration but useable with its needle moving either sideways or up and down. If an alternating voltage is applied to the Y plates, then at very low frequencies (say 1 Hz), the spot will move up and down the Y axis equidistant from the X axis. As the frequency is increases, the spot will plot out a luminous vertical trace, or line, equal in length above and below the centre of the X and Y axes. How the signal is applied to the plates is the subject for another time, so do not forget the diagram and to zero the brilliance control before you switch off. Oh, don't lock away the multimeter yet, you might need it again!

Kit Updates

Adjustable CW filter. Gerrit PA0FOY and Ed EI7DV, both observed that the CW sidetone was just audible all the time when the kit was added to their Tauntons. The cause of this is failure of the switching or keying transistor (TR4, a BS170) to act as a perfect switch! When off, its effective impedance was sufficiently low for there to be still some signal passed to the output filter and buffer TR5. The cure is to lower the impedance after the switch so as to increase the attenuation when the switch is off. This is done by reducing R21 and R22 to 22K. The on resistance of TR4 is a few Ohms when the key is down, so reducing these resistors will cause a slight decrease in output level but there is plenty of signal available and only RT5 and RT6 should need resetting afterwards. More significantly, they also noted that the first burst of RF in a CW sequence, after going to transmit, had a very slow rise time. This was due to a slow rise in the standing current of the TX's output stage IRF510; Gerrit tracked this down to excessive decoupling of the FET bias line. This cure is to replace the yellow bead 10 μ F tantalum capacitors in the Taunton (C304) and in the Bruton (C302) with 100 nF disc ceramics. These components are now included in the Adjustable filter kit. My thanks, gentlemen!

Taunton - unused section of 4066. Ed EI7DV also had another strange symptom. After switching on, the RX worked fine but after going to transmit, it failed to fully revert to receive with the TR relays still just held on. It was eventually traced to a damaged 4066 IC105 which was holding the RXC line to 8 volts after transmitting, this was sufficient to partly turn on TR305 and hence hold the relays. The damage appeared to be associated with the unused section of the 4066, so if you have problems, it is best to connect all pins of this unused transmission gate to 0 volts. Cut the RXC track between pins 12 and 13 of IC105 and put a wire link from the track linking pins 10, 11 & 12 to 0 volts.

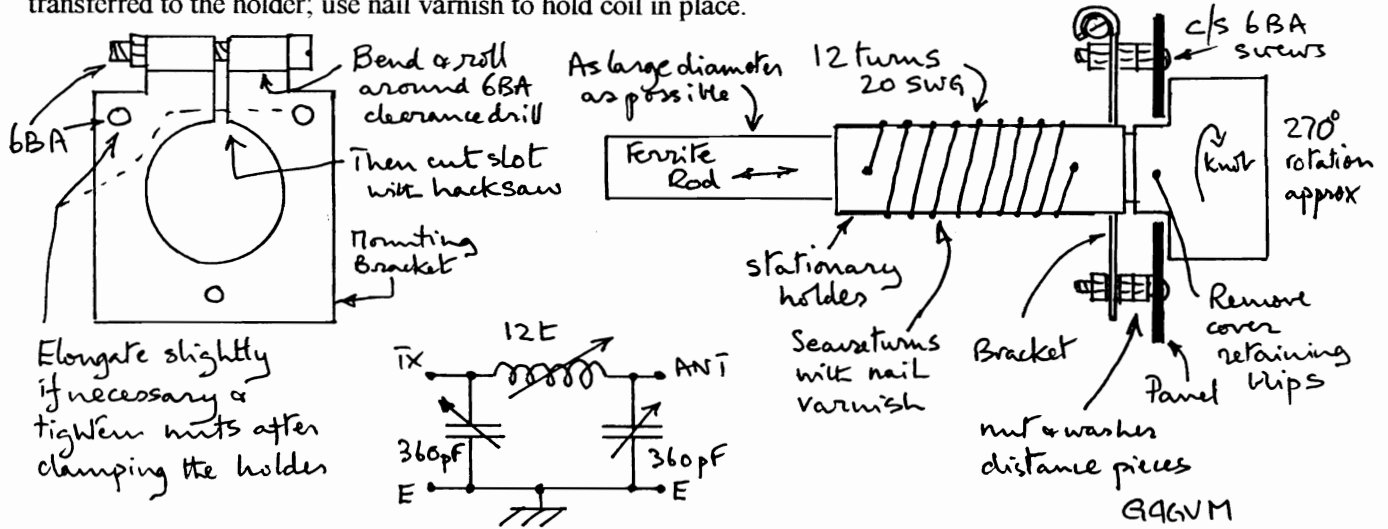
Bruton and Taunton. Dave, G7BTX/2E0AMS, experienced a nuisance hunting of the AGC in his Bruton between two widely separated received levels when the actual signal was somewhere in between. The data sheet for the SL6270 suggests that when it is used with a single ended input, the 'unused' input (of pins 4 or 5) should be connected to 0 volts by 22K and heavily decoupled at audio. This is to stop a nasty control type oscillation at about 0.5 Hz. My experience is that often a lower resistance is needed hence these two rigs have 10K/10 μ F specified for this. Dave found that his worked best without any resistance. I presume that it didn't oscillate either. Let me know what your does!

White Rose/Taunton. Fred Maddison, from Australia, mentions that he tried making his White Rose rig into a switched multi-band version and fitted one of my 5 digit counters. There was breakthrough problems from BC stations and other sources so he eventually abandoned the idea. Ray Donno also tried it with his Taunton using a bank of interlocking push button switches. It was too complicated and subject to breakthrough. As the wires to the parts that change on each band get longer, all these problems becomes increasingly severe. Switched multi-banding has to be designed in right from the start and not added afterwards! G3PCJ.

Simple and effective AMU by Derek Alexander G4GVM

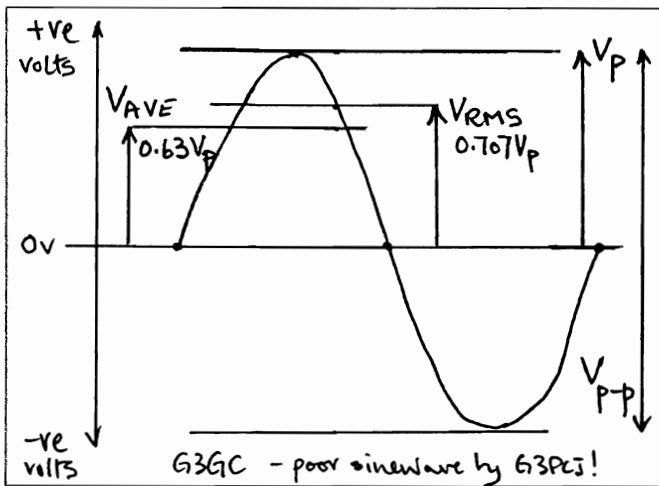
For a couple of years now, I have been using G4LDY's design, as illustrated in the G-QRP Club Circuit Book, when /P with my Yeovil rig. The design is a simple π circuit using two transistor radio type tuning capacitors and an inductance, varied by the position of a ferrite rod within it. It is this last item that makes it somewhat clumsy and so I was delighted to note G4UEL's idea in Sprat No 89 which made use of a used lipstick holder to move the rod in or out of the coil. Many lipstick holders are made of metal but fortunately whilst on holiday, I discovered a 'lip-salve stick' which is identical but made entirely of plastic. This meant the coil could be wound on the holder thus reducing the total depth and obviating the need for a separately mounted coil and former. The tricky bit was how to fix the whole set-up to the panel so that the control is presented as just another knob. After some thought, I

decided on the method illustrated. Helpful tips - use the bracket as a template to cut the panel holes as this will make it sit true. Use nuts and washers as distance pieces to place the bracket on the edge of the holder static piece. wind the coil on a slightly smaller diameter former so that it hold tight when transferred to the holder; use nail varnish to hold coil in place.



More about Power Measurement by Eric Godfrey G3GC

This note is in response to a letter sent to Tim G3PCJ by Stephen Melling, G8FUH. The fundamental definition of power is related to the heat dissipated in a resistive load when a certain voltage is applied across it. The power dissipated in a circuit is given by $P = E \times I$ or E^2/R . This presents no problem at DC where the voltage is constant. However with AC, independent of the frequency, the voltage is varying through the cycle but for the same nominal power the heating effect over the period of each cycle must be the same as for DC. The fundamental alternating voltage is a sine wave as shown in the diagram. The different voltages, i.e. peak, peak to peak, average and RMS,

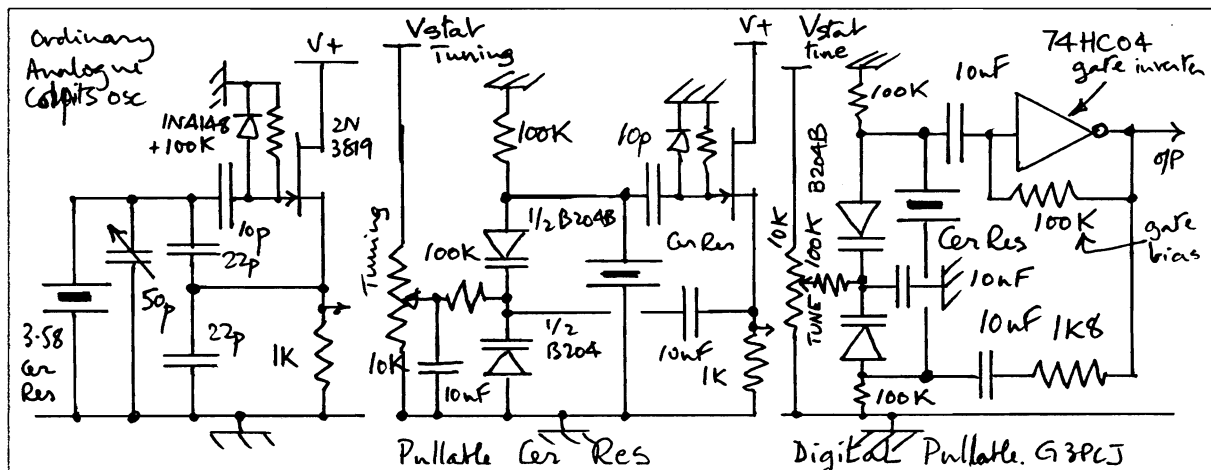


applicable to a sine wave are also indicated on the diagram. Since the voltage is varying during the cycle the power dissipated in the load will also be varying during the cycle. It is therefore necessary to sum up all the varying powers during the cycle which in turn requires knowing what the voltages are which are directly related to the sine of the angle in the sine wave. This can be done mathematically or by taking samples at regular intervals throughout the cycle. If one does this every 5 degrees from 0 to 180 degrees, then summing these and then finding the average or mean by dividing by the number of samples then one gets that the average voltage is 0.63 times the

peak voltage. However using this in the V^2/R formula yields an incorrect result since the average power is the sum of all the individual powers. What has to be done is to take each of the sample voltages, square it, add them altogether, average them and then find the square root. This is what RMS voltage is compared to average voltage, i.e. the root of the mean (average) of all the voltages squared. This results in the familiar value that $V_{RMS} = 0.707 \times V_{PEAK}$. Using average voltage instead of RMS voltage to calculate power will result in a difference of 1.002 dB. Some of the confusion around this has I believe been brought about by the use of the expression "RMS" power, meaning the power calculated by using RMS voltages but which in fact is the average power. The use of the term "RMS" power is in my opinion quite incorrect and one should always use average power. Our licences use the term average power and defines the peak envelope power as the power averaged over one cycle at the peak of the envelope. Thus the $P = 0.707 \times (V_{PEAK})^2/R$.

More on Ceramic Resonator VFOs

Since I last wrote about these last Autumn, I have devised more useful circuits. As their Q is roughly midway between a crystal and a good inductance, they tend to have the advantages of both! I have already mentioned the commonly available 3.582 MHz types which can be pulled down to cover most of the CW section of 80m. I have been developing various varactor diode tuned versions of the Colpits oscillator configuration. The usual analogue circuit (left) suffers from having fixed 'Colpits' capacitors so reducing the pulling range, but the middle diagram below shows how they can be made variable with twin varactor diodes; the right diagram shows the conventional digital 'Colpits' oscillator modified for varactor control. In both circuits, the labelled 100Ks are to apply DC bias to the varactor diodes only; their value is not critical. Although the digital circuit is biased into its linear region, the output is digital. A word of warning! Any digital oscillator (without a very high Q resonator like a ceramic resonator/crystal) is quite likely to suffer from phase noise due to jitter on the switching action of the gate. This is why you don't find a digital VFO oscillator directly driving a RX mixer.



Most ceramic resonators have a tolerance of 0.5% which can be significant. For fixed frequency use, their nominal load capacitance should be 30 pF reducing to nearer 20 pF over 15 MHz or so. The load C is made up from the series value of the two Colpits capacitors which are usually equal. If the Colpits Cs are varactor diodes, then strays will mean that it is unlikely to be possible to get it operating at a frequency higher than the nominal value, so they should always be considered as going down only. With care, it is possible to go down up to about 2% of their nominal frequency. They are available in quite a wide range of standard frequencies, but so far 80/160m are the only bands where they are within the band; the others are on the LF edge and hence not directly useful. Frequencies can be mixed with a 612, eg. a fixed 20 MHz less a pulled 6 MHz for 20m. The 5.6 MHz value might also be useful when doubled to 11 MHz. I have found sources for the following MHz frequencies:- 0.455, 0.5, 0.56, 1, 2, 2.45, 3.58, 3.69, 4, 4.19, 4.91, 5, 5.5, 5.6, 6, 7.3728, 8, 10, 11, 12, 16, 20, 32, 33.86, 40! G3PCJ

Progress on the Minehead

This is the new rig for 10, 6 and 4m. The major problem to overcome is VFO stability, so a mixing scheme is inevitable. In the interests of overall simplicity, it will be a double sideband phone or CW rig with a DC RX. I want it to do any single band by changing the coils/capacitors/ceramic resonator(!); the oscillator plan will also do any of the major HF bands but I am not sure that I can obtain all the inductances for 15m to 160m in the same TOKO can size required for a common footprint! No problems with the three above bands though. I hope to have a lash up working soon!

Free Yeovil 40m Converter!

Jim Geary, GW8HKY, has returned his built 40m converter because he decided against altering the main rig. He has asked that I offer it free to anyone who has a good home for it. If anyone who has a Yeovil without 40m and would like it, please get in touch with me. He has also made up his signal generator, with a three digit counter, into a smart instrument using a Maplin box type PC25.

Cleaning PCBs

When I had Ed, EI7DV's, Taunton back for investigation, its PCB was immaculate! After a little prodding, he told me the secret. After loading the PCB, the flux residue can be scrubbed of with a toothbrush and cellulose paint thinners - obtainable at your local paint spraying garage or paint shop.

Hot Iron

Issue 16

“Journal of the Constructors Club”

Summer 1997

Editorial



Firstly, I regret being a little late in the production of this issue of Hot Iron - my only defence is that I have been very busy in work and domestic matters - my apologies.

This time of the year tends to be a little less hectic for radio activities; things like gardens assume a higher priority for most people! I wish there was an electronic equivalent of grass; cut it and all it does is produce even more! (Thank goodness I say with the farming hat firmly in place!) I suppose the nearest equivalent is noise - electronic that is. No matter what one does, it's always there and you cannot avoid it; from a design viewpoint it is usually a nuisance and you ignore it at your peril - at best you can use it to help evaluate your antenna! It is a widely misunderstood subject and I am very pleased to have a contribution from Eric G3GC on the subject. The lull in (some!) activities allows a little time for pondering over future projects. After the Street is finished (see later), my HF range is fairly comprehensive apart from rigs for FM. This mode will assume more importance on the higher HF bands as the sun-spot cycle develops and I am beginning the doodlings to address 10 and 6m FM. I have a

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- Two band mixing
- Noise
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- Measuring inductors
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part finished project for a new version of my QRP Booster aimed at /P operation with less than ideal aerials; the power amplifier has a target of 25 Watts output on 12 volt supplies to 30 MHz with a 10 dB receive RF amplifier. Aside from a few items of test gear, my list of future projects is small - so any suggestions for projects not already covered will be glad received.

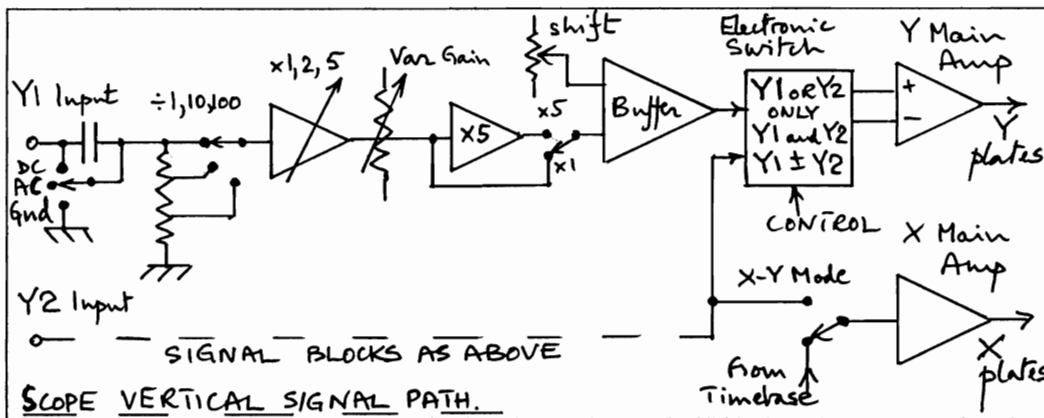
The Street

After many hours going round in circles, I have changed the name for the 6m rig to get away from earlier DC or transverter designs! *The* problem, with any rig operating above a few MHz, is frequency stability - both on receive and transmit (chirp and unwanted FM). So clearly this has to be a crystal mixing design. The direct conversion approach has many attractions, but most builders tackling a fairly advanced rig, would much prefer a superhet. Luckily the Taunton's 6 MHz IF system lends itself to the higher bands provided the crystal oscillator will also work as an overtone oscillator. A 40 MHz crystal mixed with a 4 MHz VFO produces a 44 MHz LO which is then added to the 6 MHz IF to produce 50 MHz. Other standard value crystals can be used to give all the other HF bands except 12m/25MHz; this needs an awkward crystal frequency and sideband inversion - so no 12m I regret! A rig of this complexity needs to be different from the Taunton so it will have CW and SSB facilities as standard. Furthermore, an idea for two band mixing (see later article) means that it can do any two bands without much difficulty. Hence it is a single/twin any band phone and CW superhet for up to 6m. For frequency reasons, the TX output stage has to be a VN66AFD with a power output of about 1.5 Watts on 12 volts, perhaps 5W on 22v. It will have an IF amplifier for extra HF sensitivity and TX output low pass filters but other frills have been omitted to keep the cost and size down; it is still too large for one PCB so it has to be on separate RX and TX PCBs. I am starting the PCB layouts now - to those who have expressed an interest, thank you for your patience. Tim Walford G3PCJ Editor

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year. 1/9/96.

Using an oscilloscope by Dick Turpin G0BFU

Usually the first item in the input signal path from the input probe to the Y plates, is a switch which allows for AC or DC coupling; the latter allows applied DC signals to deflect the spot (together with any AC component) whereas the AC setting has coupling via a capacitor which rejects the DC component. This switch sometimes also has a 'ground' position which applies 0 volts direct to the X amplifiers so that the spot's vertical position (or line) can be set to a convenient vertical point or graticule line with the Y shift controls. The following stage is an attenuator/amplifier with a control marked AMPL/DIV starting with attenuation in the first three stages of X100, X10 and X1, followed by three stages of amplification of X1, X2 and X5; thus a suitable setting or sensitivity can be found to deal with a wide variation of signal strengths. In older scopes, these stages were separated or non-existent; instead individual Y_{DC} and Y_{AC} terminals were provided. Some controls were marked as 'Amplifier Selector Control' for use when signals under observation required extra amplification. In modern scopes, extra sensitivity is often provided with a pull switch but beware that usually the signal bandwidth is reduced when this extra gain is used. Some scopes also have a continuously variable sensitivity control - useful for making a waveform fit exactly to two calibration points or lines - do remember to return this control to full sensitivity after the test has been done or your subsequent measurements will be wrong! It is following these input stages that in more modern scopes, the signal passes into a buffer stage where it can be routed (by the Channel Switch) to the final Y amplifier; the latter being connected to the Y deflection plates (or routed to the final X amp and plates). The following partial block diagram helps explain the sequence. In a similar manner to the X plates, the Y plates will produce a vertical spot displacement for a DC voltage or a vertical line for an AC voltage



with the spot moving up and down at a speed depending on the applied frequency. The height of the vertical line or band representing the peak to peak voltage.

The scope's Y deflection system can be used as a voltmeter for gain or attenuation measurement, or alignment or as a null indicator such as might be used in an AC bridge for measuring resistance, capacitance and inductance. For DC measurements, it is often easier to have the timebase on (free running) with a moderately fast sweep speed as it is easier to measure vertical displacement between lines rather than the movement of a single spot. When used in this manner the actual timebase speed is immaterial. Even with high input frequencies, it is not essential to have the actual waveform displayed with a synchronised timebase; the height of the signal's horizontal band can still be assessed.

If the scope has two Y channels, the above input coupling and sensitivity controls are present for both channels. The display of the second channel is achieved by an electronic switch prior to the final Y amplifier which can take signals from either Y input amplifier. When both Y channels are to be displayed, this switch changes between the channels at a sufficiently high speed so that the screen's persistence gives the impression that there are two sets of Y deflection plates. For scopes where the switching mode is automatically selected when both channels are in use, the switching mode is usually dependent on the selected timebase speed; at high sweep speeds, the channel switch gives 'alternate' operation where each input channel is connected in turn to the Y amplifier for a complete timebase sweep or cycle. For lower sweep speeds, the switch 'chops' between both input channels many times within a single timebase sweep or cycle.

Most scopes are provided with a facility to test scope probes (and hence allow their adjustment), this maybe a terminal or a metal loop marked 'probe test' or just 'cal'. In older scopes this provides a 50 Hz signal derived from the mains supply via a special winding on the mains transformer. This is protected by a series resistor so that if accidentally shorted, the transformer will not be damaged. The voltage available on the terminal will be marked (usually as a peak to peak

figure) so that the probe maybe calibrated. On modern scopes, the signal is often a 1 KHz square wave of 0.5 volts (pk to pk); this can also be used to adjust the trimmer of the probe so as to obtain the flattest overall frequency response. This is done by viewing a complete cycle of the square wave (with the timebase on) using the most sensitive Y input attenuator setting that fills the screen; the probe's trimmer is then adjusted for least overshoot and sharp right angled corners where the vertical section of the trace changes to horizontal (for both rising and falling edges). Once a probe has been adjusted, it should be kept on that input channel as swapping to another will need readjustment for a possibly different amplifier/attenuator input capacitance.

Now for a word of warning! Most scopes have the chassis (and sometimes one of the vertical Y deflecting plates) connected to earth via the mains supply cable. This is done for safety reasons and to prevent unwanted 50 Hz hum signals being mixed with wanted signals thus confusing the picture. When the circuit under test also has its 0 volts connected to mains earth, connection of the scope probe earth lead (which is connected directly to the scope's chassis and mains earth) will complete a mains earth loop. Unwanted, uncontrolled and unknown earth loop currents, caused by poor mains transformers and RFI filters etc., can inject significant currents, and hence voltages, in series with the signals being measured. Often this can be overcome by using a mains isolating transformer to power either the scope or the equipment under test. When doing a measurement, if the scope shows a vertical deflection when you would not expect any signal (perhaps because all the gain controls are right back etc.) then be suspicious of your 0 volt connections or that there is an unwanted mains earth loop. The practice of disconnecting the scope's mains earth lead in the supply plug is definitely not recommended! With modern scopes having the ability to subtract one input Y channel from the other Y channel, this problem can be overcome for low/moderate speed signals by connecting the tip of the second probe to the chassis of the item under test and connecting the probe earth leads to each other and nothing else - use the same sensitivity on both channels.

The final article about using scopes, will deal with timebases and triggering.

(Since writing this note, Dick has suffered a stroke - we all wish you a speedy recovery. G3PCJ)

Snippets!

Cleaning PCBs. Following the advice in the last Hot Iron, that cellulose thinners is a good soldering flux remover, Jim Geary G3HKY, warns that it is also very good at removing the identification markings from components! Take care to keep the thinners on the underside of the PCB.

40m converter for the Yeovil. I still have the assembled 40m converter kit that Jim Geary kindly offered to anyone who wants one. Its free!!!

Cases. Ken Shaddick G0TDS recommends the Maplin line of 'Blue Cases' which come in various sizes. Ken has built his splendid Taunton complete with digital readout in the 233 model.

Bruton on 40m. Mike Connolly G0NKC has pointed out a small error in the Bruton Manual concerning the parts for the CIO. In order that the correct sideband is received, the CIO has to be on 6001.5 KHz for 40m not 5998.5 KHz; this means that the inductor L202 should not be fitted.

Yeovil readout on 40m. When Derek Alexander G4GVM fitted the digital readout to his rig, he noticed the 3 KHz error between actual frequency and the readout. He tried the modifications advocated by Jim Chick G4NWJ in Hot Iron 7 but found that it moved the crystal the wrong way going up in frequency producing an error of 6 KHz! Being unable to move the frequency down more than about 1 KHz with the 22 pF trimmer he took the expensive solution and ordered a special crystal for 10997 KHz. It now reads correctly and Derek hopes that Jim could re-explain his method!

Change of FAX number. Due to telephonic congestion, Walford Electronics now has a dedicated FAX line whose number is 01458 241186. The old number 01458 241224 remains for voice.

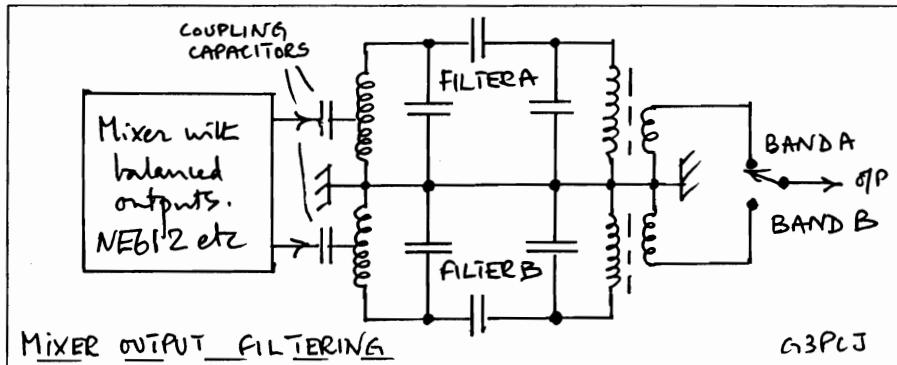
Reverse supply protection.

John Worthington GW3COI had an unfortunate incident with his Yeovil. I am sure that he does not actually look like his cartoon! Since the IRF510s act as diodes to a reversed supply, the PCB tracks then act as fuses. I now have the cautionary tale from his own pen; I shall keep it for another HOT IRON for those interested in what happens to a Yeovil! Thank you John.

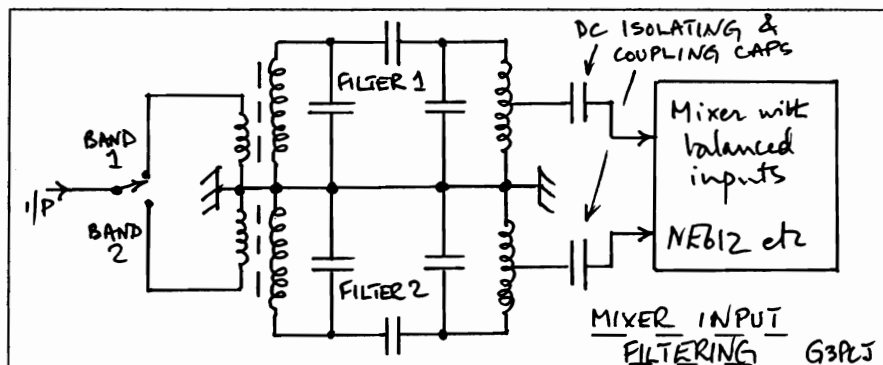


Two band mixing with NE612s

While pondering how to give the Street an economical two band capability, I realised that the balanced **outputs** of the NE612 (also NE602 and MC1496) provide the possibility of driving separate RF bandpass filters tuned for different frequencies. In consequence only a single pole switch or relay is required to select the wanted filter with no contribution from the other filter. Such filtering on mixer outputs is need for crystal mixing local oscillator schemes and for final transmit mixers in a superhet. There is usually adequate rejection when the filters are selecting mixer images, eg 20 and 80m in a superhet with 9 MHz IF and a 5 to 5.5 MHz VFO, but further rejection is often present because the mixer inputs will alter for the chosen band meaning that only one filter will be presented with a valid sum or difference signal. The following diagram shows a typical circuit. (On researching the literature, I find there is nothing new about this idea!)



It would be very nice to be able to do a similar bandpass filter selection with a single switch/relay at the input of a mixer, such as at the front end of a receiver. The NE612 (and 1496) also has balanced **inputs** for one of the input signals, often used for the RF signal. The other mixer input, usually the local oscillator, is single ended and applied internally in the 612. When these mixers are driven by a single ended RF input signal, the other one of the balanced inputs has to be bypassed at RF to ground by a blocking capacitor. (A direct to connection to ground is not possible because it will upset the internal DC bias conditions.) The 612 mixer input impedance is 1K5 so it is seldom possible to connect the inputs to the 'hot' end of an input tuned circuit; it would reduce the tuned circuit's Q too much. In consequence the matching has to be done by 'tapping down' the tuned circuit either capacitively or inductively. If inductive matching is used, then, both above and below the parallel tuned circuit's resonant frequency, the impedance looking back from the input will decrease substantially meeting the requirement to bypass the other one of the balanced inputs. Ideally, the frequency of the rejecting filter would be at least an octave different from the wanted frequency present at the other input. The DC blocking capacitors between filter inductive taps and the device inputs must have a low impedance (less than 150 Ohms) for all frequencies that might be wanted from the filter on the other input. Capacitive 'tapping down' cannot be used. See below for typical circuit:-



In both the above circuits, the filter selection is done at the opposite end of the filter from the mixer; here the impedance is often 50 Ohm and stray capacitance is not a problem. A drawback of the high input and output impedance (1K5) of the 612 is that high stray capacitance can reduce the available bandwidth; this is particularly so where signal routing to the inputs and outputs of the mixer are done with CD4066 electronic switches or relays. The solution used in the Street is to directly connect the filters to the mixers using the above circuits, and to provide separate mixers for the first one in the receiver and another for the final mixer in the transmitter. In this way, the CD4066 has only to route signals at the IF of 6 MHz or audio, and the mixers will work happily with 50 MHz filters at input or output. Luckily the NE612 is not too expensive!

Tim Walford G3PCJ

Noise by Eric Godfrey G3GC

The noise in a receiver comes from two sources, one is the internal noise generated in the receiver and the other is external noise from the aerial.

INTERNAL NOISE

Thermal Noise This is due to the random movement of electrons in any device such as a resistor, valve, transistor etc. These random movements of electrons collide with the relative immobile ions that make up the bulk material. The final effect is that there is no net current in any particular direction on a long term average but rather a series of pulses. These pulses are what produce the thermal noise (Johnson noise).

The noise power may be expressed as:- $p = kTB$

Where p is the thermal noise power
 k is Boltzmann's Constant (1.38×10^{-23} joules per ° Kelvin)
 T is the absolute temperature in degrees Kelvin
 B is the bandwidth in Hz

As can be seen the noise generated is dependant upon both the temperature and the bandwidth of the device. The first of these accounts for why the input stages of very sensitive radio telescopes etc. have their front ends cooled in liquid nitrogen. (approximately -200 degrees C or 73 degrees K). The noise due to the second of these factors is reducible by using filters. Listen to the difference between the noise in a receiver with an SSB filter compared with the same receiver with a 250 Hz CW filter. There is a very large reduction of noise with the narrow band filter.

Care in the design of the receiver front end is most important and it should use good quality components and in the case of active devices (transistors etc.) they should be low noise devices. The soldering must be beyond reproach and any connectors should be of good quality..

The total thermal noise in the receiver should be less than the external noise from the aerial. This may be checked by seeing if you can hear an increase in noise when the aerial is connected at an HF frequency, say 7 MHz. If you can hear the noise increase then your receiver has adequate sensitivity.

EXTERNAL NOISE

Atmospherics This noise is due to lightning flashes in electrical storms which may be hundreds of miles away. These are most noticeable on the LF bands and a noise blanker will usually help to reduce their effect.

Cosmic Noise This is the background radiation in our galaxy and tends to be more apparent at VHF and higher frequencies. We just have to live with this.

Man-made Noise This is more apparent at HF than VHF and is generated by the electrical equipment used by man such as motors, thermostats, computers etc. Careful attention to detail by the manufacturer in the design stage and the use of suppression filters in the receiver can keep this to a minimum but moving to the middle of a wilderness is the best solution. A vertical aerial tends to pick up more interference than a horizontal one but both types should be as far away from the sources of noise as possible.

Hum etc. Whilst strictly this is not noise it can contribute to the ultimate sensitivity of the receiver. It may be due to earth loops or the proximity of heater wiring in the case of valve circuits. Re-routing the wiring will usually solve the problem.

OTHER INFORMATION

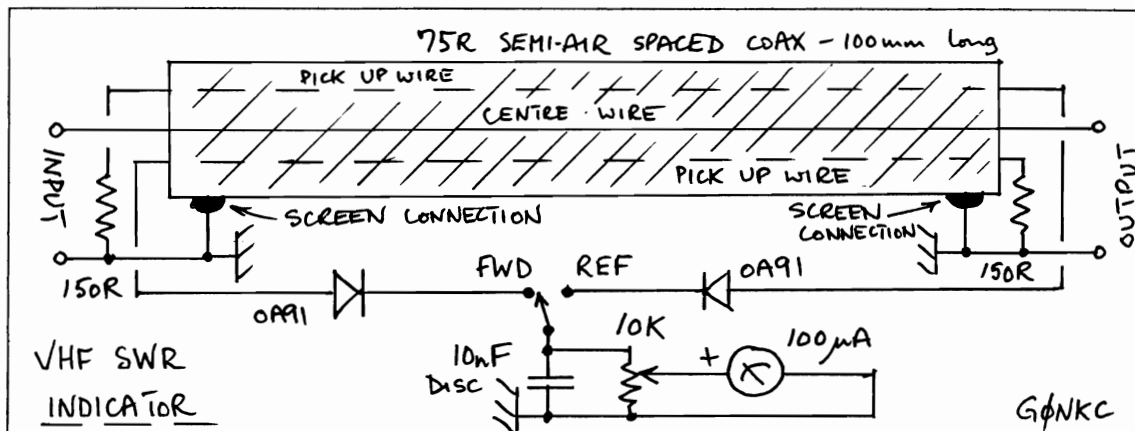
It sometimes happens that although a receiver passes the "connect aerial" test above, there is a lot of noise in the output. This must be due to noise being generated after the first stage of the receiver. This is probably a fundamental design fault.

A common way of specifying the noise associated with an amplifier or receiver is by stating its "Noise Factor". This is a very convenient way of evaluating the overall noise performance of a system but there is no room to discuss it here. This could be the subject for another note in a future issue of "Hot Iron" subject to the Editor's approval. (Yes please - Editor!)

VSWR Indicator by Mike Connolly G0NKC

This device is intended for VHF use (30 - 150 MHz approx.) to give an indication of forward (FWD) and reflected (REF) power from about 100 mW up to about 20 Watts. It is made from a 100 mm length of 75 Ohm semi-air spaced coaxial cable. The typical low loss TV cable has a 1 mm centre conductor with five spacing holes and a capacitance of about 56 pF per metre. Two 22 gauge 1 mm pick up conductors, about 110 mm long stripped from the centre of more of the same coax, are carefully slid right through two air spacing 'holes' on opposite sides of the centre conductor so that

both ends of both extra wires can be connected up as shown in the diagram. When soldering the diodes and resistors to these wires, be careful not to melt the insulation. A matched pair of OA91s is best but not essential and a 100 μ Amp meter is adequate. The whole thing can be contained within a small metal box having suitable RF connectors and all leads should be kept as short as possible. In use, the pot is adjusted for full scale reading of the meter when the transmitter is giving maximum output into a dummy load with the switch set to FWD. The meter scale can be calibrated for known transmitter output powers (after the pot has been set) or marked with a simple linear scale for relative indication.



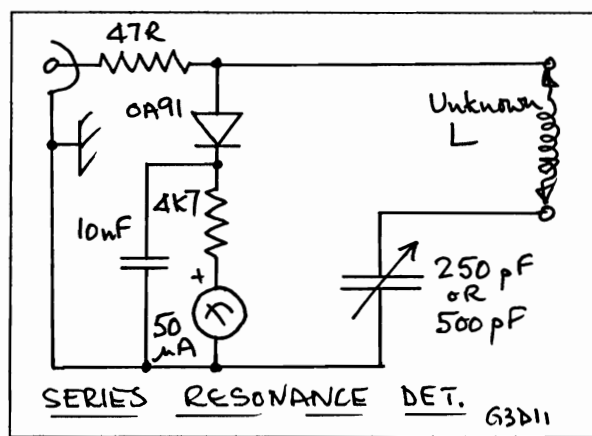
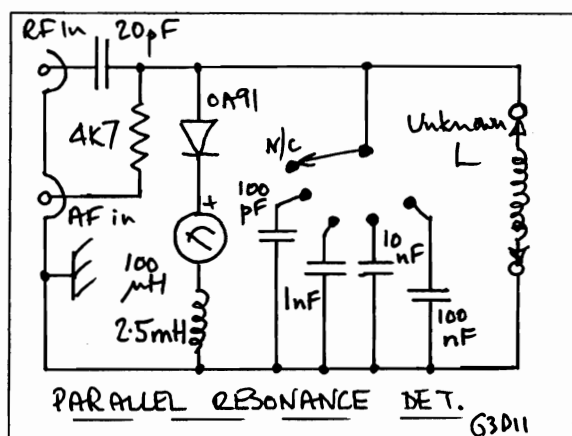
Measuring unknown inductances by Joseph Bell G3DII

Often it is necessary to measure the inductance of a coil taken from the junk box, or when building filters or tuned circuits, to ensure that the coils in use are suitably matched. An indication of 'Q' is also useful. The circuits are easily built and give sufficient accuracy for most purposes. The left circuit is a parallel tuned system, where the resonance of the unknown inductance, and one of the switched capacitors is indicated by a **peak** reading of the meter. The RF source maybe a signal generator, or GDO with a fixed pick up coil, tuned to achieve resonance as shown by the meter. Always start at a high frequency so that false readings are not obtained from harmonics of the RF source. When resonance has been found, the value of inductance is calculated using the ABAC in the RSGB Handbook knowing the frequency and capacitor value. Alternatively work it out from:-

$$L \text{ (Henries)} = 1/(6.28 \times F)^2 C \text{ where } F \text{ is in cycles and } C \text{ in Farads.}$$

Measurement of the Q factor for this tuned circuit is done by noting the two frequencies, above and below the resonant frequency, at which the meter reading is down to 70% of the value at resonance. Q is calculated from $Q = F_{RES}/(F_H - F_L)$.

For lower frequency work on iron cored chokes etc. the left circuit can be used with an audio signal generator. The circuit on the right is a series tuned system, where indication of resonance is indicated by a **dip** on the meter when the variable capacitor is adjusted. It is most useful for matching hand wound coils to a standard inductance.



Subscriptions!

This is the last issue of the current year. In order to ensure you continue to receive Hot Iron during next year, you need to send £6 to Walford Electronics by Sept. 1st 1997. (£8 for overseas members.) No reminders will be sent! Take the opportunity to tell me what articles you want and, even better, send me a written contribution! Items on disc are even better still. G3PCJ

Hot Iron

Issue 17

“Journal of the Constructors Club”

Autumn 1997



Editorial

Welcome to the start of a new year of construction activity and a sincere thank you to all subscribers; it is very pleasing to see that quite a large proportion of you have been members since we started back in 1993. I well remember one particular founder member (and subsequent contributor) who expressed some reservations about the ability to keep material flowing, recounting his experience in another field, that the main difficulties came in year two or three when all the easy topics had been written about! It is a relief to be passed that stage and my file of material awaiting publication goes up and down like most people's keys - far too quickly for my liking! I am always pleased to have contributions and suggested topics, so thank you to those who responded when renewing their subscriptions.

It is sad to see the passing of a national journal but the announcement in the September Radcom that DIY Radio would not be published any more is hardly surprising with a readership of under

2000. The effort involved in putting together a high class colour magazine is daunting - particularly if advertisers are reluctant to take space. One of my best customers remarked the other day on the phone that amateurs are a tight fisted lot! It continues to surprise me how some worry about the cost of individual parts and then loose all the price advantage on postage charges. With DIY Radio aimed primarily at young people, and many articles explaining how to do things for one's spare change, there was not much hope of advertisements paying their way. I advertise regularly in Radcom because over the years I have found that RSGB members have the highest conversion rate from inquiries into kit orders - but it is not easy to deduce whether inquiries arise from adverts or from news items following press releases. Advertising is one of those irritating overheads - it has to be done because if you don't tell people about your products they can't know of its existence and don't order!

Kit developments

I am pleased to report that my prototype Street TCVR has now been working on 80m for some weeks. I equipped it for 80 and 6 metres because the former allows easy testing etc. of the basic rig and 6m should show up the problems of the higher frequency bands - and it has! It is not yet ready for release owing to a couple of problems which took time to cure during my harvesting activities. The TX strip had insufficient gain at 50 MHz requiring an extra IC with partial relayout of the transmitter PCB. Thank you to those who are waiting having expressed an interest, particularly for 6m. About half of the manual is written. Obtaining an electrically robust 50 MHz design is proving quite challenging!

In the bath, I ponder the merits of a band changing phasing CW receiver! The scheme would use crystallised converters in front of a narrow band VFO phasing RX. Any interest? Tim G3PCJ

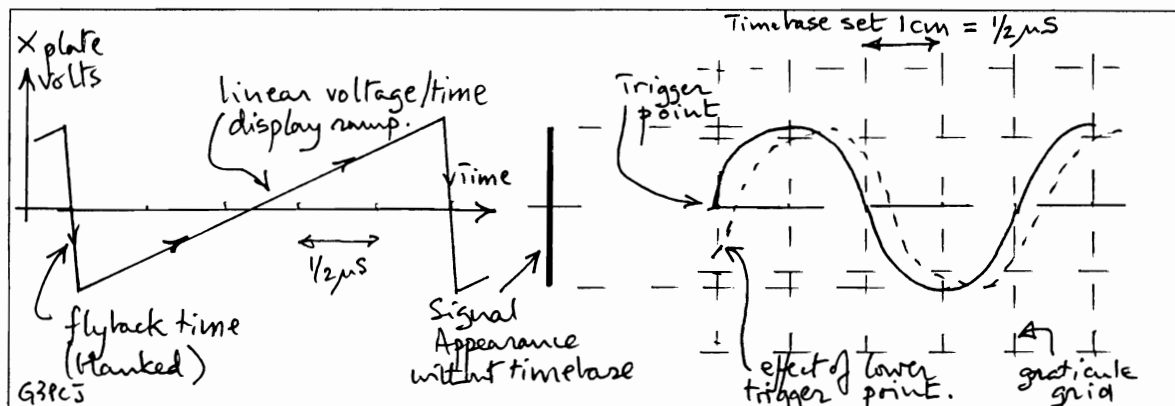
Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 The Copyright of all material published in *Hot Iron* is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year. June 1st 1996.



Oscilloscope timebases & triggering

(This note was to have been written by Dick G0BFU but sadly he is not yet fully recovered from his stroke.)

The first article in this series explained how you could measure the peak to peak amplitude of an applied signal; the purpose of the timebase is to display the shape of the waveform as well as its amplitude. In a conventional scope, the waveform is drawn out in 'real time' as the signal is applied just as you would draw a graph on paper of some signal. (A sampling scope does not work in real time because it 'samples' the signal repetitively and builds up the picture over many cycles of the applied signal - this allows a higher effective bandwidth.) In the conventional scope, the spot is moved sideways along the X axis of the tube at a constant rate irrespective of what is going on in the vertical or Y direction - hence each centimetre of the X axis represents a given time. At the end of each sweep, usually to the right, the spot is returned quickly to the left of the screen to repeat the linear sweep to the right. The spot is usually blanked off during this flyback period. The speed of the linear progression to the right is known as the timebase speed or sweep rate and is measured in time per distance - a modern scope will have a large rotary switch enabling sweep speeds from about 1 second/centimetre to around 200 nS/cm. The voltage which generates this spot motion has a sawtooth shape and it is important (for the making of accurate measurements) that it be linear and well calibrated. In the example shown below, an HF sine wave is being displayed with a sweep speed of 500 nS/cm or 0.5 μ S/cm. By measuring the distance (using the scope's graticule) between successive crossings of the same chosen instantaneous voltage level (often 0 volts for convenience), the time interval between those points (period) can be measured and hence the frequency worked out. (Frequency is 1 divided by the period of the waveform.) In the example, the period is 4 cm on the tube or $4 \times 0.5 = 2 \mu$ S giving a frequency of 1 divided by 2 μ S which 500 KHz. This drawing out process allows you to see the shape of the waveform from which you can deduce if it is a single sinusoidal signal or whether it is 'distorted' by the presence of harmonics of itself. Digital signals can be displayed showing the sharp transition from one digital level to the other and vice-versa. With such signals, often the rise (or fall) time between the two digital levels is what is of interest.



To produce repeated sweeps across the tube face in exactly the same position, which is necessary to avoid a totally confused picture when sweeping faster than about 0.5 S/cm, the sweep voltage must start its excursion across the face at the same instantaneous voltage of the applied signal. The sweep thus needs to be 'locked' or triggered by the applied signal on the Y plates. (Old scopes did not always have this facility, or even if provided, it was very poor on the high speed ranges making waveform observation very difficult.) The modern scope usually has controls to select the *coupling*, *slope* and *level* of the trigger point. AC coupling allows shifts in the DC level of the applied signal to be ignored whereas with DC coupling, triggering will always be at the same actual voltage level. The choice of *slope* allows triggering on the rising or falling slopes of the applied signal and *level* adjusts the trigger point on the applied signal. Sometimes there will also be a *hold-off* control which prevents re-triggering occurring too quickly after the end of the sweep - this is useful where many cycles of a signal are displayed during one sweep. As described above, if there is no input signal on the Y plates with nothing to trigger the sweep or if the trigger controls are poorly adjusted, then the timebase is inactive with no spot excursion along the X axis and probably a blank screen! Hence the modern scope has an *auto sweep* facility allowing the timebase to run freely in the absence of a suitable Y triggering signal - this at least gives a horizontal line all the time which will be at 0 volts in the absence of a Y input signal. If there is a signal, and the triggering controls are properly adjusted, then triggering occurs correctly, otherwise with signals below a few Hz auto-sweeping will occur. Usually when making very slow speed observations it is best to turn off the auto facility. More expensive scopes may also have facilities for delayed triggering which will allow closer examination of part of a waveform or events some adjustable (delay) time after the trigger point - this is very useful in complex logic circuits.

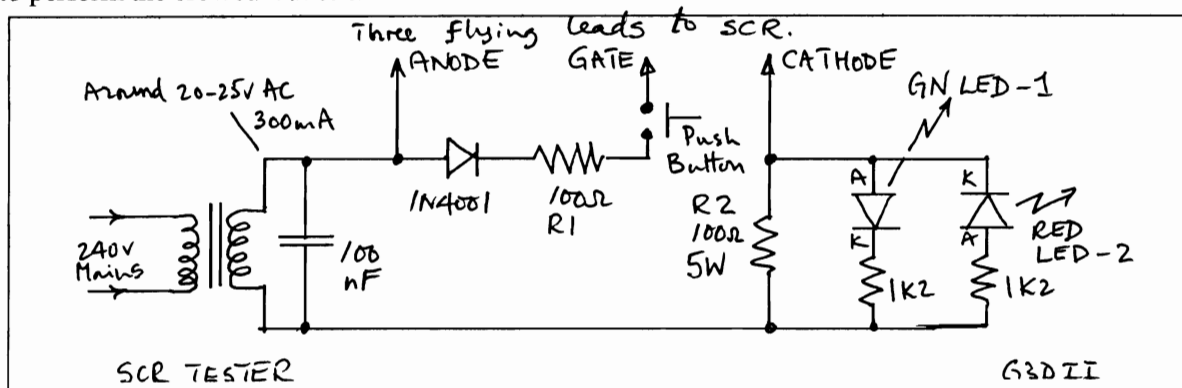
For general analogue use, the normal sweep speed control is adjusted to show about 2 to 5 cycles of the applied waveform. If most of the waveform is clear but other parts are fuzzy, it implies the presence of more than one signal, this maybe unwanted harmonics which will often appear as fuzz at the top and bottom of the wanted signal. With careful adjustment of the trigger point to be in these fuzzy regions, you maybe able to display the harmonic content; however if the unwanted signal is not harmonically related (e.g. additional 50 Hz hum) then the fuzz can not be properly resolved.

The bandwidth of the Y channels will limit the ability of the scope to display signals irrespective of timebase speed. A typical modern scope might have a Y channel bandwidth of 20 MHz suggesting that actual displayed spot excursions will be 3 dB less or reduced to 70.7% of what they should be at 20 MHz and will be even less as frequency is increased. The bandwidth figures are often worst case and the scope will often actually perform correctly to a higher frequency - even so, the scope can still be used above this region by making relative (instead of absolute) measurements as some component etc. is altered. However, at these high frequencies the scope's ability to trigger properly will be severely tested making observations increasingly difficult. The same Y channel bandwidth limitation will also limit the smallest signal rise or fall time that can be displayed - in consequence if a 5 MHz digital signal from a generator with very short (say 1 nS) actual rise and fall time edges were displayed, then the apparent rise and fall time would be those of the scope Y channel (around 10 nS for a 20 MHz scope) instead of the 1 nS of the signal generator.

If the scope has two input Y channels, then usually the timebase can be triggered from either Y input (or from an external signal). This is valuable for looking at the inputs and output of some circuit block, perhaps being driven from a signal generator - here the timebase would be triggered from the signal generator say applied to the scope's Y1 channel with the circuit's output applied to Y2. Used like this there would always be a display and the triggering controls would not need altering as the Y2 probe is applied on different circuit points to hunt for the signal. A two channel scope can also be used to measure the time difference between waveforms, for sinusoidal signals this will indicate their relative phase; where they are digital signals, time differences between voltage transitions may be caused by propagation delays through gates or excessive capacitive loading etc.. It is usually necessary, with a two channel scope viewing different frequencies, to trigger from the channel having the slower or lowest frequency signal otherwise the timebase will not be able to show all of that slower waveform. Another frill on modern scopes is a delay line in the Y channel(s); this allows the triggering action to start from a particular point on the waveform before that point is actually reached in the delayed version of the signal displayed by the sweep voltage - hence you can see the start or change of some signal before it is large enough to trigger the scope. G3PCJ

SCR tester by Joseph Bell G3DII

If a constructor contemplates building a power supply unit for a transceiver or power amplifier, then the addition of a crowbar circuit to the unit is a 'must': otherwise Murphy's law dictates that at some time the pass transistor in the PSU will fail and so will the attached piece of gear! The simple circuit below will give an instant indication of a faulty device before it is installed in a PSU to perform the crowbar function.



When AC is applied, some 20 v AC will be applied across the SCR but because it should not be conducting, there will be no voltage across R2, hence neither LED should light. When the push button is pressed, SCR gate current will flow and the device should turn on when the anode is positive with respect to the cathode. Thus for half of each cycle, current will flow through R2 so that LED1 (green) will light. If both LEDs light up, the SCR is conducting on both halves of the AC cycle and is internally short circuited. If neither LED lights when the button is pressed, the SCR is open circuit. The unit maybe built in any convenient form with flying test leads for the SCR connections. Applied AC voltage is not critical; an old 6.3 volt valve heater transformer can be used if nothing slightly higher is available. The unit can also be used to test triacs.

Noise temperature, figures and factors by Eric Godfrey G3GC

In the last issue of Hot Iron I discussed noise and I said at the end that a common way of specifying noise associated with an amplifier or receiver was by stating its "Noise Factor" but that could be the subject of another note. I have now been lent upon by Tim to do such a note and I hope that readers will find this informative. The three parts of the above heading are so interrelated that all three are discussed here rather than just "Noise Factor".

You will recall that in my last note I stated that the noise power was given by the formula $P_N = kTB^{(1)}$. Thus the noise is directly proportional to the temperature "T" measured in degrees Kelvin. Absolute zero is 0°K or -273°C and at this temperature all electron flow ceases and no noise is generated. A resistor at room temperature (approx. 290°K) would generate, into a matched load, a noise power of $P_N = 1.38 \times 10^{-23} \times 290 \times B$ i.e. 4×10^{-21} W for every Hertz of Bandwidth over the entire spectrum. Note that the noise power is independent of the value of the resistor but that it is directly proportional to the bandwidth. Consider an amplifier between a resistor and a noise free receiver. The noise at the output of the receiver comprises two components, the noise generated by the amplifier and the noise generated by the resistor amplified by the gain of the amplifier. The noise contribution of the amplifier may be considered as an imaginary increase in the temperature of the input resistor. This is known as the equivalent noise temperature or more usually just the noise temperature of the amplifier. It is worth noting that the noise temperature is not necessarily the same as the physical temperature and in fact in most cases they are different. Amateurs usually talk of the noise factor or noise figure rather than the noise temperature. The noise factor F_N is related to the noise temperature by the formula $F_N = 1 + T / 290$. In the equation the 290 is the normal room temperature of 290°C i.e. $290 - 273 = 17^\circ\text{C}$ or 62.6°F . From this formula it can be seen that when the noise temperature is 0°K then the noise factor is 1 and for all other temperatures it must exceed 1. More often than noise factor the term noise figure N_F is used by amateurs which is merely the noise factor ratio expressed in decibels i.e. $N_F = 10\log_{10}(1 + T / 290)$ or simply $10 \log_{10}F_N$.

The above discussion deals with the fundamental side of noise which is very relevant when designing systems⁽²⁾ but in amateur circles the noise temperature is not usually considered but only the Noise Factor or Noise Figure. The Noise Factor and Noise Figure when defined without reference to noise temperature are given by the following two formulae:-

Noise Factor $F_N = \text{Input S/N} \div \text{Output S/N}$, where S/N is the signal to noise ratio

Noise Figure $N_F = 10\log F_N = 10\log(\text{Input S/N} \div \text{Output S/N})$

What does all this mean? Well it clearly shows that in a perfect amplifier, generating no noise in its own right, the Noise Factor will be unity and the Noise Figure will be 0 dB. If any noise is generated then the Noise Figure be greater than 0 dB. So when making or buying an amplifier such as a head-amp or pre-amp one should try to get the lowest Noise Figure possible. It is worth noting that an amplifier set up for maximum gain will usually have a higher Noise Figure than if it is adjusted for minimum Noise Figure. A typical 23 cms pre-amplifier, using a GaAsFET such as the MGF 1024, has near the band centre frequency of 1295 GHz a gain of 14.8 dB and a Noise Figure of 0.55 dB. This is an excellent Noise Figure and is typical of what can be achieved today using modern transistors. It is not so long ago that a typical 144 MHz pre-amplifier using a 6CW4 valve (low noise valve) would have a Noise Figure of about 3 dB.

There should be the minimum of loss between the aerial of any system and the pre-amplifier since any loss will attenuate the signal reducing the signal to noise ratio at its input. Thus a pre-amplifier should be right at the aerial and not at the other end of the feeder. With it at the aerial both signal and noise at the receiver are reduced equally by the loss in the feeder but if it is at the other end then only the signal is reduced.

In conclusion when buying a pre-amp or head-amp always choose the one with the lowest Noise Figure rather than the one with maximum gain.

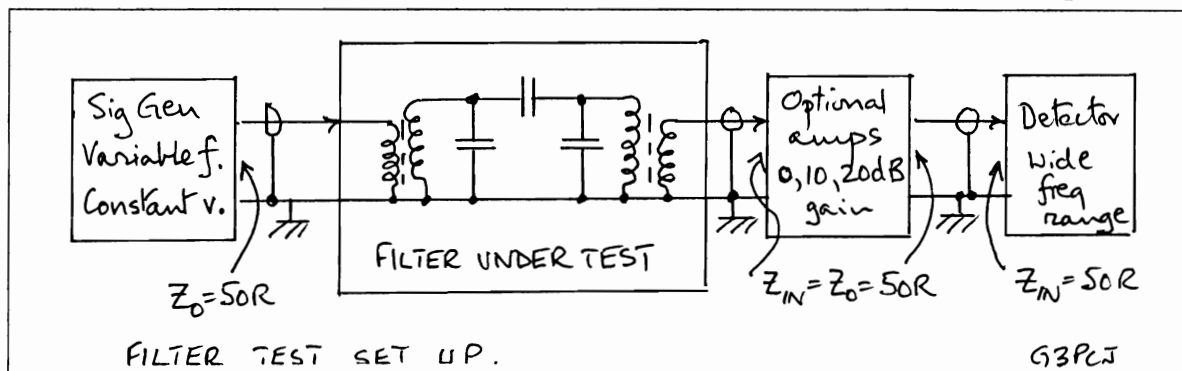
References

(1) Hot Iron Issue No. 16. Noise, G3GC

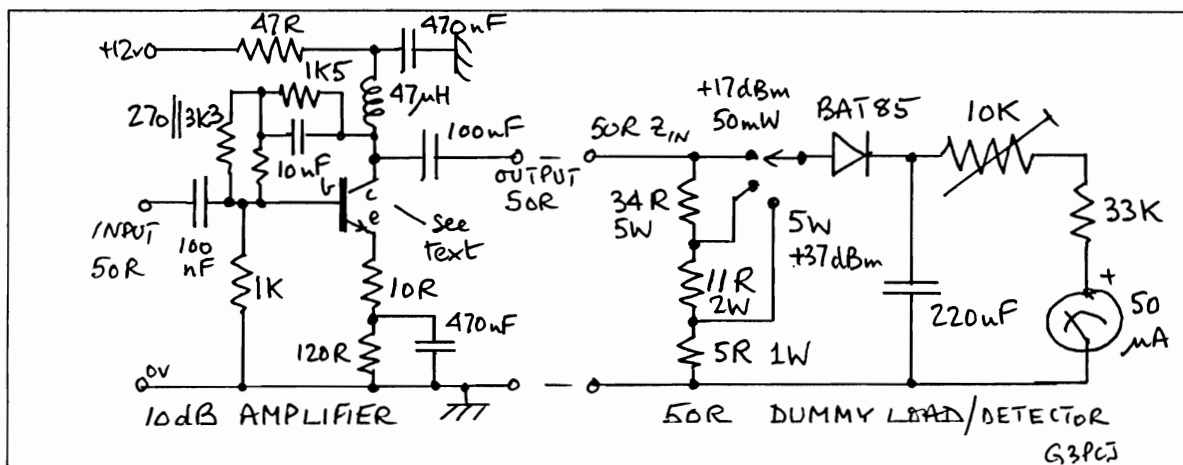
(2) RadCom April, May, June and July 1985. Modern VHF/UHF Front-End Design, G3SEK.

Measuring filter responses

This note follows similar requests from David Proctor G0UTF and Jim Geary GW3HKY about using signal generators and RF voltmeters. Apart from a signal source and the filter (which might actually be a more complex circuit like an amplifier etc.), the measuring instrument, or detector, is usually the most important and difficult item! In order to take sensible measurements, the detector has to a) either not load the circuit under test or apply a known load, b) have adequate frequency range for the circuit being tested and c) have adequate dynamic range. This last point is often the hardest because the signal source will probably not be able to generate more than a few volts at best (and an amplifier under test wouldn't either); if the circuit is passive with a small voltage loss then a simple detector can be used, but away from the pass band where the output drops off rapidly, a simple detector will not be able to read the signals due to lack of sensitivity. Hence a wide band amplifier with known gain, which can be switched in between the circuit under test and detector is a very useful adjunct - see later. Loading of the circuit under test is a bit complicated because, filters for example, are designed to operate from and into specified load impedances (see the example below) whereas an amplifier stage would have its source and load impedances presented by other parts of the circuit so that the 'detector' must not load the circuit under test - hence the detector needed for this has to have an input impedance many times the circuit impedances. For RF work, say on the band pass filters that might be used in the front end of a RX, or following a mixer, often the circuit design impedances will be a nominal 50 Ohms - in this case the correct load for the filter can be the input impedance of the detector or any amplifier used to increase sensitivity provided they are known to be 50R over the frequency range of interest. Often signal generators will have a nominal 50R output impedance so they can directly feed into a filter designed to operate with 50R source impedance. The test set up is:-



For RF work the detector shown on the right below can be used; in fact it makes a very convenient TX 50R dummy load and power output meter with three ranges in 10 dB (power) increments up to 5 Watts. Calibration is easy with a DC voltage - see Hot Iron 3. The circuit on the left provides a gain of 10 dB power with nominal 50R input and output impedances. With BC108, BC182s etc. the bandwidth will be up to 30 MHz, changing to a 2N5179 will extend this into the VHF region. For extra sensitivity, two or more amplifiers can be put in series.

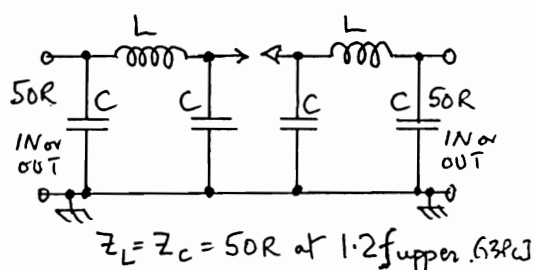


The actual measurement technique should be to sweep the expected frequency range roughly and check that the detector is able to make sensible readings at the extremes; this will also show where the response changes rapidly, where to start/finish and where you might wish to take more readings. Then carefully take about 10 readings, initially equally spaced in frequency increments of say 500 KHz and note the output for each. Plotting these on ordinary 'squared' paper will be adequate for most purposes - for really wide ranges, use 'log-log' paper. Non loading detectors next time! G3PCJ

Class C power amplifiers and filters

Some people are puzzled when they get very little output from a simple CW TX until they add some form of filter prior to the antenna matching unit. Often the reason is that the output stage is operating in class C, without any standing DC current, so that the amplifying transistor is driven into conduction for only part of the whole RF cycle. If the rig does not have any form of 'tuned' load then these pulses of current will produce pulse waveforms full of useless harmonics which often mask the useful carrier. With a tuned load, the pulses of current when the device conducts, make the tuned circuit 'ring' at its resonant frequency so that, when the load is tuned to the same frequency as the driving signal, useful power is produced at the fundamental which can be extracted to the antenna and the harmonics are severely attenuated. This is how the traditional pi matching network of a valved RF amplifier could be used on CW. A Q of 12 used to be recommended to give sufficient harmonic attenuation but nowadays a low pass filter is often suggested to provide extra harmonic attenuation. The 'half wave' low pass filter is easy to remember because the circuit element impedances are made to be equal to the line impedance at the corner frequency where the response is to be 3 dB down. These filters have three elements and two such sections in series will get rid of most harmonics!. Different values are required for each band. The design frequency for the corner frequency should be about 1.2 times the upper band edge so as to not attenuate the wanted signals - they will pass all lower frequencies. The table gives values for the common bands in a 50 Ohm system. The capacitors need to have a voltage rating sufficient for the AC voltage implied by the power through the filter. G3PCJ

Band	f_c - MHz	C - pF	L - μ H	Turns	Core
160	2.4	1,300	3.3	24	T68-2
80	4.6	700	1.7	17	T68-2
40	8.5	375	0.9	13	T50-2
20	17	180	0.5	10	T50-2
15	26	120	0.3	9	T50-6
10	35	90	0.2	7	T50-6

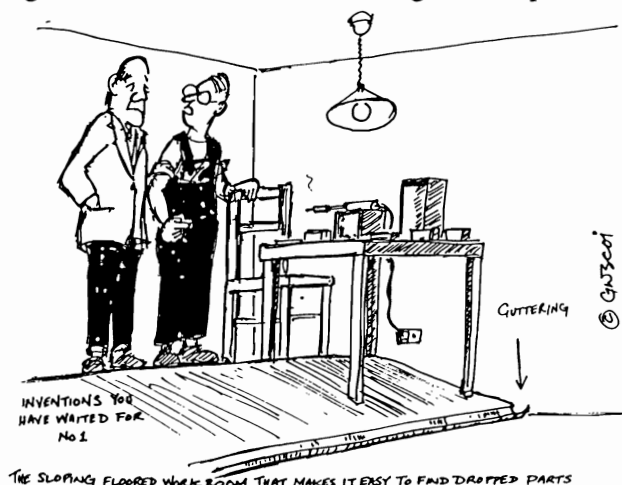


These low pass filters can also be used after a class C amplifier without any internal tuning.

Reversed supply Yeovil! by John Worthington GW3COI

Some folk never learn! Having built a Yeovil and eventually corrected all my errors I had a happy year using it almost daily on 80m. It even went to VK7 with me as with poor DX conditions, I reckoned 80 m QSOs would suit me well enough during my six week stay. Not only that, it is a very light rig and would keep my hand luggage inside the limit etc.. I was lazy about diode protection from wrong connection to PSUs and having boomed some years ago with another rig I was always very careful. We get a lot of power cuts in Gwynedd and a recent one lasted 12 hours far into the night. I always keep a car battery in the house to operate a light or two etc.; after the fourth hour of no mains I decided to go on air. In the dim light of an oil lamp I fitted the croc clips from the rig carefully on the lugs and heard that dreaded slight frying noise. Realising the truth quicker than the speed of light I started to swear. It was a month before I had recovered sufficiently to tackle the job of repair. Following the designer's advice, I confirmed that two tracks had acted like fuses. I then found that two BC182s had gone o/c. After fitting new ones, I was delighted to find it was working again but only with RIT switched in. As I hardly use this, I disconnected it but found the VFO was jumping 40 Hz or so in a random fashion, especially on CW. Fitting a new CD4093 cured this enough to complete most QSOs but the occasional 'fusspot' would mention it. I found this rather puzzling but Tim's advice was squirt switch cleaner/lubricant on the tuning pots. By the way, the first thing I did before starting on the repair job was to fit a diode in the 12 volt input! My language has now returned to normal!

John, we have all done it! Some are rather keener to keep it to themselves. In such situations a sense of humour is essential. So in tribute, I must publish one of your inventions! G3PCJ



Hot Iron

Issue 18

“Journal of the Constructors Club”

Winter 1997



Editorial

How I love and hate this computer! I have just spent a good 15 minutes trying to import my normal 'season' picture on the bottom of the page. I know it is somewhere in the machine or on my Publisher CD, but can I find it! I have given up in disgust. Please, one of you, send me something to liven things up a bit! The trouble is that I don't use these slightly unusual features sufficiently often to remember how to do it. At least amateur radio does not have these problems, not at least for most of us using simpler rigs. I suspect those people using packet may feel the same, judging by the long QSOs that one overhears and undoubtedly modern black box rigs do suffer from multiple uses of each control. Thinking of networked computers, I have just linked to the Internet so shall be very pleased to have any future contributions by e mail. I had expected my son to spend all his time surfing at my expense but in fact it is my daughters that use it most for writing to friends etc. I am only just getting used to it and still have some 'local' procedural difficulties but clearly it will become very useful and helpful to all. My address is

walfor@globalnet.co.uk. (The missing d is intentional.) My file of articles written by others is a little thin at the moment, so please, when you need some distraction after the festivities of Christmas and the New Year, get your pens out and jot something down. Don't worry about polishing it up etc. for publication - I can alter things easily! (I hesitate to use the word polish as I am conscious of the somewhat informal nature of Hot Iron.) Anyway, all the best of festive greetings for Christmas and the New Year, and may you enjoy good health throughout 1998 and beyond. Tim

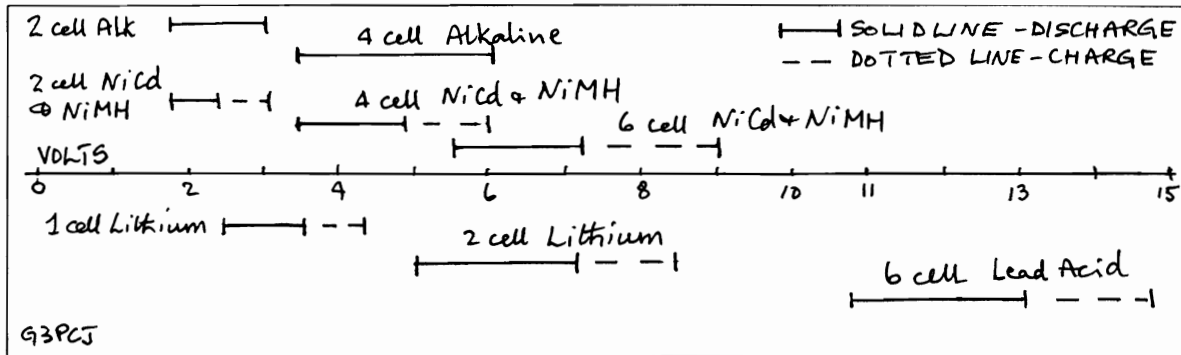
Kit Developments

The *Street*, any single or two band CW and SSB TCVR, is now available. A few are out and no troubles to date - I keep my fingers crossed because 6 metres is a challenge! I have also produced an *Optional Extras* kit for the Street and other rigs that have some of the embellishments left out of the basic rig - e.g. AGC, RIT, S meter/output power with matching bridge. There have also been a few inquiries over the months for low pass filters - particularly for the simple broadband CW rigs. I now have available a single kit that contains two relay switched dual half wave *low pass filters* for any pair of bands 6 to 160m. Two of these units can also be used for a three band rig like the Godney. I have also completed the kit for a QRP *Antenna Unit*. This contains a matching unit, based on the low pass L network with variable L and C, together with an optional resistive matching bridge and output meter. L and C switching uses switches as well as a polyvaricon to keep the cost down. For mobile use, it has been squeezed into the small kit format 100x100x65mm high. I have laid out the PCB for the *Midney* which is a simple any single band 20 to 160m superhet phone/CW receiver - writing the instructions is the next task after this! The matching CW TX and any two band CW phasing RX are not far behind! I am looking for some prototype builders so let me know if you are interested in any of these. G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year. June 1st 1996.

Battery types and Charging

Recently several members have had questions about batteries; being not too confident about this topic I was pleased to receive a couple of articles from which much of the following has been culled. There are many different cell chemistries with a wide variety of battery or multiple cell stack voltages; it is not often appreciated just how big the difference actually is between lowest useful cell voltage and that at the end of charging. The chart below shows this for various cells chemistries.



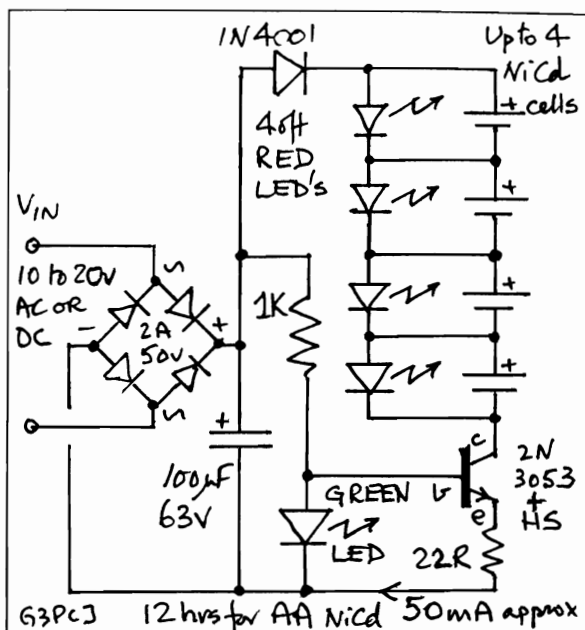
Crucial to charging properly, is knowledge of the cell or battery stack capacity C , measured in ampere-hours. This is literally the product of current and time that the battery can 'normally' supply after being fully charged - a figure which is not dependent on battery voltage. The suggested charging current is often expressed as some fraction or multiple of C ; this allows you to estimate the time that it should be on charge - divide the cell capacity by the fraction of C used for charging. (e.g. Charging at half C will need two hours theoretically.) The following table shows some example capacities (in amp-hrs) for typical cell sizes and chemistries. The ordinary carbon-zinc cells are not supposed to be rechargeable but I have seen it suggested that some charge can put back in again shortly after partial discharge - particularly if the DC charge current has a small additional AC component produced by a capacitor across the charger's rectifier. Chargers are commercially available for alkaline cells, I think using the same technique. I have no data, or experience with either, so cannot recommend it!

CAPACITY Size - AHrs	Primary - Carbon zinc	Alkaline - Copper top	Lithium -	Standard - Ni-Cads	Nickel metal hydride
AA	1.5	2.5	2.3	0.6	1.1
C	4	7.2	8	2	2.6
D	10	17.5	19	4	5
PP3	0.3	0.5		0.15	1.1

There is some debate about the need to discharge cells before recharging - most experts reckon that discharging down to 1 volt per cell (for practically all chemistries!) will reduce dendritic formations which are responsible for the so-called memory effect. Fast discharging, in less than an hour, is not generally recommended unless the cell is specifically designed for such hard work; however it is suggested that any preconditioning discharge take less than 10 hours. Fast charging (as opposed to trickle charging) for *NiCd* and *NiMH* cells is similar; it can be done at up to twice the one hour rate but it is more usual to use the two hour rate or half the rated ampere-hour figure. A constant current scheme should be used for these two chemistries until the cell voltage ceases to rise any more. For ordinary NiCds a little more charge (5 - 10%) can be put in till the voltage just begins to decline past its peak value. (You will need to measure the cell voltage very carefully to observe this effect so is not done by most amateurs!) Once fully charged the cell temperature will begin to rise more quickly as all the energy is now converted to heat rather than being stored. *Lithium* cells are usually charged with a constant voltage, with initial current limiting to prevent damage, just like the simple chargers for lead acid batteries. Eventually the lithium cell voltage rises to a float voltage of 4.2 volts per cell when charging is complete, so this should be the charging 'voltage'. For lead-acid batteries the charging voltage is not quite so critical, again a current limited supply of about 2.45 volts per cell should be used but the 'float charge' voltage should be lower at 2.2 volts per cell. For Lithium and lead-acid charging, the current limit should be set to about $4C$ but actual current will fall below this soon after charging is started. After the 'fast' charging as above is complete, an indefinite trickle charge (mainly to counter self discharge) can take over. Self discharge is worst with lead-acid and the articles infer a trickle rate of around $0.1C$, that for NiCds should be less at about $0.05C$. Trickle charging is not necessary or suggested for NiMH or Lithium cells. With all cells, err on the side of caution by using a low charging current if you don't have any data. If in doubt, use the 5 or 10 hour rate for the cell size and chemistry from the above table. Whatever you do use, it is always sensible to feel the cells a few minutes after starting to charge, then again 15 minutes later, to make sure they are only warm. G3PCJ

Charger for 4 AA NiCd cells

This circuit was designed for use off a car battery (or 12 volt AC) in the dark so had to have polarity protection! It depends on the green LED acting as a 1.4 volt zener diode to define the voltage between the transistor's base and bottom of the emitter resistor, hence defining the constant charging current through the cell string. As each cell becomes charged, the cell voltage approaches the 1.4 volt 'on' voltage of the red LED across it causing the LED to light up because it is now passing the current instead of the cell. This also allows charging without having to have a full string of cells. I used to use this on holiday for the kid's Walkman batteries with the charger under the bonnet - I found out the hard way that it is advisable to do the charging while driving with the unit visible when leaving the car! G3PCJ



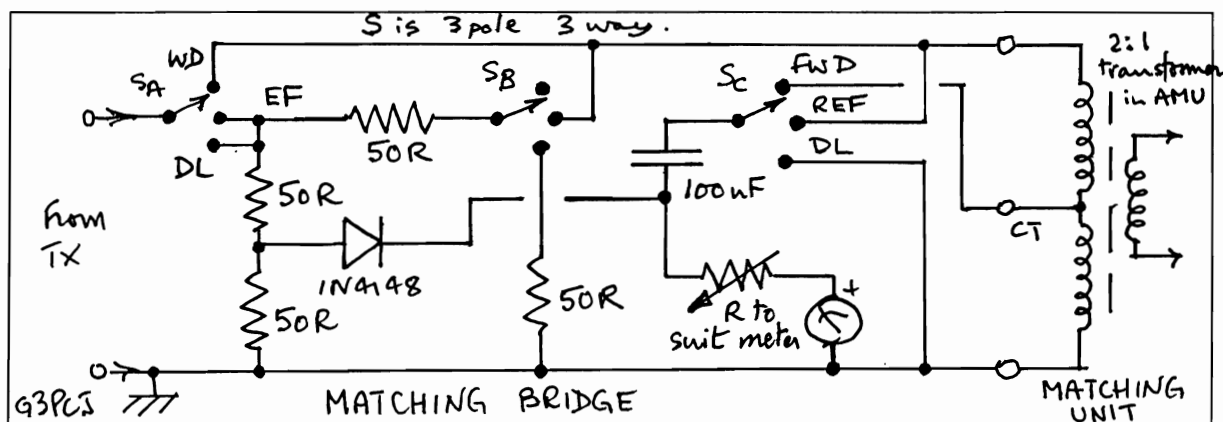
Rig Updates

Bruton and Taunton AGC A few builders, have reported difficulties with the audio AGC system of the SL6270 VOGAD chip oscillating at about 1 Hz or less having the effect that sensitivity pumps up and down at this slow rate. I used to think that it was associated with too high DC resistance to ground on the unused audio input. (The chip is designed for a balanced input from a mike transformer etc..) However I now think that this instability is caused by a too high supply voltage impedance - over 10 Ohms or so leading to possible problems. Both rigs have precautionary supply voltage dropping resistors with decoupling to prevent audio feedback from the output stage to the VOGAD chip. The chip can take the full 8 volt supply voltage so the easiest modification is to short out these resistors, R112 in the Bruton and R121 in the Taunton, if your rig is affected.

Wedmore While the ceramic resonator VFO has many benefits, it does have a reputation for not being quite as stable as one would like! With helpful experiments by a number of builders, it now appears that part of the blame can be attributed to using plain ceramic coupling capacitors to the varactor diode(s). The ordinary 10 nF ceramic disc capacitors have a large positive temperature coefficient which I thought would not be important in their role as a coupling capacitor; however changing one to a 4n7 COG type (with nominally zero tempco) has made a marked improvement in most of those rigs which were suffering drift. Changing both C27 and C28 in my own Wedmore overcorrected the drift so I suggest you only change one (either) of them. Not all Wedmores drift and in one case changing the ceramic resonator effected a cure. Send me a stamp with a stamped envelope if you wish to try a 4n7 COG capacitor or another ceramic resonator. G3PCJ

Versatile Resistive Matching Bridge

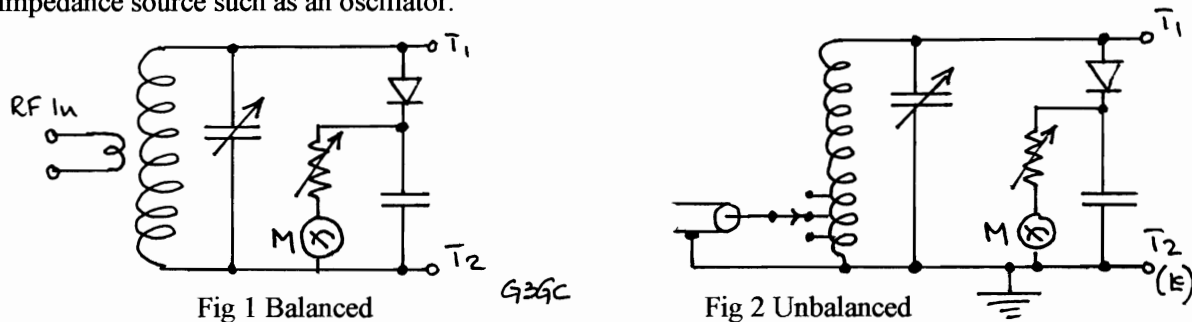
The circuit shown below is an extension of the simple resistive matching bridge which normally uses a DPCO switch to insert the bridge in circuit and to make the meter show either full output when the bridge is out, or reflected voltage when the bridge is in circuit. A minor irritation is that, with the simple circuit, the meter will never show more than half-scale on the reflected position. If the bridge is used with an antenna matching unit that has a 2:1 input transformer, having a centre tap, then the meter can show full scale on all switch positions including the extra dummy load position. You have probably guessed correctly that the CT is available in my new Antenna Unit kit!



Measuring Your Aerial Impedance by Eric Godfrey G3GC

Many of us at some time or other have wanted to resonate our aerial system for use on the particular band on which we wished to operate. It is not uncommon for this to be attempted using a grid dip oscillator (GDO) or using a noise bridge. However neither of these in my opinion is particularly satisfactory and the object of this note is to put forward another method which is not only capable of indicating resonance, or lack of it, but also able to measure both the resistive and reactive components of the impedance of the system.

The method is to make use of the fact that an aerial which is resonant at a particular frequency has no reactive component but behaves like a pure resistance. If such an aerial is connected across a circuit tuned to resonance then, since its impedance of the aerial has no reactive component, there will not be any change in the tuning of the tuned circuit which will still be at resonance but will now be loaded by the resistive component of the aerial impedance. It is possible, by substitution, to be able to measure this resistive component of the aerial impedance. Figs 1 and 2 show such a system connected to a low impedance source such as an oscillator.



Preferably the source of RF should be at a low impedance and this has to be connected to the tuned circuit by loop coupling which should be at the centre of the coil to maintain balance assuming that one is going to measure a balanced system such as a dipole (Fig 1). If some form of monopole aerial, such as a vertical quarter wave, is to be measured then the loop should be at the earthy end of the coil. In fact if one wished the coil could have taps at its earthy end thus avoiding the need of loop coupling (Fig 2). It does not matter which method is used and is simply a matter of personal convenience. The diagrams show a peak voltmeter across the coil and resonance will be indicated by the maximum voltage across the coil. This peak voltmeter does not have to be calibrated since it is only used as an indicator but it is worth having as sensitive a meter as possible with a nicely calibrated scale. It does not matter in what the scale is calibrated, it is simply for re-setting purposes. A variable resistor is included in the meter circuit to adjust the sensitivity as required.

The method of operation is to first set the RF source to the frequency required and then to adjust the tuned circuit to resonance, indicated by a maximum reading on the meter. It should be noted that some modern transmitters on high power may not like this and turn the power output down. The meter reading may be set with the variable resistor for full scale deflection on the meter (FSD). Then attach the aerial to the terminals T₁ and T₂ which more than likely will reduce the meter reading. This can be re-adjusted to FSD by the variable resistor (it is possible, depending on the amount of power and meter sensitivity, that you may not get FSD but adjust for a maximum). If the aerial is resonant then there will be no change required to the setting of the tuning capacitor for a maximum reading. If more capacity is required the aerial must have some inductive reactance and is therefore too long. If less capacity is required then the aerial is capacitive and is too short. Reduce or increase (much more difficult) the length of the aerial as required until there is no change to the tuning of the tuned circuit when your aerial is connected and Eureka you will have an aerial resonant at the measuring frequency. You may calibrate your variable capacitor by connecting different known values across the terminals without an aerial connected and retuning the capacitor. The RF source frequency for this operation should be adjusted so that resonance is achieved when the vanes are fully meshed. A calibration chart of capacity against capacitor rotation can then be drawn and from this, the capacitive or inductive (negative capacitance) component of the aerial impedance may be deduced. You will have noticed that the meter reading tends to be less with the aerial connected which is due to the resistive loading on the tuned circuit. However this gives a way of finding the resistive component of the aerial impedance. All one has to do is to make a note of the meter reading, remove the aerial and replace it with a suitable non-inductive resistance until one is found that gives the same meter reading as there was when the aerial was connected. It is worth keeping a series of resistors specifically for this purpose.

The problem of using this gear is how do you get it, and for that matter yourself, up some 30 ft in the air or do you lower the aerial which will then affect the impedance and give false readings. Well the answer is you do neither. You measure the aerial through a length of twin feeder connected to the centre of the aerial which is any number of electrical half waves long at the desired frequency (the

smaller the number of half waves the better). The input impedance to a half wave feeder is the same as its terminating impedance irrespective of its own impedance (Fig 3) and therefore the aerial impedance is transferred to the input which can be connected to the measuring gear situated on the ground with the aerial still at its operational height. It is essential that a balanced aerial is measured through balanced feeders. The monopole should use unbalanced coaxial feeders.

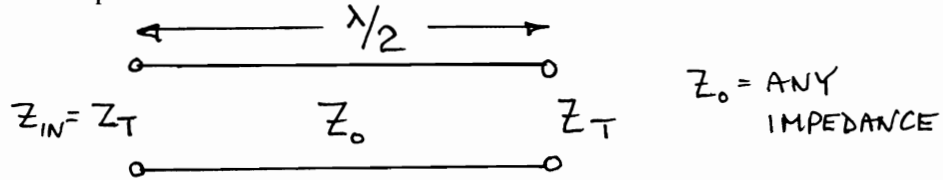


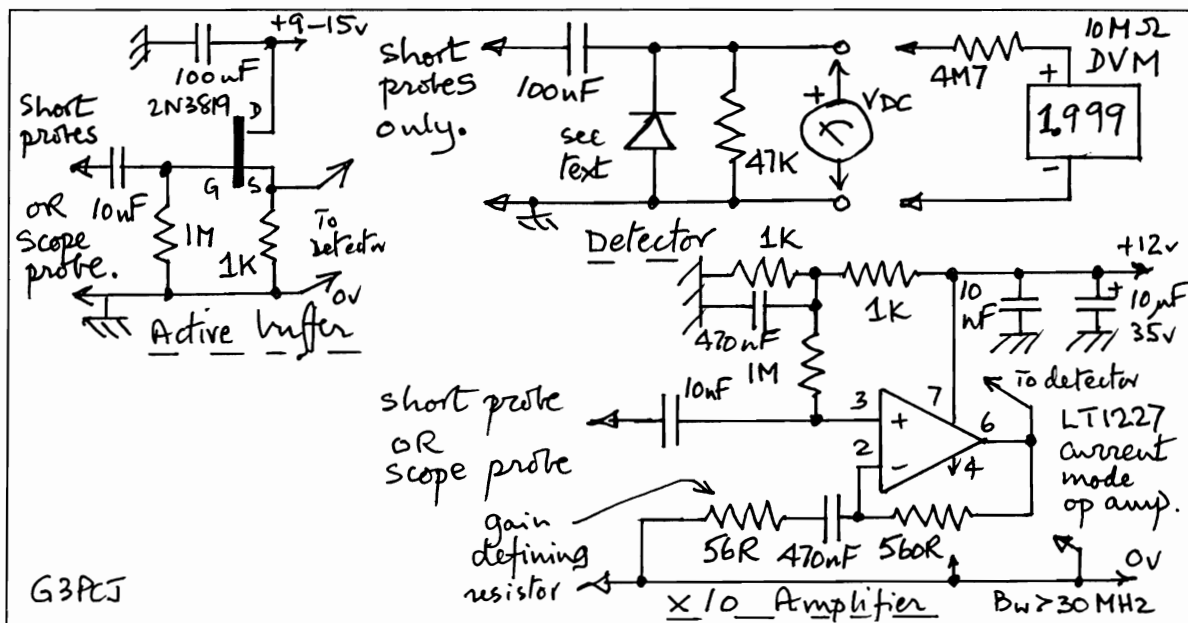
Fig 3

G3GC

It may be that you do not know the velocity ratio of the measuring feeder but this is no problem since all one does is to cut a piece of feeder about a half wave long in air (velocity ratio of 1) and then connect it across the terminals of the tuned circuit. It will then exhibit an inductive reactance and the tuning capacity would have to be increased for resonance. However what one does is to reduce the feeder length until there is no detuning on connection. This length divided by the length in air is the velocity ratio of that feeder expressed as a decimal. This technique may be applied to any feeder whose velocity factor is unknown. (The tuned circuits can be home brew using plug-in coils which should be of such an inductance so as to require the tuning capacitor to be set around mid-capacity.)

High Impedance RF voltmeters

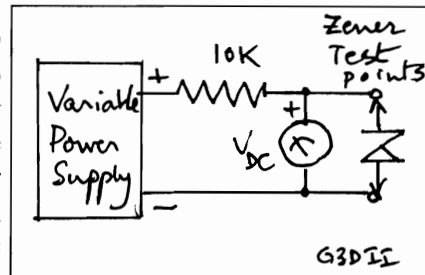
Assuming that a DC multimeter is the indicating instrument, some form of rectification has to take place. Silicon diodes (1N914, 1N4148 etc) should not be used in simple circuits as the input voltage has to exceed 0.65 before they begin to conduct, instead germanium (OA90, OA91 etc) conducts over about 0.1v but they are too slow for HF circuits; the best are Schottky silicon diodes like the BAT85 which conduct over about 0.35 volts and are good to VHF. For the simple circuit shown below, the input impedance is of the order of 47K and the series 4M7 should make a 10 MOhm DC voltmeter read the RMS value. Be careful not to apply too much RF voltage (from a transmitter) as the PIV rating of the BAT85 is only 35 volts! The next step up in complexity is to add an active buffer stage to further increase the input impedance by mainly raising the input resistance, to 1 MOhm in the *left* circuit. Note there is no increase in sensitivity and there is still a few pF of input capacity. With both of these circuits, they need to be very close to the point being measured and must not be connected by screened lead - its capacity will heavily load the circuit under test. However the nominal 1 MOhm input impedance of the active buffer does allow a 10:1 scope type probe to be used. This will attenuate the signal by a factor of ten, but it does allow the cable (of the probe) to connect to the buffer amplifier. Finally, the operational amplifier circuit will allow the scope probe to be used and regain the full sensitivity of the detector. This circuit has the 1 MOhm input impedance required for a scope probe and should be useable to at least 30 MHz when a good layout and short lead lengths are employed. It should feed the detector direct. The circuit gain can be increased but bandwidth will suffer. The chip is a current mode op-amp with a limited range of feedback resistors; gain alterations are made by changing the other gain defining resistor between negative input and earth. G3PCJ



Testing Zener diodes by Joseph Bell G3DII

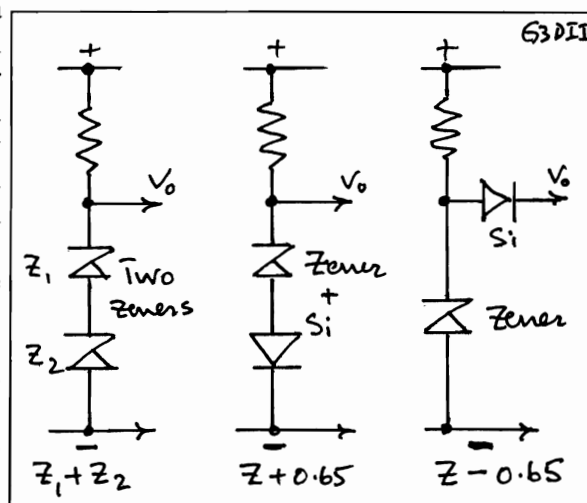
Zener diodes are often used in ham radio equipment and can commonly be obtained with voltages in the range 2.7 to 200 volts. Typical maximum dissipation is in the range 300/500 mW for the smallest glass bead type, 1.3 W for more solid black 'slugs' and 5 Watt for the top hat shape. In circuit, the actual dissipation is easily worked out as the product of zener voltage multiplied by the current through the zener.

Many hams have a bench variable PSU covering 0 to 20 or 30 volts; if such a DC source is available then all we need to test the zener is a 10K resistor and a DC voltmeter, preferably high impedance. The 10K resistor is placed in positive leg of the PSU as shown alongside with the zener placed between the other end of the resistor and the PSU negative terminal. Start by setting the PSU to some convenient value near 15 volts and measure the voltage across the zener. If the zener voltage is under 15 volts



this will be shown; if the voltage is 0.6 volts the zener is connected the wrong way round and is showing the voltage drop of an ordinary silicon diode. This is also a way of testing whether you have selected a zener or an ordinary diode from the junk box. If it is an ordinary diode it will show about 0.65 volts when connected one way and the supply voltage when connected the other way. If you have a short circuited zener or diode it will show zero when connected both ways; if open circuit, it will show supply voltage both ways unless it is zener with a voltage higher than your supply voltage. In this case slowly increase the supply voltage and see if the meter reading fails to increase with the supply voltage - in which case you have now found the zener voltage.

You may have a zener whose voltage is a bit high or low for your need but all right on probable power rating. You can increase the zener voltage by connecting two, or more, zeners in series (the same way round) or by adding ordinary silicone diodes between anode of the zener and earth. They need to be able to handle the maximum zener current. If you need to reduce the voltage, add silicon diodes between the junction of the resistor/ zener diode and the load. In both cases, each silicon diode will add or subtract about 0.6 volts from the zener voltage. As a rough guide, for circuit design purposes, the zener voltage should be limited to not more than about $\frac{3}{4}$ of the lowest available supply voltage. If the load current is fixed, then the current through the series resistor



should be about 1.25 times the load current so that $\frac{1}{4}$ goes through the zener. If the load current varies, then use the maximum load current so that 1.25 times it flows through the resistor BUT remember all that current will go through the zener when the load current is zero, so do check that the zener power rating is adequate! The series resistor value is (supply voltage less zener voltage) divided by 1.25 load current. Do also check the resistor's dissipation. The slope impedance of small zeners is around 5 Ohms so changes in load current will have a small but definite effect on voltage ($5R \times$ change in load current.). (If you need better stability use a fixed voltage regulator of the 78XX series - XX is voltage - 05, 08, 09, 12 & 15v are available; the TO220 devices have a 1 Amp rating. The 78LXX has a 100 mAmp rating. Neither is good enough for varactor tuning diode voltages - use a 317 series regulator.)

There are many other diode tricks - do a little experimenting - send the results in to Tim!

14th Yeovil QRP Convention

The date is earlier next year, *April 19th* at Sherborne as before. Star attraction is the Rev George Dobbs G3RJV. All the usual attractions - traders, bring and buy, food, talks, demonstrations and Construction Challenge. This is to produce the most power efficient 20m QRP transmitter. Details from Peter Burrige G3CQR, QTHR or Tel 01935 813054.

Signal Generator Tuning Label

Craig Douglas G0HDJ found that printing a small adhesive label, fitted beside the tuning knob, with the adjacent signal generator coverage table saved getting out the instructions each time. The 3 digit counter is even better!

Happy constructing in 1998!

Tim G3PCJ

1. 26 - 55 MHz	7. 2.6 - 5.1 MHz
2. 17 - 38 MHz	8. 1.7 - 3.3 MHz
3. 12 - 26 MHz	9. 1.1 - 2.1 MHz
4. 8.5 - 17.9 MHz	10. 807 - 1900 KHz
5. 5.7 - 11.5 MHz	11. 543 - 944 KHz
6. 3.8 - 7.5 MHz	12. 395 - 616 KHz

Hot Iron

Issue 19

“Journal of the Constructors Club”

Spring 1998

Editorial



The cold wet weather of early January stopped much outside farm work leading ultimately to the several new projects mentioned below; however the recent spell of unusually dry and warm weather stimulates the brain. Flicking through the component catalogues, I recently stumbled on a new style of resistive preset capable of taking a shaft (and knob). This costs only a fraction of a normal potentiometer, and through mounting directly on the component PCB, it can reduce the need for extra PCB material for a front panel. With most control wiring as DC or low impedance audio, it makes it easy for the kit builder to add his own full size controls if he wishes, having bought them more cheaply than I can at a rally! This is all good news because it keeps kit prices static or maybe reducing. The new price of ‘mechanical’ type electronic parts (e.g. pots, knobs and sockets etc.) is out of proportion to their contribution to circuits - compare a pot costing 70 pence at the 100 off rate with a typical digital counter chip having dozens of transistors at 25 pence. Viewed in a simplistic way (ignoring material costs and production run aspects), the cost of the chip making plant is a great many thousands of times that for the

mechanical part so it should be the other way round! Nowadays several low cost parts can sometimes replace a single IC at a lower overall kit price but with more work (and slightly increased risk) for the kit builder whose time the kit supplier does not value. I think most builders would favour using several parts if the IC approach doubled the price for that task. What do you think - letters please!

Kit Developments

The *Sparkford* is an 80m CW TCVR using several new ideas which I shall explain in more detail later in this issue. Its low cost, small size and minimum 9 volt supply should appeal for those wanting /P gear. Just £34! The *Midney* which I mentioned last time, is now available; it is a single band superhet receiver with phone and CW filters. Any band from 20 to 160m for £49. The *Antenna Unit*, also mentioned last time, is now available. Designed for QRP purposes, it comprises a *antenna matching unit* using switched inductors with a polyvaricon variable capacitor plus an optional matching *bridge* for adjusting the match conditions. The bridge meter indicates reflected or output voltage, which after matching adjustment for 50 Ohms load to the TX, can be calibrated for power. It suits the more common antenna types and feeders covering 10m to 160m. Price £39. The latest project is a versatile *Audio filter/oscillator* kit using an exceptionally sharp cut off clock tuneable low pass filter. A typical filter application would be for CW after a phone bandwidth receiver. The kit can also generate either a single high purity audio sine wave in the range 260 to 4300 Hz or two audio tones suitable for SSB transmitter testing. Price £22. Hope to see you at the QRP Convention. Tim G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 E mail walfor@globalnet.co.uk The Copyright of all material published in *Hot Iron* is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.



Rig Updates

Taunton and Bruton AGC Further work on this aspect mentioned last time confirms the wisdom of running the SL6270 VOGAD chip directly off the 8 volt supply in these rigs. It is also evident that the extra input bias resistors which were originally 10K should be increased to 22K, accordingly I have now changed the instructions and parts lists for both rigs. For those experiencing AGC troubles, in the Bruton, R112 should be replaced by a wire link and R114 should be increased to 22K. For the Taunton, R121 should be replaced by a wire link and R123 increased to 22K. Unless you have problems, I doubt if these modifications will improve any other aspects, so only do them if necessary.

Bruton VFO on 20m Hans Puhlinger OE3HPU had already sent me an e mail explaining his modifications to the VFO to improve stability so I was pleased to be able to try them out on another Bruton for myself. He had recommended changing the original TOKO 3335 coil, which has a high μ core for the more stable powdered iron type. Without changing anything else, I found that 12 turns of 24 gauge wire, with a tap at 3 turns for the 2N3819 source connection, on a T50-2 core worked very well. Since there is no trimming device to set the VFO high frequency limit, this had to be done by adjusting the turns on the T50-2. The low frequency VFO limit is set as before using the preset setting the most negative varactor diode voltage. Using 12 turns set the HF limit to just over 8.4 MHz (corresponding to 14.4 MHz RF) - from cold it shifted less than 200 Hz in half an hour.

Hans also commented on the problems of IF breakthrough in central Europe where there are several very high powered AM transmitters operating near to 6 MHz. He suffered quite significant problems until he applied screening to all of the IF section, i.e. both NE612 mixers with their 4066 switches and all of the IF crystal filter. In the UK, I have never had this problem when using open construction *however* these stations can be a very useful source of signals for checking that the IF onwards of the rig is working. Just put your screwdriver, with finger applied, to any hot point in the IF filter - if you get mushy signals, the subsequent stages are working! After these modifications, Hans had some excellent DX contacts using 4 watts into W, VE and VO land. Having found a source of cheap Bulgarian 9 MHz IF filters, he has a new multiband rig in development using ideas out of the Bruton with a Lopen TX. We look forward to hearing about it in the future.

Power Supplies Gerrit ten Veen PA3FOY tells me about his experience with various supplies used with his Taunton. It all started when other stations complained of chirp which Gerrit found to be caused by RF getting into the PSU's regulator circuit leading to an unstable supply to the rig. Plenty of 10 nF ceramic disc capacitors are the cure for this - put them on all supply lines wherever a longish lead enters or leaves a PCB. The wire used for supply leads should err on the large side - the 1 to 2 Amp peak currents on speech peaks can cause significant drops in small wires. Although Gerrit did not tell me his antenna matching unit arrangements, I have a suspicion that poor separation of RF and mains or 0 volt wiring does often lead to problems. I strongly advocate using a link coupled form of resonant antenna matching unit so that the real RF earth is isolated from the rig's 0 volts. Quite often mains earth is connected to the PSU 0 volt line, so without the preferred link coupling, some of the relatively high antenna system RF currents are quite likely to flow into domestic supply earth system and hence the PSU. End fed antennas worked against mains earth are notorious for trouble! If your normal 50 Hz supply uses PME (protective multiple earthing), which depends upon continuity of the electricity supply company's neutral conductor to provide earth fault protection, you must not join mains earth to RF earth and also ensure it is not possible to touch real earth and mains earth at the same time. I do not like PME and much prefer the alternative of using a RCD earth leakage trip.

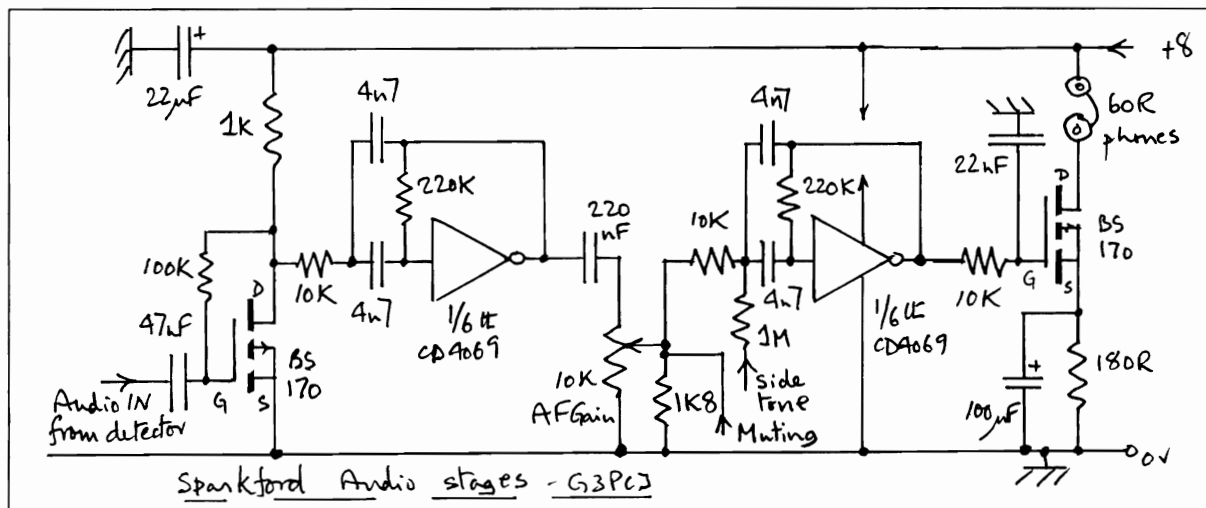
Tips from Joseph Bell G3DII

Zener diodes If you are stuck for a Zener diode in the middle of a project don't forget that most bi-polar transistors exhibit the zener effect between base and emitter with the collector open circuit. Obviously they have to be biased backwards compared to the normal way. Connect the base of p-n-p device to the positive side, with emitter negative. Alternatively, connect the emitter of a n-p-n device to the positive and the base to negative. The heftier the transistor, the greater will be the dissipation that it can handle. Try audio devices like BD139 which shows a zener voltage of between 8 and 12 volts typically. Measure the device's actual zener voltage using the circuit in Hot Iron 17.

LED polarity The lead polarity of LEDs varies between manufacturers and errors can be fatal to the device! There is a simple way to identify the leads. Hold the device up to a strong light. You will see through the package that one lead is directly attached to a largish cup, the other lead having a fine wire going to the cup. The cup is always attached to the cathode lead which should connect to the negative side of the circuit. You may not be able to see the fine wire but the cup is always visible, sometimes with a different shape, but the cathode is always connected to the larger of the internal structures.

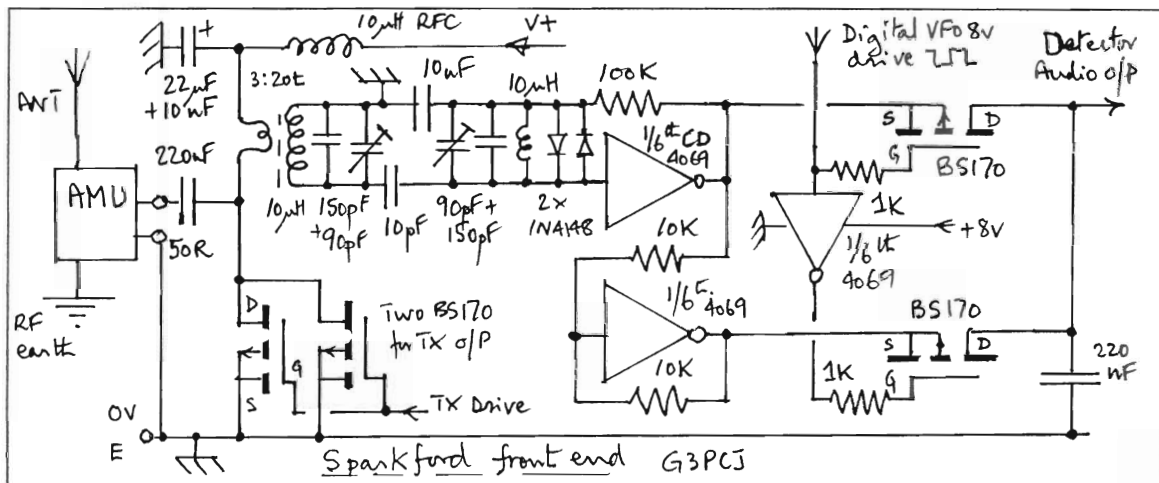
Development of the Sparkford

This design started life as my version of the typical simple 80m CW TCVR. Ingenious as many are, often performance is compromised by using a device for at least two purposes so that it fails to do either or both jobs properly. Some designs also lack essential functions like a VFO, automatic TR changeover or sidetone. Having been brought up on digital devices, I knew a hex CMOS inverter gate package can provide six very cheap 'op amps'. With the output biased to mid supply, the slope of their transfer characteristic shows a voltage gain of times 10. Their cheapness, which allows several to be used, can compensate for low voltage gain. When digital gates are used in this unofficial linear manner, stability can be a problem when negative feedback is used to bias them at the midpoint of the digital transfer curve. The solution is to use the simple unbuffered form of these gates type CD4069 which can work over the wide supply range of about 3 to 18 volts. These inverting gates can be easily arranged as bandpass filters with a gain of 10. The rig actually has two such stages centred on 750 Hz arranged either side of the AF gain control with further audio amplification, and more filtering, both before and after the bandpass filters. On 8 volts, the chip is also fast enough to work as an RF amplifier on 80m. I have previously used a 'digital' signal type VFO in the Wedmore so was confident that they could be used with a 3.58 MHz ceramic resonator tuned by varactor diodes for the main tuning and transmitter frequency offset. Already it looked as though one device type might do several tasks so reducing the number of different types of parts - always a desirable factor. Audio output stages are a problem in a low cost rigs; I do not like the LM386 which is frequently used because it has a narrow recommended supply range. Output for phones would be adequate but not many people have high impedance versions. The common cheap walkman types phones present 60 Ohms when connected in series but even this is too low for the CMOS hex inverter so some form of discrete output device is essential. The BS170 MOSFETs is now cheaper than BC182 etc. and is also more versatile. They are also quite fast so I was happy to add them to the parts list! Further BS170 FETs are actually used for muting and the sidetone oscillator which manages to stop and start with the minimum of thumps! Using these ideas, the main AF circuit that evolved, is shown below.



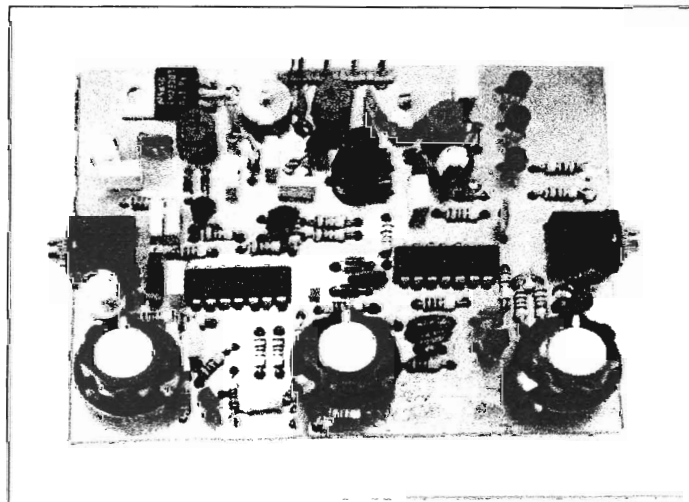
The RX had to be a simple direct conversion type but the choice of detector was not obvious. I wanted to avoid a NE612 because of cost and, to some extent, complexity. A simple diode detector was tried initially but at night it was awful! Wanted 80m signals were swamped by the broadcast stations near 4 MHz even with multiple stages of RF filtering. A doubly balanced form of detector is essential to reject this AM breakthrough. After searching the literature for ideas, I eventually stumbled on an article about switching or synchronous detectors using a quad of special MOSFETs in place of the diodes in a conventional doubly balanced diode mixer. The decision to use BS170's instead didn't take long but avoiding the trifilar wound toroidal transformers was harder! Avoiding that associated with the VFO was easy - use another digital inverter gate, after the VFO oscillator stage, to provide normal and opposite phase signals for the MOSFET switches. How to provide normal and opposite phase RF signals for the MOSFET switches? Solution - use another inverter gate adjusted for a gain of one which is easily arranged! The result is a fairly simple and cheap doubly balanced mixer (see over) which does reject the unwanted AM and which avoids the dreaded coil winding! Using another inverter gate as an RF amplifier lifts the overall gain without risking too much AF gain and possible instability. Further spare gates are used to provide offset tuning T/R voltage control.

The TX had to have 'automatic' TR facilities but avoiding a relay would be good for the cost and might allow full break-in operation. Some form of TX harmonic suppression is necessary; I prefer a tuned output stage rather than extra low pass filters. The TX output device was to be a FET so it is easy for it to be switched off completely when receiving, thus not loading the RX tuned circuit to which it is connected. By using the antenna matching unit 50 Ohm load impedance (when properly adjusted) as the TX FET drain load, will define the device drain load, hence power output on a given supply voltage. By directly coupling this to the first stage of the RX bandpass filter, as required for receiving, the receive filter is active on transmit and provides harmonic attenuation. These RX bandpass filters actually use cheap 10 μ H TOKO chokes, in order to have the current handling ability needed by the TX, with tuning by preset capacitors. RX front end protection has to be included because the combined RX/TX tuned circuit multiplies up the RF swing way above the safe limit of the RX inverter supply voltage - hence silicon diodes across the second RF bandpass filter coil. They conduct during transmission, with current being limited by the small filter coupling capacitor. On reception, signals are too small for the diodes to conduct. Originally I was going to use an IRF510 as the TX output device but I soon realised that two more BS170s directly in parallel (without heatsinks) could handle the 1.5 Watts output on a 13.8 volt supply implied by the 50 Ohm transmission line load.



The final uncertainty was supplies. The varactor diodes controlling the actual frequency of operation of the nominal 3.58 MHz ceramic resonator, need a very stable voltage. The TX output stage is run off the incoming supply to avoid pumping of the internal varactor supply and this also allows higher RF outputs on higher supply voltages. 8 volts is needed for the varactor supply to get adequate capacitance change and frequency range (50+ KHz). 9 volt operation is desirable for /P. LM317 regulators need a minimum of 2 volt headroom so would not do, so I gave in to the more expensive LM2930-T8 low drop out regulator. I was not able to devise an alternative circuit using only N channel BS170s! It needs a P channel device (see later) and was looking complex compared to the rest of the rig. On 9 volts, the TX produces about 0.75 Watts, or without modification, about 4 watts for short QSOs on 20 volts - above this output does not increase due to lack of RF drive. Finally, I show the complete rig in its working minimalist form below. Remember, that you can easily change the board mounted preset controls and switch for normal ones very easily and more cheaply than I can supply them!

I plan a Sparkford derivative with phasing receiver for single sideband CW reception, audio output for a normal LS or phones, with TX output power of 5 watts on 13.8 volts - I suspect it may have to use the IRF510 or more BS170s! The mechanical style is undecided yet - PCB mounted shafted presets or the normal PCB front panel open style? With presets it will need a 100 x 160 mm PCB but with separate pots it might fit onto 100 x 80 mm. Another low cost derivative might be a double sideband suppressed carrier phone rig. Comments please - Tim.

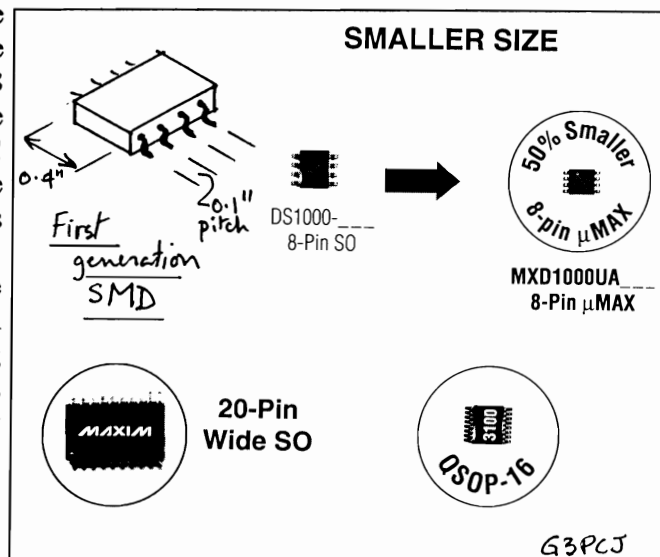


Surface mounting (and the future!)

One of our regular contributors thought we ought to have something on this very important development but declined my request to write the article! Having very little experience myself, I am somewhat hesitant but here goes! There are two main factors which are leading to the use of increasingly (or is it decreasingly?) small components. The first is that normal through printed circuit board mounting technology just *will not work* as operating frequency is pushed higher and higher. This is because the leads of components and their connecting tracks have significant inductance at frequencies above low UHF - say over 300 MHz. Even at this frequency, an unwanted extra quarter of an inch or 3 mm can be the difference between success or failure of a circuit. Obviously actual circuit impedance levels are relevant but as frequency is pushed up, devices are increasingly designed to have 50 Ohm in and out impedances. Most commercial development effort is directed towards mobile phone uses, or other exotic military or satellite applications where operating frequencies are frequently over 1 GHz with many new devices aimed at 20 GHz plus applications! It makes 80m look like DC! (But you would be surprised how often people come unstuck on 20m when home designing/building!) There are many new 'chips' being developed for these applications such as complete phase locked loops to provide stable oscillators, or complete receiving sub-systems capable of complex modes. The minimum operating frequency of these devices is still many hundreds of MHz so they are practically useless for most home constructors. The commercial need for similar devices to work in the HF or low VHF region is practically zero as ordinary point to point HF radio links are superseded by satellite links or fibre-optic cables. In addition, the newer very high frequency applications tend to use increasingly complex forms of modulation, often digitally based, so that the signals have to be processed by some form of microprocessor to make them useful. The linear functions within these chips are often controlled by some form of digital bus driven by a microprocessor. This trend is demonstrated by the modern mobile phone whose properties are far more dependent on the ingenuity of the programmer, and the user services perceived to be needed, than the underlying feat of wireless communication. The cellular structure of the network, where frequencies are reused and allocated dynamically, would be impossible without very significant base (and mobile) station computing. Commercial radios, even for broadcast domestic use, are now hugely complex in comparison to the typical amateur home built rig!

The other factor is *cost!* Size of parts dictates the area of PCB required, and even in my kits, the PCB is a major part of the kit cost so size reduction is important commercially but slightly less so for home building where extra space reduces the risk of errors. Apart from PCB area, having to drill holes for leads is a significant cost as I know! Not only is there the actual drilling time, but it complicates the PCB manufacture through needing more stages and increased chance for errors. Obviously, commercial designs are done with computer controlled drilling jigs but unless the whole process and layout is computerised, it can be very costly for small production runs. Nowadays, most commercial electronic sub-assembly is done with pick and place robotic machines; provided sufficient different parts stocks can be accessed by a particular assembly station, they can be easily reprogrammed to handle multiple product lines. Despite the unit cost of surface mount parts being slightly higher, even in quantity, the cost reductions through PCB area reduction, avoidance of drilling and automated assembly, are well worthwhile.

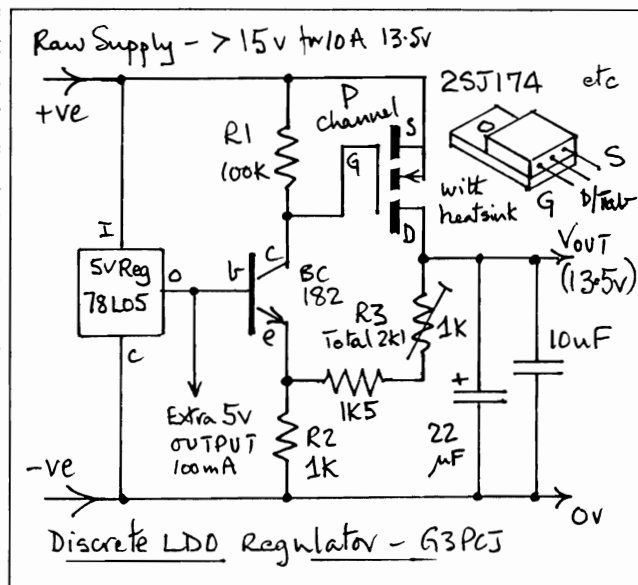
So what do these devices look like and can they be handled at home? The dimensioned sketch right shows a typical 8 lead *first generation* surface mount device with those alongside being actual size! (Assuming it will print properly.) There are many standards and packages with various numbers of pins and different plan shapes. How are they soldered? The pick and place machines use a special paste to stick and solder the pads on the underside to matching patterns of the copper tracks. Soldering is done by many different ways automatically but they tend to depend on the whole device being able to withstand soldering temperatures for a short while. The good news is that all modern devices are much



more robust than they used to be, hence there is no need for any form of heatsinking when soldering leads provided you make the joint quickly. Completing the joint within about 3 seconds (about three times longer than usually necessary) is very unlikely to damage modern devices of any package style. If you are going to attempt to build circuits using surface mount devices, you must use a copper track pattern to suit the particular footprint of the device. There are a few specialist development patterns on pre-etched PCBs but these are seldom suited to high frequencies. If you etch your own PCBs, the track pattern is no problem providing the line width of your technique is small enough and dependable. Soldering is best done with a very fine tipped hot iron using the normal 60:40 tin:lead solder. As the devices are so small and light, it is essential to hold them down in the correct place with a third hand while you apply soldering iron and solder to the lead/pad joint area. The use of a large illuminated magnifying glass, on its own mounting arm, is highly recommended. Removing and re-using a multi-pad surface mount device from a PCB is always very difficult (worse than dual in line chips); often it is easiest to cut it in half and accept the loss! I would love to hear about any member's experience and whether builders would like a surface mount project - if so what? Something simple like a wide band active scope probe maybe? Tim

Discrete Low Drop Out linear regulator

Low drop out (LDO) refers to the minimum difference between input and output voltage which permits proper operation; this is often quoted as 2 volts minimum for bi-polar device designs like the 1 Amp fixed voltage 78XX series or the variable LM317T. Using a P channel MOSFET for the main pass device gets this down to fractions of a volt! This is important when a wide variation in load current is expected with the typical poorly regulated raw supply from bridge rectifier plus reservoir capacitor. High output current makes the incoming supply sag so a regulator which reduces the need for more input voltage will make it possible to use a lower transformer secondary voltage, lower voltage capacitors, less heatsink etc. (Or lower raw battery supply). The circuit shown right can be used with any



size of P channel MOSFET pass transistor. The minimum drop out voltage is output current times the device On resistance. For the 75 Watt 25J174 costing under £4, the on resistance of about 0.13R gives a drop out voltage of 1 volt at 7.5Amps. Max current is 20Amp continuous! Smaller devices like the 0.65 watt BSS110 @ 50 pence can handle up to 0.2 Amps with an $R_{DS(on)}$ of 10R. Both devices can withstand 50 volts between drain and source. The circuit works by using the BC182 transistor in a common base mode so that changes in emitter voltage (derived from the output voltage) cause its collector, and hence the output device gate, to move in the same direction. Thus when the output droops, the MOSFET gate goes more negative turning the MOSFET on harder and so correcting the output droop. The output resistive potential divider R2/R3 is arranged to have a mid point voltage which is normally about 0.65 volts below the BC182 base voltage derived from the fixed voltage regulator. Using a fixed 5 volt regulator enables the common output voltages to be achieved easily - the values shown should provide about 13.5 volts output. The loss of gain through using a resistive potential divider is easily made up by the high collector load R1 for the BC182; since the pass transistor gate looks like a capacitor it does not materially load R1 - only affecting the response to load or line voltage changes. High frequency load regulation is provided by the output capacitors. G3PCJ

Finally, do not forget the

14th Yeovil QRP Convention

The date is earlier this year, *April 19th* at the Digby Hall in Sherborne as before. Star attraction is the Rev George Dobbs G3RJV. All the usual attractions - traders, bring and buy, food, talks, demonstrations and Construction Challenge. This is to produce the most power efficient 20m QRP transmitter. Details from Peter Burrige G3CQR, QTHR or Tel 01935 813054. Hope to see you there.

Best wishes,

Tim Walford G3PCJ

Hot Iron

Issue 20

“Journal of the Constructors Club”

Summer 1998



Editorial

Gorgeous weather makes it rather hard to come inside and sit at the computing beast but this time I am pleased to have contributions from several members so I don't have to exercise the grey cells quite so hard! Thank you to those who have contributed. To those who have not yet done so, please do not think you have nothing to offer - I am quite certain that most builders have some tips or experiences that others would love to share. Do not be modest! There is one particular subject that should concern most future kit builders - namely the continued supply of chips suitable for home construction. Increasingly, new designs are surface mount devices and, judging by the deafening silence following my note last time about these techniques, none of you fancy building with them. There is a particular problem over mixer chips suitable for HF work to replace the well loved workhorse NE602 or 612 which form the backbone of many QRP rigs including mine; manufacture has stopped and they are no longer available at reasonable prices. While I have stocks to last for some while, I hesitate to incorporate them into major new designs.

The alternatives that I have considered so far all have some significant

problem, either needing more space and/or supplementary parts, or more LO power, or higher cost or are in surface mount format or a combination of all these points! Get your thinking caps on because this is a real problem especially for low noise and wide bandwidth operation.

Kit Developments

First the good news; early reports on the **Sparkford** are very encouraging and I shall be doing a special offer for members of the GQRP Club soon - ask me if you particularly interested in this rig. I mentioned last time that I had in mind a phasing CW version of the Sparkford - after ugly style bench trials, I did a full design but sadly the performance was not good enough for the complexity and it has been consigned to the shelf of interesting ideas! Realizing that I needed a wider range of CW rigs, I have put the **Frome** scheme on to a single PCB, with the option for any 1 or two bands 10 to 160m, and called it the **Wellington**. This is considerable improvement brought about by a new Thompson chip which can drive an IRF510 to 5 Watts on 10m using a 13.8 volt supply. The scheme uses a 6 to 6.1 MHz VFO with crystals for each band allowing all bands to tune the same way with nominally 100 KHz coverage from the lower frequency band edge. This crystal mixing VFO scheme avoids chirp and gives good frequency stability. The single band TCVR looks like costing about £60-65. I could do with some early model builders please! The prototype is now working on 10 and 160m - the last few nights there has been a similar amount of (reasonable) activity on both these bands!

I continue to search for a cheap entry to 6m, including converters to 3.5, 7 or 14 MHz but given that most activity is FM, maybe that is the way to go. Any comments? Tim G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 E mail walfor@globalnet.co.uk The Copyright of all material published in *Hot Iron* is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.



Non-Ionospheric Propagation

David Rowlands asks about the relative signal strengths, ignoring ionospheric reflection, that would be received for any band (KHz to GHz) over a distance of a few miles using a constant radiated power in the direction of the receiving site. The answer is not simple and depends on many factors.

Firstly, the method of propagation will depend upon the frequency. At the lowest frequencies it will be by surface (ground) wave and at the highest frequencies by the direct wave. Tabulated below is the commonly accepted propagation method for different frequencies used by professionals.

<u>Frequency</u>	<u>Main means of propagation</u>
Below 500 KHz	Surface wave (Ground wave)
500 KHz to 1.5 MHz	Surface wave for short distances and Ionospheric wave for longer distances
1.5 MHz to 30 MHz	Ionospheric wave
Above 30 MHz	Space wave (Direct wave) within line of sight

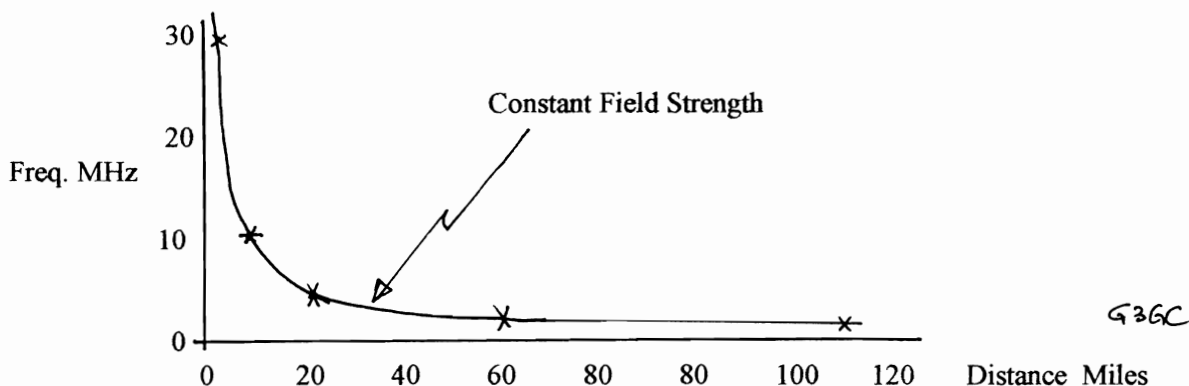
Obviously, the changes in the method of propagation are not discrete as the table suggests but tend to gradually change from one category to the next. This is quite obvious to us as amateurs as we will use many bands in the range of 1.5 to 30 MHz for local communication although admittedly this becomes more and more difficult the higher the frequency that is used.

The surface wave is the wave that travels just over and partly within the ground - hence its other name of ground wave. The wave front gets tilted downwards thus allowing the wave to follow the curvature of the earth. An example of this form of propagation is the BBC's long wave transmitter at Droitwich on 198 KHz. This, as you all know, covers most if not all of the UK without any of the fading problems that are experienced by the medium wave (0.5 MHz to 1.5 MHz) transmissions due to ionospheric reflection and propagation. Even lower frequencies than this are used for secure long distance communication. The depth of penetration of surface wave into the earth varies depending on the ground's characteristics and the frequency in use. This can be as much as fifteen metres at broadcast frequencies but only one or two metres at shortwave frequencies. This penetration means that some of the power is dissipated in the earth's surface, thus reducing the signal strength as the distance to the receiving station increases. These ground losses depend upon two main factors namely the "Relative Permittivity" and the "Conductivity" of the ground. The higher both these are, then the lower are the losses. Tabulated below are the values for different types of surface.

<u>Type of ground</u>	<u>Relative Permittivity</u>	<u>Conductivity (mho/m)</u>
Sea water	80	5
Fresh water	80	0.005
Moist soil	15 - 30	0.005 - 0.01
Rocky ground	7	0.001
Dry soil	4	0.001 - 0.01

Theory shows that at low frequencies the surface wave is dependent mainly on the conductivity and is strongest for high conductivity. At higher frequencies a high permittivity is the important factor in giving a strong surface wave. Thus for all frequencies surface wave propagation is best over a sea path and worst over dry ground.

If one uses a short ground based vertical aerial radiating a constant power then for the same received field strength the distance increases as the frequency decreases. The graph below is the curve of constant field strength plotted for frequency against distance.



From this graph it can be seen that with ground wave propagation the same field strength is obtained at 3 miles on 30 MHz as would be obtained at 20 miles on 3 MHz or 110 miles on 0.5 MHz.

Above 30 MHz, the ground wave as we understand it, does not exist and the main method of propagation is by the direct wave. If there are no reflected waves from the ground, buildings or other objects, then the received signal will approach the free space propagation law:-

$$E_0 \text{ (dB, } \mu\text{V/m, one KW)} = 102.8 - 20\log D \quad \text{where D is the distance in miles.}$$

This simply means that if the power radiated in the direction of the receiving site is 1KW then E_0 is the field strength in $\mu\text{V/m}$ expressed in dBs. If the power is not 1KW but 100W then this reduction expressed in dBs is 10 and E_0 would be reduced by this amount. An amateur station on two metres with a high gain aerial and using full power can easily have an effective radiated power of 1KW. For the formula to apply with any degree of accuracy, then the aerials must be elevated above ground to ensure there is a "line of sight". The radio horizon from an elevated position is further than the figure obtained by calculation using the physical diameter of the earth. The reason is that, due to refraction in the atmosphere, the radio waves are bent downwards and therefore they can "see" further than would be expected. This is the same as saying that the earth is a bit flatter or has a larger diameter than it actually has. The factor taken for normal atmospheric conditions is that the earth's diameter is effectively increased by some 30% or that its diameter is four thirds the physical diameter. The formula for calculating the "radio horizon" for a four thirds earth is given as $D = \sqrt{1.414 \times H}$. Under abnormal weather conditions, the refraction becomes greater and the 4/3s factor will increase considerably with consequent increase in the distance to the radio horizon. This is what we call a "lift".

The effect of using a low aerial will not only be to reduce the distance to the radio horizon but it will also reduce this field strength due to losses from objects in the line of path. This is commonly called clutter loss. A further effect that will affect the signal strength at gigahertz frequencies is the amount of water in the atmosphere either as droplets or as rain.

Propagation is never a precise discipline but I hope the above helps. Eric Godfrey, G3GC

Zinc-air cells and Battery Technology

Following the note in Hot Iron 18 about rechargeable batteries, I spied the following note in a trade magazine:- "The battery industry uses three measures to compare battery technology. They are: energy per pound weight, energy per volume and cost per unit of energy. Rechargeable Zinc-air cells have 1) almost twice the energy per pound weight as Li-ion; 2) slightly more energy per volume than Li-ion and 3) cost just one third of Li-ion per unit energy." Watch out for them in future!

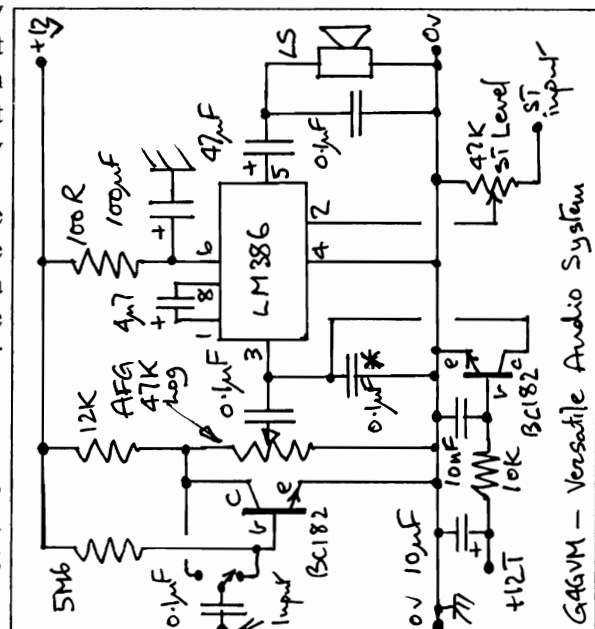
A Versatile Audio System

The circuit alongside has become my standard audio system for DC rigs etc. because it uses few components, is stable and compact. An input port for a sidetone oscillator is available at pin 2 of the IC and muting at pin 3 is easily achieved when used with a transmitter.

For general use it is made up as a separate unit with the input switchable to include the pre-amp for very weak signals such as from a crystal set, or mixer, or for signal tracing, or as the power amplifier to drive a loud speaker for stronger input signals.

Derek Alexander G4GVM

(Note that Derek has set the capacitors for CW, so if used for phone, the starred input capacitor would need to be reduced and the output coupling capacitor might need increasing depending on LS impedance. G3PCJ)



Taunton Tips

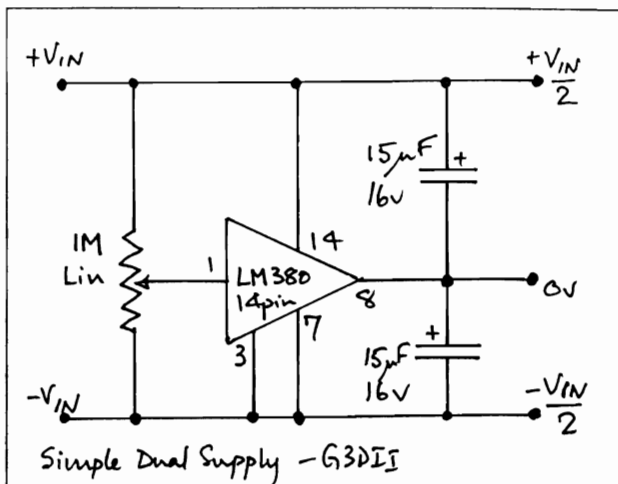
When tuning up two band cards, David Rowlands G6UEB suggests that after you have set the first band's inductor cores, that you cover them up with some form of tape to prevent inadvertent adjustment while setting those for the second band. Alternatively, mark the cans with the band's wavelength! He has also done away with the fine tuning control by using a slow motion drive on the main tuning pot. Other builders advocate gluing the ends of the band card connectors with araldite.

Simple Dual Power Supply

A glance through the list of operational amplifiers available will show that only a few are designed for use with a single supply. This can be a nuisance to the constructor when, for instance, he wants to build in say a 741 into a circuit using a common supply. It is well known that it is sometimes possible to bias pin 3 of a 741 and the like to work from a single supply but this dodge cannot always be used.

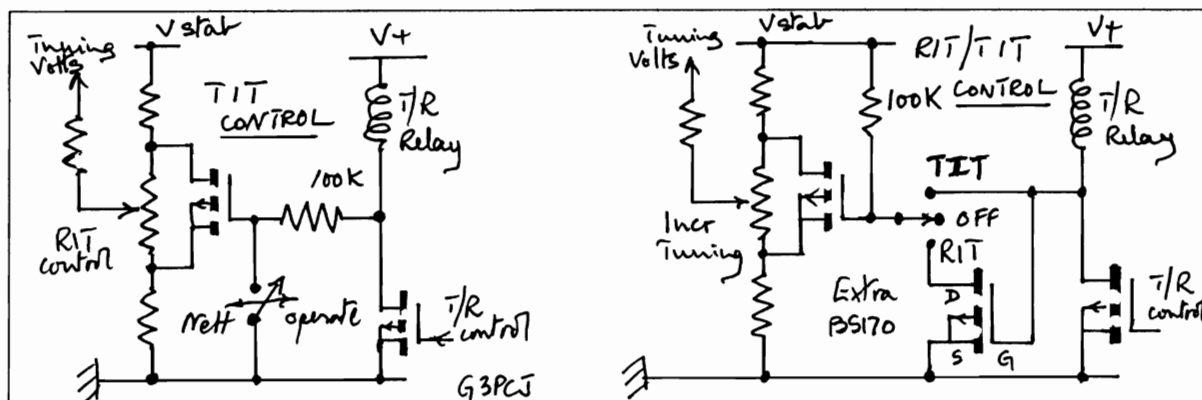
The circuit alongside offers a cheap and simple way of obtaining a split supply using a LM380 audio power amp IC. The device is internally biased so that with no input, the output voltage is held mid-way between the supply rails. The 1M pot should be initially set to mid-travel and is used to nullify any unbalance in the output.

The regulation of V_{out} depends on the regulation of the source supply but positive and negative outputs will track accurately irrespective of input regulation and unbalanced loads. The maximum free air dissipation is a little over 1 Watt so extra cooling in the form an aluminium fin stuck to the top of the package maybe required. The device is fully protected and will go into thermal shut-down if dissipation is exceeded. Current limiting occurs if the output current exceeds 1.3 Amps. The input voltage should not exceed 22 volts. The details given are for the 14 pin version, the 8 pin can be used with less dissipation. Joseph Bell G3DII



Changing TIT to RIT

David Proctor G0UTF told me how he had changed the Frome's frequency offset arrangements from a Transmit offset, set with a netting control, to provide Receive Incremental Tuning. To make this change, the signal driving the offset gating transistor needs to have its sense reversed. Usually the tuning offset is inhibited when the controlling transistor FET gate is high at 8 or more volts - thus we need to arrange for this gate voltage to be high (8 volts or more) during transmission or when the RIT is switched off. For the Frome this is easily achieved by disconnecting the gate of TR307 from R316 and the output at pin 10 of IC301C and reconnecting the gate of TR307 to pin 11 of IC310D. In simple rigs, TIT control is often provided since it can be driven from the TR relay without further transistors - this is the scheme in the Wedmore sketched on the left below. It is easily changed to RIT control by adding a second BS170 inverting stage and re-arranging the resistor. In fact, using a centre-off toggle switch allows you to have RIT or TIT as you prefer! Remember the tuning procedure changes; for TIT you tune initially for either sideband with the TIT off and then, with the TIT on, adjust the TIT control for zero beat. For RIT, you tune for zero beat with the RIT off, then switch it on and select whichever sideband you want with the RIT control. With care, provided you always tune in the same direction (to always use the same sideband) you do not need to keep switching the RIT on and off as you tune around; but you do need to always tune for the same pitch that you earlier set the RIT control to achieve when the main tuning without RIT gave zero beat. G3PCJ

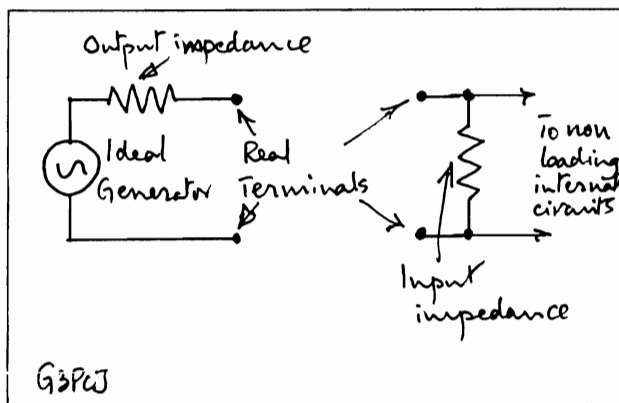


Boxes

Jim Geary advocates the JS19 from JAB which is 202x204x75 for 2 PCB rigs. It costs £6.25 + 1 P&P

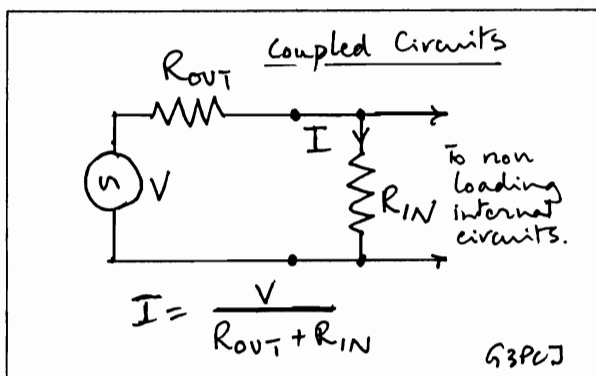
Interstage Coupling and Impedance

Constructors often lift circuits from different sources and couple them together only to find that they do not perform as expected - frequently the culprit is mismatched impedances. All real circuits have an input and output impedance and knowledge of these, or at least their rough magnitude, is essential to transferring energy satisfactorily from one to the other. Take the simple example of a small zinc-carbon primary cell. It is said to have an output voltage of 1.5 volts but in reality you can only draw a fraction of an Amp out of it (for a moderate sized cell) because it has internal resistance. This is its output impedance. The term impedance is rather more general, since it also covers AC situations, but for this note I apologise for being slightly loose with the terms impedance and resistance/reactance. The equivalent circuit of the above cell can be represented by an ideal voltage source or generator in series with a resistance - see the left diagram below. The actual values can be easily measured; the voltage of the ideal generator is measured with a voltmeter (having a high input impedance which draws a negligible current hence no volt-drop in the internal resistance), the internal resistance or output impedance is assessed by measuring the current through a short circuit across the output. Then the internal resistance is worked out by Ohm's law ($R = V/I$) using the previously measured voltage. Another less damaging method is to use a resistor across the output, whose value is adjusted till the voltage across it is half the open circuit voltage. The value of the external resistor is then the same as the internal impedance. (If doing this at HF remember to not introduce extra capacity from the resistor or voltmeter.)



In a similar way, the input of a circuit can be represented by an impedance across the input terminals with some sort of ideal generator creating an output depending on the applied voltage - see the right hand diagram. The actual value of the input impedance can be measured by seeing what current a known applied voltage creates and then use Ohm's law. You can also use a variable resistance in series and adjust it till the voltage across the unknown input is half that from the source. The resistance then has the same value as the input resistance.

When two such circuits are connected together, the actual current that flows between them is dependent on generator voltage and both output and input resistances - see below. The problems arise when one of the resistances is very much larger than the other so that it massively restricts the current that would flow into the load circuit. Try putting a high wattage torch bulb across the single cell - it doesn't even glow because the cell's output resistance is much higher than the load resistance! Note that either of them maybe the culprit limiting the desired current flow. Generally, the desire is to

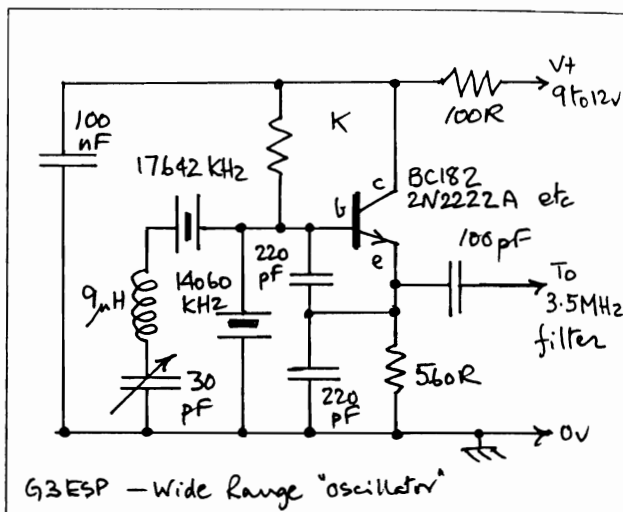


transfer maximum energy from the driving circuit to the load circuit and theory shows this occurs when input and output impedance have the same value. For example, 50 Ohm interstage impedances in the front end of a RX. In the later stages of a RX, when noise is less important, the rule can change to ensure that the load impedance is somewhat larger than the output impedance so that there is negligible voltage drop across the output impedance. In all cases, *the important thing is to make certain that the load impedance is equal to or higher than the source impedance.*

In many practical situations, the exact impedances are not known but their approximate value can be assessed or guessed from experience. Series tuned circuits have very low impedances, while parallel tuned circuit have very high values - but the impedance presented to other circuits can be altered by inductive or capacitive 'tapping down'. Active circuits tend to have 'middling' impedances but feedback can modify them up or down - this is a widely used and powerful technique beyond this note. Components directly in parallel with the input or output, in a signal sense, set a maximum for the impedance; similarly components in series with the signal line will set a minimum value. Modern op-amps have very low output impedances which are further reduced by feedback. A derivative of the impedance rule is 'don't mix impedances unless you have an idea of their values!' Tim G3PCJ

Wide Range Crystal Control for 80m

Walter Farrar G3ESP sent in the circuit on the right which generates a wide frequency range for the 80m band by pulling a high frequency crystal and mixing with another. Frequency stability is excellent. He happened to have two crystals which enabled an output from 3509 to 3587 KHz with the values shown. The circuit works by oscillating on both frequencies at the same time and mixing them together all in one transistor. The detail of the output filter is not shown because it will depend on what it is driving. The 9 μ H inductor can be 44 turns on a T68-6 toroid or a 10 μ H small choke. (Make the 14.060 MHz crystal the variable one and it might do 20m as well! G3PCJ)



Somerset Homebrew Contest

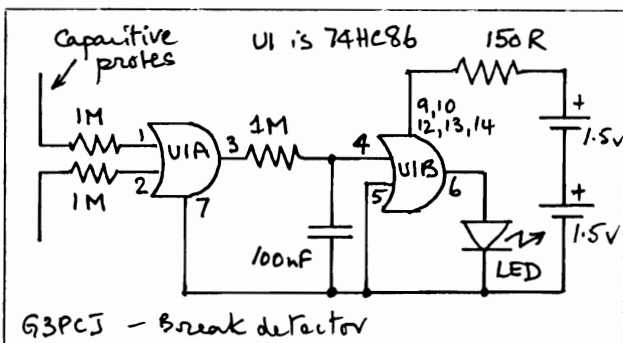
The full details will appear in Spratt but Stan Laing G4MQC has been declared the overall winner this year. He was using a Taunton! There was a larger entry with some overseas operators which is good. Get your rigs ready for next year! Thanks go to Peter Barville G3XJS for organising it.

Web sites!

There is a wealth of fascinating information available on the World Wide Web. For example, the ability to download the full data sheets of any device you fancy using is worth a lot of time and money. There are also some very interesting home pages from many radio amateurs including that from Frank Lee G3YCC who has some smart colour pictures of his Taunton. His home page address is <http://www.homeusers.prestel.co.uk/g3ycc> and of course there are others for the GQRP Club etc. My son is supposed to be working on mine!

Christmas Tree Lights!

It's a bit early yet but finding the failed bulb in a long series connected string is very tedious! The circuit right appeared in a US journal and should save many hours of frustration and broken bulbs due to screwing them in and out! Wave the two capacitive probes slowly all around the string when it is connected to the live mains. At the failed bulb, the voltage difference is high which, when coupled to the probes, causes the LED to light. Nifty! G3PCJ



Various PCBs

I have surplus to my needs:-

One pair of new Yeovil RX and TX PCBs plus another TX PCB.

A Coxley PCB with minor track defect. The associated 20, 40, 80 Regen TRF RX kit is available. There is also the matching Godney 3 band CW TX.

Slightly damaged variable CW filter PCB - rest of kit is also available.

A number of Issue 4 Taunton PCBs which need only minor alteration to update them to the latest Issue 5 state - rest of the kit also available.

Please contact me if you want to build these kits or use any of the PCBs.

Subscriptions!

I am afraid it is that time of year again! If you wish to continue receiving Hot Iron, I need to have your subscription by the next issue, due out in early September 1998. £6 please for UK members and £8 for overseas. I shall not be sending any reminders. Back issues for complete years are available for £5. Thank you for your support during the last year and I hope for articles for the next. Tim G3PCJ

Hot Iron

Issue 21

"Journal of the Constructors Club"

Autumn 1998



Editorial

Welcome to the start of a new Construction Club year which is now our fifth - without the active support and encouragement of you I could not have kept it going this far - thank you and please keep sending in your contributions. For those who have hesitated to contribute so far, please don't be worry about writing/drawing tidily - I can 'adjust' most contributions without too much difficulty. I should love to have some new contributors and many members would find it interesting to hear about other member's rigs, test equipment and homebrew projects, including those that are not too successful!

We had a weeks holiday in Cornwall just before the harvest on a farm (where else!) where all the old buildings had been converted into holiday accommodation. I took the prototype Langport (see below), AMU and a reel of wire with me. With plenty of space here for antennas, I normally use a 160m dipole fed by open wire feeders and a versatile matching unit, which obtains a good 'grip' on the aether and performs well. When on holiday, being close to others and not wishing to intrude too much, I started by erecting my end fed wire along the plastic guttering of the old barn; despite a total length

of nearly 50 ft which produced quite adequate reception, I failed to even raise the locals on 80m! Messing around with alternative RF 'earths' made no difference so I eventually strung the same wire across the yard (out in the open) at about 15 ft minimum height. I called the first person who I heard calling CQ - it turned out to be Rob Mannion G3XFD in Hampshire who is Editor of PW - neither of us recognised each other despite many conversations by other means! All of which goes to show that when operating QRP, you have to have an efficient antenna in reasonably clear surroundings.

Kit Developments

Last time I mentioned the **Wellington** TCVR, CW for any 1 or 2 bands to 10m; this is now available after helpful trials by early builders. The mark 3 **Booster** is now out incorporating several improvements aimed at portable operation where antenna efficiency is often poor - I could have used it on holiday! On transmit it produces 20 W on a 13.8 volt supply from about 1 to 1.5 Watts drive over the frequency range 1.8 to 15 MHz. For reception there is a 10 dB RF amplifier. Control is direct or by RF sensing with the option to separately control the receive and transmit amplifiers.

The **Langport** is a 5 Watt CW & phone SSB superhet TCVR for 20 and 80m. It is a Yeovil derivative with an IF amp, better RF and AF filtering and many simplifications. I have managed to squeeze it onto a single 100 x 160 mm PCB so it is pretty full! The VFO runs at 2 to 2.5 MHz for 80m, for 20m this is mixed with an 18 MHz crystal so stability is excellent. Price will be about £115 - a couple of early builders are needed - please let me know if you are interested. The same PCB could do 20 and 160m phone & CW OR 160m CW plus any other band phone & CW to 10m! A £10 discount for the first correct explanation received for this odd set of possibilities! Tim Walford G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 E mail walfor@globalnet.co.uk The Copyright of all material published in *Hot Iron* is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st.

Effective Radiated Power

Jim Geary GW8HKY asked about erp and our licenses - Eric Godfrey G3GC kindly came to my rescue:-

'The Amateur Radio Booklet BR68 which accompanies the Amateur Radio Licence (A) and (B) contains a schedule of the maximum powers that may be used for different bands. It specifies the power which may be supplied to the aerial in dBW except in the case of the band 431.0 to 432.0 MHz where the specification is in dBW erp. This specification of erp power also applies to the licence variation order for 73 KHz. So what are the implications of these two different specifications?

In the majority of bands where the power is specified as so many dBW to the aerial this is the power at the aerial terminals. This means that if there is any loss in the feeder then the power from the transmitter into the feeder may be higher so as to give the specified power at the actual aerial terminals. It is of no consequence as to what type of aerial is used. This means that if a beam with a power gain of say 10 dB over a dipole in the direction of maximum radiation is used then the power actually radiated in this direction will be 10 dB greater. 10 dB is a power gain of 10 and therefore, if the power at the aerial terminals is 100 W, then in the direction of the main beam the remote field strength and therefore received signal strength (compared with a dipole) will be as though the power was 10 x 100 Watts or 1 KW. This is the effective radiated power normally abbreviated to erp. So when the power is specified in absolute terms it is possible to effectively radiate, in a particular direction, power far in excess of the transmitter power.

When the power is specified as an erp then this implies that this is the maximum power that may be radiated in any direction. Therefore the aerial gain has to be taken into consideration and the transmitter power, after allowing for any feeder losses, adjusted accordingly so as not to exceed the specified erp. This means that if one is using a beam with a gain over a dipole then in the 431 to 432 MHz band the transmitter power will be less than the erp power so as to not exceed the specified 16 dBW erp (39.8 W). In the case of 73 KHz where the erp is specified at 0 dBW (1 Watt) the opposite will usually apply since most aerials are unlikely to be anything approaching a half wave long which is 2055 metres. Since the aerial is likely to be considerably shorter than a half wave dipole the resultant effective gain will be less than unity i.e. a loss with respect to the dipole (indicated by negative dBs) and therefore a larger transmitter power than 0 dBW will be required to achieve the 0 dBW erp. If the aerial shows a loss of 10 to 1 (-10 dB) over a half wave dipole then the transmitter power will have to be increased by the same factor of 10 to 10 dBW or 10 Watts.' Eric Godfrey G3GC

Tips and comments

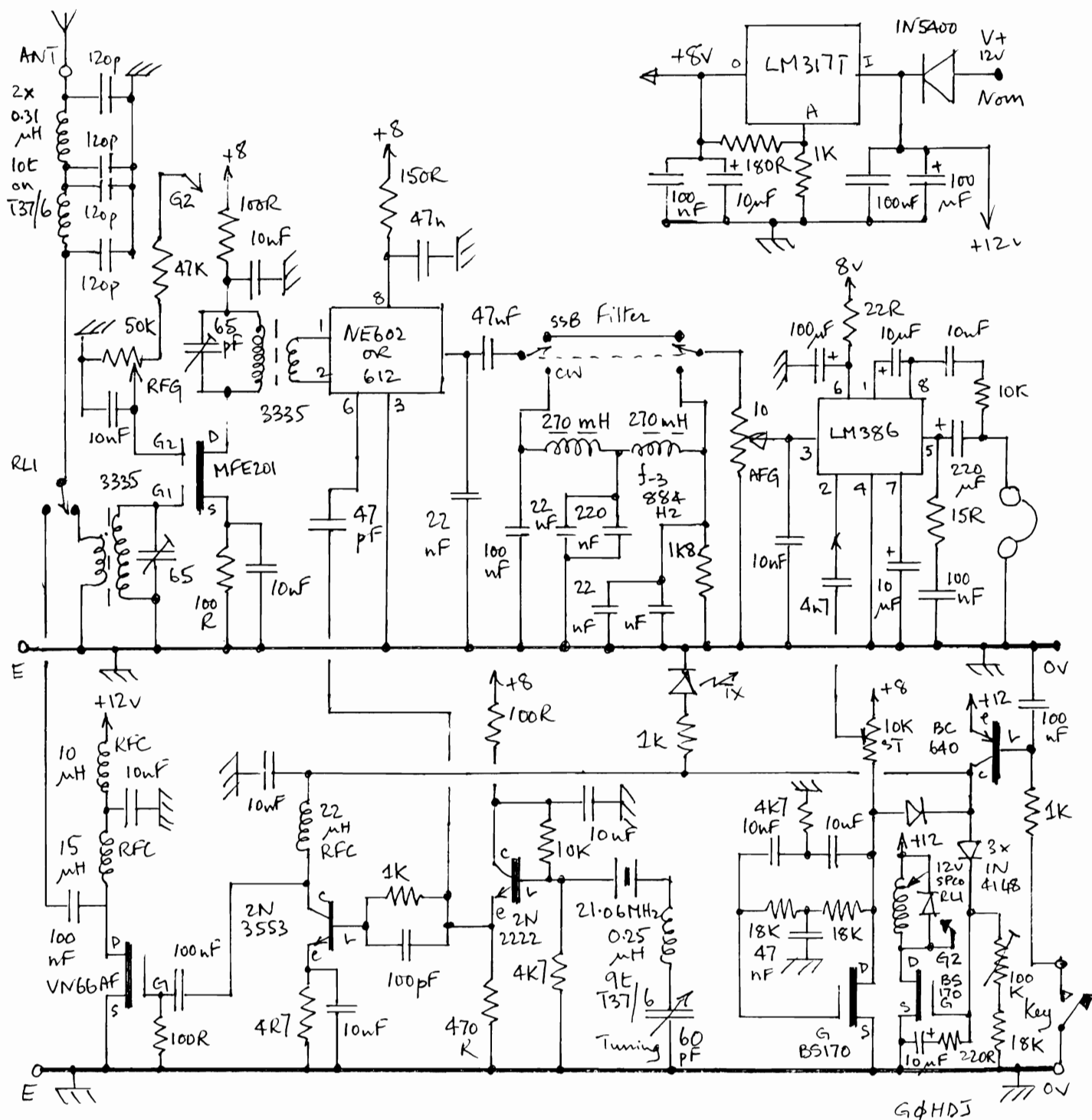
Norman Hixson M0ALB suggests that taking reverse tracings of parts layout diagrams by photocopying greatly eases finding the position of individual parts - if you want, the magnification can also be adjusted on the photocopier. Norman also comments that using preset controls as normal front panel controls (as in the Sparkford) may lead to premature failure as they were never intended for such extensive use. True if heavily used but in defence I would point out that *you* can go to a rally and buy full size replacement pots/knobs for far lower prices than I can supply them new and it avoids the initial cost/mechanical complexity of a front panel as part of the kit while allowing you to get it on air quicker! I think it also adds distinction to the rig but do appreciate that point is debatable!!!!

Austin Muir (ex ZS5KH) also comments on controls, preferring a large wooden (for cost/ease of building) front panel, with protective wire mesh, so that the circuit PCB can also be mounted on it. He hankers after designs with more options for experiment, particularly by changing inductors for coverage of other bands. I hope he will forgive any implied comment but his experience derives from a much earlier age when all coils had to be home wound and were large by modern standards; nowadays builders are much more weary of inductors and small size is highly valued - which is why I squeezed the Langport onto one PCB. Superhet rigs usually contain many more inductors than a simple regenerative RX so band changing is also impossible if not designed in from the start.

Cases! I normally include a blank single sided 100 x 160 mm PCB in the more complex kits for builders to use as a front panel. For my own purposes, I hardly ever box anything because it does not allow demonstration so easily; furthermore it aggravates fault finding or testing during construction because a box invariably prevents access to the PCB underside. I^{am} aware of at least one person who builds like me but would love to have some wider feedback. Nearly every rig that gets returned here has been cased. Do builders want PCB front panels? Omitting them would save about £3. I have considered offering a U shaped aluminium cover to match the PCB panels, attaching directly to the main PCB. They would cost about £6 extra with a rear blank PCB panel. Any interest? G3PCJ

15m CW transceiver

Craig Douglas G0HDJ has been developing this little rig over the last 18 months and now reports good success. He wanted a small rig for portable use using a 12 volt battery. It produces 1.5 Watts and is a classic of fitness for purpose. It incorporates circuit ideas from a number of different contributors. When I first saw this rig, it was laid out over quite a large area with undesirable long signal leads darting back and forth but Craig now reports that the final tidy version performs well and is stable in an oscillatory and drift sense. Craig has sent it in for Sprat but I have taken the liberty of altering the control circuit very slightly so that a single pole antenna relay can be used. I would also comment that all three RF chokes in the transmitter could have any value from about 5 to 20 μ H. Apart from using the specified inductors in the RF amp, audio filter and RF low pass filter, there is very little that is critical. It should be laid out in the normal sequential manner to minimise the chance of unwanted feedback. Why not try building it 'ugly' style on a sheet of copper clad board? The scheme can be used on other bands near 21 MHz quite easily. In the RX, only the RF amp Toko coils/trimmers and crystal have to be changed. In the TX, only the RF low pass filter needs altering.



Broadcast Station Interference

David Proctor G0UTF and Mark Worsfold have both had problems with BCI which is more likely to affect direct conversion receivers than superhets. The root of the trouble is that the mixer, which in a DC rig converts the RF down to audio directly, is unable to reject the very large RF signals emanating from broadcast stations close in frequency (and maybe physically); this overloading of the mixer causes it to act as a poor envelope detector (not as the desired product detector) hence partially recovering the broadcast station's modulating audio. The real solution is to use a 'strong' mixer, meaning one which can handle large signals without overloading; most of us however, are stuck with NE602 or 612 mixers which cannot easily be changed - their replacement is another story! Because the mixer of a DC rig is followed by audio amplification stages, these 'noises' are passed to the output - typical symptoms are weakish mushy sounding audio which is independent of the rig's tuning. Quite often, a small reduction in the BC signal will cure the problem. In a superhet, the first mixer, which is the one prone to BCI overload, is followed by the IF strip which does not pass the BC station's audio so superhets seldom exhibit this particular trouble. (Superhets can still suffer overload from other in-band signals but this is a different problem which seldom lasts for more than one operating session.)

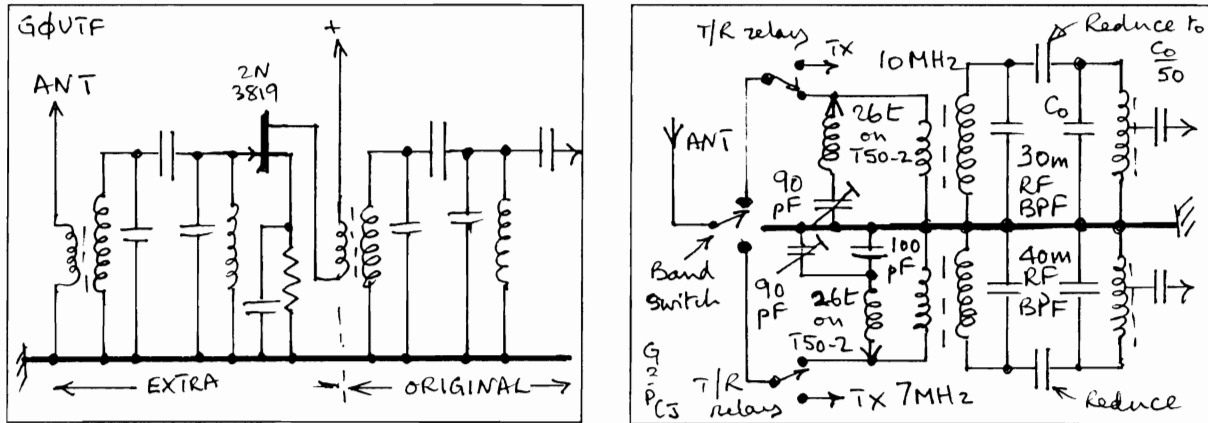
Some amateur bands are more likely to suffer BCI than others due to the proximity of broadcast stations; the worst offenders are 40m, with the BC stations only a few KHz away from the top end of the band making it a stiff test for any rig, and 30m which can be nearly as bad. In principle any desired band can be affected by any strong RF source but due to the rig's RF filtering, trouble is most likely to come from BC stations whose frequency is near to the wanted signals. People also have trouble with 160m but the cause is usually slightly different; this is because 160m antennas are often long wires (giving large BC signals) and matched to the rig with an L network matching unit. The 160m antenna is high impedance so the L network has a low pass response which fails to attenuate the lower frequency signals from the powerful BC stations in the HF end of the medium wave band.

There are two main approaches to overcoming BCI, the first is better RF filtering to allow only the wanted signals into the receiver. If this does not effect a cure, then attenuation specifically of the unwanted signal is necessary. Do not do anything which *increases* RF gain, this will only aggravate it! Filtering to allow in only wanted signals should start with the antenna matching unit; link coupling and a parallel tuned circuit will provide the best out of band rejection on both the high and low frequency side of the wanted signal. Changing to this style of AMU is often sufficient to cure problems on 160m where the interference is not that close in a frequency sense, which allows the low Q found in AMUs to be effective in attenuating the unwanted. The next step is to reduce the bandwidth of the rig's RF filter - if it uses a double (or triple) tuned circuits with capacitive top coupling, try reducing the small coupling capacitor until sensitivity begins to fall noticeably. A typical value of top coupling capacitor might be one fifteenth of the resonating capacitance but reducing it towards one fiftieth may help. (This is all right for narrow HF bands but may not be sensible for the wide LF bands where the whole band has to be received - these will require more resonant circuits. The maths of such filters is beyond most of us!) Make certain that the coupling into and out of the resonant circuits is sufficiently light to not degrade the Q of the individual circuits. This is especially important if there is only a single tuned circuit. Use a small number of turns, on the low impedance antenna RF input primary, compared to the main resonant winding to give a high turns ratio. Unless the tuned circuit feeds directly into the high impedance gate of an FET, make certain that the next stage is either inductively or capacitively coupled down the main resonant winding. Occasionally BCI can enter the rig after the RF filters, so see if it is present while shorting out the RF bandpass filter, this is a clue to look elsewhere. Longish RF leads (e.g. to plug in band cards) can pick unwanted signals which is why the Taunton has provision for a trap to suck out BC interference near to the 6 MHz IF. It is also worth remembering that overall screening may help.

If improved RF filtering fails to effect a cure then the unwanted signals have to be directly attenuated. Broadband resistive attenuation certainly works well (this is why many rigs have an RF attenuator control), but it affects all signals equally so will also reduce sensitivity to wanted signals. A better solution is to use an extra selective tuned circuit to suck out the interfering signal(s). A series tuned resonant circuit is connected across the low impedance antenna input to the RF bandpass filters. Assuming the offending station is near to the wanted band, this trap should be designed to resonate on the wanted band. Use a 'fixed' inductor wound on a powdered iron T50-2 toroid with sufficient turns to resonate at roughly half mesh of a 90 pF trimmer. Tuning of the trap is checked by using it to first attenuate the wanted signals and then tuning off on whichever side best reduces the interference while causing least wanted signal reduction. The trap should have as high Q as possible (high L to C ratio) so

that the steep slope of its response causes least reduction in wanted signal away from its actual resonant frequency. Experiment with the tuning of the trap, on the opposite side of the offending station to the wanted band, so that it provides just sufficient attenuation of the unwanted signal to cure the problem and hence least reduction in wanted signal.

David Proctor found that with his Frone, there was some improvement from adding a single resonant circuit with a buffering FET RF amplifier prior to the existing RF filters; but the best solution came from an extra double tuned RF filter with the buffering RF amplifier and an input attenuator to reduce the gain back to what it was previously! His solution is really the first approach of keeping out the unwanted without attenuating the wanted. He is actually using four resonant circuits in his 'RF' filter. I have sketched it below left. For Mike's rig, reducing the top coupling capacitors of the existing double tuned RF filters helped on both 30 and 40m but fitting a series trap for each band was most effective. This approach also allows some adjustment to cater for use with different antennas which might have alternative BCI consequences. The diagram right shows values for both bands. G3PCJ



Replacements for the NE602/612

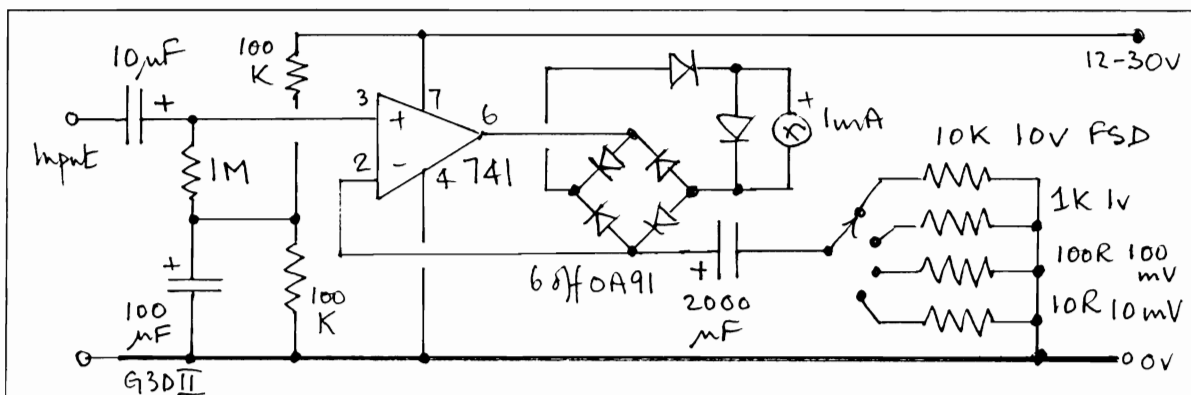
Although these are not being made in pinned dual in line format any more, the surface mount version SA612AD is *definitely* available. Poor Craig G0HDJ ordered some and could barely see them! With patience, you could mount one on an 8 pin header by wire extensions from the surface mount pads. Soon we will have to build like this as new devices are made in only in surface mount format. The hunt for a replacement continues, perhaps with a better strong signal performance!

Cirkit Electronics

Several people have asked if they are still trading. The answer is yes. I ordered bits last week without any difficulty but possibly they are concentrating on account or non-retail customers.

An audio milliVoltmeter by Joseph Bell G3DII

Not a device that is used every day but nevertheless very useful for audio projects. The circuit shown below is simple, cheap and accurate over not less than 8 Hz to 50 KHz on all ranges covering 10 mV to 10 volts FSD. It can use any DC supply between 12 and 30 volts drawing about 2 mAmps in the quiescent state. The input resistors bias the op-amp input and hence output normally to mid supply; when a signal is applied to the input capacitor, the output AC load current flowing through the scale resistor selected by the range switch, is full wave rectified by the diode bridge to show on the meter. The two diodes across and in series with the meter are for protection purposes. Z_{IN} is 1 MOhm.



High Power Linears

Peter Thus from Oslo wrote to me regarding his experiments with watty MOSFETs of the BUK445-200A type. Using a 24 to 30v supply he obtained about 100 Watts on 80m from a 3 Watt QRP driving rig. He had all four FETs in a single ended parallel arrangement with suitable matching input and output transformers. I have not included any circuit because the details he gave me were incomplete and his experiments on other bands were continuing. However, his remarks set me thinking about high output devices. MOSFETs specifically intended for RF radio service are still very expensive (£20+ whatever the power!) but there are now many (hundreds) of different types of watty MOSFETs intended for low frequency use; their price is low and they are inherently high speed devices but with significant drawbacks! The worst aspect is the high input capacitance but modern designs are improving with several application notes describing fixed frequency (non radio) uses up to 50+ MHz with powers of 2-300 Watts. I spent one afternoon searching the data sheets, on CD and the web, to find the best performing low cost device that might produce about 100 Watts of RF. Supply voltage is crucial - while nominal 12 volts has many advantages for amateurs, not many suitable devices have low input capacitance, so I then wondered if something working off 100 to perhaps 250 volts might be feasible. A single ended device directly coupled to a 50 Ohm load and using a 125 volt supply would have the potential to generate around 100 Watts easily. No nasty output matching transformers and plenty of devices able to take the voltage and power - looks interesting! Double the supply to 250 volts and 400 Watts looks possible! Achieving a sufficiently low harmonic output would suggest that a push pull arrangement might be better - still quite promising. Typical devices have an input capacity of around 1 nF and might cost a pound or two. Using input step down transformers to match gate resistors of 10 Ohms or less would need a few watts of driving RF on 80m for a few volts of gate swing. Going up to 20m would need lower impedance at the gate and hence more input power for the same gate AC voltage. Not impossible! I was about to order some devices to play with when I remembered the power supply!

Experiments years ago using VN88AFDs on a 35 volt supply had highlighted the problems of higher voltage ampy supplies; poor regulation of the mains input with simple transformer, rectifier, smoothing capacitor circuits can lead to large output voltage variations over time, and with load, making a linear regulated PSU design quite difficult. There are also new EC regulations to worry about concerning current harmonics on the mains caused by simple rectifier & reservoir capacitor circuits. A simple half wave choke input filter direct off the mains would solve this aspect and produce around 125 volts but where does one buy ampy 'Henry' sized chokes nowadays? This arrangement would not be safe without a mains isolating transformer - these are available but cost at least £30 plus VAT new! Add a smoothing capacitor at say £5 - £10 and allow £10 for the choke and it is quickly apparent that the PSU will cost at least £65. An alternative approach might be to modify the cheap computer switch mode PSUs but this also has its drawbacks.

Even allowing for the extra costs of heatsinks, RF transformers, decoupling and bias parts etc., it is clear that the amplifier cost will be well below half that of the PSU. Conclusion - concentrate on the design of the PSU and not the amplifier!! What a disappointment that we cannot get away from 50 Hz! The situation has not changed from years ago when the PSU powering early computers cost more than the calculating bit! (As a footnote, the first computer that I helped design back in the sixties used so much power that it had to have a chilled water supply for each cabinet to keep it cool!) G3PCJ

After all that heavy text, we need a little humour:-



Hot Iron

Issue 22

“Journal of the Constructors Club”

Winter 1998



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Editorial - The role of Morse?

There has been much written in recent months about the need for a Morse Test as one of the conditions for obtaining an amateur radio licence but it seems to me that it really has little to do with radio technology as we enter the next century. It has been evident for a couple of decades that, *for commercial purposes*, the use of morse as a method of communication would soon decline to the point of extinction. The improvements in all aspects of technology have driven down the cost of using alternative methods to the point where the advantages of (usually) simple equipment are no longer important. Of course, for those of us wishing to build our own equipment, this advantage is very important. What has this to do with entry conditions for the hobby? We enjoy the privileges of being able to use a mass of different frequencies and modes because we are willing to demonstrate commitment by undertaking courses and self training. Viewed from Government's position, there is little reason to allow unrestricted access without some form of payoff because there are many other organisations who are prepared to pay considerable sums to do what we are allowed to do. The real question is what is the best

form of demonstrating that commitment. I doubt that being able to do X words per minute is really relevant - historically interesting, yes, but not suitable. We don't want something that is perceived to be a hurdle but something that demonstrates a willingness to 'stick with it'. Certainly, encouraging new entrants to start with the V/UHF bands will do nothing to improve knowledge of how a rig works and absolutely nothing to encourage home construction and experimentation with the electronics. Morse, thankfully, will definitely remain one of the many excellent alternative aspects of the hobby which is eminently suitable for those wanting to experiment. Change is needed! What do you think?

Kit Developments

Early reports on the **Langport** (SSB and CW on 20 and 80m) are very encouraging; to quote Jim Geary GW8HKY ".....Lexington North Carolina at S9 +20 and many other similarly on 20 & 80m - nocks spots off my 101E - it is the best kit yet!". Reports on the latest QRP **Booster** are also very encouraging - thank you to those who have let me know how you have got on. Over the last couple of months I have been looking for a way to get on **6m** with a few watts of RF - the solution came last week. The rest of the household are now tired of me crowing about obtaining 5 Watts from an IRF510 on 13.8 volts at 50 MHz! When I started using IRF510s more than a decade ago, I would never have guessed at the potential of these low cost devices. Transverting from 20m is my solution because it is easy to obtain the necessary 36 MHz LO for the mixer. Many home constructors will have 20m TCVRs available whereas 10m rigs are less common. I am just completing the text etc. for this kit which I have called the **Porlock** to reflect the uphill struggle to higher frequencies! It is all on a 80 x 100 mm PCB and will cost £44. Any volunteers for early builders? There is also a 10m version.

New Competition!

I have been reviewing my product line of late and would welcome your suggestions for new projects hence the draw quiz detailed on the last page. Don't miss out on your chance to win a £25 voucher!

Happy Christmas and have a good building year in 1999! Tim Walford G3PCJ

Logic Families

Digital devices are the backbone of all modern consumer electronic products including radios; despite operating in an analogue real world environment. I can confidently say all recent black box radios will at least have a digitally controlled frequency synthesiser within them and very probably at least one microprocessor. The numerical readouts are always digitally driven and over the last 35+ years several families of digital logic devices have been developed, starting with DTL (diode transistor logic) and the once common TTL (transistor transistor logic). More recently CMOS (complementary metal oxide semiconductor) devices have dominated because of their much lower power consumption and circuit simplicity leading to low cost. With most individual CMOS devices, speed increases (or propagation delays reduce) as the supply voltage is increased - there is a rough guide that for ordinary 4000 series devices the maximum speed in MHz is roughly equal to the supply voltage. Modern TTL and ECL (emitter coupled logic) are still used for very high speed tasks. There are literally hundreds of devices made by many firms in many physical formats so one should be a bit cautious about using an apparently similar device to that specified - one different letter in the part number can make a big difference. The smallest device might be just one gate - so called pico-logic; the largest might contain a whole microcomputer. As higher speed has been demanded, new ranges with lower operating voltages (which usually defines the logic voltage swing) have been designed because it is quicker to charge/discharge the circuit capacitors if the signal swing is small. If noise immunity is important because there are strong interfering signals around (e.g. transmitters), you have to use the higher voltage devices because their ability to withstand interference is often about 30 to 45% of supply voltage. The following is a very brief resume of the main families and characteristics.

4000 Series CMOS Very wide range of parts, 3 to 18 volt supply, low power, slow, 20 nS delays.

HCMOS High speed, 2 to 6 volt, low power widely used, T version for compatibility with TTL.

AHCMOS Advanced, faster than HC, 4 nS delays, 3.3 volt, few mA drive capability.

LVC MOS Low voltage, 1.2 to 3.6 volt, low speed, 4 nS delays and -24/+24 mA drive capability.

ALV CMOS Advanced LV, 2 nS delays, -24/+24 mAmp drive, fastest CMOS currently.

TTL - Bipolar technology, orion of 54/74 series numbers, slow and power hungry, 5 volt.

LSTTL Low power Schotky TTL, faster and less power, 5 volt, similar performance to HCMOS.

ALSTTL Advanced LS series, 4 nS delays, half the power of LS, 5 volt.

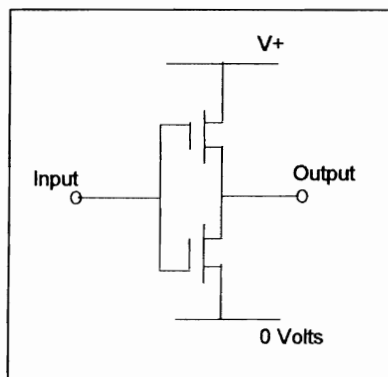
LVT Low voltage TTL, 2.7 - 3.6 volt, very high speed 2 nS delays and high drive, -32/+64 mA.

ALVT Advanced LVT, ultra fast bipolar technology, 1.5 nS delays and -32/+64 mA drive.

CBT Crossbar switch family. Near zero delays! Is more like an electronically controlled relay.

FBL Future Bus Logic, 3.3 volt version of standard 5 volt, uses BiCMOS technology, 100 mA drive.

I would suggest that for most purposes, you nowadays consider using only CMOS devices selected from the wide range of 4000 or HC series. They have low power and the HC family can be used to 50+ MHz; they are cheap and available with pins (or in surface mount!) with many sortsof gates, inverters, counters and flip-flops. In some rigs like the Sparkford, CMOS devices are used as linear amplifiers but only a few types can be used this way since the more advanced devices have many stages internally and thus tend to oscillate when feedback is applied. You should be aware of the potential for damage to any MOS device from high electrostatic voltages on their very high impedance input terminals ($10^{10}R$); if you live in a modern dry house you will need to be more careful than me in an old damp farmhouse! Get used to having all your equipment earthed and consider using a wrist strap connected through a 1M resistor to earth. Most devices are based on the simple inverter sketched in the box below.

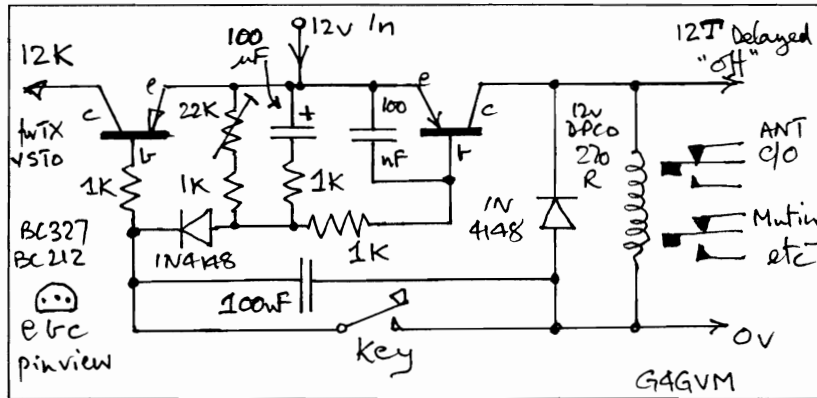


Inverting gates consist of a pair of complementary MOS transistors connected between 0 volts and the supply. Only one of them is normally on so that the transistor's main task is to charge/discharge the capacitance of the next stage during output voltage transitions. As the input changes from 0 volts to the high level (= V+), and vice-versa, both devices are temporally on so there is a small spike of current through both transistors. 4000 series devices can drive a 10K load to either 0 volts or V+; HC devices can drive a 1K load to either rail. Both series have the very high input impedance allowing slightly clever arrangements at the input for such things as timing circuits etc. A simple gate such as one of the six inverter devices in the CD4069 can be biased for linear operation with a 100K resistor from output to input. Voltage gain is about 10 to 20. G3PCJ

CW TR control circuit - by Derek Alexander G4GVM

Here is another circuit that has become a 'standard' for me. It gives positive keying of the TX while keeping the actual key at negative potential, and provides adjustable delayed return to reception.

It uses a minimum of components and fits into a very small space on a PCB. BC212s will serve for most low power needs but use BC327s if you need more output current - up to 800 mAmp.



More simple tips from Joseph Bell G3DII

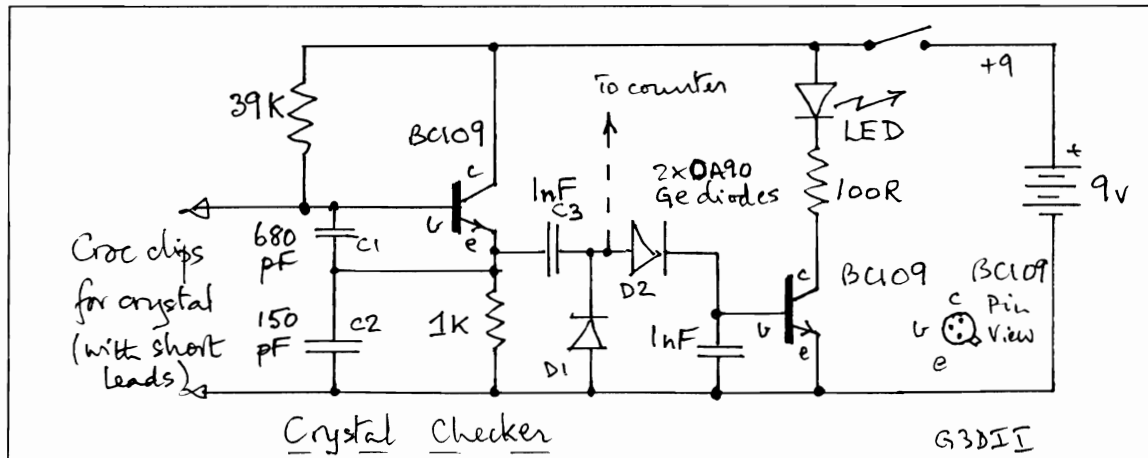
Aluminium foil (1) Ordinary kitchen ali foil can be used effectively to seal up cracks or holes which must be covered in the interests of good shielding. Cut a piece of foil large enough to cover the aperture plus an overlap then seal the overlap with masking tape preferably using the sort with a fabric base. If the aperture is small, cover the whole area with masking tape.

(2) Soldering irons. With many soldering irons, particularly of the cheaper variety, after some use, the base of the tip ceases to fit snugly in its socket. A layer of oxide forms on the base of the tip inside the socket and heat conduction is greatly impaired. Scrape the base of the tip until bright copper shows and then scrape the inside of the socket to remove the oxide scale. Then wrap the base of the tip with ali foil using enough to shim the base of the tip to a snug fit within the socket. This little tip will usually restore the iron to its original efficiency.

Drilling aluminium When drilling ali, apply a drop or two of alcohol (meths will do). This not only makes the work easier but results in a much cleaner cut.

Checking crystals for overtone activity To check a crystal for overtone activity merely wind a few turns tightly over the grid dip meter coil and connect to the crystal pins. If the crystal has overtone possibilities, the GDO will dip as the oscillator is tuned through the odd harmonic frequencies of the crystal's fundamental. Some crystals exhibit surprising results!

Checking junk crystals At rallies etc., at one time or another, most of us tend to pick up a crystal in case it might be useful at some time. The little circuit below can be built into a very small case and tell you there and then whether the crystal is active - if the less LED does not light up it is duff. The circuit will work with most crystals from 100 KHz upwards although some of the old crystals might struggle a bit if they are low frequency. A small plastic box makes a good housing for the checker. If used at home, a small capacitor connected to the side of C3 adjacent to D1 and D2 will drive your counter, the more sensitive the counter, the less the capacity needed. A minor problem when using the counter is that it may read low because of the crystal is loaded by C1 and C2. For instance, the readout might be 1 KHz low on 7 MHz and up to 3 KHz at 20 MHz.



A Basic LC Bridge - by David Proctor G0UTF

The bridge has ranges for 10 μ H to 1 Henry, and 100 pF to 1 μ F; using the scaled balance control, you can resolve 2 μ H - 5H and 20 pF to 5 μ F. It consists of a 20 KHz oscillator feeding a bridge via a balancing transformer. The bridge balance is effected by a 1K calibrated linear pot and the balance is verified by a simple millivoltmeter.

The accuracy of the instrument is governed only by:-

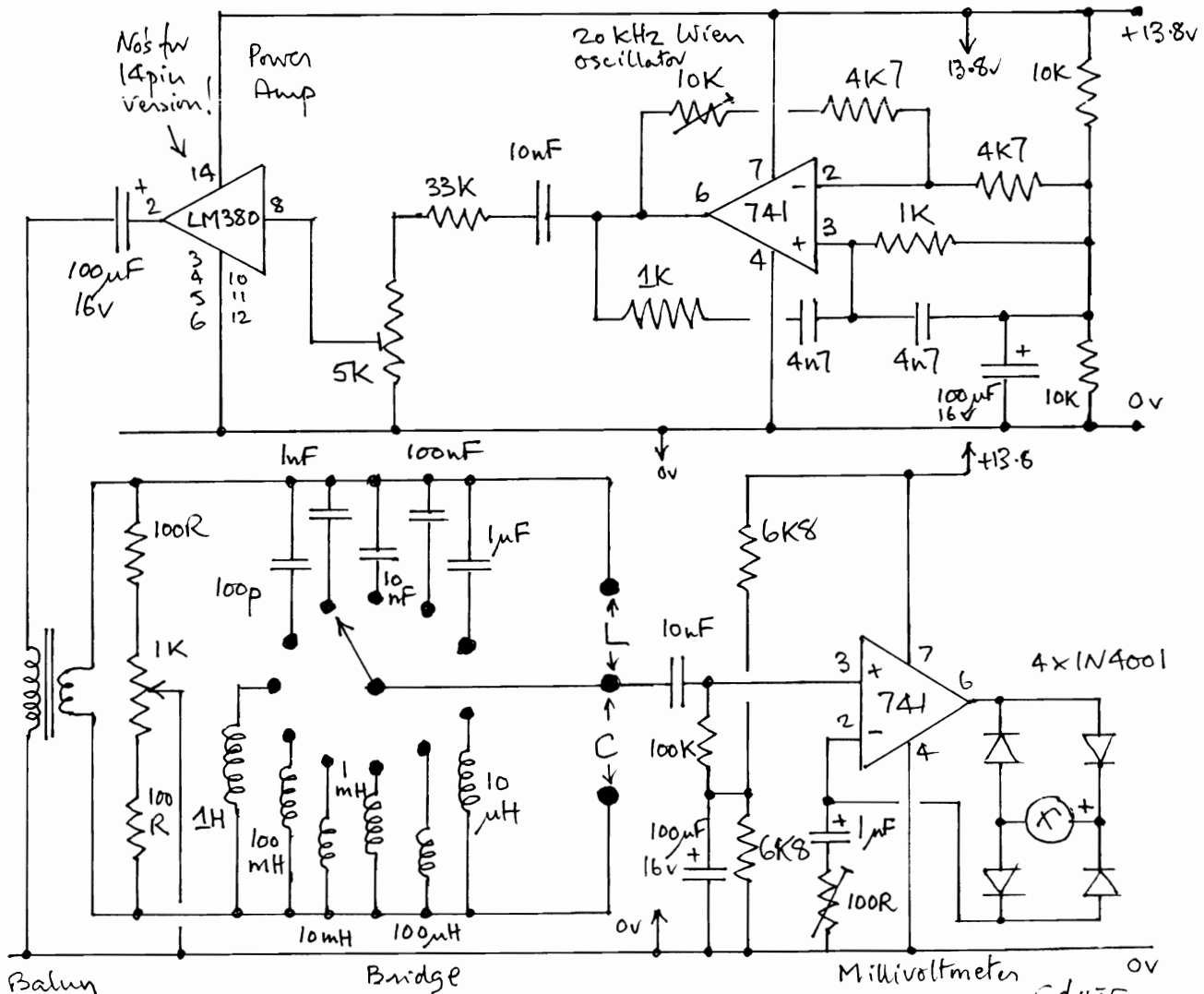
1. The linearity of the pot
2. The calibration of the pot
3. The onboard inductors and capacitors for the bridge.

Because the bridge circuit uses the null method of measurement, the accuracy of the oscillator frequency is not important, neither is the meter sensitivity. For the transformer, I went to the junk box and found an 18:1 step down (ex Coker!) (I have some still if wanted - G3PCJ.) You could even make a small step down transformer yourself with a 3:1 turns ration - at 20 Khz you don't need much core. Calibration of the 1K pot is as follows:-

Dial reading	Percentage rotation	Dial reading	Percentage rotation
0.2	10%	1	50%
0.3	18%	2	70%
0.4	24%	3	80%
0.5	30%	4	86%
0.7	39%	5	90%

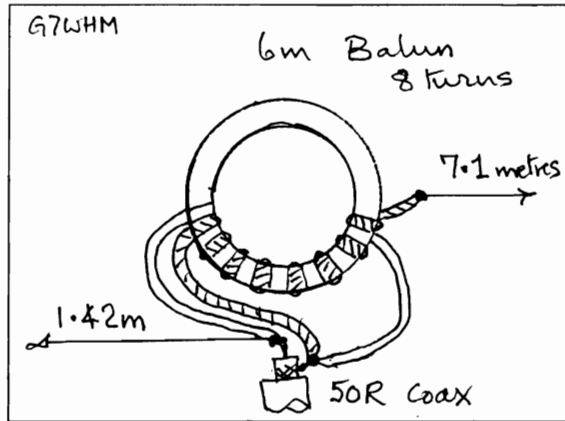
Setting up is simple:-

- Adjust the 10K feedback pot of the sinusoidal Wien bridge oscillator so that it starts/runs reliably with clipping.
- Set the 5K pot for about 3 volts RMS output from the LM380.
- Tweak the 100R for sensitivity as necessary for the meter - about 0. mAmp FSD.



Windom Antenna on 6m etc.

Andy Howgate G7WHM based his experiments on the FD4 design published in the G-QRP Club Antenna Handbook. Instead of using a section of ferrite rod, he salvaged a toroid from the filter of an old switched mode PSU. The ferrite material, although not intended for use at 50 MHz, might help and it certainly does provide a convenient former for the 8 turn windings of the matching transformer. The electrical arrangement is shown below without any supporting mechanics which are needed to prevent the wires pulling the turns out of shape. The wire was hard drawn plastic coated.



As shown it gave a maximum VSWR of 1.5:1 across the band. He also tried the same antenna on 144 MHz with considerable success; the balun showed no signs of distress after passing 25 Watts for 15 minutes. 50 Watts from his TS60 happily accessed the Norwich repeater 50 miles away - normally he has to use a collinear to achieve this.

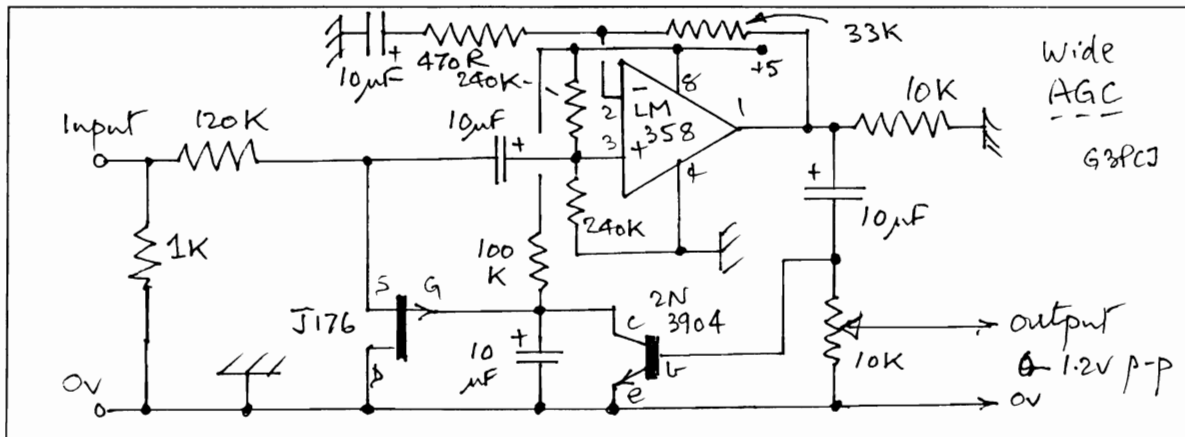
By way of comment, he changed the standard carbon pots in his Street for wire wound multi-turn types and feels this is a mod worth considering. He says sound quality is now almost like FM when adjusting the Fine control!

Modern carbon pots

Jim Gearey GW8HKY notes that modern pots have crimped tags instead of the older design which used rivets to hold the solder tags in place. If the tags are bent inadvertently, in the post etc. or to make the wiring arrangement neater, it tends to loosen the crimping so that in use there are intermittent connections resulting in erratic tuning. The solution is to re-tighten the 'crimps' with a pair of snipe nosed pliers before fitting to the control panel. In time the lubrication of these pots does dry up which can also make tuning irregular, again the cure is easy - a squirt of switch cleaning fluid through the holes in the protective cover followed by vigorous end to end rotation!

Wide ranging Audio AGC

I found this circuit in an American Journal; it might be useful to replace the Plessey SL6270 circuit when that becomes unobtainable. A 50 dB dynamic range is claimed, with an output level of 0 to 1.2 volts p-p (300 to 30 KHz) while operating from a 5 volt supply and drawing less than 1 mA supply current. Signal input range is 40 mV to 20 volts p-p. It works by altering the attenuation offered by the 120K input resistor working in conjunction with the variable 'resistance' of the p channel JFET under the control of the positive output peaks as DC detected by the 2N3904. The op-amp is set to run with a gain of about 67. With no, or a very low signal, insufficient to operate the detector, the FET is turned off completely by the 100K resistor to the positive supply. Higher output voltages are detected by the 2N3904 which begins to turn on drawing the gate of the FET towards 0 volts which also turns on the FET and increase the attenuation at the circuit's input. This is a negative feedback control loop. It will probably work with most modern op-amps having the ability to drive 1K or so and can use a 12 volt supply if the FET is changed to a type with a higher pinch-off voltage such as a 2N3993. The 2N3819 is not suitable - its the wrong sort being n channel! (I spent some time wondering how the FET was controlled without noticing the 'polarity'!) G3PCJ



Digital Signal Processing

Tony Measures has asked whether this might be the subject of a starter kit. The advantage of handling a signal in digital format, where a sequence of binary words (groups of binary digits) is used to represent instantaneous signal amplitude at frequent sampling intervals, is that filtering can be easily applied in mathematical processes executed by the software within the signal processing chip or microprocessor. By altering the software control parameters, it is easy to change say the cut off frequency of a low pass filter used to reject unwanted audio signals. With slight extra complication you can change the software filter from say a low pass to band pass form or include a band reject filter to get rid of an unwanted heterodyne. For a full understanding of the possibilities you need advanced mathematics with all sorts of obscure names! It is definitely not something that most of us could have a dabble with! The hardware is also quite complex, requiring an analogue to digital converter sampling at several times the highest input frequency, memory for the data samples, processor with control software in its own memory, timers and an output digital to analogue converter. All this lot can be fitted on one chip but there are very few opportunities to experiment because you have no means of control without a keyboard. Designs are already available for a complete HF receiver using digital signal processing, including all the mixing and filtering. The phasing form of single sideband receiver is easier to implement than the filter type. Watch how the technology develops! G3PCJ.

Audio loops

Quite often I see rather unsatisfactory audio wiring on rigs returned for tweaking up or repair. The most common fault is 'shared' earth returns for the LS socket and the audio gain control. This is a recipe for trouble since the relatively high currents flowing in the loud speaker are sufficiently large to cause a small audio voltage to be developed across the wire (often thin) linking the socket's 0 volts/earth contact to the main 0 volt ground plane. If the same wire is also used for earthing the audio gain control, by connecting the earthy end of the pot to the LS socket earth tag, then these small audio signals (caused by the loud speaker currents) are injected into the input of the audio amplifier and hence form a feedback loop. At some frequency within the audio band, this is quite likely to be positive so that instability is likely. Howling does not always occur, but a tendency for the audio to be rather harsh or grating at high gain control settings, is a warning sign of near oscillation. The symptoms will only be present when a low impedance LS is connected. The cure is simple. If the front panel is PCB material, make certain that it is soldered to the main PCB every inch or so and bend the tags of the socket and the pot backwards so they can be soldered direct to the back of the front panel. Alternatively use separate leads for gain control and LS socket and connect them to the ground plane a few inches apart. Use thickish wire for the LS leads. G3PCJ

Fifteenth QRP Convention

Make a note! It will take place on April 18th 1999 at Sherborne as last year. There will be the usual attractions of pre-event fun run CW competition, talks, trade stands, demonstrations, food, and a **CONSTRUCTION CHALLENGE**. The task is make a stable free running VFO settable within the range 5 to 5.5 MHz. No more than 15 parts; the winner is the one with least drift (after a 30 second warm up period) from a frequency specified on the day somewhere in the range. Full details from Peter Burridge G3CQR.

Win a £25 voucher - help me to design the kit you want!

The authors of all reasonable responses (post or e mail - see below) to the five questions below will be put into a hat just prior to the issue of the next Hot Iron. The draw will be made by a visitor. The voucher can be used against any future purchase of Somerset Range kits.

1. Describe the rig you would most like to build indicating what you think would be a realistic price.
2. What is the most complex piece of equipment that you have built previously?
3. What other topics or material should be included in Hot Iron?
4. What is the best aspect (any sort) of your preferred Somerset Range rig?
5. What is the least attractive aspect of Somerset Range kits, its importance, & suggestions for curing?

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 E mail walfor@globalnet.co.uk The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

Hot Iron

Issue 23

“Journal of the Constructors Club”

Spring 1999



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- Designing traps
- Cabling
- Aerial Matching Circuits
- Diary dates
- Pulse generator stability

Editorial - The role of Morse - part 2

I am pleased to say that my comments last time did produce some reaction! Many accepted that morse as a method commercial communication has had its day but that it is still highly sensible for amateur communication. There are many reasons for keeping it as a fundamental part of our hobby - it adds to the variety of modes etc. which are available to us, hence attracting potentially wider participation in the hobby, it can be done with simple equipment, often permitting home building and better understanding of how it works, possibly leading to construction of more complex gear, probably helps to promote good operating practice, provides further contest opportunities, and is historically very important. It is actually still used (and likely to remain so) for certain commercial purposes such as the identification of radio beacons. As a method of controlling access to any particular part of the spectrum, I doubt it has much relevance. Some correspondents made the point that none of the current exams or tests, assess whether the new entrant has been taught how to use his gear to best effect without upsetting others who have an equal entitlement to use their facilities - in short how to behave

sensibly in a crowded spectrum. Is this any different from doing a test to check that you can drive without upsetting others? It has little to do with operating on any particular part of the spectrum and not much with the self education, and technical experimentation, that is assessed initially by the various exams, and which differentiate this hobby from other forms of radio usage. Maybe it would be sensible to make all new entrants operate QRP for a period!? The extra sales of relatively simple gear would drive down production costs, reducing the cost of entry to the hobby, encouraging more home construction and hence understanding of the innards. Of course it would be good for kit suppliers!!

Kit Developments

The **Porlock** 6m transverter, from 20m, has now been built by several builders with good results. It produces 5 Watts from a 1 to 5 Watt 20m driving rig. Cost is £44 plus £1 P&P. I fancy this is a cheaper way to get on 6m (with CW or SSB), than via the FM route as suggested by Emma's challenge for a two channel FM TCVR kit, with a target price of under £40. That is a tough target! Most of my development time has been devoted to the **Radstock**. This is an any two band to 10m CW TCVR; on receive it is arranged as a crystal converter ahead of a 6 MHz phasing DC receiver with special narrow audio filters to give sharp single sideband reception. The low frequency VFO gives good stability, with all bands having (very nearly) the same incremental frequency calibration from the lower band edge. On transmit, the receiver mixers become crystal converters so avoiding chirp. Full break-in TR control with sidetone is provided. Available shortly for £79.

Five Questions draw - worth £25 - see back page of last issue of Hot Iron

So few responded that I have decided to extend the closing date to May 17th 1999. Tell me:-

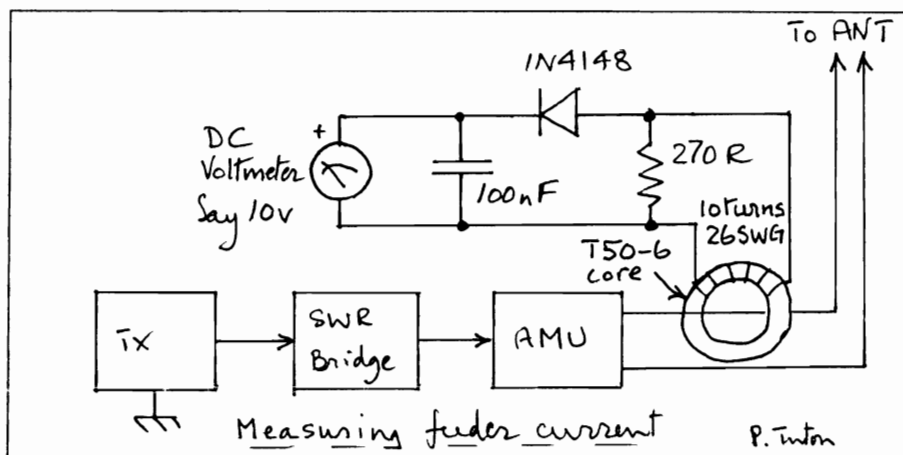
1. What rig you would most like to build and what you think is a realistic price?
2. What is the most complex thing you have built previously?
3. What other topics or material should go into Hot Iron?
4. What is the best aspect of (your?) Somerset Range rigs?
5. What is the least attractive aspect of Somerset Range rigs? (Don't be too coy!)

Tim Walford G3PCJ

Antenna Matching Unit efficiency by Paul Tuton

I've built quite a few QRP / physically small transmitters and receivers over the years, and it's always an irritation when the only ATU that seems to tune them effectively is the size of a large cornflakes box. It's also a pretty effective deterrent to /P working if you have to lug it around. So Tim Walford's miniature Antenna Unit and Matching Bridge looked particularly attractive. But would it be efficient? I suspect most of us have fallen into the SWR trap at some time - the ATU that shows a perfect 1:1 match, but somehow, results are disappointing. The fact is, that ATUs both home built and commercial, vary between excellent and dreadful, and a 1:1 SWR is no guarantee of good performance. The question is, how can you measure the efficiency of various ATUs, and even different configurations of the same ATU?

There is one sure measurement of how much RF is going up your antenna, and that's the current flowing in the feeder. Regardless of anything else, given a constant transmitter output power and frequency, more current up the spout means more signal is radiating. In the valve PA days most of us had never heard of SWR - today, we need to be concerned mainly because of 50 ohm output solid state PA stages, but RF current is still the ultimate measurement of the power in the antenna. RF ammeters are hard to come by these days, but there's a simple alternative that can be made in a few minutes - a current transformer wound on a toroid and slipped over the feeder:



The components are totally non-critical and I claim no originality for this circuit - I've seen similar ones in many places over the years. It works well with open wire or ladder line feeders, slipped over one leg. If your output from the ATU is coax, you should wangle some way to slip the toroid over the centre conductor at the outlet of the ATU. I use an AVO and 2 or 3 watts output is enough to give a 3 or 4 volt reading though this will vary with the band you tune on, and your own particular antenna. The point is, you don't need much power to show a reading. Connect up the TX and set it to the band you want to tune up on. Find a clear frequency and transmit 2 or 3 watts of carrier. Adjust the power and multimeter range to give a reading around mid-scale. Now the interesting part, adjusting the ATU. I could write pages but I'll summarise the key points to keep it brief:

- You might find several settings of the ATU's capacitors and inductors that show a 1:1 SWR, but there could be large variations in the antenna current. Find the setting that gives a low SWR and maximum current.

- If you can configure your ATU in different ways e.g. T or L format, try different combinations and observe the result on the antenna current.

- If you are using a doublet type antenna, try "floating" the ATU on a current balun - typically a sizeable handful of ferrite rods with 30 / 40 turns of coax wound on them, between the TX and ATU (ATU side of SWR bridge). Don't connect the ATU to earth! If the ATU has a metal case, it will be at RF potential so beware - keep to QRP. I've known this to produce spectacular results - particularly on 160 and 80 metres. This whole subject actually needs more explanation - maybe in a future Hot Iron.

- Many of the popular commercial ATUs in neat metal cases appear to be very effective dummy loads, showing a 1:1 SWR but expending most of the RF energy in heating up the innards. I had one where part of the case got too hot to touch with 20 watts continuous for about 2 minutes.

- Metal cases are generally not good news - particularly when inductors are mounted close to them.

- Baluns (usually toroidal) on the OUTPUT of the ATU are a great way to choke off your RF before it reaches the feeder, and at higher power levels, to start exciting fires in your shack. This is not

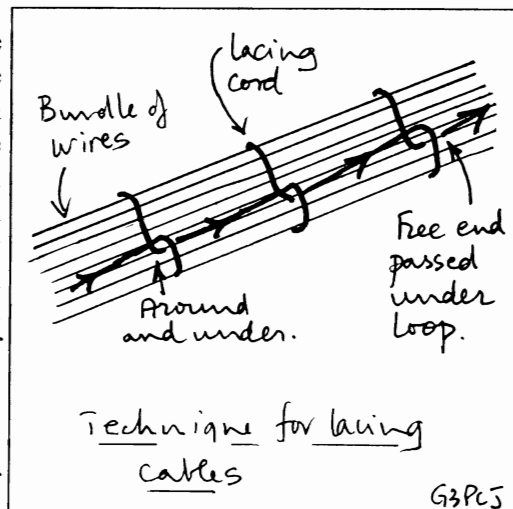
Cabling - some suggestions for you to consider!

Audio stages Probably the most common deficiency that I see on returned rigs, concerns the 0 volt or ground connections to the loudspeaker socket and the AF gain control. These should NOT share the same thin common wire because there is a fair chance it will make the AF output stage will actually oscillate (at AF) or scream, or with a tendency to oscillate, leading to a rather harsh sound quality. The LS socket 0 volt/earth lead should be either directly connected to the front panel ground plane, which itself should be connected electrically to the main PCB ground plane at several points, or the LS socket earth tag should be connected by a thick wire to the main PCB ground plane close to the audio output stage. The earth lead of the AF gain control should be either connected directly to the ground plane of a PCB front panel or, by a separate wire (as short as reasonably possible) to the main PCB ground plane midway between the audio pre-amplifier feeding the AF pot and the input to the output AF stage. The LM380 series of audio power amplifiers do have a tendency to self oscillate at near 2 MHz which may well be aggravated by failure to observe these precautions. The 1 Ohm in series with a few hundred nanofarad across the output are essential to stop this mode of oscillation.

Supplies Another frequently seen weakness is thin supply leads. Do make certain that your incoming leads, and those within the rig, are not causing the loss of say 0.5 volts when the rig is drawing maximum current. This can lead to the internal regulator not having sufficient supply voltage headroom to function properly with again the possibility of instability. Often it causes a sort of squeeging RF instability as the bias voltage to the RF output stage falls when the supply droops, TX output falls, volts recover, bias recovers, output rises and volts collapse again. The LM317 series of regulators need at least 2 volts between the regulated output and the incoming supply. The LM2930T8 is a LDO type (low drop out) regulator which will work with around 0.2 to 0.4 volt difference but they are more sensitive to the decoupling capacitance on the regulated line - they must have at least 10 μ F - use 22 μ F because the tolerance on electrolytics is huge. Without this capacitance, they will oscillate!

Controls etc. For other wiring, which is often DC tuning or control signals, one should generally route them away from sensitive areas such as RF oscillators which might have their stability impaired, from the input stages of (receiver or transmitter) RF amplifiers, and away from the transmitter output networks. It is also important to make certain that, for example, a relay control signal does not loop from a relay selecting the receiver RF band pass filter onto a transmitter relay selecting the output matching network, because in a bi-directional superhet, this can be an RF feedback path - both relays should be fed separately from the control switch to increase the RF impedance between the two sensitive areas. I prefer to see wires laid in a rectangular grid across the main PCB (and behind the control panel) with them pressed down tight against the ground plane - threading or routing them through the gaps between components. Where a wire connects to the PCB, you can fit pins in the PCB to form little vertical tag posts or solder the wire in directly. When fitting wires direct to the PCB, always make the PCB joint first before the control panel end. Tin the pad first (without blocking the hole) and keep the wire at right angles to the board while applying the iron and gently pushing the wire against the board till the insulation is just within the hole's countersinking. Hold the wire until the solder has solidified and allow the insulating plastic to cool fully before bending the wire to shape to reach the other attachment point. Cut off any excess wire which is projecting below the solder joint of the PCB. If extra anchoring points are needed, solder small bare wire hoops (before threading the wires through) to the ground plane in suitable places.

This style of wiring imparts a tidy look and keeps the leads secure. Another approach is to lift them off the PCB and route them in a bundle (with branches) down the centre of the rig about an inch above the parts. The wires are then laced together to keep them rigid. Special lacing 'string' is available - it has a central core with an outside cover which collapses slightly when tied tightly so that it jams and keeps the knots tight. Use the 'around and under' style of lacing knot so that it stays tight as you progress along the bundle of wires - see alongside. If you feel that screened wire is advisable for RF or audio signals, generally it is best to connect the screen to 0 volts/ground plane at both ends near to the signal connection points. For test points, use pins or short stiff wires - do not fit wires with long dangling tails! G3PCJ

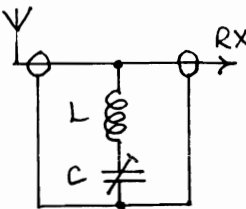


always the case - it depends on whether or not the feed impedance of the antenna falls within the limits of the balun on the chosen frequency. In my experience, it rarely does. (Note that Tim's ATU has the toroidal transformer BEFORE the tuned circuits which is a totally different matter. It always sees an impedance in its design range).

My favourite main station ATU is an elderly Capco Transmatch in a plastic case, fed via a large choke balun. A couple of years ago, I spent several weeks of evenings experimenting with different settings, configurations and balun types until I could get no further improvement. In that time, I doubled the current on top band - and as power is proportional to the current squared, that was effectively a 4 times power increase. My antenna's only a 2x50' doublet, but it now works well around the UK on top band. So how does Tim's ATU compare? My current meter shows identical performance on 160 and 80, and better performance on 40. I've not yet compared it carefully on the higher bands, but quick comparisons suggest it will be at least as good as the Capco. It works on 6 metres as well. Not bad for something small enough to sit in the palm of your hand. Power handling? Well, 10 watts SSB or CW seems fine with no discernible heating. But 5 Watts is probably more sensible. When's Spring coming? Time for some /P working.

Designing series resonant RF traps

Jim Gearey asked me to suggest some values for a 100 MHz trap because he had a local transmitter that was causing interference which might be cured by placing a trap across the receiver input. The technique can be used for any band but it is necessary to know the frequency of the offending transmitter. At VHF, it is easier to use capacitors for the variable element necessary to adjust for best attenuation. Start by using a capacitor value of say 20 pF; this might actually be a part 'closed' 65 pF trimmer and would be appropriate for say 30 to 100 MHz. You then need to work out the required inductance to achieve series resonance using the well known formula:-



$$f = \frac{1}{2\pi\sqrt{LC}}$$

Hence

$$L = \frac{1}{(2\pi f)^2 \times C} \quad \text{OR} \quad C = \frac{1}{(2\pi f)^2 \times L}$$

For 100 MHz, $f = 1 \times 10^8 \text{ Hz}$
 Guess $C = 20 \text{ pF} = 20 \times 10^{-12} \text{ Farad}$
 Makes $L = 1.26 \times 10^{-7} \text{ Henry}$
 $L = 0.126 \mu\text{Henry}$

G3PCJ

Inductors wound on powdered iron toroidal cores are easiest to make. The first number is the core diameter in hundredths of an inch; the second number indicates the core material mix which have recommended frequency ranges. You need to know how much inductance each turn contributes, which is indicated by their A_L value. The values for common cores are given in the next box together with the formula for working out the number of turns required. For the 30 to 100 MHz range, a green/white (number 10 mix) or yellow (number 6 mix) core is required, so that a T50-10 would need 8 turns.

Core	Colour	Size	f Range MHz	A_L ($\mu\text{H}/100\text{t}$)	No of turns = $100\sqrt{\frac{L(\mu\text{H})}{A_L}}$
T68-2	Red	68/100 inch	1-30	57	For $0.126 \mu\text{H}$ on T50-10 where $A_L = 18$ $n = 100\sqrt{\frac{0.126}{18}} = 8.37 \text{ turns}$
T50-2	Red	1/2 inch	1-30	49	
T50-6	Yellow	1/2 inch	10-90	40	
T50-10	Green/White	1/2 inch	100-200 MHz	18	

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For HF offending transmitters, use a fixed capacitor and a TOKO variable coil. First select a coil, with the higher inductance ones for LF work, and then use the formula to work out the required capacitor. Use the nearest available value. Note that if the offending signal is near to a wanted frequency, then tune the trap on far side (in frequency sense) of the offending transmitter, so that it just gives sufficient attenuation to cure the BCI etc. with the minimum attenuation of the wanted signal.

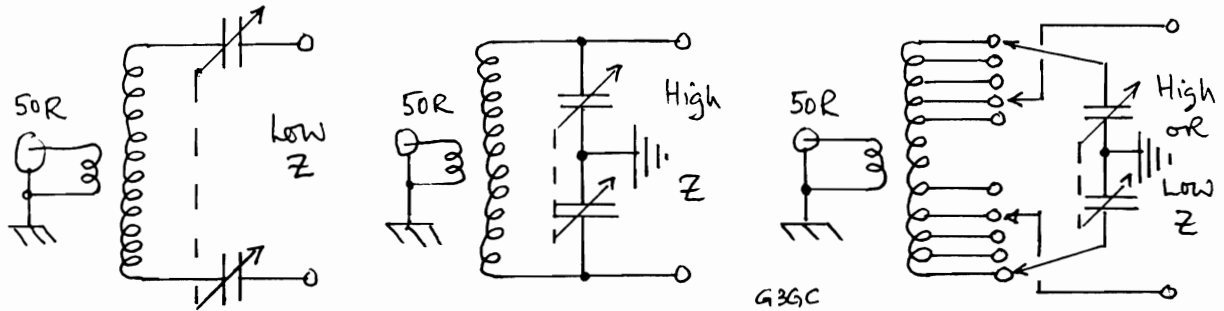
freq Range	TOKO Coil	Inductance Pins 1-3	Example: $f = 7 \text{ MHz} = 7 \times 10^6 \text{ Hz}$ Choose 333A, $L = 5.5 \mu\text{H} = 5.5 \times 10^{-6} \text{ H}$ $C = \frac{1}{(2\pi \times 7 \times 10^6)^2} \times 5.5 \times 10^{-6} = 9.4 \times 10^{-11} \text{ F}$ $= 94 \text{ pF}$ Use 100 pF + adjust L.
1 to 5 MHz	3333	45 μH	
3 to 15 MHz	3334	5.5 μH	
10 to 30 MHz	3335	1.2 μH	

G3PCJ

Aerial Impedance Matching Networks - Part 1 - by Eric Godfrey G3GC

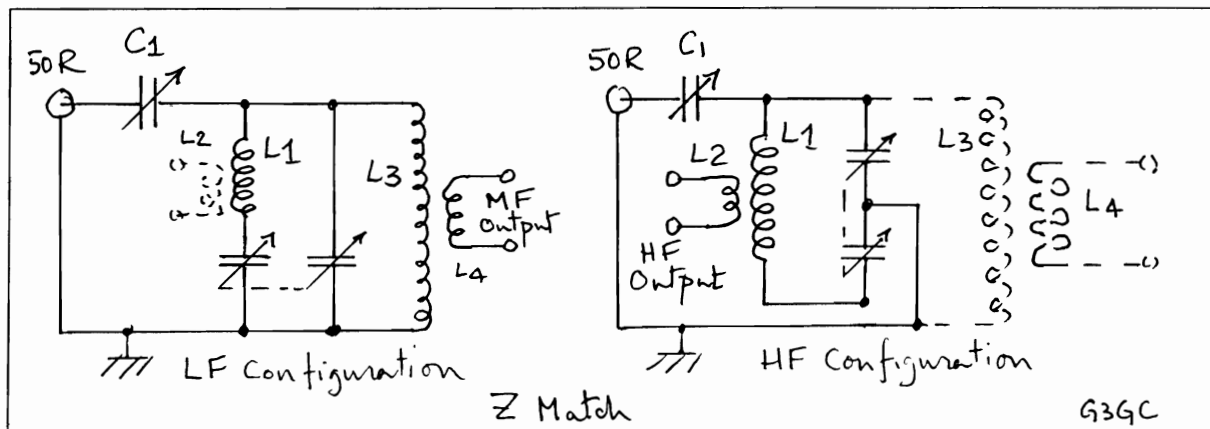
Impedance matching (transforming) networks are used for matching devices or circuits of differing impedances together to ensure their correct and most efficient operation. Probably the most common use in amateur radio is for matching an aerial to the transmitter, commonly but incorrectly called an aerial tuning unit. The one thing the unit does not do is to alter the tuning of the aerial, this is determined by its physical configuration, but it does ensure that the transmitter is presented with the correct load impedance, usually 50 Ohms. This note covers various matching circuits for balanced aerial systems with a variety of impedances. Part 2 will cover unbalanced systems.

The two main categories of matching networks are 1) Resonant and 2) Non-resonant, both of which may be a balanced or a non-balanced arrangement. Although it may not be possible or convenient to use the resonant network, it is always preferable, since it will reduce any possible break-through from broadcast stations and also reduce the radiation of any harmonics that may be generated in the transmitter. This is particularly important if simple equipment is being used.



The diagrams above show examples of a balanced aerial system connected to a resonant circuit which may be either parallel or series tuned depending on the impedances to be matched. The inductance of the tuned circuit is in turn coupled to the receiver by link coupling. The advantage of this circuit is that by changing the configuration of the coil and condensers for either parallel or series tuning, virtually any impedance at the input to the feeder can be matched to the transmitter's low impedance. However there are a number of practical disadvantages with this arrangement: 1) The need to be able to switch from a parallel tuned circuit for high feeder input impedances, to a series one for low feeder input impedances by either the use of a switch or with "Banana" type plugs and sockets; 2) If a number of bands are to be covered with one matching unit then this will require a tapped coil which again will require either a switch or "Banana" plugs and sockets; 3) The link coupling should be located at the centre of the main inductance thus precluding the use of a "Roller Coaster Coil" instead of a tapped coil, unless arrangements are made to move the link coupling as well. Remember that all parts must be suitable for the power being used.

A more convenient arrangement using two tuned circuits is the Z Match or "E-ZEE Match" circuit which is very popular and available commercially. Two balanced outputs are provided from the matching unit; one is normally used for 3.5 and 7 MHz and the other for the HF bands 14 to 30 MHz. On the LF bands it operates as shown on the left below, the split stator capacitor working with both sections in parallel with L3, except that the small inductance of L1 slightly reduces the effectiveness of one section. On the HF bands, the unit operates as shown right. Here the inductance L1 is tuned by the split stator capacitor working normally but there is the large inductance L3 in parallel with L1 which will slightly reduce the effective value of L1. C1 has to be fully insulated from the chassis.



There may be occasions when, due to an unusual feeder input impedance, a match may only be achieved using the “wrong” output. If this is necessary there is nothing wrong with doing this to provide a match. If a match cannot be obtained then another trick is to increase the length of the feeder to change the impedance presented to the matching circuit, the length being found experimentally. My own aerial is a half wave on 80 Metres, which is low impedance at the centre, fed with about 60 feet of 600 Ohm twin feeder. In order to be able to get a 1:1 SWR on 80 Metres using my E-ZEE Match I have to switch in (using “Banana” plugs and sockets) about an additional 50 feet of twin 300 Ohm ribbon feeder strung back and forth along the ceiling of my shack. On all other bands, where the impedance at the centre of the aerial is high, the unit is used without any extra feeder.

Another problem which amateurs encounter, is using of unbalanced feeder to feed a balanced aerial, such as a coaxial feeder connected directly to a dipole. This is bad engineering practice but is commonly done although a balun of some form should be used. We now have a coaxial feeder to connect to the balanced output of the E-ZEE Match. The solution, although not sound engineering, is to connect the coax screen side of the E-ZEE Match output to the chassis.

Somerset Homebrew Contest

Don't forget this event on March 27th from 1700z onwards. Either, or both, the TX or RX must be home made. Any mode - 80m only. First prize is a £50 voucher - full details in Winter 98/9 Spratt!

Yeovil QRP Convention

Make a note of the date, April 18th in the Digby Hall in Sherborne. A must for homebrewers!

Tips from Joseph Bell G3DII

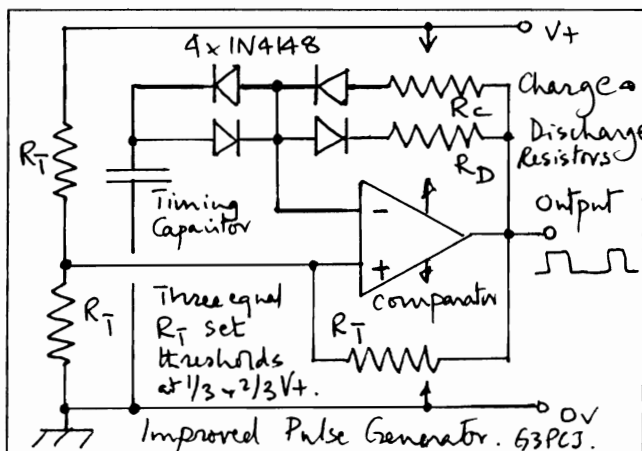
Coaxial Switch A very useful piece of equipment to have in the shack! Commercial switches are not cheap but there is a method of constructing one at minimum cost and do the same job. The components needed are die-cast box, a rugged ceramic wafer switch and as many sockets as you require, SO239 or BNC or whatever. Mount the switch on the lid of the box and position each socket so that its central connection is immediately next door to the switch tags. A short piece of 16 gauge wire can then be used to bridge the gap between centre pin of the socket and the switch wafer tag. If this type of construction is used it will be found that there is negligible effect on the SWR when inserted in a coaxial line operating at its nominal impedance. The more robust the switch the better, even if you are using QRP, as such a component will stand up well to continuous use.

Dental tools For many years I have used these useful tools in and around the shack. The ones with a hook on the end, which the dentist uses to clean cavities after drilling, are the most versatile. Even if the end of the hook has snapped off, it can be reground. Other ‘unhooked’ tools can be made into fine centre punches. Hooked tools can be used to retrieve inaccessible spots of solder or to check the number of turns of fine wire on a coil. Next time you visit the dentist, ask him if he has any broken or unserviceable instruments. Modern ones are made of stainless steel which does not take solder.

Emergency coax connectors Recently I wanted to join two PL259 plugs together using the threaded barrel double ended type of double socket. The junk box let me down and I hit on the idea of using two SO239 sockets. I had two of the bulkhead mounting four bolt type. I put the two back to back and soldered the central pins together with a short wire. To join the bodies together, I used some copper flashing (brass or tin plate would do) formed into a cylinder to enclose the central part of the sockets just inside the bolt holes of their flanges. I then soldered along the cylinder long joint and around each flange where it abutted the cylinder. Perfectly satisfactory and much cheaper than buying one!

Preserving the stability of pulse generators

The 555 timer IC has excellent frequency stability against supply and temperature variations for square wave outputs. If two diodes are added to permit separate resistors controlling the charge & discharge of the timing capacitor, then the stability is badly spoilt. Adding two more diodes as shown right will restore the stability without upsetting the timing. The circuit is drawn for the general case of a bistable with set and clear thresholds at one third and two thirds of the supply voltage. (Eg. Schmit trigger circuit.) It can also be arranged to give independent pulse repetition rate & width controls. G3PCJ



Hot Iron

Issue 24

“Journal of the Constructors Club”

Summer 1999



Contents

- Unbalanced matching
- Active antenna
- Matching unit losses
- Single knob tuning
- Absorption wave meters
- Five question draw
- Snippets!

Editorial

Feeling rather lazy yesterday afternoon, I decided to reread the April 1999 edition of Electronics and Communication, published by the Institution of Electrical Engineers for their members. I had put it aside previously because the issue is devoted to futuristic radio techniques. Of particular interest was an article about ‘Software Radio’ which I touched on briefly in a previous Hot Iron. Nearly all future development in radio matters is being devoted to ‘mobile’ or similar highly portable uses. The basic principle of a software radio is to use digital signal processing techniques for as much as possible of the radio transmitter and receiver. The performance of very high speed analogue to digital converters (& D/A) is such that practically everything of a UHF receiver, apart from the very first low noise amplifier, can be done in a programmable general purpose computer like block following the A to D converters. This makes it possible to change the modulation formats, and other pretty fundamental aspects, purely by changing the software of the processor. This would be a very major advantage because the same hardware unit could be used

in many different parts of the world (where formats are not yet standardised) and would lead to much larger production runs and lower prices. Even the ‘RF’ filtering would be done in software and so band changing no longer requires different circuits tuned to the working frequencies! Most of these techniques are equally applicable to the transmitter. Interestingly, because full duplex operation is essential, the TR switch becomes one of the most challenging items. If you are interested in where radio is progressing, this article is well worth obtaining. Needless to say, I shan’t be offering software radio kits! While I used to do some programming, I don’t enjoy it much and I don’t think most current kit builders are too keen on any technique which is not readily understood. Hence my avoidance of microprocessor controlled gizmos etc.. Tell me if I am wrong!

Kit Developments

The **Radstock** is at last available after considerable help by several early builders for which I most grateful. Any two bands 5 Watt CW TCVR but with a phasing receiver for single sideband reception. Full break-in, £79. Recent attention has been devoted to updating and improving my rigs at the lower and middle part of the range. Shortly the Radio Today **Chedzoy** will be launched in that magazine; this is a regenerative TRF RX for first time builders covering MW and a short wave band near either 80m or the 4 MHz broadcast band. Very detailed instructions and costing £19. Next up the revised range comes the **Priddy** as a suggested first serious construction project, it is a DC receiver covering 20, 40 and 80m with filtering for CW and SSB. It can be used with the three band ‘crystal’ controlled **Godney** 1.5 Watt CW TX. Price £39 or £64 with the Godney. The last new rig is the **Minehead**, this is a 5 Watt CW transceiver for any band up to 20m. Again not too dense and easy to set up. It has a crystal mixing VFO scheme covering the whole of the CW section of each band and costs £49. I could do with some early builders for these rigs to help prove the instructions, so drop me a line if they are of interest. I have also re-jigged my catalogue if you wish to see the whole range.

This is the end of our sixth year of Hot Iron so it is time to ask you to renew subscriptions before Sept. 1st 1999 if you wish to carry on. There will be no reminders! Tim Walford G3PCJ Editor

Send £6 now to secure Hot Iron for next year please!

Aerial Impedance Matching Networks - part 2 by Eric Godfrey G3GC

In the last issue of Hot Iron I dealt with matching units for balanced aerial systems. In this issue I shall be considering unbalanced systems which includes aerials such as end fed quarter waves, end fed half waves and wires of random length. The last category of aerials are often mistakenly referred to as long wires but this is only really true if they are more than a wavelength or so long. Consider 100 feet of wire on 10 metres, it is about 3 wavelengths long and therefore may be called a long wire (with respect to wavelength) but on top band it is only about 0.2 of a wavelength and thus is no longer a long wire but is often referred to as such. All these aerials come under the general heading of end fed wires that may or may not be of resonant length.

If the length of the wire is such that the aerial is resonant then the input impedance will look like a pure resistance, either low (say 25 to 75 Ohms) or high (thousands of Ohms) depending upon whether the aerial is an odd or even number of quarter waves long. If it is odd, then the impedance is low and if it is even it is high. However if the aerial is not resonant then by definition there must also be some reactance which, depending upon the length of the aerial, will be capacitive if the aerial is shorter than a quarter wave and inductive and if it is longer. If on the other hand the aerial is nearer a half wave long then the inductive and capacitive reactances will be reversed.

One way to match different impedances is by using an inductance and capacitance connected in the form of an "L" as shown in Figs. 1 and 2.

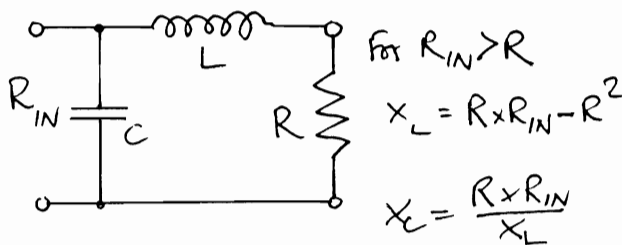


Fig. 1

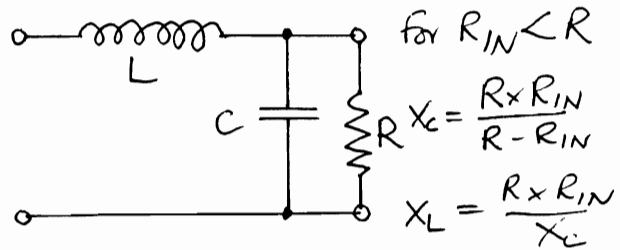


Fig. 2

The formulae for calculating the values of inductance and capacitance assume that "R" is a pure resistance. In practice it is more than likely that there will be some reactance associated with it which will modify the values of inductance and capacitance required. This is accommodated for by making them variable, using a variable capacitor and either a tapped coil or a "roller coaster" for the inductance. These arrangements are shown in Figs. 3 and 4.

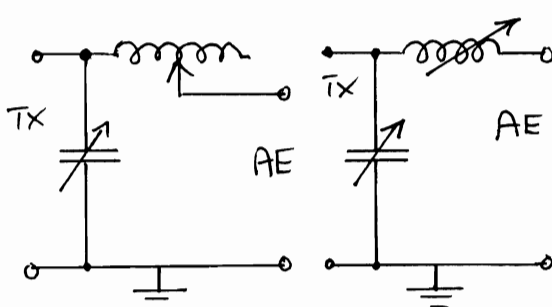


Fig. 3

Fig. 4

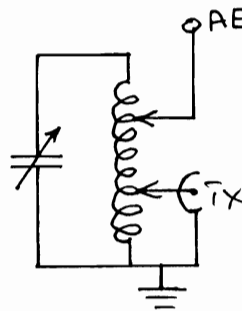


Fig. 5

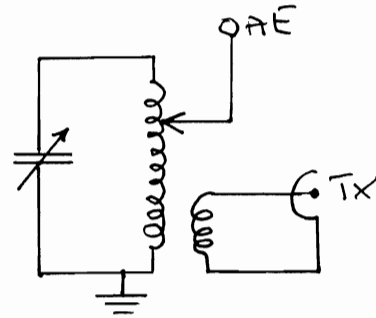


Fig. 6

G3GC

The simple LC circuit is a series resonant circuit and has the frequency response of a low pass filter. If the L and C components are transposed, as is permissible, then the circuit becomes a high pass filter. A better arrangement is to use parallel resonant circuits such as those shown in Fig. 5 and Fig. 6. The frequency response is now that of a band pass filter and as such attenuates frequencies both above and below the resonant frequency. For best results the circuit shown in Fig. 5 requires a tapped coil for both the input and output connections. However the input connection, instead of using taps, may be linked coupled to the coil by a small number of turns depending upon the frequency as shown in Fig. 6.

An important point with unbalanced systems is the RF earth connection. It is unsatisfactory to rely on the earth wire of the AC mains. It is not uncommon for shacks to be in the spare bedroom or the loft area, in which case it the earth wire will be very long, meandering around the house before being taken to ground. It is far better to create your own virtual earth by connecting a counterpoise, preferably an odd number of quarter waves long (usually one) at the operating frequency, to the

matching circuit's earth connection. A number of different lengths will be required to cover all bands but a quarter wave cut for 7 MHz will be satisfactory on 21 MHz where it is three quarters of a wavelength long which is an odd number of quarter waves.

These two articles only touch on the surface of the subject of impedance matching and the circuits described are only of use up to about 30 MHz or possibly 50 MHz. The use of lumped circuit components is not feasible at VHF / UHF and therefore impedance matching techniques at these frequencies usually employ coaxial lines in some form or another.

Hints and tips from Derek Alexander G4GVM

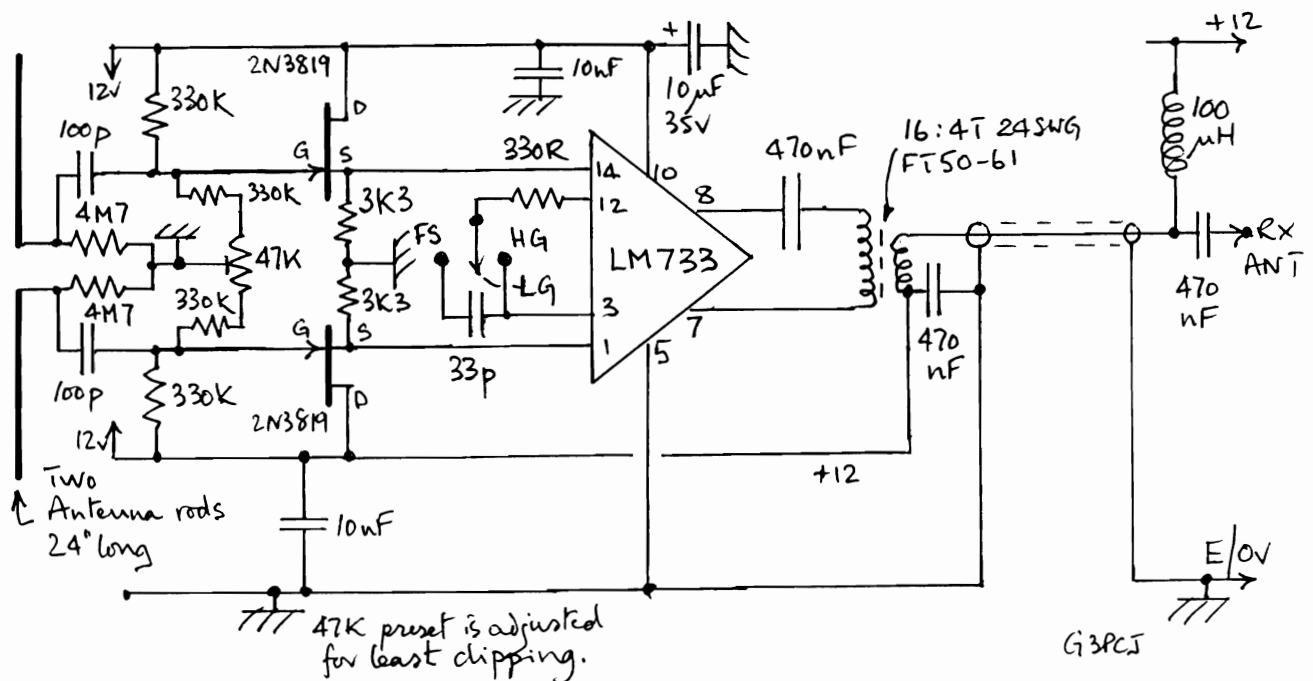
I purchased a couple of large silver plated capacitors and a roller coaster at last year's Longleat rally. They were black! I tried dipping them in 'silver dip' for about 30 seconds, agitating them in the solution. I then quickly ran them under the tap to remove all trace of surplus dip solution. (Beware of stainless steel sinks!) I was very pleased with the result for not only were the plates cleaned but so were the ceramic ends and frame. I have also similarly cleaned all my Jackson 804 type capacitors.

Speaking of these, they are about £10 new (and the rest! - G3PCJ) or about £2.50 second hand. However, the trimmer type 804 can be had at rallies for as little as 50p. They can be modified by aralditing a length of 1/4 inch brass tubing - obtainable at any good model shop. Some have a 1/8 inch stub of spindle with a screwdriver slot in the end, others a nut formation with the slot. The latter type will need filing down. The brass rod can be cut to the desired length when fixed.

An old potentiometer can provide a bush for mounting on a panel to steady the extended spindle of a capacitor, switch or potentiometer.

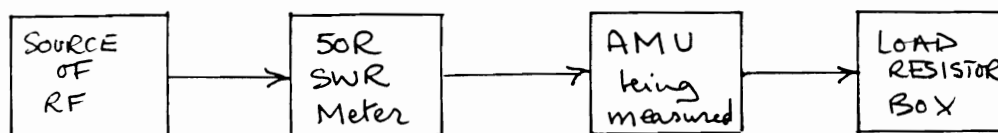
Active Antennas

The common problem with relatively simple active antennas is overload of the internal amplifier and or the receiver front end from high power broadcast signals in the medium wave band. A recent article suggested using an op amp whose gain is reduced at the lower frequencies of the medium wave band. The original article had several extra features and complications which are incidental so I have altered it slightly as something to experiment with! I have not tried this out but am fairly confident it should provide quite useful results for a receive only portable antenna. It is a balanced design with two rods for the antenna - it was suggested these be 24 inches long but their actual length is not critical as long as they are equal. The centre-off toggle switch provides three gain settings; in the middle position with it open circuit (the low gain setting), the response is flat from 200 KHz to over 30 MHz with a stated gain of 9 dB. In the high gain position, the response is nominally flat over the same frequency range but with about 19 dB gain. In the *frequency selective* position, the gain slopes from about 9 dB below 1.6 MHz to 19 dB at 25 MHz so you get the high short wave gain without strong MW signals. Being an electrically short balanced dipole, the radiation pattern allows you to rotate it to further null out unwanted signals. The circuit also shows power being fed up the antenna coax. G3PCJ.



Aerial Matching Unit Losses by John Teague G3GTJ

The losses in matching units should be of particular interest to QRP operators. Frank Witt, AI1H, in the original highly recommended April/May 1955 QST articles found some surprisingly lossy commercial units which were also able to match open and short circuited outputs! His technique is potentially capable of 0.5 dB accuracy. The underlying principle is that the indicated SWR measured between a transmitter and AMU, when the latter is matched, will depend on the degree of mismatch of the load and any losses present in the AMU. Thus if the mismatch is known, the AMU losses can be found. You need a source of RF for the chosen operating frequency (your QRP rig adjusted low so as to not burn out the resistors), a matching indicator which shows the SWR with respect to 50 Ohms and a 'resistor box' going up by a factor of 2 in value from say 6.25R to 1600R (see later). Connect them up thus:-



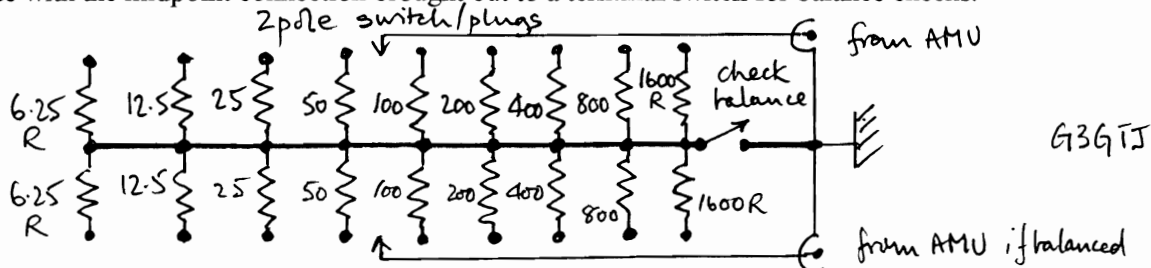
The procedure is to select a typical load resistance which you think your antenna/feeder presents to the AMU, say 200R and adjust the AMU for 1:1 SWR. Without altering the AMU settings, the load resistor is changed to *half* the previous value (100R) and the new SWR noted. If there are no losses in the AMU the SWR should now be 2:1. You can repeat the test by *doubling* the load resistor to 400R, again the new SWR should be 2:1 if the AMU has no losses. The original article has a complex formula to calculate losses from the indicated SWR following a 2:1 load change but a small simplification leads to quite useful results (with slightly less accuracy) from the following table:-

SWR	2	1.9	1.8	1.7	1.6	1.5	1.4
Loss, dB	0	0.3	0.7	1.1	1.6	2.2	3.0

This illustrates the well known fact that once aerial coupler losses are more than a 8 to 9 dB such a system will always present negligible SWR to a transmitter. These methods can provide useful insights into the factors underlying a successful - or unsatisfactory - AMU design and reveal immediately which of a range of AMU settings is optimum. In my own case, I abandoned my pi coupler in favour of a Z-match, finding, incidentally that:-

- Losses, load matching and balance over the HF range are largely independent of the number of turns used for coupling links over the range 2 to 12 turns,
- Coils (not toroids) can be mounted very close to metalwork or in small screening cans without causes losses,
- The Z-match provides excellent balance on all bands. (See last Hot Iron!)

A simple load box can be made using ¼ watt resistors so that a wide range of loads can be selected by a multi-turn switch. Each load resistor in the chain should be in the ratio 2:1 in adjacent switch positions as below. Non standard values can be made by paralleling standard values. All leads should be kept as short as possible. If your AMU output is balanced, then a balanced load box can be made with the midpoint connection brought out to a terminal/switch for balance checks.

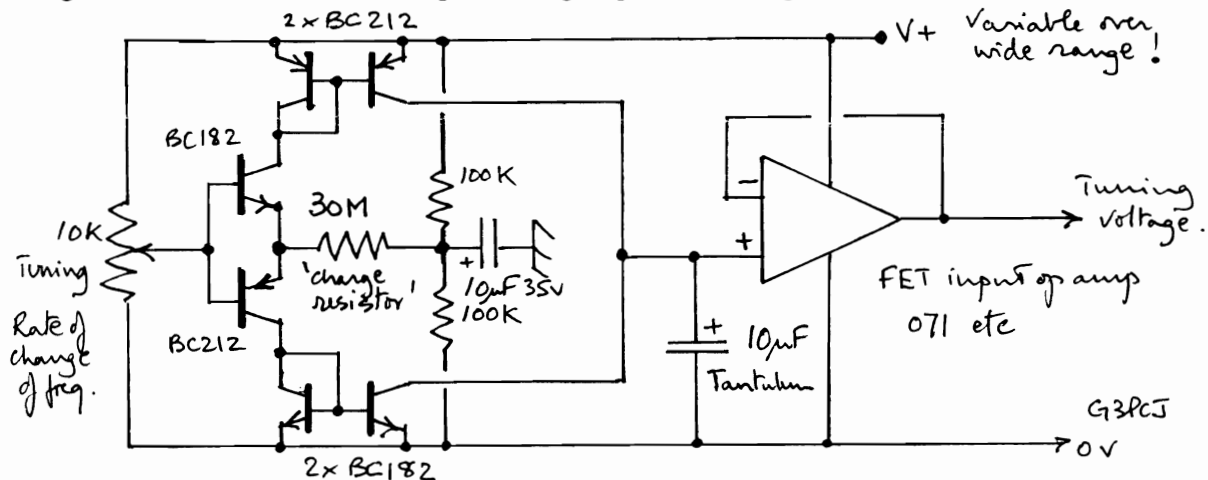


Checking balance is very simple. Load the balanced output of the AMU with a load of two equal resistors in series (balance switch open). Adjust the AMU for 1:1 SWR at the AMU input and then connect the mid point to ground by closing the balance switch. Any change in SWR will indicate unbalance within the AMU. Baluns can also be checked this way and their losses established using the AMU test procedure.

Single Knob Tuning

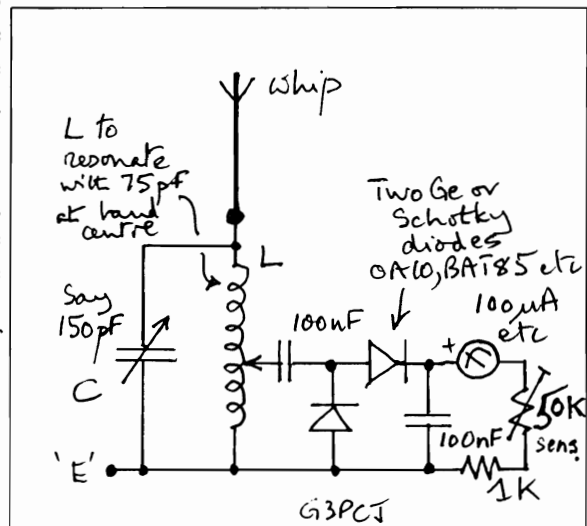
Those of you lucky enough to have air variable tuning capacitors driven by slow motion drives need not read this! The rest of us stuck with varactor diodes probably have a coarse and fine tuning controls where the tuning range is more than 100 KHz or so. While doodling one day about how to improve tuning arrangements with 'huff and puff' stabilisers or synthesisers, I hit on the idea of deriving the normal varactor tuning voltage from that stored on a capacitor and injecting/extracting charge to change the tuning voltage. The first snag is how to 'buffer' the capacitor voltage so that it can drive the varactor diode without altering the capacitor's charge - this is fairly easy using a low leakage tantalum electrolytic capacitor feeding a FET input op-amp like the TL071. The major advantage of this scheme is that you do NOT need a stable supply any longer! The op-amp's supply voltage can change quite dramatically if it has typical supply change rejection figures.

To inject or extract charge from the capacitor some form of rotary control is desirable; hence the idea of a pot whose central position corresponds to no change, and where movements on either side control the rate of frequency change up or down. I very quickly found that minute currents are required in or out of the capacitor to change its voltage so a driving circuit without any current gain is essential! This all boils down to two current mirror circuits for each polarity driven by a pair of 'common emitter' transistors biased at the control potentiometer's mid voltage. Only when their bases depart from the mid supply voltage does one of them inject current into the associated mirror and hence into or out of the capacitor. The finite turn-on base to emitter voltage of the two 'common emitter' transistors means there is a small (wanted) dead band at the central position of the pot. The size of this dead band can be varied by altering the pot supply voltage and it does not affect the tuning either! I tried this scheme out on my Langport and it worked quite well - you might find other charging resistor values better for your rig! 30M is pretty large so a pulsing scheme might be indicated but this adds complication. It takes a little while to get used to a tuning control which alters rate of change of frequency (and you do need a digital readout) but one control and being able to change the supply voltage from 8 to 30 without affecting the tuning is quite something! G3PCJ



Absorption Wave meters

Prompted by a note from David Roper who asked about 6m wave meters, I reproduce alongside the general circuit of such gadgets. The tap on the inductor is to avoid the diode detector from spoiling the Q of the tuned circuit. It should be about 1/4 to 1/2 of the turns up from the ground end. The whip antenna, made from a couple of feet of stiff brazing rod, can be connected direct to the hot end of the coil. The more sensitive the meter, the more sensitive will be the whole instrument. The L and C need obviously to resonate over the bands of interest; the L can be made plug-in for several bands. Calibrate the tuning dial by connecting the whip input and earth in series with your RX antenna; it should attenuate off-air signals when tuned to the same frequency as the RX. G3PCJ



Five Questions Prize Draw!

Several members eventually answered my questions: I am most grateful to them because it is very difficult to obtain market research data of a positive nature. Here is a synopsis of the answers:-

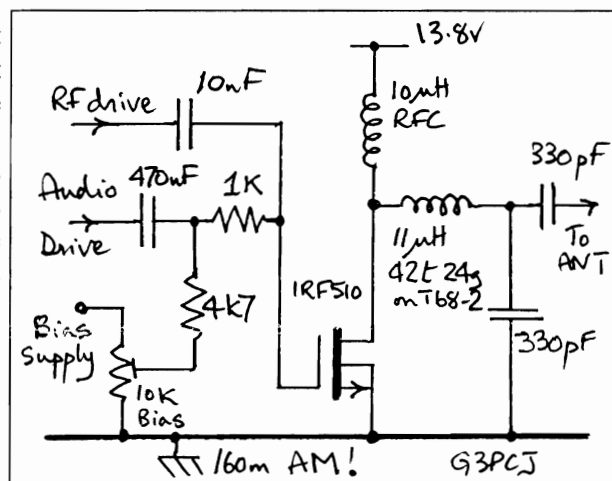
1. Desired rig. Large variety - tubed rigs to 2m multimode (phew!), high spec CW, no drift VFO, etc.!!
2. Experience. Taunton, Street, Oscilloscopes, 23 cm transverter, 40 Watt 6 to 160m CW/SSB TCVR.
3. Other topics. More practical things, simple test gear, /P antennas, humour, more feedback (please!!)
4. Strengths. Value for money, interesting solutions, step by step tests/instructions, they work!
5. Weaknesses. Range too extensive, none, lack of enclosures, 612s, transistor lead/holes.

I have already made good use of a number of these points but the one that haunts me is enclosures! I have been searching for what I think is a good value solution for two years or more without success. You can obtain good quality cases where you can remove any single side or end without it collapsing (for tests etc.) but they are expensive at around £25 each and then they need drilling and some sort of labelling scheme. Another problem is that of accommodating options like digital readouts, plug-in cards and other extras etc. without having a large inventory of expensive cases waiting in stock for customers. I would very much welcome some suggestions on how to solve this.

My son Charles, who some of you have met at the QRP Convention, is open to influence but on this occasion claims to be acting independently, has chosen G3YCC at random as the winner of the £25 voucher - well done Frank. Its on its way separately. My thanks to all of you for your help. G3PCJ

Top Band AM

Paul Tuton wanted an AM TX but I can't find the circuit that I used many years ago. It used gate modulation of the TX output stage IRF510 FET. Try this: design the drain load to produce a maximum of say 5 Watts on 13.8 volts which actually needs a drain load of 12.5 Ohms easily obtained by a LCC network. Apply gate bias/RF drive to obtain ¼ of this (1.5 Watts) as carrier with no modulation, then apply audio to the gate to just achieve 100 % modulation. Since the gate circuit is very high impedance for DC and audio signals it can be driven from a speech amplifier. I certainly had several contacts using this approach. Write it up for us Paul! G3PCJ



High Current Batteries

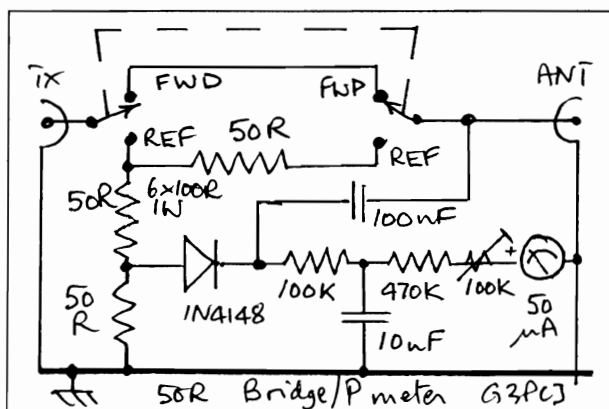
Lead acid batteries have now been fabricated like capacitors (Swiss Rolls) so that they have very large area cells with very low lead inductance. Experimental devices can now pack a huge punch - 6 off cells each 23 mm in diameter and 70 mm long connected in series for a 12 volt battery could start between 15 and 20 V8 engines on a single charge!! Even more impressive is their rapid response - a single cell discharged at over 1000 Amps just 1 microsecond after switch on (including a 700 A switch bounce spike after just 500 nS!) and had risen to 1500 Amps by 6 microseconds! Makes the cranking of my tractor diesel engines by conventional lead acid batteries sound very tired! Can't find where to buy them! G3PCJ

Most Often Used Gadget!

Filling the last few lines is always tricky! This QRP matching bridge is the unit that I use most frequently. It indicates forward and reflected voltages but after the AMU has been adjusted for a 50 Ohm load it can be calibrated in power. In the reflected position, it also protects against any AMU load. Very handy - G3PCJ

Finally - don't forget your subs!

£6 for UK, £8 for overseas



Hot Iron

Issue 25

“Journal of the Constructors Club”

Autumn 1999



Contents

- 50Hz & RF earthing
- Joseph Bell's circuits
- Quote & Radstock note
- Direct Digital Synthesis
- Six metre Linear
- High speed logic
- Real components

Editorial

Welcome to the start of our seventh year of the Construction Club which will span the anniversary into the new Millennium. The last 100 years (roughly) since radio was 'invented' have seen increasingly rapid developments and the last 6 years in the world of amateur radio construction are no exception! There is no sign of things slowing down. As is happening in the commercial world, the technology of radio and computing are growing closer together. I wrote last time about the 'software radio' concept and nowadays digital techniques are widely used even in test gear for analogue equipment. A later article in this issue discusses the merits of Direct Digital Synthesizers (DDS) to replace conventional tuning oscillators - this is another example of digital techniques permitting significant improvements. Sooner or later we serious home constructors have to bite the bullet and tackle more complex digital matters and the other hurdle of surface mount technology. The latter has to occur because all the new interesting devices are now only made in surface mount package styles. Given the tremendous value of 'owning' a decent oscilloscope, I wonder if members would be interested in a test gear

project for a 'bandwidth extender' to use in front of a plain scope with limited bandwidth. It would take in high frequency signals, say up to 30 MHz, digitise them in an 8 bit analogue to digital converter for storage in a digital memory, and then spew the data out again at say 100th of the original sampling rate into a digital to analogue converter for display on a lower bandwidth scope. (A more complex version could feed into a PC but I am not up to the software!) An alternative project would be a DDS unit, perhaps as a signal generator or replacement VFO. I welcome your views please.

Kit Developments

Farming and work on barn conversions have got in the way so not quite so much to report! The **Pridy** (DC RX for 20,40 &80m) and **Minehead** (DC CW TCVR up to 20m) are now available. The **RT Chedzoy** is fully out with an article in the August issue of Radio Today magazine. It is aimed at first time constructors. Apart from medium wave, it can be tuned to either 80m or the broadcast stations near 4 MHz. It can copy AM, CW and SSB. I have been trying to improve my **Antenna Matching Unit** design with increased power, say to about 30 Watts, and to make its construction slightly less fiddlesome. Obtaining reasonably priced air spaced variable capacitors is the main hurdle; G3TUX kindly inquired about these when he was recently in the States and reports that kit suppliers there have the same problem. For this application, where smooth continuous variation in capacitance is not essential, I suspect the most cost effective solution is to use a range of increasing capacity high voltage fixed capacitors switched into circuit with toggle switches. Edge mounted tuning meters are also a bit expensive so I think that a change to an RF driven LED indicator can make an appreciable saving in cost. The technique will be to tune for least brightness. This approach suggests an updated design of my L match AMU can come **down** in price to between £30 and £35. Any early builders?

Having revamped most of the Somerset Range during the last 18 months, I am on the lookout for new ideas. What do you want to build that is not available in mine or other suppliers lists? Some have suggested valved projects but I am not keen for a variety of reasons; apart from the obvious ones, I would have to stock up with a completely different set of 'impossible' to obtain parts! Letters on any topic from members are always most welcome.

Tim Walford G3PCJ Editor

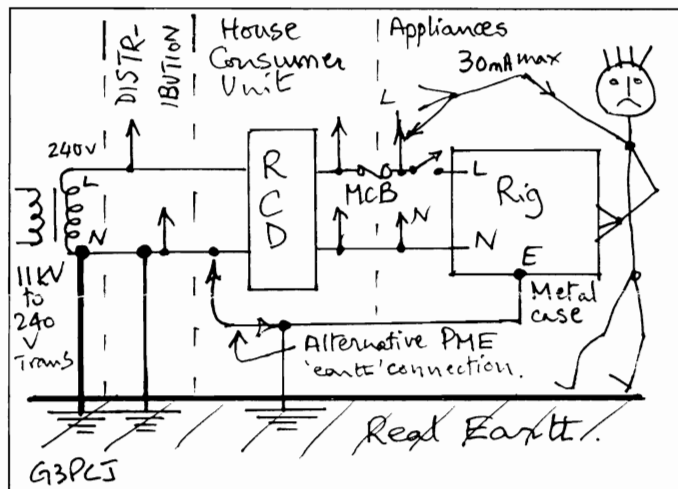
Earthing for 50 Hz & RF

David Proctor G0UTF asked for a note on the best way to connect up mains power supply, rigs, antenna matching units and antennas. None of our 'consultants' was willing to tackle this topic, so its down to me! Apologies for the length, but there are many aspects. Firstly the mains safety bit.

Mains earthing

Modern domestic wiring should be protected by a *residual current device* (RCD) which senses when the current in the 50 Hz main incoming phase (or live/line) wire and the neutral wire are not equal and then turns everything off. The currents are unequal when some of it 'escapes' somehow to earth and back eventually to the neutral connection of the electricity substation transformer so that less flows in the neutral wire through the RCD (see circuit). Usually this condition indicates a fault, either through poor insulation of some live part, or worse, due to a human standing on the 'earth' while in contact with a live part. Of course we don't have actual earth all over our houses, so the next best thing is to connect (or bond) all exposed metal work together through the mains earth wires with extra bonding to pipework etc., and to connect this lot to the best available earth. In ordinary houses this takes the form of an earth rod or spike driven into the ground. RCDs are available with a range of sensitivities but often a 30 mA device is used to protect sockets and normal domestic appliances. This current is (alleged to be) below the fatal levels for humans (do NOT put it to the test!) and can easily be passed by earth spikes without a significant rise in voltage of the mains earth metalwork above actual earth. So when you inadvertently connect yourself between something live and the 'earthed' metal work, the RCD senses that less current is flowing in the neutral wire and turns itself off before you can leap to the switch.

In high rise flats, you cannot have individual spikes driven into the actual earth, so an alternative system had to be devised; it uses a technique called *protective multiple earthing* (PME) where the supply neutral is frequently grounded (with buried wires) throughout the local distribution network in addition to the neutral connection on the distribution transformer. (This often done anyway.) By doing this, the neutral wire can be assumed to be as near earth potential as is reasonably possible in these difficult buildings and the electricity supply companies allow the exposed mains earth metalwork to be



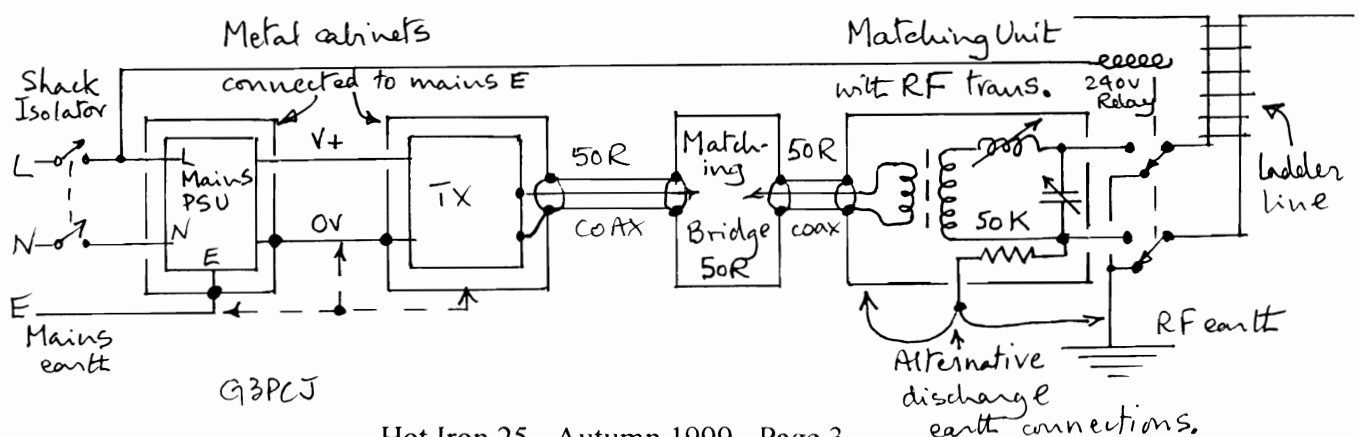
connected directly to the neutral. As before, if a leakage path exists between live and the mains earth metalwork, a lower current flows in the neutral conductor through the RCD and it turns off. This system is supposed to be safe even if the incoming mains neutral is broken because then everything is live including the 'earthed' metalwork, so with no voltage difference between live parts and 'earthed' metal work, you should not get a shock. The problems come if you can touch a live part and real earth, either something connected to a spike in the ground or an RF earth such as buried radials associated with an antenna. (Think also about outside water taps fed by metal pipework!) Now you would feel the full 240 volts so it is important to prevent contact between mains earth and real, or RF earth, if you use PME and the incoming neutral as the basis of mains earthing - a separation of 2m is suggested between different types of exposed earth metalwork to obviate contact by outstretched arms. Using an RCD is still sensible even with PME and it is a good idea to have your shack supplies protected by their own RCD even if the rest of the house is covered by another RCD. (The older style of voltage operated safety trips are no longer in favour and should be changed to RCDs.) Do not connect mains earth and RF earth together because if PME earthing is being used and the neutral does break, your RF earth wire might attempt to carry several hundreds of amps of 50 Hz - so see below regarding antenna matching units.

So the general advice is 1) always use an RCD, 2) have mains earth (and all exposed metalwork) connected by 16 mm² cable to a proper earth spike if possible, 3) avoid using the PME/incoming neutral earthing if there is an alternative, 4) prevent contact between mains earth and RF earth, 5) do not connect mains earth to RF earth. This short note does not fully cover the subject so please do take advice from a qualified Electrical Engineer if in any doubt and explain there is an RF aspect.

RF earthing

If the antenna system is balanced with equal length radiating arms (or a loop), then RF earthing is seldom a problem because there is return path for the 'outgoing' feeder current from the antenna matching unit (AMU) which enables it to return through the other feeder wire and back into the AMU. By implication the two AMU output terminals must not have any *internal* low impedance connection to RF earth and will often (but not always) be fed by a symmetrical circuit within the AMU. A balanced circuit is preferred for balanced feeders, e.g. ladder line, but can also be used for coax fed balanced radiators; here the radiation pattern maybe skewed by induced RF currents on the outside of the coax which do not have a proper return path through the AMU - hence the use of coiled up coax 'choke' baluns. For unbalanced radiators such as verticals or end fed long wires there is no copper wire return path and some sort of connection must be made to the actual physical earth to allow the driving current to return to the AMU. Because the need for this connection is often overlooked, it can lead to a 'hot' shack with 'RF everywhere'. Often the next best available earth is perceived to be mains earth, so people do join one side of the their AMU output to mains earth but as explained earlier, this is not a good thing for mains safety reasons. Furthermore, it seldom provides a good low impedance RF earth, risks RF currents through the PSU and may turn off the RCD trip. The ideal solution is to provide a good RF earth, connected by short thick low inductance cable from the AMU to a system of ground spikes or a mat of wires buried over a large area. This is not always possible, especially for the awkward high rise flat, so a counterpoise has to be used; this is a quarter wavelength long for the frequency in use and in crude terms, is providing the missing other half of the ideal balanced radiator. The main point is to provide a known path for all the currents, RF or 50 Hz fault currents, so that they are under control always! Hence the need for the RF output circuits of the AMU to be 50 Hz isolated from the transmitter's output and its chassis, which is likely to be the power units 0 volts and hence also connected to mains earth. This is why the AMU should have an RF transformer or link coupling circuits within it. It is a good thing to have a DC path between elevated radiator arms and earth (of any sort) to provide a static discharge path which will also help prevent lightning strikes. This should be fairly high impedance so as to not waste RF energy but it will not prevent serious damage if you do suffer a direct lightning strike. Another sensible scheme is to automatically ground the antenna when the power is off using a relay.

Finally a few points on AMU design. The internal output circuitry does not have to be fully symmetrical for feeding a balanced feeder and radiators; it is better but the complications often mean that an asymmetrical RF 'floating' arrangement can be accepted with the small penalty of skewing of the radiation pattern due to slightly unbalanced feeder currents. A separate RF output transformer can be used on the output of an asymmetrical matching circuit but it should have a ferrite core (not powdered iron to obtain sufficient leakage reactance), and it should work into a flat feeder line without standing waves due to a mismatch between radiating arms and the feeder - the reason is ferrites do not like reactive high power loads. This restriction means that such balanced AMU output transformers are less flexible than schemes where the output terminals connect direct to the matching network which thus allows them to absorb any reactive effects from random length line and mis-matched radiators. It is quite in order for the tuning inductor of a matching circuit to use a powdered iron core. The matching circuits should at least have a low pass characteristic to attenuate unwanted harmonics. It is also desirable to have a high pass characteristic to reject unwanted MF broadcast stations during reception hence the preferred option is a link coupled parallel (or series) tuned resonant circuit with a bandpass characteristic, and tapped for the anticipated load impedance. This can be complex for mutli-band operation so often the best compromise is an L match circuit fed by an RF transformer. This is the shown below with the suggested earth connections; this is the basis of my AMU kit. **Balanced ANT**



More circuits from Joseph Bell G3DII

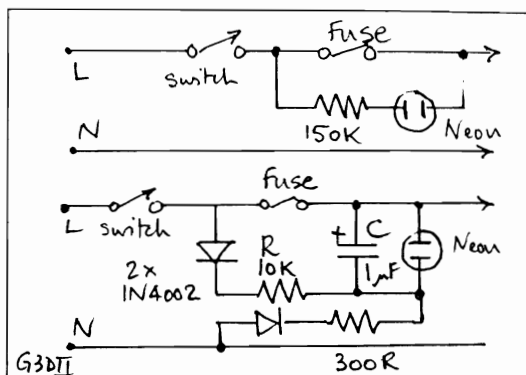
Blown fuse indicator

Wire a neon in series with 150K across a fuse and it will glow when the fuse is blown. Top circuit right.

Pilot light fuse indicator

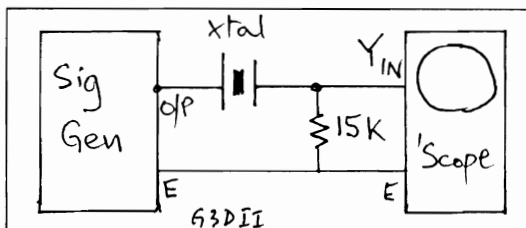
With the addition of two diodes, two capacitors and a resistor, the neon pilot light can also be made to blink when the fuse is blown. The R and C control the flash rate.

Take care with both these circuits due to the mains voltages!!



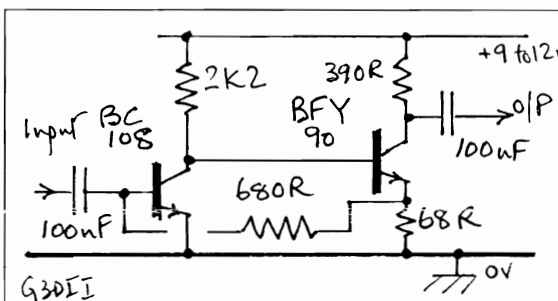
Crystal checker

This simple circuit can check the activity of a crystal and the calibration of your signal generator. As the signal generator output approaches the frequency of the crystal, at the exact point of series resonance, there will be a sharp increase in value of the Y amplitude on the scope. If the signal generator has sufficient output amplitude, the harmonic activity of the crystal can also be tested but the frequency will not be exactly 3 or 5 times the fundamental.



Broadband amplifier

Some of the circuits I mention need one of these circuits - if you haven't got one then you should have! This is an old but very effective circuit with a gain of 24 dB in a 50 Ohm system into the low VHF range. The actual input impedance is 10R and the output impedance 390R but ignore these since in most cases there will be an increase in signal level. You will find many uses including buffering inputs to counters, raising levels for an insensitive scope or low output oscillator, etc..



Sticking meter needles

Most hams have bought meters at junk sales only to find that the pointer sticks at some point on its traverse. However it is often possible to remove a foreign body stuck in the innards of the movement using adhesive tape, Sellotape etc.. Fold a small length of tape sticky side out and trim with scissors to make a narrow tapered 'probe' just longer than the size of the armature. Gingerly move the tape in the circular path of the pole pieces until the foreign particles have been picked up by the tape. With care there is a fair chance of success without damage to the meter.

Quote by William Thomson, Lord Kelvin, 1824 - 1907

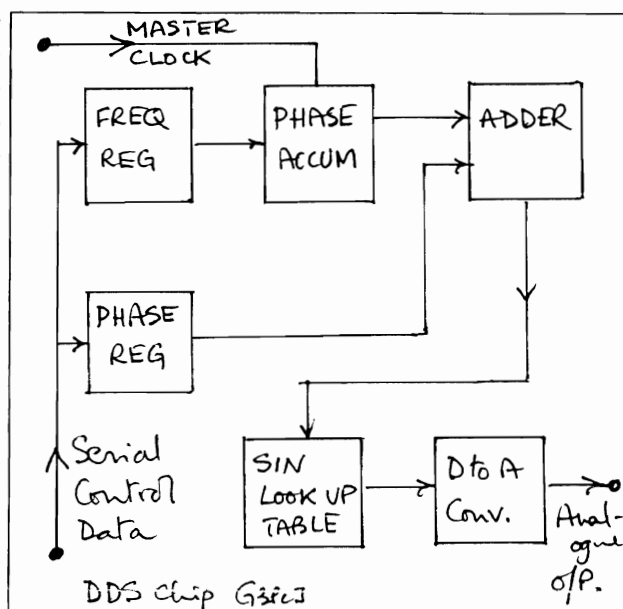
"When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it maybe the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science."

Comments on the Radstock

After failing to find a vital part with the gadget in Hot Iron 17, David G0UTF, comments:-
"Driving someone else's car instead of your own is rather like using the Radstock after using your own simple DC RX. I found it strange at first with the very small audio bandwidth. Tuning through the bands to see what is there needs care as you are likely to miss those narrow bandwidths of signal. *But when you do get the hang of it, it is quite addictive.* When you tune in your signal, there is usually no other station! This is done by the 'phasing' method, which cancels the other sideband and emphasises the 750 Hz. This means the extra components make the PCB quite full. I took my time to build it - just two resistors crossed over and it worked well after the usual adjustments. After a few QSOs I fitted the board into a metal 280x85x190 mm case with a wide range of controls, LEDs and S meter. It has a nice solid feel. As an ex-Frome user, the Radstock is now my CW rig for 30/20m. After a week I have worked QRP stations from EA/OE/CT/IUU9/DL with my 'long wire' antenna."

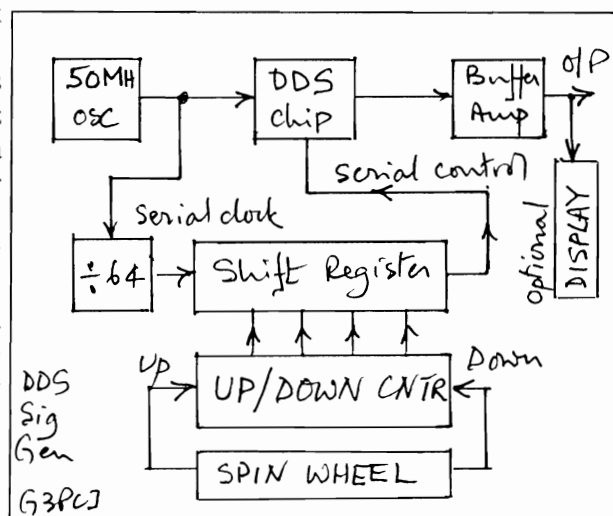
Direct Digital Synthesis

For signal generation up to around 50 MHz, the DDS technique has many advantages over conventional forms of frequency synthesis, particularly if any form of microprocessor is available to control what goes on. Its cost and complexity (in terms of the number of chips) is similar to a phase locked loop but its performance, in terms of frequency stability and agility/versatility, is very much better. I have recently been examining a DDS chip type AD9835 from Analogue Devices which can use a 50 MHz clock to generate a high purity sinusoidal output signal from nearly DC to 25 MHz maximum but realistically about 18 MHz if spectral purity is especially important - this is often the case for most oscillators. This particular product is in a 16 pin TSOP surface mount package with serial control signals for a micro controller. The device is pretty complex having provision for the instantaneous choice of two stored output frequencies either of which can have its phase instantly altered by up to four values - this is useful for novel forms of modulation. The figure below is a very much simplified block diagram of the chip. In essence a digital control word of 32 bits from the micro controller defines the duration of each step in phase of the output sinusoid by looking up the size of the output amplitude for each increment of phase angle. The output amplitude for each phase angle is stored digitally in a look up table; as time progresses these digital amplitudes are passed to the digital to analogue converter to create the smooth output sinusoid. The output frequency is the input master clock frequency (50 MHz here) times the binary (frequency) control word divided by 2^{32} . Do the sum and you will find the frequency has a resolution of 0.01164 Hz for any value up to the maximum of 25 MHz! The output frequency accuracy is directly related to that of the master clock which is usually a crystal based oscillator and hence very good.



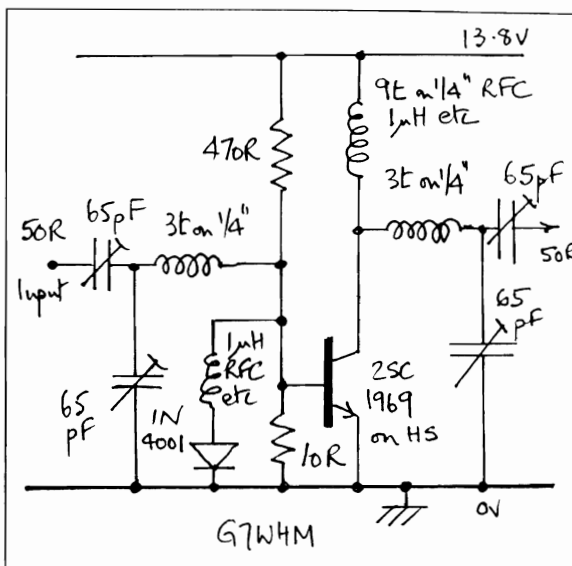
In commercial products, the DDS chip is controlled by a microprocessor which would also perform many of the house keeping functions such as displaying the output (or tuning frequency allowing for any IF offsets), choice of A or B 'VFO's, band changing, memorising channels, filter settings, etc.. As a potential kit project, where it is expected the builder would wish to have a good idea of what the controller is doing, a somewhat simpler dedicated logic controller would seem appropriate. Essentially this only needs to produce the serial 32 bit digital control word defining the output frequency. This could be generated from hexadecimal switches or an up/down counter under the control of a spin wheel or up/down buttons. The frequency could be displayed on a counter connected to the output if it was being used as a signal generator. If being used in place of a VFO for tuning a rig, then there might already be a digital readout. As a signal generator, the spin wheel might tune in (near) KHz steps whereas for a VFO steps of about 10 Hz would be appropriate. It should be relatively easy to devise a kit to do either task having a block diagram similar to that alongside. For example, if used to replace the Taunton's VFO, it would need to tune from 4.0 to 4.5 MHz with the 'spin-wheel'. I hazard a guess that a simple kit like this, to be either a signal generator or replacement VFO, would cost around £45. Obviously such a device could be designed fully into a new rig with savings by omitting the crystal oscillators in the LO chain but it would need a micro-controller etc.. I feel that these complications might be unwelcome for most builders. Interested?

Tell me what you think please!



Six meter power amplifiers

Andy Howgate has given me outline details of a PA that he has devised to run with his Street transceiver using the watty 2SC1969 transistor. It was salvaged from some commercial project complete with PCB and heatsinks. It is quite capable of producing 20 Watts using a 13.8 volt supply. Tuned input and output matching networks are used to provide the desired 50 Ohm input and output impedances. The LCC network shown here is best for VHF work because of its versatility for load unknowns. Biasing of this type of powerful bipolar transistor is tricky - often the bias circuits for bi-polar linears are quite complex, but in this simple scheme, the power diode controls the base bias so it must be in good thermal contact with the main device heatsink. Keep overs short until you are confident there are no thermal runaway problems.

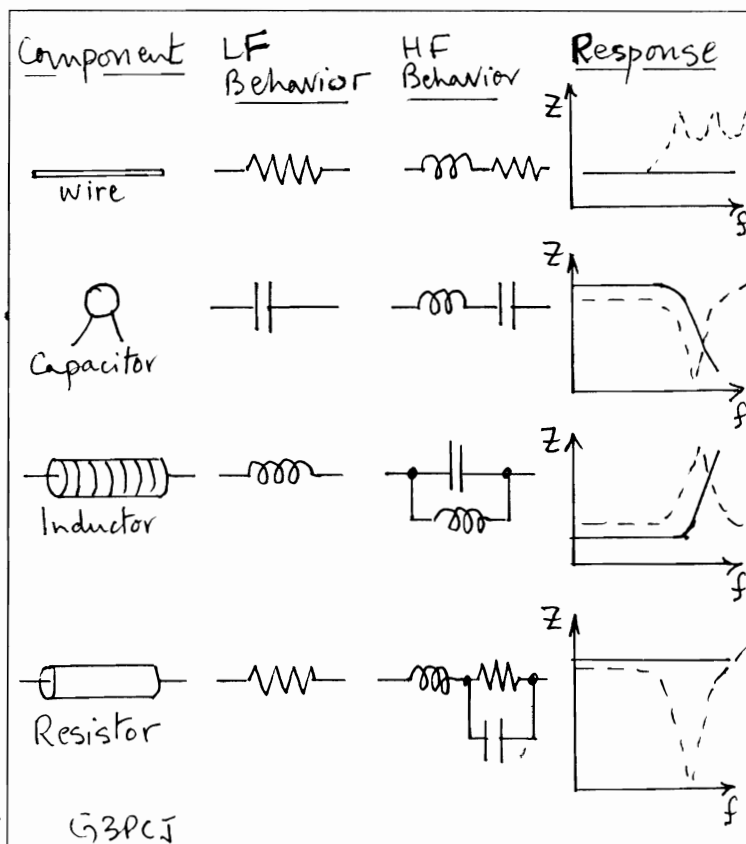


High Speed Logic

I see from a recent article that Motorola have announced a range of simple logic devices where the gate propagation delays are about 150 pico-seconds (150×10^{-12} secs). They are emitter coupled logic (ECL) devices with an upper toggle frequency in excess of 3 GHz! Rise and fall times of the digital signals are about the same 150 pS which means that any track over about 2 inches has to be terminated because it behaves as a transmission line for such high frequency signals. If the line is not terminated in its characteristic impedance, just like a radio transmission line, reflections are generated which degrade the digital signal waveform so negating the speed advantage. Generally, higher speed means increased dissipation because higher currents are required to charge and discharge the circuit capacity but they have managed to stay at around 30 mA per device for most '8 pin' functions by using lower voltage logic. Needless to say these devices are only available in surface mount format!

Real components!

Usually we draw circuits, and use parts, as though they behave in an ideal manner. But as frequency increases, this becomes a false assumption and it is worth remembering the degradation in ideal performance due to the parasitic effects, usually self capacitance and inductance. The figure right shows how parts behave beyond their 'normal' operating frequency range. Bear in mind that the actual frequency when a part ceases to have its theoretical performance may be quite low in real terms, this is especially so for large value fixed inductors. There is also a good rule of thumb, due to the same basic causes, that a low pass filter is unlikely to behave as expected theoretically when the frequency being considered is over 100 times the 3 dB down frequency. The converse is true for high pass filters where the low frequency response would not be as expected at 100 th of the 3 dB frequency.



N.B. Please write me some articles so that you don't have quite so much of my prose next time!

Hot Iron

Issue 26

"Journal of the Constructors Club"

Winter 1999



Editorial

Happy Christmas and may you have a happy, healthy and prosperous new year! May you all keep your soldering irons working hard! As we enter the next century, and millennium, it is a timely moment to reflect on the state of amateur radio. The pace of development has been startling throughout this century in most technological fields and radio is no exception. Even into the middle of this century many scientific matters could be studied with relatively simple apparatus, however that is changing as the quest for better value for money makes even small improvements in any aspect of performance worth chasing. Inevitably this leads to increasing sophistication where the string and sealing wax or brass metalwork and mahogany wood of earlier scientific instruments are inadequate. Amateur radio enthusiasts were right at the forefront of several major radio developments in the first half of this century using equipment made with very simple facilities. Apart from valves which required metallurgical and lamp bulb making skills, nearly everything else of the very early radios could be fashioned within a home workshop. Frequently, new radio technologies were pioneered by enthusiasts

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- Worms and earthing!
- Powdered Fe cores,
- Aluminium bashing,
- Surface mount devices,
- More tips from G3DII,
- Somerset Contest,
- AMU outline, etc. etc.

prior to take up on a commercial basis but, with the sole exception of computer software (whether related to radio or not), it is now the case that we follow the large organisations trying to use devices and ideas as spin-offs from commercially developed projects, often by multinational companies with huge development budgets. Unusually, software can still be written for quite impressive applications using little more than a home type personal computer costing around a £1K or so. For much of the rest of radio related projects we are the followers of others - this is not a situation that I would have chosen but it does present an interesting challenge! I see my task as a kit designer to be that of adapting the technology (and particularly the devices) of others in a manner which allows us to experiment and enjoy ourselves. I get my kicks out of the design work and hardly ever use a rig once its completed - I leave it to others to extol the virtues of operating matters, where I am not fit to make any judgements! Some would argue that operating skills have gone down hill in the last couple of decades - I hope that one of you will write me a letter (for publication) refuting this and tell us what the operating challenges are for the next century! However the hobby develops, the important thing is to have some fun and not take life too seriously - its just too short! I hope you have as much fun in 2000 experimenting as I intend to have with my pencil, paper, (waste bin), soldering iron, scope and PCB layout tools!

Kit Developments

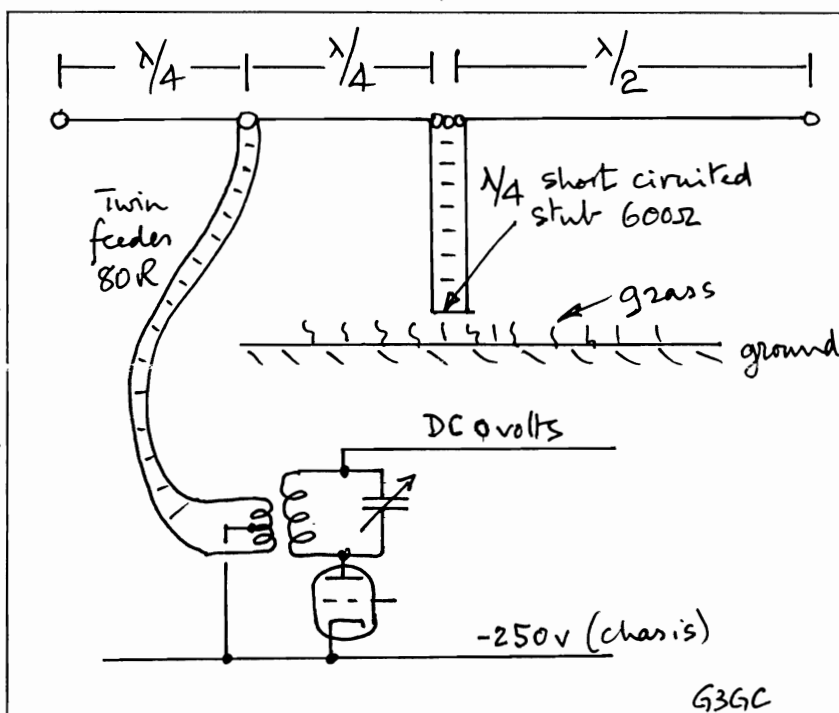
Early experience with the **Minehead** (DC CW TCVR up to 20m) is encouraging; John Gardner GW4KVJ, has been using his mobile and has been working successfully around Europe. As noted last time, I have been working on an update to my **Antenna Matching Unit** but it is proving very tiresome largely due to the non-availability of air spaced variable capacitors. They are being removed from the Maplin catalogue but I need a reputable and repeatable source which tends to exclude many of the options available to you. I thought I had this solved with switched fixed high voltage capacitors only to find that the tolerance of those I chose was far too wide! I also thought at one stage that the new design was very lossy only to find that harmonics were causing spurious readings - a low pass filter quickly cured that! It will include a *high* pass filter to remove medium wave BCI which is often a cause of interference. Progress is being made! Tim Walford G3PCJ Editor

Worms and Mains earthing - part 2! by Eric Godfrey G3GC

As one of the recalcitrant consultants who refrained contributing to the article on 'Earthing for 50 Hz and RF' I must say I think I made the correct decision! Tim's article is excellent and although I would have been happy to contribute something on the RF side, I did not think I was competent to write about mains problems, particularly PME. The article has confirmed this and I must say that I now have a much better understanding of what PME is and why it is used.

However it seems to me that in some ways PME is nothing more than a reversion to the old days of the two wire system. Before the war I lived in Finchley where the electricity supply was 250 Volts DC generated by the Finchley Electricity Company. The Company's main feeder running down the road was a three wire system, +250 / 0 (Earth) / -250 Volts. The houses were supplied with two wires which were 0 (Earth) and 250 (Live) Volts, with alternate houses being either plus or minus 250 Volts. This meant that if one was on a +250 line coming into the house then the supply positive was live and the negative at 'earth' potential. However if one had the -250 Volt supply, then the supply positive was at 'earth' and the negative was of course at -250 Volts. This -250 Volts was usually tied to all the equipment metal work because most valve circuits usually had their negative supply connected to the chassis and also to the centre taps of transmitter aerial link coupling networks. This was a potentially dangerous situation and you can guess which supply we had, yes -250 Volts live! I will now tell you a little true story to illustrate the possible dangers of mixing PME and RF earthing.

At one time I while at Finchley I had an aerial system which was two collinear half waves fed in phase. One of the half waves was fed at its centre by a low impedance balanced feeder connected to a centre tapped link coupling on the transmitter. The phasing of the second half wave was achieved by using a short circuited quarter wave pair line stub joining the two half waves together as shown in the diagram. One rainy day I looked out of the window to see steam rising from the lawn below the quarter wave stub. On closer investigation I found the aerial had sagged a bit and the stub was touching



wet grass. Because the aerial was tied to the transmitter chassis by the link coupling, the whole aerial was at -250 Volts and now had a short circuit back to 0 volts by means of the connection to the wet grass and thus warming it up. What was interesting was apart from the steam all the worms were wriggling their way to the surface. I do not know whether they were just getting warm or were getting an electric shock from having their heads and tails at different potentials. Perhaps I should have patented this de-wormer! More seriously this illustrates that there was a potentially lethal situation which was similar to that of bringing 'RF (ground) earth' into a shack which is protected by PME. Some years after the war, the Finchley supply was changed to 240 Volts AC but the two wire system in the house remained with neutral connected to earth. The voltage on the neutral was not supposed to deviate by more than 30 volts from earth. (I think the current figure is nearer 10 volts - G3PCJ.)

Lightning - The mention of a potential gradient across the ground, reminds me that this is a serious risk if you are near a lightning strike. It leads to the advice that if you are out in an electrical storm, you should stand crouching (to minimise the chance of a direct strike) on one foot so that there is no potential difference from a nearby strike if both feet are on the ground; this might otherwise allow current to pass through your sensitive regions! Do not rely on the insulating properties of wet wellington boots! You should go home while still crouching and hopping on one foot! G3PCJ

Powdered Iron Toroidal Cores

While exploring alternative approaches for the revised Antenna Matching Unit, I needed a wide range of 'thickish wire' inductances for the potentially high currents in a matching circuit. Comments from Paul Tuton had suggested that the low cost ready wound high current RF chokes, available in a useful range of inductance values from TOKO but using ferrite cores, were prone to saturation (and hence heating) so I decided to investigate powdered iron toroids. The design idea needed multi-tapped inductors to minimise the total number of cores. I tend to use the red powdered iron T68-2 core as a standard since it is suitable for use over the HF range and had checked that the A_L factor in the ARRL Handbook for this core is 57 nano-Henries per turn squared. Then, using the formula on the right, I worked the required number of turns and wound the cores with 22 gauge wire so it would not burn out in the QRP AMU role. No success! I found that the actual inductance values were way off what was intended! Why?

$$\begin{aligned} \text{No of turns } N &= 100 \sqrt{\frac{L(\mu\text{H})}{A_L}} \\ \text{OR} &L_{\mu\text{H}} = A_L \left(\frac{N}{100}\right)^2 \end{aligned} \quad \text{G3PCJ}$$

Fearing that I had poor A_L information I checked on the Amidon web site at www.bytemark.com/amidon which has some very useful information on the suitability of cores for different frequencies etc.; there is also a full A_L table from which I have extracted the data on the right for the more common cores. In addition there are tables of inductance for a given number of turns for each core type and size. These confirmed my maths but did not explain the unexpected results! Thinking that my winding technique must be the trouble I wound several different coils on the same core and resonated them with a capacitor to obtain their resonant frequency with a grid dipper. (This required a separate 1 turn link on the core connected to a couple of turns over the coil

Size	Mix 2 Red	Mix 6 Yellow	Mix 10 Black
T50	49	40	31
T68	57	47	32
T200	120	100	Not Av

of my ancient GDO. It actually uses a valve - it is a Heathkit that I built while at school!) Then using the standard formula for parallel resonance I could work out the inductance. Changing the wire size made no appreciable difference but putting the turns on the core close together, instead of around the whole circumference, reduced the inductance by roughly one third! See actual figures right. All had 12 turns on the same T68-2 core resonated with a nominal 68 pF. From theory the inductance should have been 0.82 μH but tolerances of the toroid and my test capacitor are sufficient to explain the discrepancy from the 'wide' figures. I repeated this experiment with another core and different capacitors but the result was similar. This shows that the windings of such inductances must be *spaced around the core* if you wish to obtain the correct value. This is particularly so for small numbers of turns on a given core. (It also explains why builders quite often say they add or remove more turns than suggested for TX output matching circuits!) Closing the turns up can add up to 50% to the value! G3PCJ

Gauge	Spacing	Freq	Ind μH
22	close	15M8	1.5
22	wide	19M8	0.95
24	close	15M5	1.5
24	wide	19M6	0.97

Bandwidth extender and DDS kits

I floated the possibility last time of a kit to accept analogue signals, maybe to 30 MHz, convert them into digital signals with a high speed A to D converter, store them, and then read them out at a somewhat slower frequency into a low cost oscilloscope. Three members kindly expressed interest but I have decided against it for two main reasons; firstly complexity and risk. It would have to operate with internal digital clock signals in excess of 60 MHz and although there are plenty of suitable devices they are all surface mount! It might need several such chips and I fear that the risk of builders wrongly assembling (and hence damaging) them is too large apart from the difficulty of testing. The second is price. With an input analogue gain and attenuator stage, for reasonable convenience, the cost for a single channel looked as though it might rise towards £100 or so; bearing in mind that a good new 20 MHz analogue *two* channel scope (which will often give usable readings to 30 MHz) is now about £250 they represent a better buy. (More useful than a black box anyway!)

The second possibility was a combined signal generator or digitally controlled VFO to replace that in a rig. This looks much more promising and I have obtained a suitable DDS chip which is controlled by a serial interface. I shall report progress later. I would like 'spin-wheel' frequency control but they cost many times the main chip. Ideas welcome! Perhaps a potentiometer arranged to provide no change at its central position but with an up or down action on each side of centre? G3PCJ

Hints for Tin Bashers by John Teague G3GTJ

If you fancy making a metal case for your Taunton or whatever, some tips, a consequence of a lifetime restoring vintage cars - a hobby with much in common with amateur radio - maybe helpful.

Aluminium is the obvious material: it is readily available, does not corrode and while easy to work it is also easily scratched and damaged. A good way to avoid this is to cover the surface before you start with packaging tape - the very cheap mud coloured stuff. For marking out don't use a scriber. Once you have decided where the holes have to be, stick on patches of white masking tape and mark the centres in pencil on the masking tape.

Surprising, perhaps, but for cases and panels thick metal - within limits - always looks better than thin. From an appearance point of view 1.5 mm is the minimum. Hard metal is easier to drill and cut than soft because much less burring occurs. However both hard and thick means it is difficult to bend. The answer is to anneal the aluminium and the best way to determine the annealing temperature is to rub a stub of ordinary toilet soap onto the surface. Then heat the metal sheet over a camping gaz flame all over but only to the point where the soap lines char and turn black. Go any further and you will have an unplanned hole! Let the metal cool without plunging; it should end up soft and malleable.

These methods do not apply if you happen to have one of the aircraft type aluminium alloys which are far harder than commercial aluminium sheet. However, they are delightful to work, easy to drill absolutely cleanly and make ideal flat panels. Bending without cracking is difficult. Whatever the material, holes bigger than 6 mm are a problem. Any drilling is ten times easier with a pillar drill if you have one. Whatever you use, clamp the workpiece down, don't hold it. I lacerated my hand quite badly once when a piece of thin metal (the worst) rotated with the drill.

For holes of 8 to 25 mm diameter, by far the best tool is an appropriate flat blade bit sold for woodworking. Buy a fine file at the same time as the bit so that the cutting edges can be kept keen. Put an undrilled block of wood beneath the work, use a smidgen of oil and cut right through in a single pass. The pointed tip will wander off centre if you lift it and then attempt to reengage in the hole: for the same reason don't try and cut through from both sides to avoid the burr as the bit exits the surface. These burrs, by the way can be removed with a pen knife or with the excellent tool sold by Maplin for that purpose.

Now for meter and irregular holes. There are several possibilities and I have tried them all. I assume that professional engineering cutters are not available. You can use a jigsaw fitted with a fine tooth pitch blade or you may open out a smaller hole with a file. The best way, I believe, is the most tedious. This is by the time honoured method of drilling a row of small linking holes just inside the edge of the aperture and filing to final shape and size. Again, much easier with a vertical bench drill. I have done tests: it is always quicker to mark out and centre punch the points at which the line of holes will be drilled. Mark out carefully say ten points 4 mm apart, then use a pair of school compasses as dividers set as required to mark the other points. Drill the holes with a 4 mm drill, knock out the centre. If you insist on drilling freehand then you will be left with bridges to cut away. A good tool for this purpose is an old jig saw blade ground to a point at the machine end (jigsaws cut on the rising stroke). This can be tapped through two adjacent holes to cut the first bridge.

Much has been written about techniques for panel finishing. If you fancy bare metal, then try one of the variety which can be produced by using various grades of abrasive paper in an ordinary wood orbital sander. Good bashing!

Somerset Homebrew Contest

To quote the GQRP Club contest organiser, Peter Barville G3XJS - who has the tough job of deciding who wins - 'This deserves to be one of the most popular events in the QRP calendar, with the chance of winning a £50 voucher to be exchanged towards any current Walford Electronics product. It is one of the few which actively promotes the use of homebrew equipment. The rules are very similar to previous years with a couple of small changes.' Please see the next issue of Sprat for the full details but essentially it is open to any single operator QRP station using homebrew RX or TX (or both). Any mode on 40 and or 80m near the QRP frequencies between 0900z and 1200z on Sunday March 26th in 2000. Exchange RST, Somerset Contest serial number starting from any random number over 100. Scoring is 5 points for a QRP contact both ways and 1 point for QRP/QRO contacts. Deduct 25 points if you did not build either the RX or TX yourself! Entries to G3XJS by April 30th with claimed score, details of equipment and antennas used etc..

There is still time to build a rig and avoid that penalty! It can be any make or home designed. No particular kit stable has a better track record than others! Mark it in your diary now!

Working with Surface Mount Devices

I have extracted the following from e mails from Andy Howgate who has taken the plunge and provides an inspiration for all of us! Next time I hope to include some of his ideas on boxing kits.

'I have recently repaired one of my VHF PMR converted rigs which had a fault. I was able to deduce that a 14 pin surface mount chip was acting up; I managed to find a replacement from RS and thought I had little to loose by having a go. I understand that a lot of SM component removals are accomplished by the use of a high temperature blowing device a bit like a paint stripping gun. The chip or device is heated using this hot air so that the solder becomes fluid and then chip removal is possible. Another process which I have employed is to cut the legs of the device with a sharp Stanley knife, remove the chip and then the remaining fragments (mainly legs) with a fine iron; next clean the area and check for damaged PCB tracks. Apply a small dab of flux to each track pad. Rest the replacement chip in position and solder one corner leg only, you can then apply slight movement to the chip to get it into exactly the correct position. Then solder another leg to the PCB on the opposite side and again check that all other legs are in the correct places. Solder them down in turn. It is fiddly but it can be done quite easily with patience!

Transistors and passive components I find harder to do because they usually do not have legs; the edges of the component are the often the connection points. The trick is to move quickly between the connection points with a fine iron and to gradually heat them all up or ease an edge up so that they have less restraining effect on the rest. Take care not to lift the PCB tracks with too much force on the device! (Practice on a scrap PCB is highly recommended first!) Always have some fine hook up wire for track repair and a good magnifier with plenty of illumination. I have changed 60 lead processor type devices in this way.'

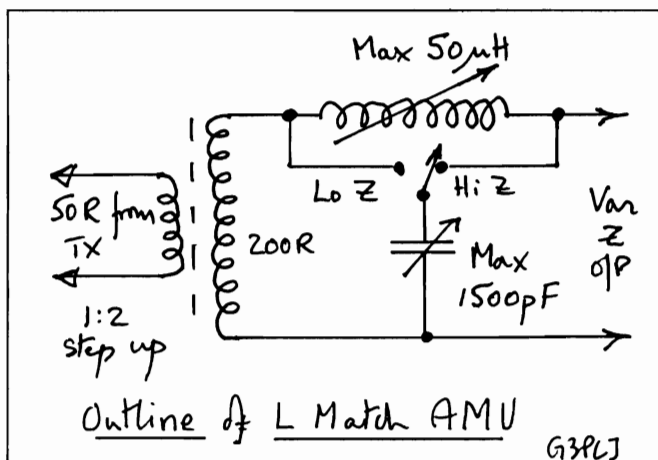
As a helpful comment to those of us laying PCB boards, Andy suggests making the pads for the surface mount devices slightly longer than usual so that the tip of a fine iron can heat the track and flux and allow the solder to flow up the track to form the joint with the leg. Note that Andy is suggesting the use of flux paste separate from that in multi-core solder; this can be obtained from any good electronics component supplier - you must not use plumber's flux - it is usually highly corrosive because it is acid based. Andy often finds that stripping off any PCB surface protection is sensible prior to soldering and to then apply a final lacquer after soldering is completed.

Surplus PCBs

I have several boards which I do not intend to make into kits; tell me if you can use them:- One good Yeovil RX board and two good TX boards; Coxley regen TRF and Adjustable CW filter boards with minor defects and several PCBs for the Five digit counter having minor track defects.

Antenna Matching Unit

It is important not to waste power (either way) through an AMU which is why the simple L network is often chosen. It has the disadvantage that the Q is fixed for any particular set of input and output impedances. The larger the impedance transformation, the higher the Q which can lead to high circulating currents and tender tuning. One scheme suggested by several designers is to transform the output of the TX from a nominal 50R down to 12.5R in a 2:1 (for voltage) transformer, which also provides DC isolation and permits an ungrounded RF load, and to then use a wide range L matching network to transform up to whatever the transmission line load presents - typically in the range 25R up to maybe a few Kohms. This latter condition leads to the undesirably high $Q = 10$. An alternative approach which seems to work well is to reverse the 2:1 transformer so it steps up to 200R and the L network then transforms from 200R either up to a high Z load or down to low Z coax etc.. This restricts the maximum Q to about 3 for the largest transformation (up or down) and leads to a worst case inductance of about 50 μ H or maximum capacity of 1500 pF for the extreme 160m load impedances. The basic circuit is shown right. G3PCJ



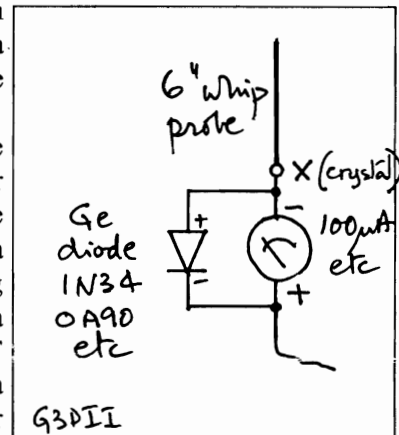
More practical tips from Joseph Bell G3DII

Salvaging components: Defunct old computers and other electronic equipment can yield masses of useful parts for those wishing to augment their junk box stores. A drastic but effective way of removing the parts is to cut the PCB into progressively smaller sections with a pair of sharp diagonal side cutting pliers. Cut the PCB into smaller sections until only a single part is left on it and then cut through one side of each lead hole so that the PCB remnants can be almost broken off - perhaps with a short application of the soldering iron. This process will obviate the damaging prolonged heat which is often necessary to extract each lead from its mounting hole. Use safety glasses as boards can shatter.

Winding coils: In spite of the growing use of toroids, the conventional solenoidal coil has its place. When winding coils, especially with thin wire, it often becomes difficult to maintain the desired spacing between turns and still have a neat coil. To avoid the problem, first wrap the coil form with cellophane tape that has adhesive on both sides. Then when the coil is wound, the turns can be placed exactly where required and will stay put. The completed coil can then be protected with a coat of lacquer or varnish. The modern type of enamelling can be burnt off with a chunky hot iron.

Base for CW key: If you are fed up with your key moving around when using it, then use the sole from an old electric iron. The old ones are made of cast iron but even the modern aluminium ones will do. Three rubber feet should be mounted underneath the sole and the requisite number of insulated terminals mounted at the pointed end.

Xtal calibrator and RF indicator: This device can be made in a few minutes and has many uses. As shown in the circuit, a germanium diode shunts a meter connected to probe wires. The more sensitive the meter the better, 100 μ Amps is ideal but even a 1 mAmp device will do. The markings on the scale do not matter since it only has to show a response. The short length of wire on the meter positive (which provides a return path for the wanted RF input to the other 6 inch probe wire) can be held in the hand or, for extra sensitivity, connected to the earthed metalwork of whatever is being investigated. If the probe wire is placed near one of the feeders in a balanced antenna line, it will give an indication of the amount of RF flowing up the line enabling proper adjustment of the antenna matching unit. Other uses are the detection of RF on power lines or for checking for parasitic oscillations.



If a crystal is inserted at the point X, it then forms a highly selective detector at the crystal's frequency. For example it allows you to check the frequency calibration of a GDO by placing the probe wire near the coil of the instrument. Say you wanted to check the resonant frequency of a 40m loop, which is likely to have a very high Q and hence need careful setting to get in band, with a poorly calibrated GDO covering 5 to 10 MHz. Using any known crystal(s) within this range will allow you to check its calibration and hence obtain the 7 MHz setting more accurately. The calibration of signal generators can also be checked by linking the probe to the output of the generator and then tuning it across the crystal's known frequency. Depending on its actual output you may need to couple it rather more directly to the generator's output. Connect the meter positive directly to the generator's ground terminal; with a similar short antenna wire on the generator's hot output, couple the two together, initially without the crystal so as to decide how much coupling is required. (If the generator output is low they can be directly coupled with a small value capacitor.) Having obtained a suitable broadband reading, insert the crystal and then adjust the tuning to find an output at the crystal's frequency. Repeat with other crystals if you have them. With a 100 μ Amp meter, even 30 millivolts will give the meter a healthy kick!

Excess capacitors!

Being forced to buy 800 off 105 pF adjustable film rotary trimmers when I only wanted 100, I have plenty to spare! Their body size is the same as the common yellow bodied 65 pF variety but a different footprint. If you could use some their cost is one and a half first class stamps each - no cheques please - plus two extra stamps for P & P; e.g. 6 trimmers for eleven first class stamps. G3PCJ

Finally

Happy Christmas, good health and fun in 2000!

Hot Iron

Issue 27

“Journal of the Constructors Club”

Spring 2000



Contents

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- Identification of caps
- Miscellany
- Instability & chirp
- Dates for diary, website
- Practical tips

Editorial

Welcome to the new century. The sun is out and Spring is in the air and the orders are beginning to come in again! It's as though radio kit builders also go into hibernation during the winter! Many years ago when I first noticed this effect I thought it was just chance but now I recognise that actually not all that many people build in the depth of winter - maybe something to do with cold sheds at the bottom of the garden! How long till global warming is the salvation of the kit suppliers?

Watching the awful scenes on the box from Mozambique, where the flooding maybe connected with atmospheric warming etc., one is reminded of the help that amateur radio can provide in such circumstances. This is especially so in less developed countries where the nation's infrastructure is less capable than in Western Europe. However there is another difference, which is to the advantage of the less developed country. If such a disaster were to strike anywhere hereabouts, the devastation on the built environment would be many times worse. Consequently the time to recover would be a couple of decades, whereas in Mozambique it will be far shorter. This is not to

underestimate in any way the awful tragedy which they are suffering. The closer people are to their agricultural roots, the greater their ability to recover their earlier situation.

What's this got to do with building radios - not a lot! None of you have sent me any difficult or provocative questions and while pondering what to write this came to mind!

New Developments

Much of the winter months have been occupied with creating a website. My son offered to do it but I felt I had to do it so that I could easily keep it up to date. My on line catalogue is not an 'all singing and dancing' affair but is, I hope, sufficient. I shall as usual be especially pleased to have any suggestions as to how it could be improved. For those suitably equipped the address or URL is www.users.globalnet.co.uk/~walfor I am afraid that clicking on this page as you read it won't bring it up but you can send me an e mail via walfor@globalnet.co.uk Note the deliberate spelling mistake!

I have also started on a new major project - with much encouragement from a few dedicated members. I don't wish to reveal what it is yet, because I am only just starting to build the first prototype and it will be a little while before I can safely announce it fully. For anyone interested in a challenging HF transceiver project, this will be a full single 100 x 160 mm PCB. Various enhancements are planned! I shall be happy to discuss it with any keen builders. My mark 2 Antenna Matching Unit is now also available; all bands 10 to 160m for low or high impedance, balanced or unbalanced feeders, with an included resistive matching bridge. £39.

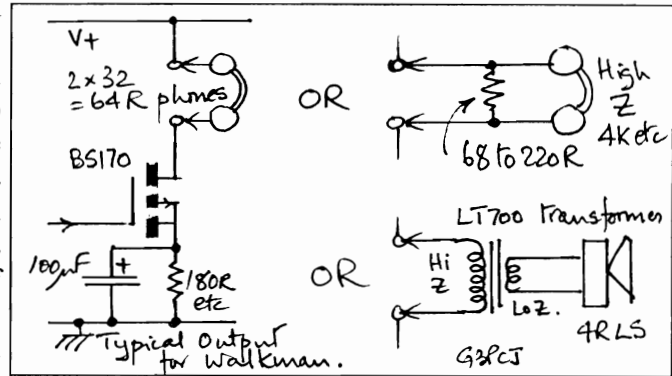
Tim Walford G3PCJ Editor

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 or e mail walfor@globalnet.co.uk The Walford Electronics website can be seen at www.users.globalnet.co.uk/~walfor The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

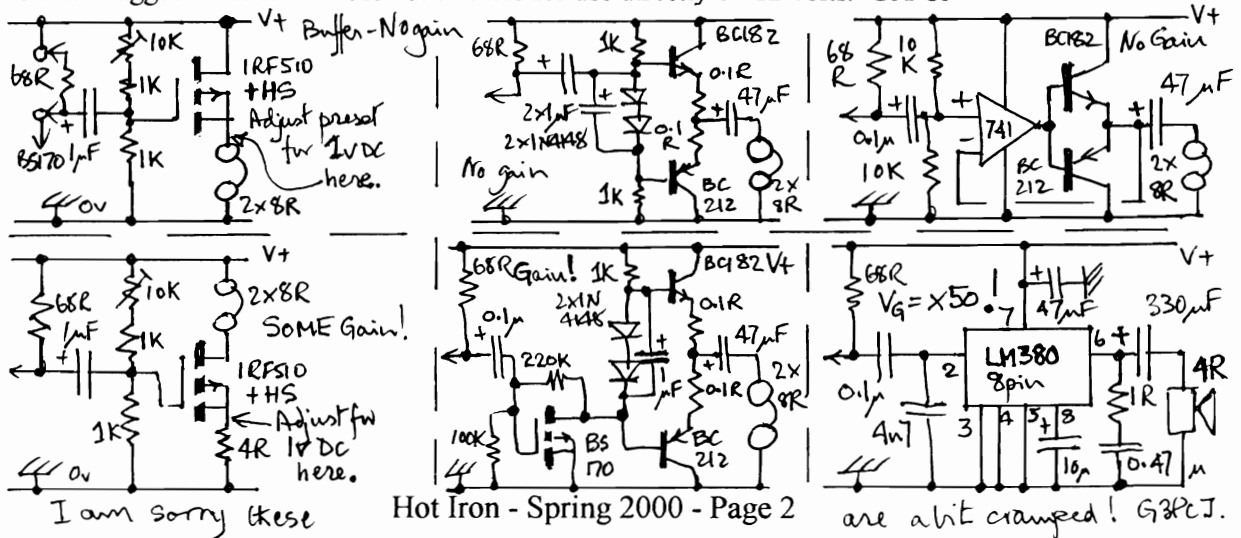
Audio Output stages and Walkman phones

It is attractive to use an output stage for walkman type stereo 32 Ohm phones in a low cost project because they are much easier to drive than 4 or 8 Ohm phones (or speakers). Some people do not like any form of phones, let alone the very low cost versions which are not much more than two shaped blobs on the ends of a forked wire! Their output can also seem low. There are several options for improvement. Firstly, try some alternative stereo 32 Ohm phones; their sensitivity and comfort are directly related to their wide range of price. I have a pair of padded 'full sized' ones that cost just over £10 a few years ago and would be cheaper now. In my rigs, which all have mono output, the ear pieces should be used in series for highest output, as gain is proportional to the output stage's load impedance. Wiring them in parallel for a 16R load will give only a quarter of the output compared to the 64R load when properly wired! (Remember that when properly connected, switching their switch to mono will short them out!) Its also worth checking that they are 32R each roughly and not 8R.

If this fails to effect an improvement, more electronics are required. The circuit alongside shows my typical walkman output stage so the first thing to do is make certain that its bias conditions are not upset when driving something else; this requires a replacement resistor of around 68R up to maybe 220R if more gain is needed. For those having the older type of high impedance phones, typically 4 KOhm, they can be used directly across the new 68R as shown in the right-hand circuit.



Transformers can be used but they may need another gain stage, are becoming scarce, and are not so easily incorporated physically! Otherwise, the extra stage for low Z loads has to provide much higher currents and maybe extra voltage gain, so unless at least two devices are added for Class AB or B operation, a single device has to be run in Class A with a high standing current drawn from the supply. This current needs to be a bit larger than the peak signal current into the load presented by the phones. The load will be 4R if both 8R ear pieces are driven in parallel implying a peak current of 250 mAmps for a 1 volt peak strongest signal giving just 1/8 W RMS output into the cans or a single 4R loudspeaker. Its better to drive the two ear pieces in series for 16R and 62 mAmps at 1 volt peak. I have sketched various possible circuits below and their characteristics. The single device circuits (left) have to be run in Class A with a large DC current in excess of the peak load current so will dissipate a few Watts continuously needing a heatsink. The two single device circuits have this DC current flowing through the phones so be rather careful about not burning them out! The multiple device Class AB approach avoids the high device dissipation but adds several components; it is the basis of practically all audio output chips. The two circuits, with 2 or 3 transistors (middle), are best for driving phones. Driving a LS, usually with higher output, needs more watty devices and heatsinks so you might just as well use a specialist chip. The first 'chip' circuit (right) using a 741 op amp can be OK for a simple rig but is a bit prone to crossover distortion which is why the previous two circuits have a pair of diodes to let a few mAmps flow through the output devices. For dedicated audio output chips, I prefer the LM380 in either 8 or 14 pin format, since it can take 8 to 22 supply volts. I am not keen on the often suggested LM386 - it is not suitable for use directly on 12 volts. G3PCJ



I am sorry these

are a bit cramped! G3PCJ.

Identification of Capacitors

Capacitors, particularly small ones, are invariably the most troublesome two leaded parts to identify and decide their value. Its quite easy to determine if they are capacitors, because their resistance between leads will be many megOhms. Small capacitors are usually quoted or labelled as pico-farads (pF) which is a million-millionth (10^{-12}) of a Farad. Middling sized capacitors are usually given in nano-farads (nF) which is a thousand-millionth (10^{-9}) of a Farad; large ones in micro-farads (μ F) which is a millionth (10^{-6}) of a Farad. Thus a capacity of 1000pF is the same as 1nF and 0.001 μ F. Giant electrolytics, or memory back-up capacitors, are sometimes found up to Farads but are uncommon in radio circuits. Makers often omit the F so that a 100 pF capacitors might have just 100p printed on it. It is also common to find the multiplier (p, n, or μ) at the start or in the middle of the numbers in the place where the decimal point would be for that unit of capacitance; for example, n15 is a 0.15 nF capacitor and 4p7 would be a 4.7 pF capacitor. When this is done there only two numbers for the first two digits of its value. If there are three numbers, usually without any other letters or symbols, the value is expressed in pF as the first two digits with the third acting as a decimal multiplier like resistors. For example, a capacitor marked 152 would be 15×10^2 which is $15 \times 100 = 1500$ pF, the common 10 nF disc is marked 103 meaning $10 \times 10^3 = 10,000$ pF. Some examples and equivalents:-

100pF	=101	=0.1nF	=n10	=0.0001 μ F
150pF	=151	=0.15nF	=n15	=0.00015 μ F
470pF	=471	=0.47nF	=n47	=0.00047 μ F
1000pF	=102	=1nF	=1n	=0.001 μ F
10,000pF	=103	=10nF	=10n	=0.01 μ F
100,000pF	=104	=100nF	=100n	=0.1 μ F
470,000pF	=474	=470nF	=470n	=0.47 μ F

It is rather harder to judge the type of insulating material in a capacitor but its shape is the best clue. Silver mica types are thin and rectangular with the leads projecting down the edges. Polystyrene are usually axial leaded cylinders in clear plastic or sometimes small metal cylinders, with close tolerance and maybe high working voltage. Polyester are usually either sharp cornered rectangular coloured plastic blocks with edge leads, or uninsulated blocks with leads projecting down the side metal contacts, or the same type dipped in an insulating material. Polycarbonate are also rectangular blocks with side leads but they are frequently somewhat bigger. Tantalum electrolytics are nearly always pear shaped blobs and ordinary electrolytics are cylindrical metal cans - with both of these sorts, the polarity of applied DC voltages must be correct or they may be damaged or explode. Disc ceramics, usually with a 'High K' dielectric giving high capacity for size but poor stability, are dipped circular thin blobs - not be confused with ceramic plate capacitors which are small rectangles with good temperature characteristics. Larger circular discs, about 3/8 in diameter, tend to be 1000v types - most others are 25 volt. If in doubt, always assume that they are high or medium K types and hence unsuitable for VFOs etc.. Ceramic ones are a little micro-phonic so should not be used in audio circuits but they are good in RF circuits. The rectangular Low K ceramic plate types, which are suitable for VFOs, have a single colour body (often light green) and a coloured tip. (Sometimes Low K ones are round and slightly bigger than high K types.) If the tip is black, it is a NP0 type with nominally zero temperature coefficient. The ceramic COG type also has zero tempco - my preferred COG ones have blue bodies, no black tip, and three digit (2 plus multiplier) pico-farad numbers! If the tip is orange it means a nominal coefficient of -150 parts per million per degree centigrade. The NPO/COG and N150 types are widely used in oscillators to counteract the normally positive tempco of the inductor. Violet tipped ones are no good for VFOs since their tempco is too high at -750 ppm/ $^{\circ}$ C. Silver mica and polystyrene types both have low negative or nominally zero tempco, so are widely used in VFOs; but in my experience they are much less consistent (and now harder to obtain). With both types there are can be marked variations in oscillator stability between different manufacturers and even between different batches from the same manufacturer.

Trying to match actual capacitors in a kit to the parts list can be difficult when the markings are faint; the best technique is to firstly compare numbers of the same size, then arrange them in ascending size which will correspond to ascending value. Best of all is to use the capacitance meter facility of many digital multi-meters! (I have complained many times to my suppliers but to no effect!) My thanks to the Editor of the Yeovil ARC Newsletter G3GC for permission to republish; he gave the subject its first airing many years ago.

G3PCJ

Mechanical Miscellany!

From Andy Howgate G7WHM - PCB protection I remove any PCB lacquer on the track side with wire wool, so that after soldering is complete, any flux residues can be scrubbed off and then re-lacquered with acrylic spray obtained from Halfords. Prior to use PCBs, can be prevented from going tarnished by wrapping in cling film.

Enclosures I like to have a rig enclosed for looks and to keep out unwanted visitors! Using a second PCB sheet for the rig's rear panel allows convenient mounting of supply and antenna connectors, occasionally used controls etc.. It needs to be the same size as the front one. Both end panels are drilled prior to fitting to the rig, sprayed with acrylic paint in your favourite colour and then labelled with lettraset etc.. I then fashion a plywood enclosure which is a rectangular 'tube' into which the rig is slid. This can have a smart front bezel all around the front 'tube' edge to stop the rig sliding right through. The rig is held inside by a suitable angle bracket affixed to the rear of the tube just behind the rear panel. The rectangular wooden enclosure is made from thin plywood with pinned & glued 90° beading inside the tube long joints. After sanding it can be covered in Fablon etc. and feet fitted. You can even have your own house style for several rigs! They can be any size and are always available so you don't suffer box manufacturers catalogue changes. (Full notes here if wanted. G3PCJ) *Craig Douglas G0HDJ* advocates a very similar technique to Andy's but using a three sided metal cover to just contain the rig. The rig sits on its normal feet on the bottom of the PCB. Either a single sheet can be bent into a large U or three flat sheets formed into a U with aluminium angle. It can even have front or rear top extensions, with sloping sides, for an eyebrow style! The metallic cover can be painted or finished with Fablon. It can be held in place with self tapping screws into the front and rear panel side braces. (Or bolts into brass nuts soldered inside to the PCB copper braces.) Ventilate well!

The smoke theory of electronics

The ingredient that allows all electronic components to operate is 'smoke'. Consider your own experiences. Remember when all the smoke was let out of your transmitter PA transistor. It immediately stopped working! When the new integrated circuit sprang a leak and all the smoke escaped, it also stopped working. When the big electrolytic capacitor gave off its smoke, it quit again! From these observations therefore it is logical to deduce that smoke is the ingredient that allows components to work and once it escapes nothing works anymore. (Thanks to QST via G0HDJ.)

Spin wheels

Eric Godfrey G3GC wants to know what I meant by a spin wheel when writing about control of a DDS chip. He understands what it does but not what it is. I meant the sort of control which is the main tuning control of modern commercial radios. Rotation one way or the other winds the frequency up or down. Usually the knob operates a shaft encoder which increments (or decrements) a digital counter controlling the frequency of the local oscillator; the counter maybe an actual digital circuit or realised in the software of a microprocessor. The LO can be based on a phase locked loop or DDS. These shaft encoders can be bought but cost many £s in small quantities. They have two sets of many markings around a disc which interrupt light shining onto a photo diode. The markings are slightly out of phase so that the timing of bright and dark signals from the two tracks indicate the direction of rotation. I had in mind to use a pot (on cost grounds) which would provide discrete up or down frequency increments in its midrange but would change to continuous up or down change at the ends.

Designing for EMC compliance

All commercial electronic equipment sold in the EU has to meet an Electro Magnetic Compatibility directive covering its susceptibility to unwanted signals and its emission of unwanted signals. Luckily for us, radio kits and individual experimenters designs have been exempted from the formal procedures BUT we still have a strong duty to be careful and not upset any other user of the radio spectrum either intentionally or not. Commercial organisations now have to spend much effort making certain that their gear is compliant. EMC aspects have now to be considered very early in the design stage, apart from exhaustive testing of prototypes and later modifications to rectify defects. Simulation can be used but sound electronic construction techniques such as have to be practised for radio equipment are often the most cost-effective. Recently there have been two excellent articles by MK Armstrong in the Institution of Electrical Engineers Journal (Sept and Oct) which advocate many of the ideas commonly used in radios. In particular, the used of a continuous copper ground plane for circuit boards comes high on his list of priorities! Next is supply distribution and decoupling!

There is now also a Low Voltage Directive covering the size of 50 Hz harmonics which can be injected back into the mains from PSU rectifiers. I think any PSU over about 10 Watts is covered. A transformer with rectifiers feeding massive electrolytics are out! Choke input smoothing is the scheme!

Instability and Chirp!

Recently, one of our members rang up about an 80m TX that he is building. The original question was about temperature compensating capacitors for the VFO but I have doctored the story slightly to make the point more general. It soon emerged that there was a far worse problem than just frequency drift. As soon as he increased the TX output stage drive level, aiming to achieve the potential 5 Watt output that should have been possible, things went wild and the whole rig was oscillating way off the desired frequency. Above about a Watt the frequency was almost uncontrollable! It soon emerged that the VFO was operating on the same frequency as the transmitter output stage - hence a single frequency amplifier chain starting from a high impedance low level buffer stage following the VFO, feeding two amp stages and output stage with tuned matching. This builder likes to make things small so the physical separation between VFO and TX output matching network was small. The likelihood of instability was high! The common factors contributing to the gross instability were all present - high impedances, lots of gain, close proximity of output and input in a single frequency amplifier chain. Although unlikely in this case, because he makes his own double sided PCBs with one side used as a ground plane, another common cause of trouble is relatively high shared impedances between different parts of the circuit operating on the same frequency. This can easily occur in the grounding (at RF) of different stages sharing a common track back to the main 'earthy' part of the circuit. An inch of shared thin track can be the culprit even on 80m! A copper sheet (on one side of the PCB) is the easiest way to minimise the unwanted shared impedances to ground but not even these are perfect solutions! Try measuring the RF voltage across opposite ends of a TX PCB ground plane when producing just 5 Watts; you will have a surprise - there might well be 250 mVolts! (Like many RF measurements, the figures can sometimes be a bit misleading unless done with care.)

Unfortunately, this part of the conversation alone left him with a major redesign task but I had to warn him of another problem! Unless the VFO has a very high Q resonant circuit, such as found with ceramic resonators or crystals, the likelihood is that some small amount of TX output current will find its way to the VFO resonator causing phase changes, and hence a frequency shift compared to the non transmitting frequency. This is the dreaded chirp where the receiving station can just hear the VFO altering frequency at the beginning and end of each morse character. (It can also sometimes be caused by other shared factors such as sagging supply voltages to the VFO or tuning diodes - these causes can be identified easily by intentionally altering supply voltage while transmitting.) I can admit to learning this lesson the hard way a few years ago with a compact single band VFO driven rig that was far too tender! There are two common ways to overcome this drawback, firstly to put the VFO in a separate rigid metal enclosure but even this must be separated from the TX output circuits. I once found that TX QRP currents were getting into a diecast VFO box casing and so coupling to the VFO coil inside which was about 15 mm from the box wall. This is why some CW rigs using a shared VFO have separate nearly empty cases for RX and TX. The second and safer solution is to change the VFO frequency, then mix it with another from a crystal oscillator, to obtain the wanted one. Because the VFO and TX output stage are no longer on the same frequency, the presence of unwanted TX RF does not affect the VFO. This approach also eases the gain distribution aspect by allowing some gain at the crystal and VFO frequencies and less at the output frequency. It adds a mixer, crystal and RF filter.

Crystals and ceramic resonators (on the TX frequency) don't suffer chirp because their high Q implies higher circulating currents so that any given level of unwanted TX output currents in the VFO are a lower proportion of the VFO resonator currents. The drawback is that the high Q also makes it much harder to pull their frequency intentionally for tuning purposes! Ceramic resonators are a reasonable compromise and can be pulled useful amounts but they have another drawback - their frequency is a bit prone to changes in temperature! They are quite adequate for a bench based 80m rig but take care with anything more adventurous. This is real reason why my latest CW rig, the Minehead, has a crystal mixing scheme allowing operation in principle on any chosen band up to 10m with the stability of a 4 MHz VFO. (For other reasons, the normal upper band limit is 20m.)

Website

For those of you suitably equipped, the Walford Electronics online catalogue is up and running. All the kits are there, with background explanations etc.. You can even see my electronics bench! I spent days arranging this photo but its not far off the usual state. As usual I am keen to have any feedback either by letter or e mail to walfor@globalnet.co.uk Note the funny spelling of Walford! www.users.globalnet.co.uk/~walfor

QRP Convention 2000

Mark April 16th in your diary if you can make a journey to Sherborne on the Somerset Dorset border. It is one of the few remaining genuine amateur radio events which have not been taken over by computers or the sellers of scrap telephones. Talks on a range of radio related topics, traders, displays, morse tests, etc.. The Construction Challenge is to build the most efficient 20m 1 Watt DC input transmitter. There will be a QRP Forum discussion session in the afternoon, with guest panel advisors covering all aspects of QRP. For those who like to make a weekend visit, there is a dinner the night before and Sherborne (with the surrounding area) is a most interesting place to visit for your partners. It is a thoroughly enjoyable event and is the only rally which I regularly attend - come and see the mystery project mentioned on the first page! Further details from G3CQR on 01935-813054.

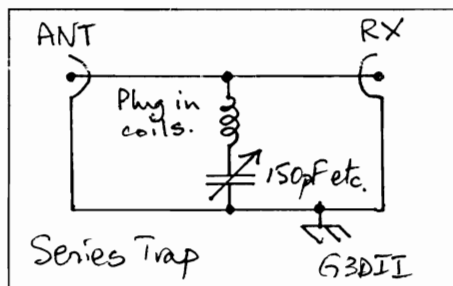
Somerset Homebrew Contest

There is still time to enter and maybe win a £50 voucher from that well known kit stable. Please see the Winter 99/00 Sprat for the full details. It is open to any single operator QRP station using homebrew RX or TX (or both). Any mode on 40 and or 80m near the QRP frequencies between 0900z and 1200z on Sunday March 26th in 2000. Exchange RST, Somerset Contest serial number starting from any random number over 100. Scoring is 5 points for a QRP contact both ways and 1 point for QRP/QRO contacts. Deduct 25 points if you did not build either the RX or TX yourself! Entries to G3XJS by April 30th with claimed score, details of equipment and antennas used etc..

Practical tips from Members

From Joseph G3DII - Makeshift Allen wrench Obtain a nail slightly larger than the key's hole and carefully file a point of 4 or 6 sides on the end; then cut off the tip so that it just avoids 'bottoming'. Bend the other end 90° for better leverage. If its badly stuck, use a rust loosening spray and maybe heating and/or a suitable blow to the makeshift key.

Interference trap The source can be any single, or close group of unwanted signals, coming down the antenna. The circuit shown alongside works by placing a low impedance short across the antenna input to the rig at the offending frequency, which is often near the wanted band. It might be BC stations just outside the wanted band, as on 40m, or possibly strong stations at the rig's IF or image frequency. (The image is twice the IF from the wanted frequency in a superhet.) Its desirable to be able to tune over a wide range to find the offending signal. A selection of coils with say 5, 8 and 15 turns wound on the bases of discarded octal valves can be plugged in to a valve socket on the top of a box containing a 150 or 300 pF variable capacitor with calibrated dial and input/output connectors. These three coils should cover approx. 3 to 25 MHz. Use only in a RX antenna feed. Once you have found the offending signal, you can fit smaller equivalent value parts within the RX case using a trimmer/fixed coil or fixed capacitor/slug tuned coil. Measure the resonant frequency, with a GDO, by shorting out either connector.



Handling MOSFETs If you are concerned about static electricity blowing these devices, and you should be if you have a hot dry shack with synthetic floor materials, then the following precautions should help. Do your electronic assembly on a metallic plate (or other conducting surface) connected to mains earth and make certain that your soldering iron body is properly earthed and connected to the plate. Then arrange to discharge static on your body by wrapping a bare wire twice around your wrist, the other end of which is connected **through a 1 MegOhm resistor to mains earth** or the conducting work surface. (Make certain this is mains earth and not RF earth.) Individual ICs can be protected with a 'bulldog' clip, obtained from a stationer. These are strongish clips for wedges of paper that have a pair of metallic sides or jaws with handles, pressed together by a curved spring. Before using the clip, make certain that it does not have any burrs on the jaws. Keep the device in its protective static conducting wrapper/bag/foam until ready for fitting. Discharge any volts between you and the device by gripping the conductive material (not the IC legs) and then gingerly place the clip on the device so that each jaw shorts the pins on the IC's side. If possible, do this before removing the legs from any packaging foam. To insert or remove the IC from a socket, grip the IC ends between forefinger and thumb so as not to disturb the clip. The clip can be left in place till the IC's legs have been soldered. The ground plane or 0 volt part of the circuit can also usefully be connected to mains earth.

From Michael G4BQA -Key for TOKO cores Toothpicks are seldom strong enough! Instead try filing down the end of the arm from the protective pocket cap of a cheap biro type pen. The cap part then becomes the handle when used as a screwdriver in the TOKO coil.

Hot Iron

Issue 28

"Journal of the Constructors Club"

Summer 2000



Editorial

Reading PW last night, what's left of my brain, was stirred by the debate about the use of morse for commercial traffic and the future of commercially made amateur radio equipment. Most of you will know that BT has closed the UK ship to shore services operated as GKB of which perhaps the most famous station was Portishead Radio. (Not that its transmitting or receiving aerials were actually at Portishead! There was also a notable special radio event allowing cross-band operation between amateurs and the coastal stations which led to a mighty pile-up.) The decline in the use of CW has come about because satellite communications are now relatively cheap, don't require specially trained officers, and can handle speech, data or video relatively easily. However many commentators make the point that morse messages can be passed with very simple equipment so arguing that it will remain a strong contender where cost or reliability are paramount. This is why there is strong continuing interest in CW by radio amateurs and a feeling that distress radio 'watches' should continue on the internationally recognised HF distress frequencies.

Contents

- Bristol out!
- 50 or 75 Ohm coax?
- Pulse Generator
- Supply crowbar
- Audio filters
- Rig updates
- Several snippets!

The same financial pressures are also likely to apply to the large commercial markets for HF radio in the developing world: it is this market which pays for the development of most HF gear - amateur and commercial. Factory made microprocessor settings allow it to work only on the designated frequencies for each service. What happens when satellites also take over this commercial traffic - no amateur black boxes maybe - because the amateur market alone is too small? Although CW transmitters can be quite simple, this is not the case for receivers which will have to work in band conditions that are likely to remain heavily congested due to emissions from high bandwidth wire based telephone systems (ASDL etc.) and from spread spectrum networks - military or Government etc.. The regenerative TRF RX just will not do in these conditions! Will this lead to an upsurge in amateur radio building and be the saviour of kit suppliers?! I hope so - times are changing!

New Developments

At long last I am able to announce that the *Bristol* will be available shortly! It is a major new high spec SSB and CW multi-band superhet for any band up to 10m using plug-in band cards. It has been over a year in development and there are still some associated subsidiary kits to be completed! However, the prototype is now working well and I shall be pleased to hear from any Club members who would like to help prove the Manual and have a go at an early model in exchange for a small discount! Eventually, it should be possible for it to have any number or combination of bands up to four plugged in and controlled from the front panel. It has many similarities to the Taunton but with extra IF amplifiers and a rather special adjustable CW filter which I have described later in this issue.

A major new project for keen constructors!

Tim Walford G3PCJ Editor

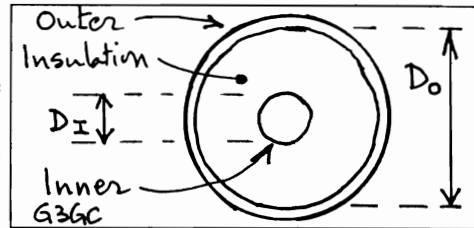
Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 or e mail walfor@globalnet.co.uk The Walford Electronics website can be seen at www.users.globalnet.co.uk/~walfor The Copyright of all material published in *Hot Iron* is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

Odd bits of Coax - are they 50 or 75 Ohms? by Eric Godfrey G3GC

From time to time we all have odd pieces of coaxial cable of whose impedance and velocity factor we are not sure. Is it 50 or 75 Ohms cable and what is its velocity factor? Well there are a number of simple ways of finding the answers. The characteristic impedance of a coaxial feeder may be calculated from the physical dimensions of the feeder and is given by the formula:-

$$Z_o = VF \times 138 \text{Log}_{10}(D_o / D_i) \text{ Ohms}$$

Where VF is the velocity factor (depends upon the insulation), D_o is the inside diameter of the outer conductor, D_i is the outside diameter of the inner conductor. If you have a micrometer then it is easy to measure the dimensions and do the calculation. Since all coaxial cables have to have



some form of insulation to support the inner centrally within the outer, the inside dimension of the outer may be found by measuring the outside diameter of the insulation. In the odd pieces of cable that we are likely to have or pick up at a rally they will most likely have solid polythene insulation and therefore easy to measure with a micrometer. The velocity factor for a cable with a solid polythene insulation is 0.67 and therefore the formula becomes $Z_o = 92.5 \text{Log}_{10}(D_o / D_i)$ Ohms. For cables having a partial air and polythene insulation such as foam polythene, then the velocity factor will have to be determined and, depending upon the ratio of air to polythene, will lie somewhere between 0.67 and 1.

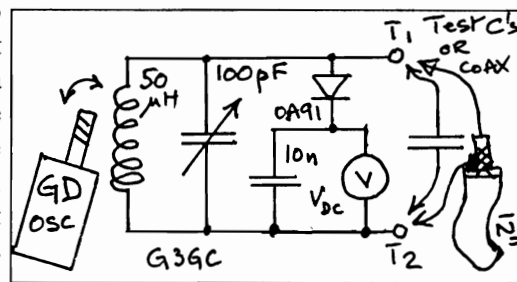
The above method is of little use to those of us who do not have access to a micrometer. However there is another way of estimating the impedance and that is to measure the capacitance between inner and outer per unit length. The capacitance per unit length is, irrespective of the physical dimensions, constant depending on the impedance and the velocity factor. For our use this reduces to a very simple formula:-

$$C = (1016 \times 1/VF) / Z_o \text{ pF per foot}$$

Obviously for air insulation this becomes $C = 1016 / Z_o$ pF per foot and for solid polythene insulation where the velocity factor is 0.67 then $C = 1516 / Z_o$ pF per foot. From this formula the capacitance per foot of a 50 Ohm cable with solid polythene insulation will be $C = 1516 / 50 = 30$ pF per foot and for 75 Ohm cable then the capacitance would be 20 pF per foot.

Now most of us these days have a digital voltmeter and the majority of these have the capability of measuring capacitance. So we can measure the capacitance of the piece of unknown cable (open circuit at both ends) and express the result as so many pF per foot. From this we will be able to determine if the coax is 50 or 75 Ohm impedance.

Another way to estimate the capacitance is to have a parallel tuned circuit, fed with RF from a GDO at about 2 to 3 MHz, the inductor is tuned to resonance by a 100 pF variable capacitor as shown alongside. The frequency should be adjusted to make the circuit tune somewhere near fully meshed, say at about 80 pF. A means of indicating the voltage across the tuned circuit will be required which may be a diode and voltmeter, as in the diagram, or scope *with* divide by 10 scope probe.

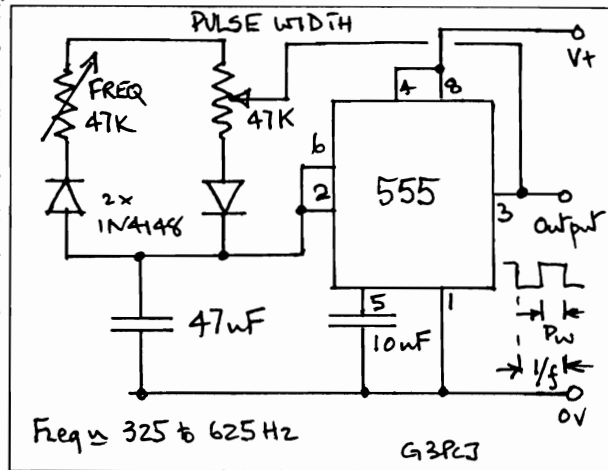


Note the position of the capacitor at resonance, indicated by maximum voltage, and then add a fixed 20 pF capacitor across the circuit at T_1 and T_2 . Retune the circuit for resonance and note the new position of the capacitor. This is repeated for a 30 pF capacitor and again the position noted. These two positions indicate 50 and 75 Ohms respectively. To check the impedance of a cable ensure that the RF frequency is correct by adjusting for resonance with the variable capacitor in its original position and then connect twelve inches of open circuit cable across the tuned circuit at T_1 and T_2 and retune the 100 pF for resonance. The position of the capacitor will indicate whether the cable is a nominal 50 or 75 Ohms impedance, assuming you have checked it has solid polythene insulation.

The impedance obtained by both the mechanical method and the electrical method may be a few Ohms adrift from 50 or 75 - do not worry as we are not trying to actually measure the cable's impedance but rather to determine whether it is of a nominal 50 or 75 Ohms impedance. Next time I will explain how to measure velocity factor if I am allowed the space. (Of course - Editor!)

Versatile Pulse Generator

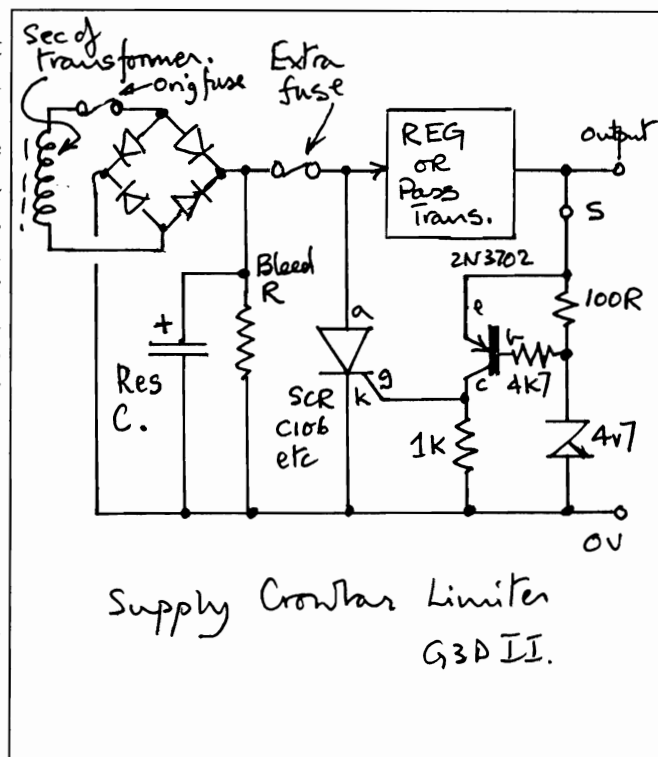
The 555 integrated circuit is the basis of many interesting designs for pulse generating circuits. One of its major advantages is its strong output stage, being able to sink or source up to 200 mA directly from the output pin with supplies of up to 20+ volts. This is why it is often used for charge pump circuits generating subsidiary supply voltages. However, it does have a small drawback! In the simplest of circuits, the duration of the high and low sections of the output waveform do not have equal periods. Over the 25 years that its been available, many designs have been published to overcome this snag; most of them relying on separating the charge and discharge paths of the timing capacitor by putting diodes in series with separate charge and discharge resistors. Often there remains some minor interaction between the two sets of timing parts. The circuit shown alongside claims to overcome this so allowing independent control of the output frequency (or repetition rate) and the pulse width duration with two potentiometers. Changing the 47 nF timing capacitor will alter both the high and low sections of the output waveform. For a general purpose instrument, a range of capacitors could be selected by a switch. The value of the pots can be reduced for higher frequencies/shorter pulses but then diode resistance may lead to some interaction. The approach suggested here is equally applicable to the dual 556 or CMOS versions.



Supply Crowbar Circuits by Joseph Bell G3DII

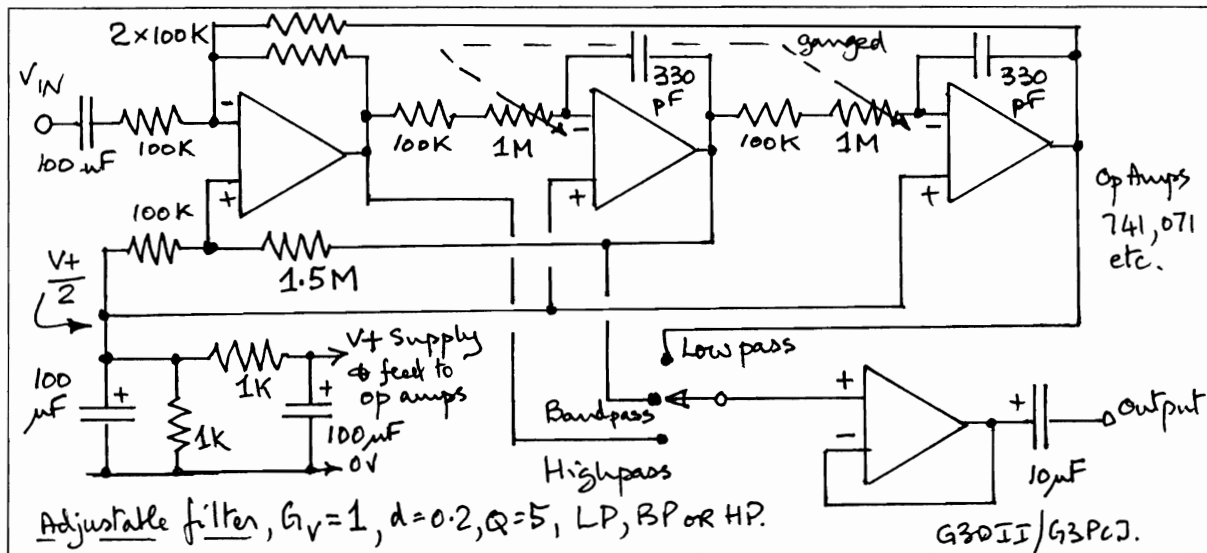
If you are going to use voltage sensitive equipment from a stabilised supply having pass transistors and a potentially damaging higher unregulated internal supply voltage, then you should use a 'crowbar' circuit because an ordinary output fuse will not blow quickly enough to protect your expensive device if the pass transistor/regulator goes short circuit. You need an electronic device to kill the volts long before your circuit melts!

The circuit shown right triggers at just over 5 volts so is suited to protecting digital devices running on a nominal 5 volt supply. The SCR should be connected across the supply to the regulator circuit and after a suitably rated fuse which will melt, so letting your SCR serve another day! While the SCR can be across the main supply reservoir capacitor so that it utilises a fuse between transformer and rectifier, it is better to fit two fuses as shown. Changing the zener diode will allow other output voltages to be protected but, whatever the intended output, do try these protection circuits first before you connect your valuable devices to the PSU. Test them by disconnecting the 'sensing' point S from the supply and explore the voltage at which the SCR triggers with a separate variable supply. The SCR should be man enough to pass a few times the rated supply output current. G3DII

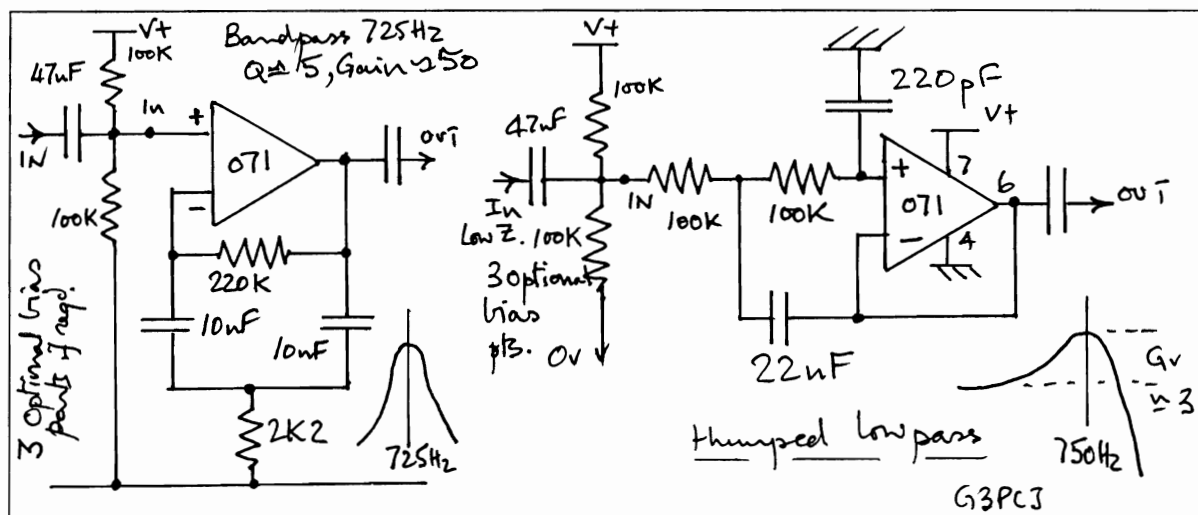


Assorted Audio Filters

Jospeh Bell G3DII suggests that a tuneable 'state variable' filter would make a good construction project for use as a receiver adjunct. The filter part of the circuit uses 3 op-amps arranged as two identical integrators (which determine the frequency response) in a loop with a summing amplifier. It can provide a choice of second order high, or low, or band pass responses where the '3 dB down' frequency (for low and high pass) is the same as that of the band pass output's peak. The fourth op-amp (of a 4 device chip such as the TL074) can be used as an output buffer or replaced by a power amplifier such as the LM380 for driving a LS. It can be used to clean up a phone SSB signal or reduce the bandwidth for CW purposes. With the values shown it tunes from about 500 Hz to 5 KHz. The drawback is that it requires a dual ganged pot and extra parts for the mid-supply bias voltage. As

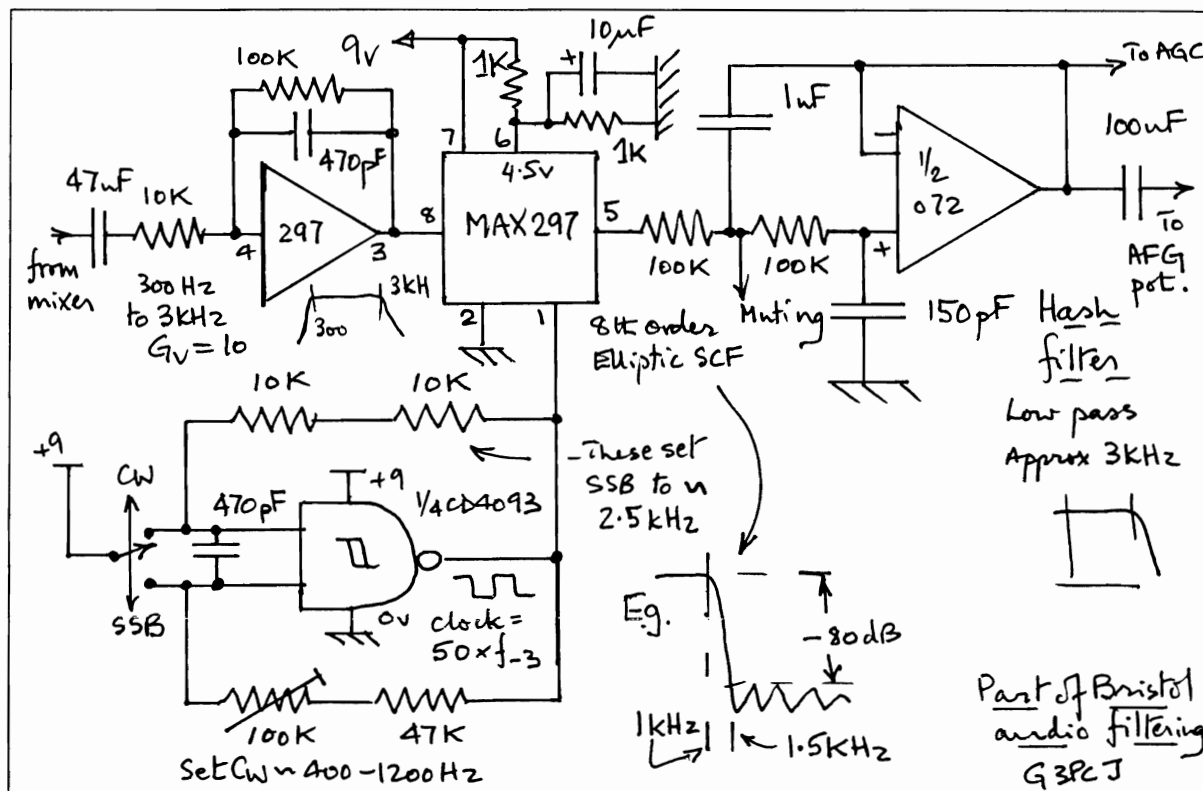


an alternative, a fixed frequency band pass filter such as might suit a simple CW rig is shown on the left below. This circuit has a voltage gain of about 50 so it is important to use a low noise device such as the TL071 if it is in the early audio stages of a direct conversion rig. It has a second order band pass response centred on 725 Hz with a Q of 5. The circuit on the right is actually a second order 800 Hz low pass filter with good HF attenuation but the values give a hump in the response just before the attenuation starts so in use it actually appears to have a band pass response. Voltage gain is approx. 3.



A more recent approach is to use a 'switched capacitor' filter whose frequency response can be easily adjusted by a single control. This is the type of filtering used in the **Bristol** to narrow the nominal IF filter phone bandwidth down to near 800 Hz for CW. There are many chips available but my preference is the MAXIM 297 which contains a single op-amp and an 8th order clock tuneable low pass filter with an elliptic response - all in a single 8 pin DIL. The advantage of the elliptic response is the exceedingly fast fall off just beyond the 'corner' frequency where the response is 3 dB down. For example, when set to be 3 dB down at 1 KHz, the response will be about 80 dB down at 1.5 KHz! It's

like the proverbial brick wall but is moveable! It requires a driving clock whose frequency has to be 50 times the desired corner frequency. The circuit below is from the Bristol. The MAX297's internal chopping action generates low level clock hash which has to be removed by a simple conventional filter after the main elliptic filter - the values used here don't generate a hump like the earlier low pass filter circuit! The MAX297's self-biasing op-amp is best used to raise the input signal level to the elliptic filter, so improving the signal to noise ratio, and to keep the input signal bandwidth well below the clock frequency so avoiding aliasing and spurious responses. The clock is easily generated with one section of a CD4093 two input Schmit trigger AND gate. A single pole switch selects the resistor chain for the timing capacitor; if desired the preset can be made a front panel control for ease of adjusting the CW bandwidth. Other coupling capacitors in the audio chain provide a 300 Hz high pass response; the spare devices in the op-amp/gate ICs are used elsewhere in the rig. G3PCJ



Rig Experiences!

Radstock Craig Douglas G0HDJ reports almost total elimination of night-time broadcast station breakthrough on 30 and 40m by reducing the 6 MHz band pass filter coupling capacitor C126 to 2p2. There was no loss in sensitivity. He adjusted L100/101 for maximum signal with very slight detuning of the band RF resonators L161 and L171 away from the broadcast stations. He has also changed C131, 47 pF, from the original COG blue type to an N150 type which improved frequency stability.

Bruton A customer's rig fitted with a CW kit, showed persistent breakthrough of microphone audio into the RX audio output stage during transmission despite having been fine without the CW kit! He had all the usual screened lead, good earth connections and short lead precautions but still had problems! Eventually I found the only way to cure it completely was by 10 nF disc capacitor soldered directly across the two audio input pins of the LM380 chip. It seems the device does not like differential RF input signals! I have seen this problem before but never found such a good solution!

If any customer wants these extra parts please let me know.

Replacement for the SL6270 VOGAD chip?

Charles Wilson M0CDD suggests the Analogue Devices chip SSM2166P would make a good speech amp; it has internal audio derived AGC and can be used in the audio stages of a receiver with a signal strength meter and noise gating. Shame I had already designed the Bristol's AGC!

Somerset Contest

Peter Barville G3XJS will be publishing the full results in Sprat but the winner Rowland G4APO has very kindly donated his prize to a worthy cause chosen by G3RJV. I have sent a George a 20m Minehead and await to hear where it went. Congratulations to all entrants, much better this time!

Slow Scan TV

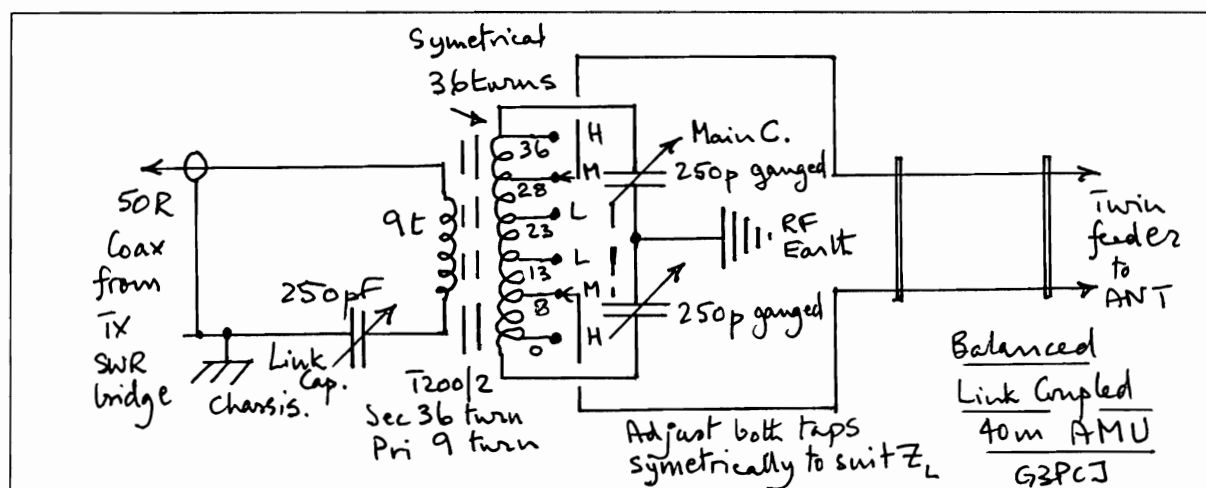
Peter Nicholson G3MYZ has been using one of his two Tauntons for SSTV work on 14 MHz. He sent me some colour stills via the Internet - sadly I cannot publish them due to my using a photocopier for Hot Iron. Nevertheless, they are very good and reveal all sorts of interesting information about the people and shacks for those contacts where he has exchanged TV QSL cards.

Decibel Relationships!

I have extracted the following useful notes from the back of a Texas Instrument data sheet:-
dB is a relative measure, either one thing to another, or one thing to a reference.
dBm is power referred to 1 mW, dBmV is referred to 1 mV, dBW or dB is power referred to 1 Watt,
dBc is referred to the carrier level; usually dB and dBm refer to power into a 50 Ohm load.
Voltage Gain dB = $20\text{Log}(V_{\text{out}}/V_{\text{in}})$ Power Gain dB = $10\text{Log}(P_{\text{out}}/P_{\text{in}})$
dBm = dB per mW dBmV = dB per mV, Half power = -3 dB, Half voltage = -6 dB
Converting from dB to dBm = dB + 30, converting from dBm to dB = dBm - 30
Converting power in Watts to dB, $P(\text{dB}) = 10\text{Log}P$, for example 3 Watts, $P(\text{dB}) = 10\text{Log}3 = 4.8$, and
1.5 Watts = $10\text{Log}1.5 = 1.8$ which is 3 dB less for half the power. 100 Watts = $10\text{Log}100 = 20\text{dBW}$.

Antenna Matching Unit for 40m doublet

Craig Douglas G0HDJ asks what component values to use in a balanced link coupled AMU feeding the antenna by twin feeder. First a theoretical approach! An old suggestion is to use 1.5 times the wavelength in picofarads as the nominal resonating capacitor, so on 40m this is 60 pF. For a split capacitor to feed the balanced line it requires twice as much or 120 pF, but practically say 250 pF on each side to allow for adjustment. The main secondary inductor has to resonate with 60 pF needing 8.6 μH which requires 26 turns on a red T200/2 powdered iron toroid. The primary should have a reactance of at least four times the rig feeder impedance, or 200 Ohms, so needs to be 4.5 μH implying 19 turns. The adjustable link capacitor needs to be able to resonate with the primary so needs about 120 pF or maybe 250 pF practically. The antenna feeder is connected with symmetrical taps across the secondary for best match. My practical feeling is the turns ratio is not large enough so I would tend to use a main winding of about 36 turns with a primary of about 9 turns giving a turns ratio of 4 and an impedance ratio of 16 ($50\text{R} \times 16 = 800\text{R}$) which might be more use for a high Z actual antenna feeder impedance. For a low actual feeder impedance the taps would need to be about 10 turns apart. Tell us if it works Craig! Comments welcome, including from our resident AMU consultant!



Subscriptions!

I regret its that time of year again. Let me have £6 by Sept. 1st 2000 if you wish to continue receiving Hot Iron. I shall not be sending reminders so act now! Thanks for your support. 73, Tim

Hot Iron

Issue 29

“Journal of the Constructors Club”

Autumn 2000



Contents

- More on AMUs
- Upstairs earthing
- Snippets
- Bristol, S meter/AGC
- Op-amp types
- Identifying capacitors
- Speech processing

Editorial

Welcome to the start of a new **Hot Iron** year! I am very pleased to report that, as in earlier years, there is a loyal group of members who support this journal in addition to those who join from the ‘free’ membership which I include with the more expensive kits. I do appreciate your support, it makes the effort of scratching the brain well worth while - thank you! That leads to my usual request for material! Contributions from all of you will make it all the more interesting - so please keep them coming. Don’t worry about producing tidy copy or drawings - I can handle that without difficulty. Articles, questions, comments etc. are all very welcome. Get your ‘pens’ out or it will all be my prose!

Our member Andy Howgate, G7WHM, has recently been in contact about the licence conditions and morse tests. He is a very keen constructor (of radio devices as well as having many other interests) and feels very strongly that the morse test requirement as a condition of entry to the HF bands is way out of date! He makes the point that this is a test of morse ability and not much else! Nor is it related to any particular group of bands! Encouraging home radio construction

skills is an essential objective but effectively enticing newcomers to the V/UHF bands means it is almost impossible for them to obtain that real thrill of the first contact with a homebrew rig. It is so much easier to get things to work at HF and it would lead to more Club construction activity. Many other countries have decided to already, or are thinking about, abandoning the morse test as an entry requirement. The UK total of five different licence classes is too complex - I would have just two. Firstly a simple theory cum practical exam, like the Novice one, permitting low power operation by newcomers for a few years min, on some HF and VHF bands for only CW, SSB and FM. The main licence would follow a tougher test demonstrating sufficient technical and operating skills for the full range of bands/services. Use the same call but with different suffices. Any comments?

New Developments

Not a great deal to report thanks to holidays and harvesting! (I have only started this on Aug. 13th because it has started raining!) I shall very soon be sending out press releases on the **Bristol**. A few early models are out and being worked on. My own is now working happily with 10, 15, 20, and 80m normally installed for SSB and CW complete with meter kit and digital readout. See later!

I have been giving some thought to a Direct Digital Synthesis driven VFO or signal generator kit. At present I am undecided as to whether it should be controlled by a dedicated microprocessor or by conventional hard logic. I have no recent experience of micros and am slightly uneasy because it would undoubtedly take me quite a while to become sufficiently proficient - I should love to hear from anybody with suitable skills who is interested in such a project.

Tim Walford G3PCJ Editor

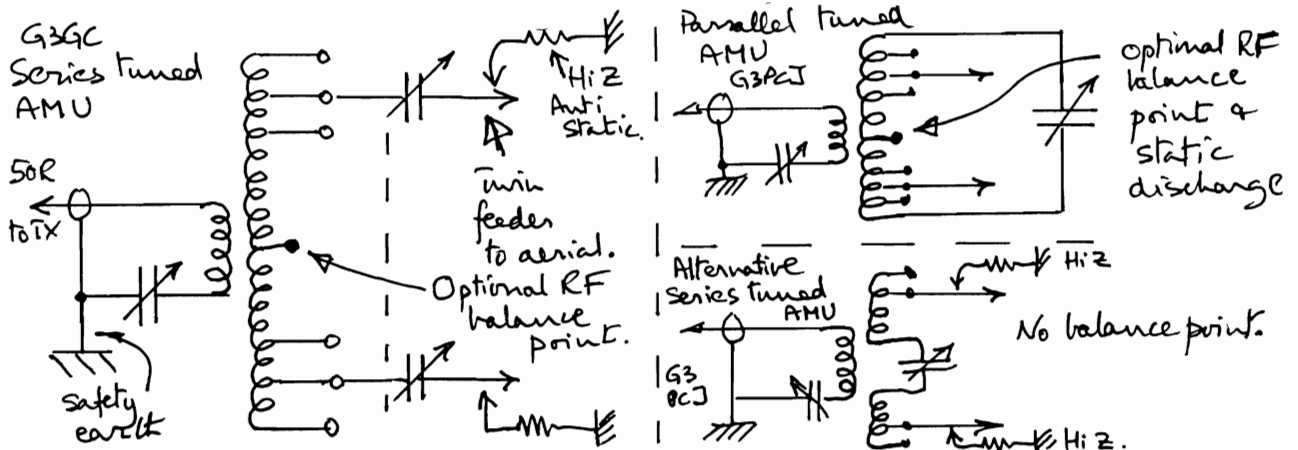
Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 or e mail walfor@globalnet.co.uk The Walford Electronics website can be seen at www.users.globalnet.co.uk/~walfor The Copyright of all material published in *Hot Iron* is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

Antenna Matching Unit for 40m Doublet - comments by Eric Godfrey G3GC

(As I hoped, Eric has produced some notes on my suggestion for Craig G0HDJ in Hot Iron 28.)

'Firstly, I am unsure what Craig meant by a 40m doublet. A doublet maybe any length but since it is defined as a 40m version, then it is presumably either a half or full wave long. It is also not clear whether the impedance of the twin feeder to be used is nominally high between 300 and 600 Ohms or whether it is low at around 80 Ohms. Both considerations, with feeder length, will make a lot of difference to the impedance which the matching unit will have to transform to the nominal 50 Ohms required for the transmitter.

When I saw the article, I was immediately surprised by the number of turns on the link coupling coil. On reading the text, I gathered you were also surprised at the initial suggestion of 19 turns and that you thought 9 was more appropriate. I have never seen a matching unit with as many link turns before. All the other values including 'safety factors' seem to be what might be expected. It is not uncommon for such AMUs to be capable of parallel or series tuning for low impedance loads but this does require more switching or a split stator capacitor as shown below left.

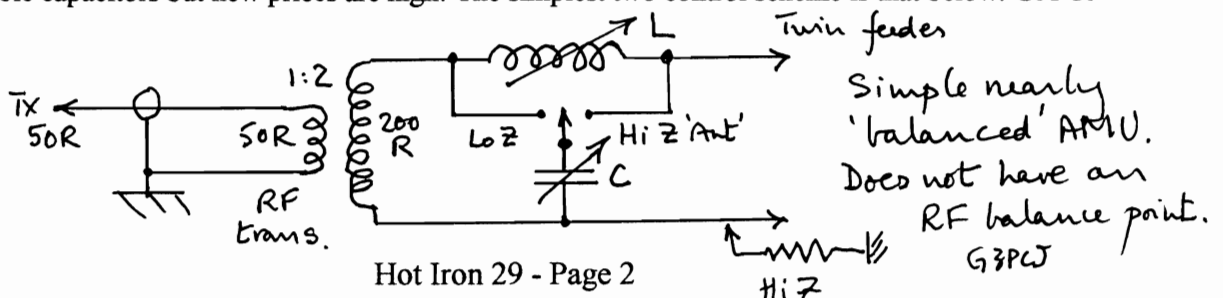


The twin feeder impedance does affect the matching unit's requirements. Consider a resonant half wave doublet, whose centre impedance will be around 70R; this will be compatible with a low Z feeder. However if a high Z feeder is used then, not only will there be a high standing wave on the feeder, but if it is about a quarter wave (or any odd multiples) long, then the impedance at its input will be resistive at around 1300 R for a 300R feeder and nearly 5000R for a 600R feeder. On the other hand if the resonant doublet is a full wavelength long then its centre impedance will be high and a high Z feeder will be satisfactory - if used with a low Z feeder there will be high standing waves. Again, if the low Z 80R feeder is a quarter wave (or any odd multiples) long and the antenna impedance is 1000 to 1500R, then the matching unit will have to work into just 5R resistive. In practice the feeder is most unlikely to be an exact number of odd quarter waves long and consequently the matching unit will have to work with a wide range of resistive and reactive components.

It would be interesting to know what range of impedances can be matched with your design to the transmitter's desired 50R. By connecting resistances across the feeder terminals, the highest and lowest values for pure resistance could easily be found. Similarly an idea could be obtained for various combinations of resistance and reactances by using resistors in parallel with capacitors or inductors across the terminals. Although obviously intended for QRP use it would interesting to know what its upper power limit might be and the associated power losses for the T200/2 transformer core.'

Craig, you have to tell us about the feeder, what you built and how you got on with the suggestions. Also do try reducing the number of link winding turns!

As a further comment, I have been trying to devise a good AMU kit for quite a while which could handle a wide range of frequencies and impedances. It really does need variable inductors and air variable capacitors but new prices are high! The simplest two control scheme is that below. G3PCJ



Upstairs earthing?

Looking in my file of snippets for Hot Iron I find a follow up note from Craig G0HDJ on earthing matters. "My main supply is electrically isolated from mains and RF earth as I often use gel cells at home as well as when operating portable. My base station is on the second floor so how should I 'earth' the station? I could run a stout but long cable (or shorted coax) to a rod driven into the dry earth outside, with rock not far below, or would a quarter wave counterpoise across the floor be better, or should I bond it all to the central heating?"

Given the earlier questions about a doublet antenna I don't think you should need to worry about RF earthing and so I think safety matters are the main concern. The reason behind this is that the doublet antenna is symmetrical with two arms of equal length irrespective of whether it is a half or full wave or some other length. Provided you feed it with a balanced form of feeder (i.e. not coax) from an AMU with a balanced output, (i.e. neither output terminal having a low impedance path to any sort of RF earth), there should be nothing to upset this desirable state of balance. Within the AMU there should be some sort of RF transformer such as that in the circuit at the bottom of the previous page. It is desirable that the matching circuits should be symmetrical as in Eric's circuit higher up the page, however it is not essential provided the stray capacity of all parts to any form of RF earth is low - to avoid the unwanted low impedance path to RF earth. With such a balanced antenna, feeder and AMU output there should not be problems with 'RF in the shack'; if there is, the best way to get a good upstairs RF earth is with a quarter wave counterpoise cut for the band in use and connected to the rig's chassis or ground plane - NOT to either AMU 'hot' output terminal. If the AMU circuits are symmetrical and do have a suitable balance point for connection to RF earth this is really the best place for a counterpoise. Connection to the real earth via a long wire and dubious rod is not going to be much good at RF and maybe dangerous from a mains safety aspect (see earlier Hot Iron article on mains earthing/PME). Connection of the rig chassis to the mains earth or central heating is not going to give a good RF earth for much the same reasons - the real earth is distant! So if there is RF in the shack use a quarter wave counterpoise connected to the rig chassis or AMU balance point. However this will not cover the safety aspect which is mainly the risk of unexpected (high? static?) voltages building up between rig and mains earth owing to the absence of any path to remove the volts. This is the real reason for connection of the rig chassis to mains earth or the central heating which should be bonded anyway to mains earth. The antenna arms should also have a DC path somewhere to earth to dissipate lightning static - without a low Z balance point which can be earthed as above, use 100K to chassis/mains earth from the point in the AMU circuit where the RF voltages are least. See sketches.

So the general answer is to use a balanced antenna and feed system, connect rig chassis to mains earth or other mains bonded metalwork for safety, provide a static discharge route for the antenna arms and if there is RF in the shack, add a quarter wave counterpoise (or several if more than one band is troublesome) connected to rig chassis. When working portable, use an earth spike instead of mains earth or the central heating!

For unsymmetrical antennas, the RF earthing becomes much more critical! G3PCJ

Snippets

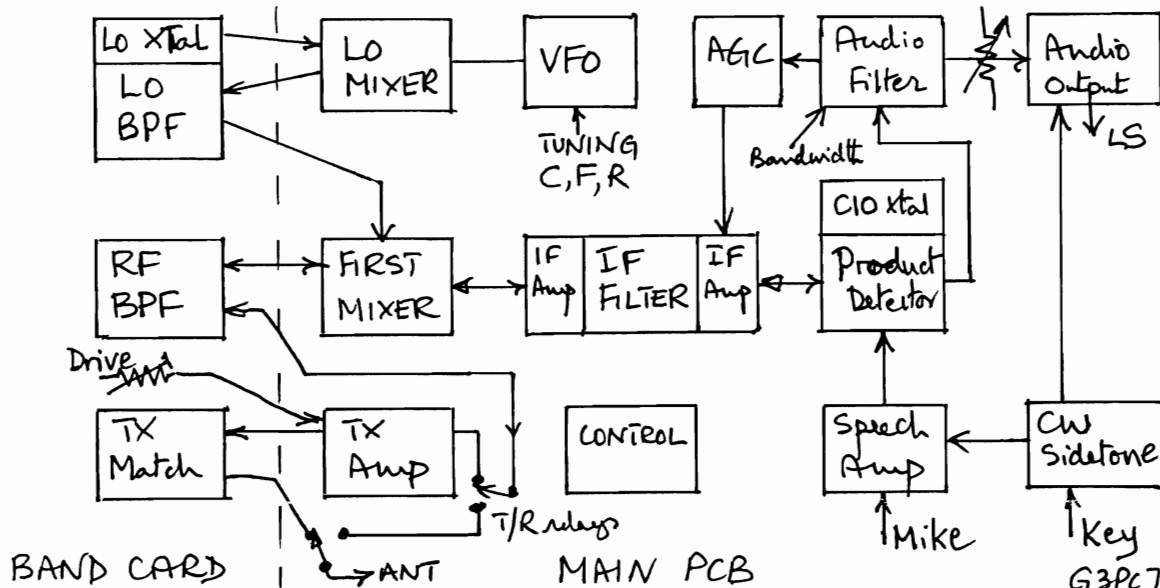
Paul Tuton sings the praises of Ethernet terminators as 50 Ohm dummy loads. They are generally a BNC connector with a built 50 Ohm resistor for properly terminating RG58 coax Thin Ethernet cable used for interconnecting multiple computers. He uses one attached to a PL259 adapter and reports it quite happy to absorb 2 to 3 Watts all day and even with 10 Watts it allows sufficient time to tune up an AMU before it gets too hot. SWR is 1:1 to at least 50 MHz and maybe a lot higher. They cost about £2 in PC World.

Printed Circuit Boards. Sometimes it happens that I produce a slightly damaged PCB because I inadvertently scratched or removed the photo-resist when handling the board prior to etching. Quite often this does not get noticed until after they have been drilled and cleaned. By that time nearly all the cost has been incurred so it is a pity to chuck them away! I keep the PCBs with minor damage in case somebody is quite happy with the odd wire bridge. Currently I have a Bruton TCVR PCB and a 5 digit counter with minor damage. If you are contemplating either projects, ask me about discounts! G3PCJ

Capacitor types. Disc ceramic capacitors are prone to microphony! Medium sized capacitors to about 500 nF in the audio signal path should be polyester. The alternative dielectrics known as X5R and Y5V are often suggested on space/price grounds. X5R changes about 5% with temp but decreases in value by 40% as DC voltage increases to just 16 volts! For Y5V, the figures are -60% for temp and -80% for 10 volts DC. Avoid! The COG dielectric is good - it hardly changes with temp. G3PCJ

The Bristol

It is a multi-band 5 Watt CW and SSB superhet transceiver, capable of operation on all 9 bands from 160 to 10m by plug-in cards. The basic TCVR can take one card, for either a single or pair of bands. If the card switch kit is added, two cards (twin or single) can be fitted allowing front panel selection of up to any four bands. You can change cards for all the others! The rig is a bi-directional superhet with 6 MHz IF and five crystal ladder filter. It has IF amplifiers before and after the filter, the latter being controlled by an audio derived hang AGC system. The audio section has a very high performance adjustable filter with settings for SSB and CW, followed by an output stage for LS or phones. TR control is semi break-in for CW. The low frequency varactor tuned VFO, with coarse & fine tuning plus RIT, has good stability and provides a nominal coverage of 500 KHz on each band card. The VFO output is mixed with a band dependent crystal using a frequency scheme that automatically selects the sideband normally used for phone on each band. The transmitter is basically broadband with a tuned MOSFET output stage. Each band card carries the LO crystal, double tuned LO and RF filters and the transmitter output matching network. This is a simplified block diagram:-



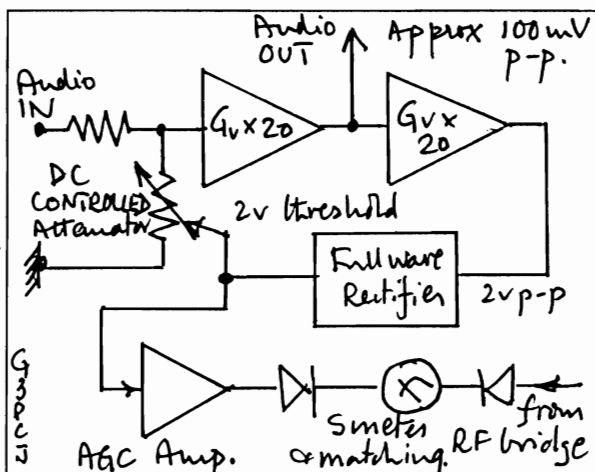
The main PCB is 100 x 160 mm with the band cards (50 x 160 mm) being inserted vertically along the rear edge. The card switch PCB has to be mounted immediately behind the main PCB. Both it and the counter PCB are 160 x 50 mm. In addition a meter kit is available to provide an S meter (with extra audio derived AGC) and a resistive transmitter matching bridge plus output indicator.

The TCVR prices include a Manual and a subscription for one year to the Construction Club.

Single Band TCVR	£129	Manual	£ 5
Two Band TCVR	£149	Extra Single band cards	£16
Four Band TCVR inc. card switch	£199	Extra two band cards	£39
Meter kit	£ 24	Five digit counter ordered with rig	£45

S Meter and audio AGC

Although designed for the Bristol, this meter kit can be used with any rig. The matching bridge section is my standard resistive bridge design. The block diagram of the AGC and S meter part are shown right. It depends on an input variable attenuator controlled by the audio AGC voltage which is also fed to the S meter circuit. Both audio amps have a nominal voltage gain of 20. The attenuator acts when the DC control voltage rises above 2 volts which occurs when it is driven by an audio signal of 2 volts p-p. This implies a stabilised audio output to the rig of 100 mV corresponding to a input of 5 mV p-p. At inputs below this the gain is times 20. G3PCJ



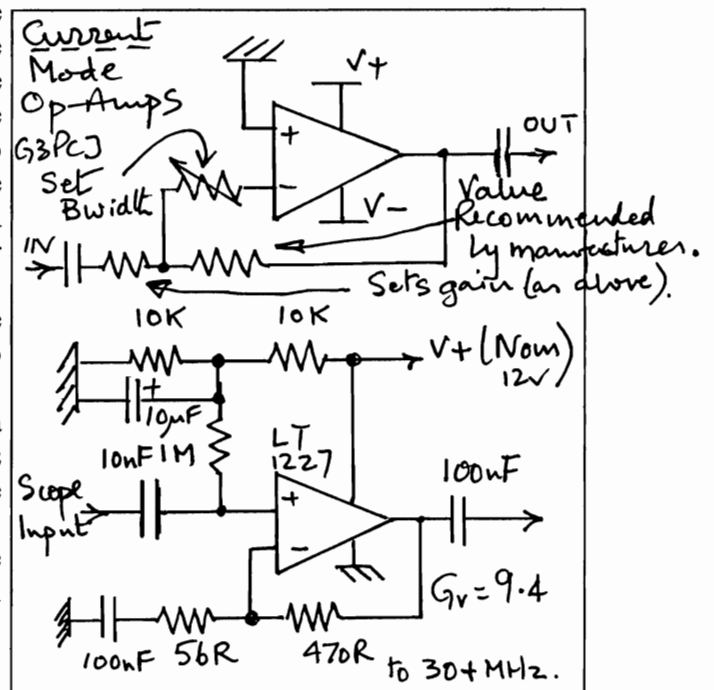
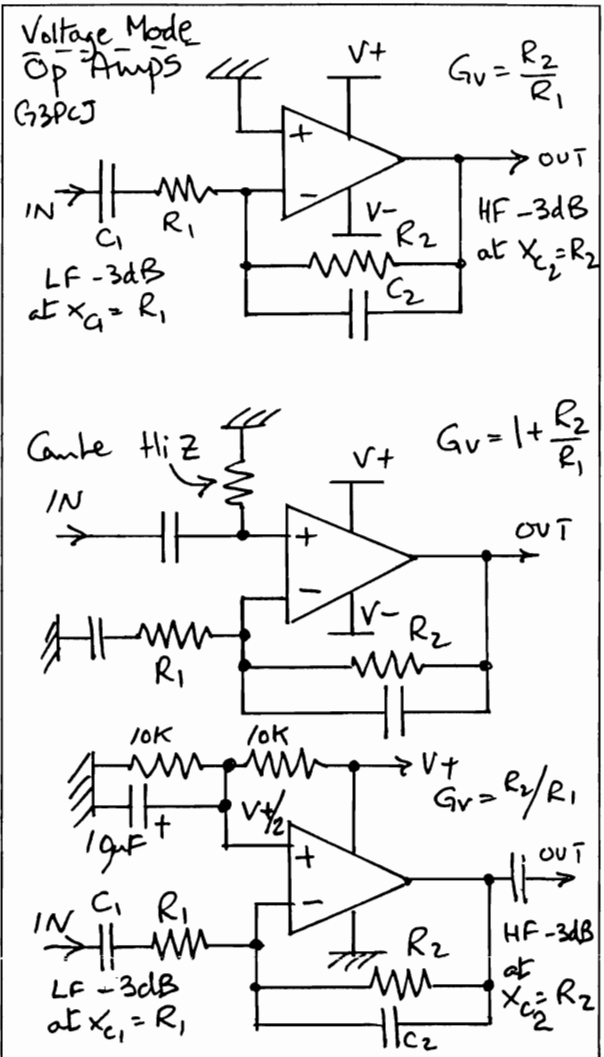
Voltage and Current feedback op-amps

Operational amplifiers can be used in many different configurations but the most common 'voltage' arrangements for audio applications are shown on the right. If symmetrical supplies either side of 0 volts are available, then the positive input is normally biased at 0 volts, either directly as in the top circuit, or when the signal input is also applied to the positive input, by a resistor whose value is high compared to the signal source impedance such as in the second circuit. Biasing in this manner is intended to set the op-amp output voltage to 0 volts for maximum signal swing. Bearing in mind that modern op-amps have very high input impedances, the positive bias input resistor can be large so allowing extra earlier stages of passive signal passband shaping without too much loading on the passive circuit. If only a single supply is available, the positive input and hence output, is biased at mid supply by a decoupled resistive supply halver as in the lower.

The gain of these circuits is principally determined by the two resistors associated with the negative input. These usually form an attenuator from the output - the greater the attenuation, the greater will be the whole circuit gain but of course ultimately limited by the gain and bandwidth of the op-amp itself. The ratio of these resistors is roughly the circuit gain - see actual formulas by the circuits. Generally the capacitor across the feedback resistor sets the high frequency bandwidth while the capacitor in series with the other resistor determines the low frequency bandwidth.

Current mode op-amps are used where the highest possible frequency range is required - often into many MHz of circuit bandwidth. Their internal circuitry is different with circuit performance (bandwidth) much more dependent on the impedance at the negative input. Data sheets often quote the

best value of feedback resistor requiring that the other negative input resistor has to be used to set the stage gain. Placing a capacitor (small) across the feedback resistor to control upper bandwidth can be a bit fiddlesome to determine the best value due to strays etc.. Another approach is to put a low value resistor in series with the negative input as shown right. I have never seen a mathematical approach for determining its value but up to 100R are suggested. One note suggests a preset but I would prefer the 'adjust on test' approach for a one off project! Zero series resistance will give the highest bandwidth. Some years back I used the lower circuit right for a wide bandwidth buffer for scope type probes. It has a nominal gain of times ten to compensate for the attenuation by ten in wide bandwidth scope probes. The LT1227 is a readily available current mode op-amp. It had a bandwidth approaching 30 MHz in this circuit. G3PCJ

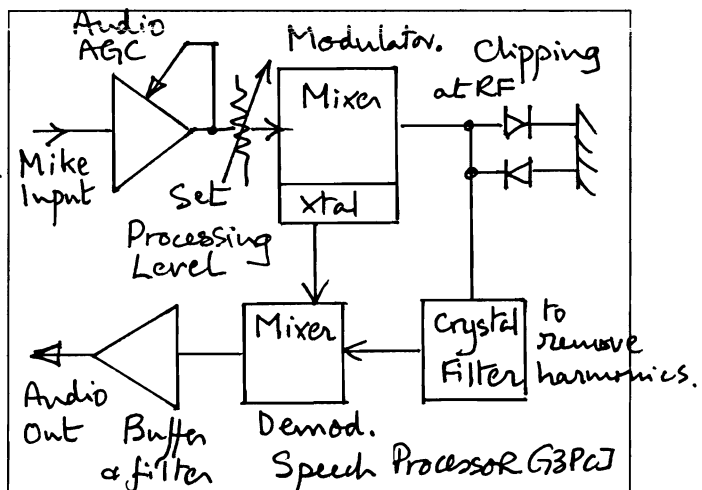


Identifying Capacitors

Alan G0HBC points out that many of us don't see quite as well as we used to and this is a particular problem for small capacitors. When trying to identify them in a kit bag, the first thing is to sort them by type. Electrolytics are easy recognised by their polarity markings. Polyester types (that I use!), in the range 1 to 470 nF, are small rectangular plastic blocks, often blue or grey or yellow, and marked somany 'n'. Ordinary low tolerance general purpose disc ceramics are small discs, often buff or reddish brown, with their value marked in picofarads as two digits followed by a decimal multiplier like resistors. Eg. 103 is 10,000 (pF) which is actually the same as 10 nF - a disc marked 471 would be 470 pF etc.. Be aware that something marked 330 might be actually 330 pF or 33 pF depending on whether its a real number or two digits plus multiplier! Other low value capacitors are either ceramic plate, with a thin rectangular green shape or special temperature compensating types (discs or blobs!). The ceramic plates have very faint small black markings - when new they can be read with a magnifying glass and some guesswork! They are usually marked somany 'p' or with the p separating two digits for very low values e.g. 4p7. These ceramic plates have a black tip if they are NPO, meaning a nominal zero temperature coefficient for values below about 27 pF; alternatively they have an orange tip for slightly larger sized values which implies a N150 temperature coefficient or one which goes down by 150 parts per million per degree centigrade. Other temperature compensating types are also ceramic discs but usually a little bigger, with buff or green bodies, marked as two digits and a decimal multiplier. Both types are N150 - in addition the buff ones have an orange tip N150 indicator. The blue blobs are ceramic COG types, again with a nominal zero tempco; their value is marked as two digits and a decimal multiplier. Having sorted them by type, compare the numbers with the parts list for each size and value. Almost without exception, for the same type, smaller physical size means smaller value. So see if you can find similar ones and compare the numbers in the bag with the numbers of different types in the parts list. Obviously, if you have a capacitance meter, such as now included on digital multi-meters, this will help but do keep the lead lengths as short as possible! This advice is of limited help - later I hope to have a simple capacitance indicator kit! G3PCJ

Speech processing suggestions

Andy Howgate has suggested a general purpose speech processing kit that would go with any brand of rig; I would also add a replacement for the Plessey SL6270 VOGAD chip which is now almost unobtainable (I do have some!). I have in mind to use the type of AGC circuit mentioned earlier for the meter kit - this would ensure that the clipping circuits have a stable input level to make it easier to set up. It would use a couple of 602 mixer chips and crystals to transform up to RF for the clipping and filtering and back down to audio. I guess that it might take up a 50 x 80 mm PCB and cost about £30. The block diagram would be something like that right. Anyone interested?



Somerset Range Rigs

Just a brief reminder of the main kits available:-

Chedzoy	Starter kit, MW plus 80m Regen TRF	£19
Priddy	First serious kit, 20, 40, & 80m DC RX	£39
Godney	3 band crystal CW TX 1.5W	£29
Sparkford	80m Cer Res VFO CW TCVR 1.5W	£34
Porlock	6m from 20m Transverter 3+W	£44
Minehead	CW VFO TCVR, 5W single band 20 to 160m	£49
Bruton	SSB Superhet TCVR, 5W, single band 20 to 160m	£84
Radstock	CW Phasing TCVR 5W, two bands 10 to 160m	£79
Langport	CW & SSB, 20 & 80m 5W superhet TCVR	£128
Taunton	Multi-band SSB TCVR 5W, 1/2 bands, 15 to 160m	£99 up

Counters, 3 and 5 digit, adjustable CW filter, optional extras, QRP Booster, Low pass filters, Two tone oscillators, signal generator and loads of spares for all the older rigs! G3PCJ

Hot Iron

Issue 30

“Journal of the Constructors Club”

Winter 2000



Editorial

As I sit here with a blank page in front of me pondering on the world for Construction Club members and the rain continues to pour down I give thanks that I am about 20 feet above sea level! Even the Government has noticed that its been raining for nearly two months and the weather systems are not behaving normally! Though I have not seen any reports in the media, I feel pretty sure that Raynet members have been out and about in Yorkshire and around the Severn Valley helping with communications in the flooded areas. Well done lads and lasses! Increasingly, computing technology is creeping into all branches of communications, especially where the radio conditions are difficult so that the benefits of digital signal processing can be used to advantage. Recently we had a talk at the Yeovil ARC about the new data mode called PSK31 - standing for Phase Shift Keying at 31 bauds or bits per second. There are several free software packages which can be run on quite modest elderly PCs and give outstanding performance under difficult conditions. Less than a watt or so of RF on 20m giving solid (typed text) copy to/from Scandinavia when there was no trace of the audio modulation when listened to on a

conventional SSB phone receiver. In part, the ability to recover signals buried very deep in the noise is due to the narrow bandwidth and special Fast Fourier Transform software which actually does a real time spectrum analysis on the audio signals coming from the receiver so that the character recognition software only has to respond to signals in a very narrow bandwidth. The ‘occupied’ bandwidth is around 30 Hz so many channels can occupy the 2 to 3 Khz normally used for phone SSB signals. Practically, a conventional SSB RX is tuned to the nominal RF frequency and then the software is tuned using the mouse and PC display, to any ‘30 Hz channel’ within the normal RX audio bandwidth. This gives over 50 channels for a single nominal RF! This suggests that there is now a good role for a very simple crystal controlled fixed RF frequency RX and TX but able to work many software channels through audio modulation/demodulation by the computer! I know some of our Club members have experimented with this mode and I should love to hear more about it! I feel a kit coming on!

Kit Developments

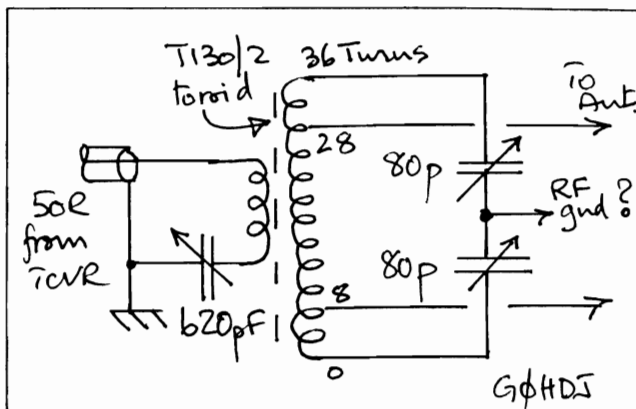
The Bristol is now available after several prototypes have been built. Its quite a rig - in many senses! You can fit plug-in cards for any single or pair of bands for 10 to 160m for CW and SSB operation, or add a band card switch kit for two card positions and hence four bands normally fitted. The Meter kit and digital readout can be added easily. Ex stock - build it over Christmas! Thanks to Andy Howgate, I have developed a speech processor kit. It modulates the audio up to 5 MHz double sideband suppressed carrier, clips it to improve the average to peak qualities of the signal, filters out the harmonics of 5 MHz, and demodulates back to audio. 50 x 80 PCB costing £24. Tim W. G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 or e mail walfor@globalnet.co.uk The Walford Electronics website can be seen at www.users.globalnet.co.uk/~walfor The Copyright of all material published in *Hot Iron* is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

Antenna Matching Unit for 40m Doublet

Following from earlier suggestions for his doublet, Craig G0HDJ reports:-

The unit was constructed but did not appear to operate as expected! (What's new!) Events overtook me for a while but last week I got back to thinking about it and went to have a word with the guru - Eric G3GC. He suggested with the aid of his Smith Chart that perhaps another quarter wave length of feeder might sort it out. This was fitted and seems to have done the trick. I have yet to put it into a box so all might turn pear-shaped. Also noticed was that it seemed to have a positive effect on my 40m night time BCI problem which afflicts all rigs.



The final circuit is shown right. I tried it on 30m but it didn't want to know!

Craig also offers the following *Snippets*. 1. Clean enamel coated wire by dragging it carefully across the teeth of a hacksaw blade - works a treat. 2. Stop keys/keyboards moving about the desk when in use with a little of the material that does the same thing for carpets - almost welds them down!

Letters to the Editor!

'With reference to the question about whether the morse test should be scrapped, my feelings are this. The test should be scrapped, and instead, maybe one should have held a B licence for a certain period of time, before then applying to be upgraded to A. Alternatively, perhaps one should be required to build a simple superhet HF receiver. This could certainly be interesting. Apart from this, I am woefully short on ideas as to what the test should be replaced with, or indeed whether we don't just all become A without further formality. Morse itself should be actively encouraged. It is part of our communications heritage and as such warrants preservation through active use. The beauty of CW is that outstanding results are possible using low power, simple transmitters and transceivers. I am an avid constructor and experimenter, generally on HF. After 28 years in the hobby, all I have to show for it is a class B licence, which obviously makes things difficult. Morse should not be a barrier but a pleasure for those who wish to pursue it. Those who are introduced to the hobby should of course be shown CW in action and encouraged to take an interest in it. David Rowlands G6UEB'

'Some years ago I built a transistor tester using a circuit from the Rad Com Handbook. Although I have successfully checked *nnp* and *pnp* transistors for go/nogo, I have never been sure if they were better or worse than they should be - how can one check the parameters or variations between similar devices? Derek Alexander G4GVM'

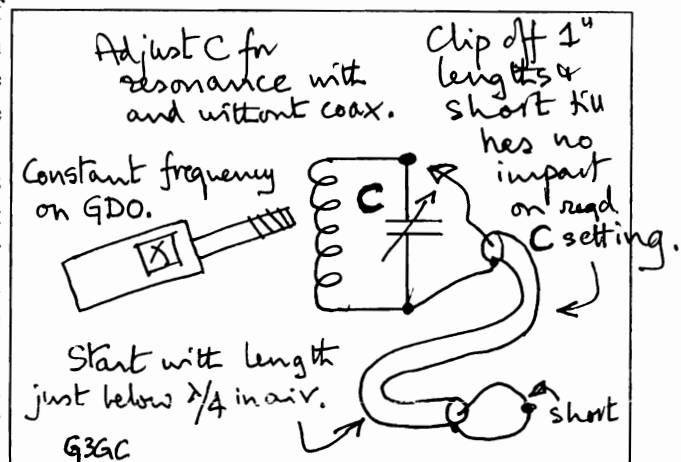
Answer! Derek continues with several other questions on FETs and asks how he can tell which device should be selected for a particular circuit. The easy answer is that they are often not worth testing! If in doubt chuck them away because new ones are generally now so cheap and a keen constructor should always buy ten if he needs just one! To make an assessment of their individual performance requires some sort of meter which will show (for example) the collector current for a specific base current so indicating the device's current gain. The cost of such an instrument would keep you in new devices for years! Junction FETs like the 2N3819 can be tested by measuring the drain current for zero bias, i.e. gate joined to source. For this device it can range from 2 to 18 mAmps and still be in spec! Assessing MOSFETs like the BS170 and IRF510 is a little harder, often the easiest way is to check that altering the gate DC voltage from about 1 to over 5 volts causes a drain current to flow - bearing in mind that both can pass Amps, use a series drain resistor of 100R to limit the current! Selecting individual devices for someone else's circuit is impractical - you just have to rely on the circuit designer having done his job properly so that the circuit will work with edge of spec devices! That is why there is always some risk in substituting alternatives if you don't have the one specified. Also be aware that some transistors like the BC106/109/182/212 families are often sorted, and sold with different supplementary letters, indicating they are in different gain groups and so circuits may not work with a transistor having a different end letter to that specified. There is no substitute for a good book listing the main device parameters - try old RS and Farnell catalogues.

Measuring the Velocity Factor of Coaxial Cables - by Eric Godfrey, G3GC

In the Summer Issue of Hot Iron I dealt with how to check what the impedance was of an odd length of coaxial cable. This note deals with measuring the velocity factor of a coaxial cable if this is in any doubt. Most velocity factors will fall between 0.67 and unity. The former is the value for solid polythene dielectric and the latter the value for an air only dielectric which of course is mechanically impossible to achieve. However there are some feeders using spiral polythene insulation which have a velocity factor of around 0.96. These are the Heliac cables commonly used at the higher frequencies because of their low loss due to the minimum amount of polythene used in their construction.

So how do we go about measuring the velocity factor? Well we again make use of the fact that the input impedance of a piece of feeder precisely an electrical quarter wave long and shorted at the far end will look like an open circuit, that is to say it will be a very high pure resistance without a reactive component. If such a shorted quarter wave feeder is connected across a resonant circuit fed with RF at a known and stable frequency, and is tuned to resonance by a variable capacity, then there will no change required in the position of the variable capacity to maintain resonance when the short circuited quarter wave is added. When this is achieved, then the physical length of the cable can then be measured and compared with the theoretical length of a quarter wave in air at the frequency in use.

Practically one starts with a length of shorted cable a bit below the theoretical length of the quarter wave *in air* at the frequency in use and then observe how much the variable capacitor has to be moved to regain resonance. An inch or so is then taken off the cable and it is then reconnected across the resonant circuit which is again tuned to resonance. The capacitor will now be nearer its original setting and again the length of the cable under test is reduced. The change in capacitor setting should now be much smaller and by successive cutting and measuring the exact length for no change of the capacitor will be found and the velocity factor may then be calculated from the formula below.



If you have got a good frequency meter then another method is to use a free running oscillator and measure the frequency. Here you adopt the same principal of successively cutting back but this time to maintain the same frequency from the oscillator whether the cable is connected or not. The fact that the frequency may drift a little is of no consequence so long as there is no change between the "on" and "off" measurements and the frequency noted. A variation of this method is to take a piece of the short circuited cable of some convenient physical length and tune the oscillator to the frequency at which there is no change whether the cable is connected or not and again noting the frequency.

Irrespective of what method is adopted, the physical length of the cable is measured and compared with the theoretical length of a quarter wave in air at the frequency in use. The velocity factor is then given by the following formula:-

Velocity Factor = Measured Physical Length / Theoretical Length of a quarter wave in air.

If possible, it is useful to measure the velocity factor before doing the measurement of impedance described previously in the Summer Issue, as a reasonably accurate value for the velocity factor is able to be used rather than relying on a visual estimate.

2001 Yeovil QRP Convention Construction Challenge

Get your irons and thinking caps out now! You have to build the most sensitive grid dip type oscillator that you can! It has to cover the 3 to 5 MHz range, not using more than two discrete transistors and must obtain the correct frequency to within 100 KHz. The maximum distance at which the operator calls the 'correct' frequency as the instrument approaches the test resonant circuit will be measured. The resonant circuit will be altered between competitors and the resonant frequency revealed after each entrant has had his attempt to get it correct! Full details from G3CQR.

The **Convention** will again be held at Sherborne on **April 22nd** with a full programme of talks, demonstrations, traders and other goodies. There will be a Dinner the evening before open to all by prior booking with G3CQR who can assist with arrangements for accommodation if required.

Military QRP with the PRC316/A-16 - by John Teague G3GTJ

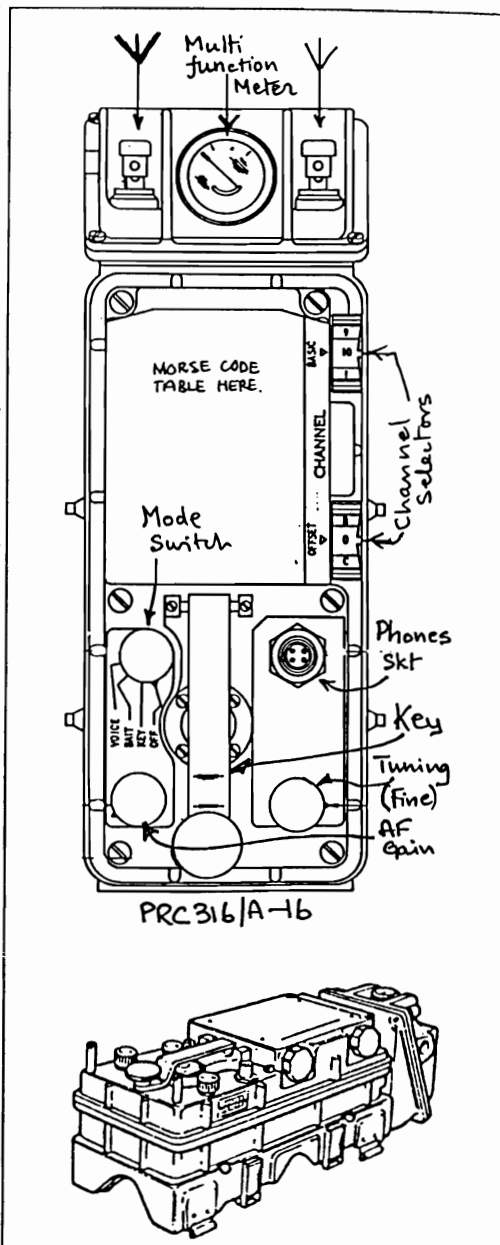
The PRC 316 is a compact transmitter/receiver which was in British Army service from around 1970 to the early nineties. (See drawings right.) It was used for tactical and strategic communications in many theatres and will (I hope) be of interest to Hot Iron readers because the design, by the Signals Research & Development Establishment in the mid-sixties, was based on sound QRP principles from the start. The set was conceived as the solution to the problems of communication with remote patrols operating in jungle, typically in Malaya and Borneo. It had to be lightweight, rugged, have low power consumption and provide reliable communication from near zero range to 500 miles plus in conditions of exceptionally high RF noise levels and the severe attenuation of wet foliage. The requirement was more than achieved by a small kit bag of equipment weighing under 5 Kg. In service the PRC 316 was used on a number of long distance circuits including Belize - Hereford.

The chosen electronic configuration was a 45 channel crystal controlled 5 watt output transmitter allied with a narrow band receiver operating with CW in the frequency range 2 - 7 MHz. A dipole aerial of adjustable length was provided, draped over available scrub and trees by means of a throwing cord. In the jungle the mode of propagation was Near Vertical Incidence Skywave (NVIS). For transmission over long paths greater than 1000 miles the aerial elements could be raised and fed by coaxial feeder. Otherwise the elements connect directly to terminals on the set and are the only signal frequency resonant element in the transmitter PA. The receiver uses double conversion and incorporates a 300 Hz Collins filter. Two banks of crystals are used to generate nine basic channels in the frequency range, each channel variable by two incremental steps of 1.3 KHz above and below its nominal frequency. A further "side-step" crystal at the 455 KHz IF is used to generate the transmitter drive signal. The whole is all-solid state using discrete components powered by a small 16 volt alkaline battery which plugs into the base of the set to provide 20+ hours of operation with 9:1 receive/transmit time. A built in morse key of good quality is fitted and an alternative mode of conventional AM intended mainly for short range ground to air use is available using the combined earphone/microphone.

There is no RIT/XIT which means that use on amateur bands with appropriate crystals is possible but not at all convenient. However a VFO drive to replace one of the signal generating crystal oscillators is easily arranged and the actual tuning range of the set covers most of top band and 40m.

The complete radio has overall dimensions of 10 x 4 x 4 inches with an airtight case of aluminium and metallised plastic. It is designed for hard usage and tolerates open or short circuited aerial terminals. Five variants were produced lettered A to E with different channel crystal combinations. All sets except E have one channel in the 80m band at 3710 MHz. A small range of accessories was developed for the PRC 316: an adaptor for connection of an external DC supply; a headset with boom mike and some specialised test equipment. The main attachment was a high speed morse keyer (300 wpm) and its interface unit.

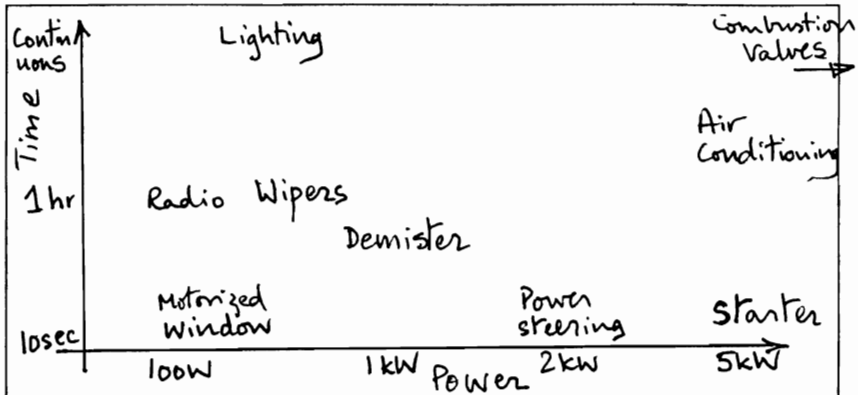
These sets were released onto the open market in the early nineties: the bad news is that relatively few have since entered amateur service. They are sought after and difficult to find although advertised occasionally in the amateur magazines; prices are variable but unlikely to be under £100. I shall be glad to provide any further details to anyone who is interested.



Next Generation Car Electrics

There is a growing awareness that the current widespread use of nominal 12/14 volt lead acid battery systems for cars will not meet future vehicle needs. Already most commercial vehicles use 24 volt systems to crank the larger engines but research into future major mechanical aspects suggest that more electro-mechanical control will bring major advances. The diagram below shows how car power demands have grown as consumers desire more 'performance' - this is without the latest electro-mechanical ideas!

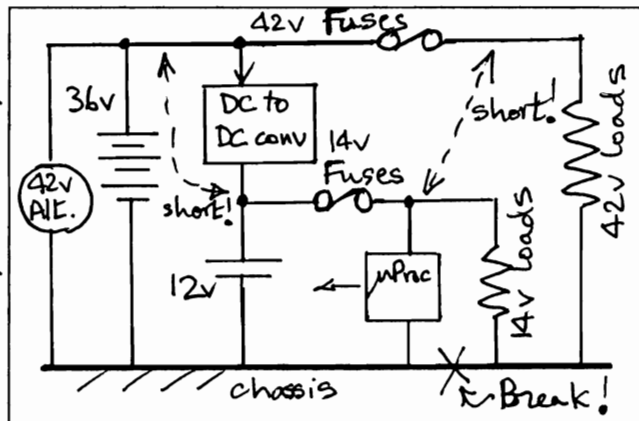
With a 12/14 volt system, supplying 5 kW (even intermittently) implies over 400 Amps which is testing for many batteries so it requires a large alternator if battery storage capacity (and hence weight) is to be kept within reasonable bounds! Obviously to reduce volt drop in cables, they have to be very thick, and so are heavy, difficult to install



and require extra large connectors. Designing an electrical or electronic item to work on system voltages which vary from about 10 to 16 under normal conditions is pretty challenging if it is to cost next to nothing, be small, light and work for ever! These considerations all suggest that a higher nominal system voltage would be desirable.

A new 'standard' of 42 volts is emerging based on the charging voltage for a nominal 36 volt battery. This would not only reduce the weight of the wires for the same system functions by some 40% but could support much higher power loads from the newer electro-mechanical devices such as disc brake and steering actuators, and could greatly simplify the drives for conventional engine ancillaries such as water pumps, temperature control systems and even combustion chamber valves! Electric control of the valves might enable a sizeable reduction in necessary starter motor torque as the valves could be held open for negligible compression when first cranking. A higher system voltage would allow the alternator - required to supply the long term average power demand - to supply more power for a given frame size due to the smaller conductors and their lower I^2R dissipation. Using one AC machine permanently 'engaged' for starting with an inverter, and for charging, would reduce weight, cost & eliminate the unreliable starter mechanics. There are many other lesser advantages (e.g. smaller/cheaper electronic switches) with easier recycling of scrap materials becoming more important.

What are the drawbacks? The main snag is the process of technology changeover. Both 14 and 42 volt systems are likely to be needed for some years owing to the lack of higher voltage parts. If a mixed system has to be fitted there are many safety problems - ranging from the dropped screwdriver to what happens in a crash. (See a rough scheme alongside with possible faults indicated.) If multiple voltages are supported by separate batteries, then fusing becomes very difficult and also complicates reverse supply protection. Another approach would use DC to DC

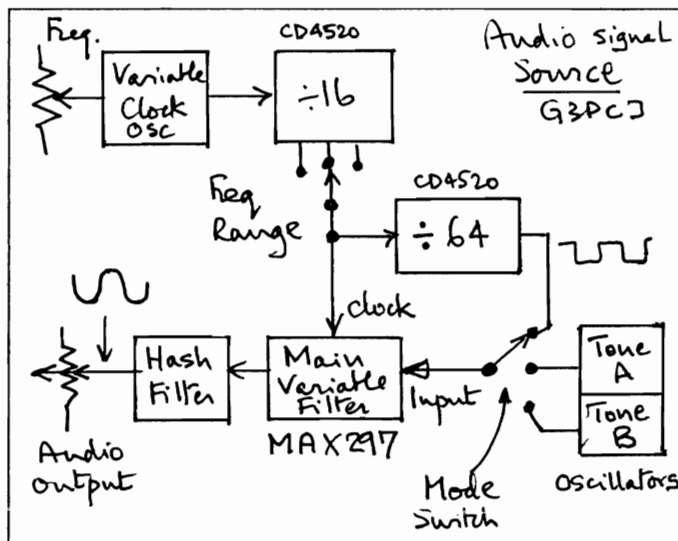


converters. Bear in mind that increasing use of micros might require other supply voltages of 5 volts or less! Load dump conditions for the alternator, when the battery (or any other major load) is suddenly disconnected, can lead to very high voltage damaging transients! Other practical problems yet to be overcome include the fragility of light bulbs made for higher voltages. Existing 24 volt bulbs have a 30% shorter life than 12 volt ones! Small motors such as wiper and window actuators may have to get bigger to accommodate the trebling in number of winding turns for the higher voltage since the wire size cannot get much smaller. Much further ahead, hybrid cars may have 50 kW networks with fuel cells operating at 300 to 400 volts! There is much going on in this field! See www.42volt.com for more details. Much of this is has been drawn from a recent IEE article. Tim G3PCJ

Generating low distortion audio sinewaves

Recently, when evaluating the new speech processor kit, I needed a better audio signal source than I had on the test gear shelf. I recalled that Ian Hickman, who writes regular excellent articles in Electronics World, had suggested the use of modern switched capacitor clock tuneable filters for this role. Luckily the Bristol's adjustable audio filter is based on the Maxim 297 clock tuneable elliptic low pass filter so I had suitable devices to hand. This low pass filter has a very sharp cut-off just above the frequency at which the response is 3 dB down - it is over 70 dB down at 1.5 times this -3 dB corner frequency! Consequently it can be used to filter out all the unwanted harmonics of the desired sinewave. Because the corner frequency is tuneable by adjusting the frequency of the driving clock, it can be used to make a high performance tuneable audio source. The crucial -3 dB corner frequency is exactly one fiftieth of the clock frequency applied to the MAX297 - consequently if the clock actually runs at 64 times the desired audio output frequency, then the wanted audio signal will always be a little below the filter's -3 dB corner frequency irrespective of its actual frequency and the harmonics will be negligible. The attenuation of this wanted signal through the filter will always be the same and the output level will then remain constant across the whole tuning range.

The diagram right shows the block diagram of my 'device' covering 200 Hz to 4.8 KHz with the extra oscillators to provide the fixed frequency outputs for two tone testing of an SSB transmitter. One of these is at 800 Hz so is useful for evaluating CW filters. When laid out properly, it might fit onto a 50 x 80 mm PCB, cost about £24 including 3 switches (var/800/2tone, H/M/L freq range, H/M/L level), with two pots for var freq control and output level. If anybody would like such a device, let me know and I will tidy up my ugly bird's nest! Tim G3PCJ



Tips

Paul Tuton, as a reluctant 'PCB front panel man', asks about how to drill clean large circular holes in PCB material for control shafts etc.. The best approach is to use a pillar drill with the PCB material clamped firmly in place to the base of the drill stand just near the desired position of the hole - on top of a piece of wood. Drill through first with a small pilot bit, then change to the desired size, with a sharp bit using medium speed. Advance it slowly into the material especially as it just breaks through on the underside of the PCB.

Paul also suggest the use of a generous blob of 'blue tack' as a means of holding components in place after insertion into the PCB holes, so that they stay in place when turned over for soldering.

Somerset Homebrew Contest

Peter Barville G3XJS has again kindly agreed to run this contest for the GQRP Club. The objective is to encourage the use of home-made gear - especially in contests. The detailed rules are in Sprat but it is essentially the same as last year. Either or both TX or RX need to be home built. A £50 voucher from Walford Electronics awaits the winner. Any mode on 40 or 80m between 0900Z and 1200Z on Mar 25 2001. Beware clocks change the night before! Scoring favours two way QRP contacts but can be QRP/QRO! Somerset Range rigs often feature in the submitted logs but I emphasize that it is completely open for any brand of kit or other source! Full details in Sprat.

Minehead TCVR

In conjunction with Michael Morley, I have been trying out an alternative TX matching arrangement which I think leads to a better balance between TX and RX tuning. Please contact me if you would like to try this alternative approach. Tim G3PCJ.

Thanks! Finally, I must say that it has been a pleasure not to have to generate so much material myself this time! Thank you very much to all contributors and please keep it coming! Tim.

Hot Iron

Issue 31

“Journal of the Constructors Club”

Spring 2001



Editorial

As a first for Hot Iron, I am very pleased to include some colour photos with an article about the building of a pair of Bristols by our keen supporters Andy G7WHM and his friend Bob. They also very kindly produced the colour copies. It was the encouragement of Andy who kept me going during the long development of the Bristol. Being a major project, the transceiver alone took nearly a year of thinking, experimenting and laying out - despite many aspects having already been proved in other rigs! The various ancillaries took another few months so I was very glad to have that encouragement right from the start when it was little more than a few scribbles on a sheet of paper! Andy said something along the lines of ‘That sounds good - I shall have one, and guide my friend to build another.’ Bob’s electronic construction experience was not large but with a willing mentor, he has now built and got working one of the most challenging kits on the market! It has been most helpful to me - as a sounding board for ideas and to find the errors which are inevitable in an instruction Manual of 36 sides. (£5 post paid if you want a look!) It also shows the value of doing things with others, either friends or

through a Club. Another member Doug G7HYG has purchased one as pilot for his Club, and I am sure his guiding experience will enable others to succeed. Club Construction projects (at any experience level) do boost the morale of most Clubs so find your construction leader!

Kit Developments

A little bit of recent publicity in Radcom over kit construction gave a welcome boost to sales of the Chedzoy regenerative TRF receiver which is really intended for very first time builders. It set me thinking again about the next step up and the possibilities of a simple 20/80m DC receiver, complete with front panel, audio filters and loud speaker drive. The result is a new kit called the Chinnock which has two separate conventional VFOs tuned by a polyvaricon capacitor. The matching transmitter is a 1.5 Watt CW ‘crystal VXO’ controlled rig complete with TR changeover, low pass filters and sidetone etc.. The design is quite simple and the article later in this issue has sufficient information to build your own version. East and West Chinnock are actually two villages between Yeovil and Crewkerne! Some early builders would be welcome; the RX is £39 or with the TX £59.

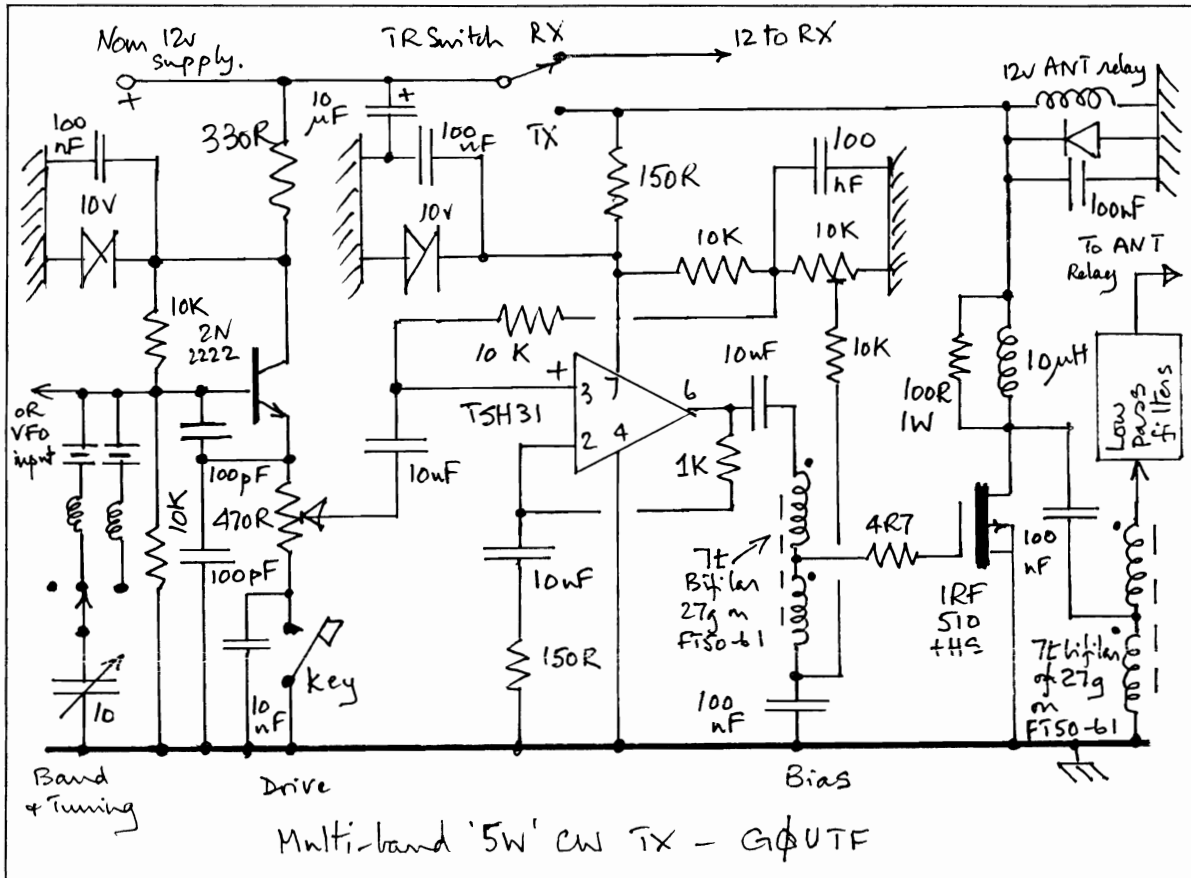
Another new kit is the Tone! As you might guess, this rig is for the data mode PSK31 which I mentioned in the last Hot Iron. (The Tone is a Somerset river.) For simplicity, it will be 80m only. It will be capable of double sideband suppressed carrier phone (for voice or PSK31) and CW. It will have a two pullable ceramic resonators and trimmers for the VXO, with nominal frequencies of 3.58 and 3.69 MHz to suit the modes available. I have done the PCB layout and etched it but have yet to build the prototype so its not yet ready for sale! Contact me if you are interested. Tim Walford. G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 or e mail walfor@globalnet.co.uk The Walford Electronics website can be seen at www.users.globalnet.co.uk/~walfor The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

Multi-band CW Transmitter by David Proctor G0UTF

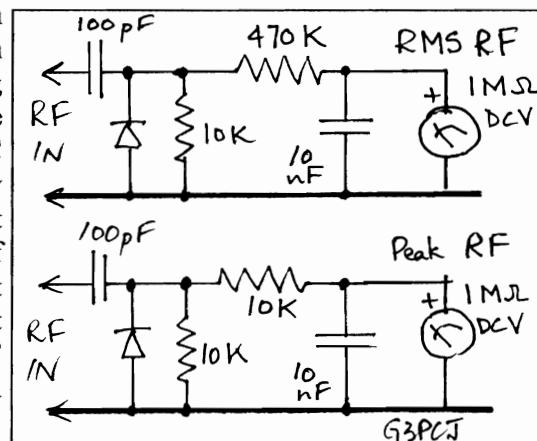
(David originally asked me a technical question about this rig which he has adapted from several sources, but I thought it worth publishing - albeit in a slightly simplified form. G3PCJ)

The rig comprises a multi-band VXO oscillator with a broadband 5 Watt TX with plug-in low pass filters from another well known kit producer! It has given me lots of contacts on 7, 10, 14 and 21 MHz using a range of crystals which can be pulled over several KHz and still be exceptionally stable; on the lower bands I use a normal VFO instead of the crystals. It only needs a communication RX to work all HF bands on CW. The TR changeover is conventional and controlled by a switch. In addition, the crystal oscillator stage is powered all the time so that pressing the key alone will produce a netting signal in the RX. I use a sidetone oscillator powered from the transmitter's RF.



RF Voltmeter

This simple circuit detects the peak value of an RF signal. It presents a load impedance of about 10K on the driving circuit so can be used without any loading effects on a 50R line etc.. It is actually a half wave rectifier and, when used with a 1 MOhm input DC meter, the 470K series output resistor causes it to show the RMS value of the RF signal. If the alternative output circuit is used the DC meter will show the peak value of the ac signal. The RF power can easily be worked out assuming you know the value of the impedance at that point. If the load is actually a 50R dummy load, the RF power in Watts will be the (peak voltage) squared divided by 100. G3PCJ



The Godney CW transmitter

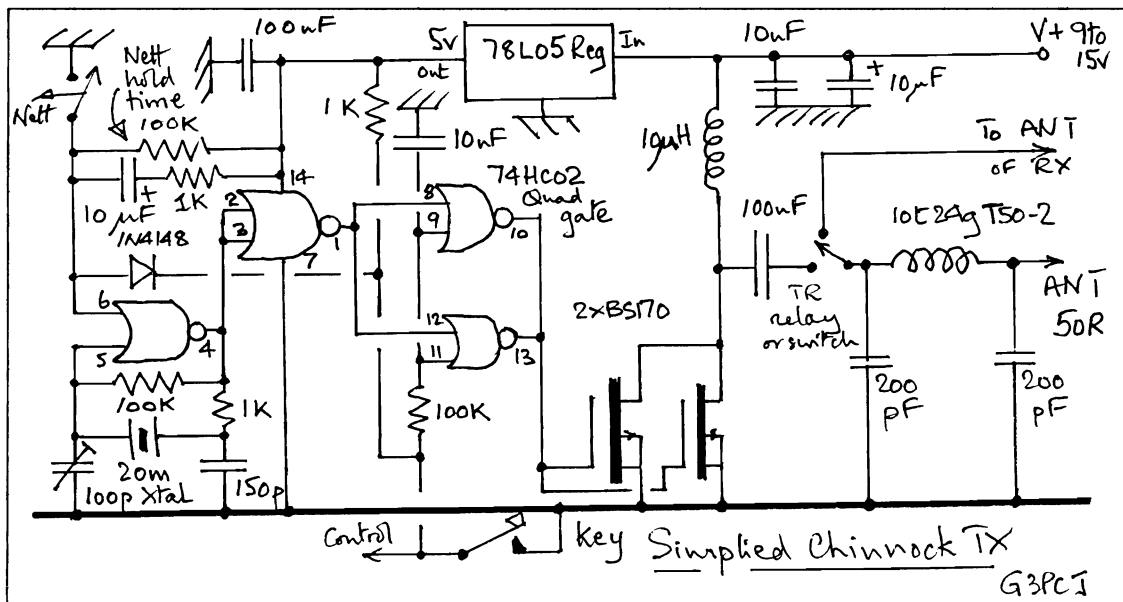
I have some of these kits which no longer fit in with the rest of my range and am keen to avoid resorting the parts. It is a three frequency 1.5 Watt 'crystal' controlled transmitter. An 80m ceramic resonator is included but all three can be any frequency up to 15 MHz. TR changeover and sidetone included. PCB 50 x 80 mm. Contact me if you want one - I am open to offers! Normally £29. G3PCJ

The Chinnock CW transmitter

Simplicity was the design point about this transmitter! Experience elsewhere had showed that high speed CMOS digital chips (74HCxx series) can operate to 50+ MHz so running on 20 or 80m would be a doddle! It had to be 'crystal' controlled to avoid chirp which would occur with a normal VFO operating on the transmit frequency. On 20m a crystal can be pulled about 5 or 6 KHz so this is not too much of a limitation. On 80m, a crystal can only be pulled about 1.5 KHz which is too little, so a ceramic resonator is used instead - this permits a much wider pulling range. This is because the ceramic resonator has a lower Q, measured in thousands, rather than hundreds of thousands for a crystal. The ceramic resonator Q is however still high enough to avoid chirp problems. A standard 3.58 MHz ceramic resonator can cover all of the 80m CW section. Their drawback is slightly worse temperature stability and a wide initial frequency tolerance - both tolerable in a simple rig.

To make an oscillator using HC chips is very easy, you only have to add a couple of resistors to bias it into the linear region of its operating characteristic, with the load capacitors for the 'crystal', and off it goes! The quad two input NOR gate allows for easy gating of the oscillator for netting purposes, with 3 gates left over for RF keying and driving the output stage. The BS170 MOSFET does perform well on 20m so I decided that two devices, operated in parallel, would handle the currents implied by a 50 Ohm load which will give 1.5 Watts output using a 13.8 volt supply. The BS170 has a gate capacity of about 50 pF but using two driving gates would halve the driving impedance and so charge or discharge the gate capacitance sufficiently quickly. Provided that the BS170 gates are driven with a square wave, and never kept steady at the logic 5 volt positive supply voltage, there is no need for any form of bias preset for the output devices.

The only other thing required is a low pass filter to remove the harmonics inherent in such a 'digital' oscillator and output stage. A three element half wave low pass filter is sufficient when used with a resonant antenna matching circuit. The maths of such filters is very easy - the reactance of each element should be the same as the feeder impedance (50R) at just above the operating frequency. Apart from the crystal, these are the only band dependent parts. It is convenient to fit the TR antenna changeover switch between TX output stage and the LPFs so that they also provide protection against BCI etc. on receive. The complete circuit (for the RF parts) is shown below; the Chinnock TX kit has a complete set of RF circuits for each band together with common RX sidetone, TR control, etc. G3PCJ



Somerset Homebrew Contest

Don't forget this contest with a £50 Walford Electronics Voucher for first prize! The objective is to encourage the use of home-made gear - especially in contests. The detailed rules are in Sprat but it is essentially the same as last year. Either or both TX or RX need to be home built. Any mode on 40 or 80m between 0900Z and 1200Z on Mar 25 2001. Beware clocks change the night before! Scoring favours two way QRP contacts but can be QRP/QRO!

The Grid Dip Oscillator and its uses by Joseph Bell G3DII

The name Grid Dip Oscillator derives from valved designs which used a meter to indicate the oscillator RF voltages by measuring the current in the grid bias resistor of the oscillator valve. Nowadays transistors are used instead of valves but the name has stuck! The instrument is primarily used to measure the resonant frequency of a circuit under test. When the oscillator's resonant circuit is coupled to another resonant circuit of the same frequency, it draws energy from the first so reducing the oscillator RF voltages and hence a reduction in grid or indicator current. As the GDO frequency is tuned through the frequency of the circuit being investigated, the indicator current will suddenly reduce, or dip, and then rise again when the frequencies no longer agree. Because the GDO usually covers a wide frequency range, consequently with varying oscillator RF voltages, it usually has a sensitivity control to adjust the normal meter indication. To be of any use, the GDO should be frequency stable. They are simple to make but do use sturdy construction and hefty variable condensers. The best accuracy is obtained when also coupled to a frequency counter. To those not familiar with using a GDO, the under mentioned points are worth noting:-

- a) When using the GDO, keep your hands away from the coil as body capacitance can spoil readings.
- b) Remove all extraneous metals and poor grade dielectric materials from near the circuit under test.
- c) Before making a frequency measurement, adjust the meter reading to halfway up the scale.
- d) When searching for a resonant frequency, tune the GDO from the highest frequency downwards.
- e) Always use the lightest practical coupling between the GDO and the circuit under test for the final reading. Too tight or strong coupling, which is often necessary for initial searches, will cause the GDO frequency to be pulled by the circuit under test. Apart from an inaccurate reading, it causes a 'snap' action of the meter rather than the smooth movement of the pointer in and out of the 'dip slot'.

There are a number of ways of connecting the GDO to the circuit under test. The most common is by placing the coil of the circuit under test parallel to and alongside the GDO coil, i.e. inductive coupling; another method of inductive coupling is by means of a link comprising a couple or so turns at the base of the GDO coil and a similar number of turns at the base of the coil with capacitor under test. Inductive coupling is normally also used for a toroid where one or two link turns on the GDO coil are connected to a turn or two wound through the toroid and capacitor under test. Sometimes if slightly longer leads are used for connection between a toroid and its resonating capacitor, it is sufficient to insert the GDO coil between these leads. Alternatively, capacitive coupling is obtained when the turns of the coil under test are placed at right angles to the coil of the GDO. This is used for high Q circuits and devices. Direct capacitive coupling is obtained by winding a wire say twice around the end of the GDO coil and connecting it to one end of the test circuit coil. This has the effect of connecting about 1 or 2 pF between the 'hot' end of the GDO coil and the circuit under test. This method is mandatory when the test coil is shielded or inaccessible for inductive coupling. The disadvantage is that the small capacity affects the frequency accuracy of the GDO. Usually, inductive coupling is far easier to use as the degree of coupling can be easily adjusted - use a small separation of the coils for a strong initial dip and then increase the separation for a less pronounced dip for the final accurate reading. Having found a dip, it is always sensible to check that the dip is NOT present when there is no coupling to the thing being investigated. Here are some common GDO uses:-

Measuring a choke's self resonant frequency Knowing that a high power linear's anode choke is not resonant in band is rather important! The fundamental frequency at which a choke resonates is a function of its inductance and self capacitance. Thus a choke with its leads unconnected can be regarded as an LC circuit. Some chokes will exhibit several resonances other than the fundamental because of their geometry - often if they have multiple winding sections. To check the various resonances, start with the GDO's highest frequency range plug-in coil. Note the dips which occur as you progress downwards in frequency. Many chokes have a low Q so coupling maybe difficult; coupling can either be axially end on, or alongside, or with a link of a few turns over both coils with the link's ends joined together.

Inductance measurement This is measured indirectly by first finding out the resonant frequency when connected by short leads to a known capacitor. Known capacitors of say 47 pF, 470 pF and 4700 pF, will cover most amateur applications. Use the smaller capacitors for small coils. Place the coil/capacitor combination near the GDO coil and sweep the GDO frequency till a definite dip is found. Note the frequency and work out the inductance from this formula.

$$L(\mu H) = \frac{25,400}{f^2 \times C}$$

f in MHz \propto C in pF. G3DII

Checking mutual inductance The GDO can be used to measure the mutual inductance between two coils. Connect one winding across the known capacitor as above and measure its inductance L1. Disconnect the first coil and then measure the inductance of the other one L2. Then work out the mutual inductance from the formula right. Critical coupling between two identical tuned circuits occurs when the mutual inductance between them is the inductance of either coil divided by its Q.

$$M = \frac{L1 - L2}{4}$$

G3DII

Finding 'sprogs' Most GDOs can also be used as absorption wavemeters. Usually there is a switch which turns off their oscillator action but which still allows them to detect RF currents in a coupled circuit. Turn up the meter for the highest sensitivity. If you suspect there is an unwanted 'sprog' or oscillation (strange hand effects, unpredictable behaviour etc.) they are often at many times the circuit's normal operating frequency. Start sweeping down in frequency starting from the GDOs highest frequency range till you have confirmed there are no unexpected readings. Be aware that, for a working transmitter strip, you should find RF energy at the circuits normal operating frequency with possibly progressively weaker readings for its second, third and maybe fifth harmonics.

Sorting small value capacitors Kit builders often find it difficult to read the value (which was) printed on small ceramic plate capacitors and comparing size/numbers with the parts list isn't conclusive! The solution is to measure the resonant frequency when each is connected in turn to the same inductor. There is no need to know the value of this inductance, unless you actually need the capacitor's value - if so use the formula right. An inductance of a few μ H, say

$$C (\mu F) = \frac{25,400}{f^2 \times L}$$

f in MHz \rightarrow L in μ H
G3DII

10 turns of stiff wire (e.g. 18 gauge) wound on a half inch diameter former, is connected in turn across each capacitor and the resonant frequency noted - using inductive coupling. The higher the resonant frequency, the smaller the capacitor value. Line the capacitors up in a line of increasing frequency along your workbench. Put those with the same frequency close together as it implies the same capacity. Then compare the sequence of capacitors/groups with the kit's parts list.

Audio Signal Generator

In the last Hot Iron I mentioned the possibility of a kit which produces high purity sinewaves based on a clock tuneable switched capacitor filter chip. It is now available for £24 + £1 P & P. There are 3 adjustable ranges covering 250 to 5000 Hz, with two fixed tones of 800 and 1000 Hz which can be output either singly or together for SSB transmitter setting up. Output amplitude is variable in three ranges up to 0.7 volts RMS. PCB size is 50 x 80 mm and it runs off 9 or 12 volts. G3PCJ

2001 Yeovil QRP Convention

Mark your diary now for this event which should be attended by all keen South of England constructors! As recently, it is being held in the Digby Hall at Sherborne on **April 22nd**. There is a full programme of talks, demonstrations, traders, competitions, morse tests and other attractions. There is also a Dinner on the previous evening which is open to all by prior booking with G3CQR who can assist with arrangements for accommodation if required. Do make yourself known to me if you do come - if you are thinking of purchasing a kit, give me a call beforehand to check its in stock.

You still have time to make an entry for the Construction Challenge. You have to build the most sensitive grid dip type oscillator that you can! It has to cover the 3 to 5 MHz range, not using more than two discrete transistors and must obtain the correct frequency to within 100 KHz. The maximum distance at which the operator calls the 'correct' frequency as the instrument approaches the test resonant circuit will be measured. The resonant circuit will be altered between competitors and the resonant frequency revealed after each entrant has had his attempt. Full details from G3CQR.

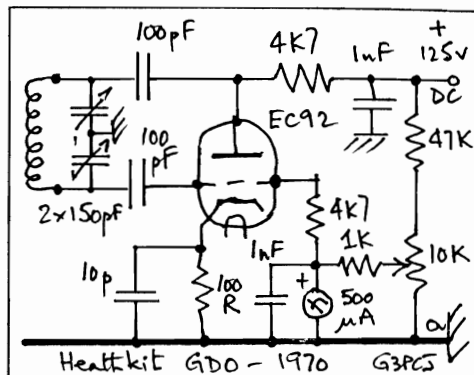
Snippets!

Craig G0HDJ recommends the following website for all sorts of interesting projects on crystal sets and old time radio projects. Some books are available from PW. www.midnightscience.com

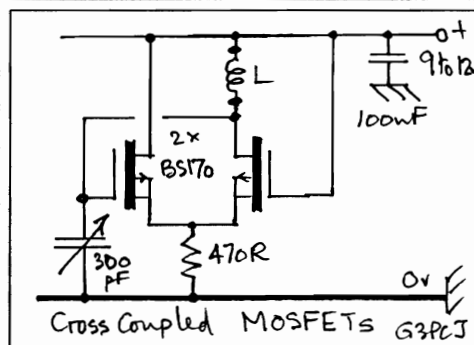
Eric G4ERN recommends doing electronic work on an insulating mouse-mat since it avoids unwanted shorts from offcuts of resistors capacitors etc. He also removes solder from through board holes while it is still molten with a wooden toothpick. They can also be sharpened to adjust TOKO coils.

Oscillators for GDOs

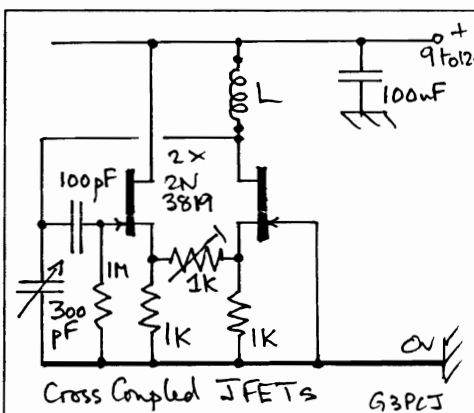
Most GDOs have to cover a very wide frequency range so need several plug-in coils. If these inductors have only two leads, it makes the plug and socket design rather easier! Hence the theme here is oscillators which use untapped inductors. The classic untapped inductor oscillator is the Collpits because the feedback is arranged by 'tapping' of the resonating capacitor. Unless a split stator variable capacitor is used, there has to be at least two fixed capacitors which leads to a limited frequency range for each inductor - hence the Collpits is not often used. (My 1970s valved Heathkit GDO does use the split stator capacitor Collpits scheme shown right!)



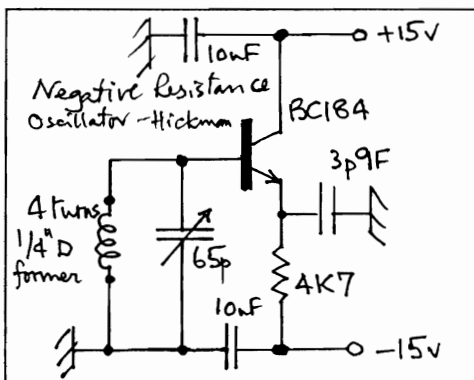
Decades ago Messrs. Franklin and Butler also devised untapped inductor oscillators using a pair of active devices in a differential amplifier configuration. They are variations of the same circuit - a very simple modern form is shown right using two MOSFETs such as the BS170. Owing to the roughly 2 volt positive gate bias requirement of these devices, a very simple differential amplifier can be used, but the relatively high gate capacity of the left hand device across the tuned circuit again limits the capacitance swing hence change in frequency for each range.



The JFET version of this is very satisfactory owing to the lower gate capacitance but it does need a few extra bias parts and a gate 'stopper' to prevent uncontrolled VHF oscillations! The circuit shown right uses a source resistor for each device so that amplifier gain can be controlled by the preset linking the sources so as to adjust RF levels for a meter. With the preset set to zero for strongest oscillation, it is essentially the same as the MOSFET version above. Increase the preset till it stops oscillating and it becomes an absorption wavemeter. A version of this is used in the RF signal generator kit covering 400 KHz to 50 MHz. Another version is given in the Circuit Ideas section of the Feb. 2001 Electronics World, this one has the advantage of also working with a crystal instead of a normal LC tuned circuit.



Another possibility is the negative resistance oscillator right written up by Ian Hickman in the Dec. 2000 Electronics World. I have not tried this out but its advantage is the single active device. In this article, the single emitter capacitor is quoted as being a few pF for an oscillator running over 65 to 165 MHz. I suspect that for operation on lower frequencies, it should be increased. Add a single device meter amplifier and this could be the one for the QRP Convention Challenge! I shall leave that to you!



Snippets!

Paul Tuton found a most interesting website giving information of many different types of capacitor. Have a look at http://www.interq.or.jp/japan/se-inoue/e_capa.htm

While talking to a local computer supplier, he mentioned that after every local thunderstorm, he always receives several modems to repair. As well as earthing your antenna when thunder is about, you should unplug your modem from the phone line, especially if it comes to you on poles. Maybe you should add a set of double pole relay contacts in the phone line, the 240 volt ac coil being powered only when the PC is turned on. It should be a largish one with excellent insulation between coil and the contacts. Make certain the relay frame is mains earthed. G3PCJ

A TALE OF A PAIR OF BRISTOLS

I can recall sitting in my radio shack with my friend Bob having a chat about radio when I suggested that perhaps we should both build a new rig from a kit supplier rather than gloat over the latest offerings from the Orient. To my surprise Bob thought it would be a good idea especially since he liked my six metre radio which was an earlier offering from Walford Electronics. We had decided pretty much at that time that we would build a Walford kit, the question was what to build and how much would it cost. After an e mail or two between myself and Walford Electronics we had decided to build the Bristol but unfortunately this rig was yet to be designed and made available as a kit. Since both Bob and I are B licence holders I must confess that a HF rig was really only useful to us as a receiver however we were also looking for amusement from a constructional point of view. Very early on we both purchased the Porlock six metre transverter with a view for fun on that band. Bob had very little experience in construction so we had to decide on a plan of action so that we both ended up with a working radio. The notion was for me to lead the way by assembling each section ahead of Bob. Surprisingly this worked very well - we took our time, corrected any mistakes and after a month we had the RX working a treat, the TX took a little longer. I had decided on a few minor changes to the kit, more cosmetic than anything else. The open plan construction would be changed to a fully cased rig with a 4 pin mike connector and all sockets etc. are located at the rear of the radio with the digital read out and signal meter both together for easy viewing. The finished result is an uncluttered fascia.

The one electrical mod is the VFO pot which I have changed to a ten turn wire wound. I had found that this type of potentiometer worked well in my six metre rig - in actual fact the Fine tune pot could be omitted. In our case, it is fitted but will be changed for a drive level control at a later date. In truth, the case took as much time to do as building the kit. We wanted very little visible fixings so much so that we assembled a base board to mount the PCBs so no screws are seen on the underside of case. See the photos overleaf.

Fig. 1. Lid removed, two single band cards are fitted although 4 bands can be installed.

Fig. 2. Perhaps a better photo, the main radio PCB is nearest the front fascia, the band cards which are mounted vertically, are plugged into the band card switching PCB, the five digit counter is to the right hand side of the TCVR PCB with the signal meter PCB mounted above the counter. The signal meter is clearly visible mounted in the fascia.

Fig. 3. Front fascia layout, on-off switch is on the right hand side of the case just out of view. This is a black flush mount switch, the 4 pin mike socket is mounted on the left hand side of case and is visible in Fig. 1.

Fig. 4. This is Bob's rig mounted onto the base board.

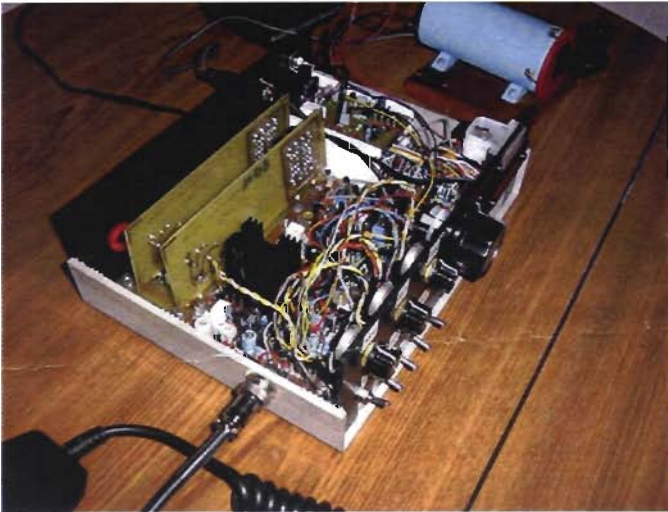
Fig. 5. Again Bob's rig with the base board now fixed to the lower half of the case with the all important constructional Manual as back drop.

By way of interest we have just recently tried some simple VFO stability testing. The rig was set to a predetermined frequency at room temperature, then turned off and left in my shack for 24 hours at sub zero. The rig was then powered up at this low temperature and we found the frequency was still set exactly as we had left it! Raising the temperature to normal in about an hour had no effect on the stability - we were both amazed.

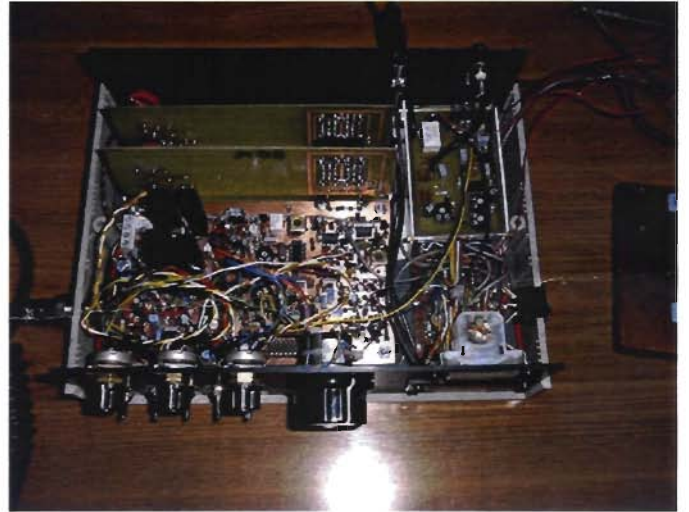
The future - we still have to assemble the Porlock and plan to have a good selection of band cards for both radios.

My thanks go to Tim Walford for allowing me to include this article with Hot Iron. Also my thanks to Bob MICQR for his attention to detail while we were engaged as early builders.

ANDY HOWGATE G7WHM



(Fig 1)



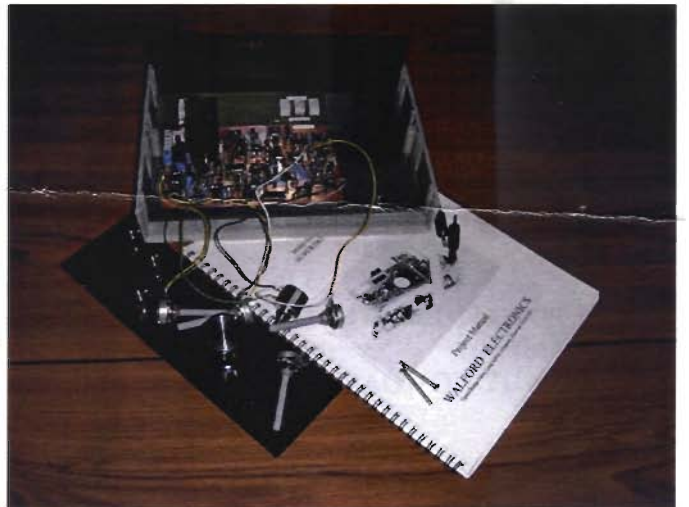
(Fig 2)



(Fig 3)



(Fig 4)



(Fig 5)

Hot Iron

Issue 32

“Journal of the Constructors Club”

Summer 2001



Editorial

Many of you will know that my normal daytime work is farming - both my wife and I have been much touched by the expressions of sympathy and good wishes that many of you have sent over recent weeks following the foot and mouth outbreak. Apart from our arable crops we do have a beef finishing herd (and a few sheep) so have been very concerned that we should not find ourselves affected by this most devastating disease. Although Somerset has had a few cases, the major worry has been the scale of the outbreak in Devon and the chance that it might get transmitted our way. We continue to keep up our precautions and keep all fingers and toes crossed. It has been a nuisance for us, with much extra paperwork and lower sale values, but nothing compared to those who have lost their livestock. Even more badly affected are those mainly rural businesses whose customers have just dried up - there are many of them and there is practically nothing available in the way of help despite what Government says! These are the ones who are really suffering. Although many paths are being opened again, those crossing fields with livestock are quite likely to remain officially closed. Thank you

Contents

- Indicating Dummy Load
- More on GDOs
- High Current Supplies
- 500 KHz maritime CW
- Ni-Cd charger
- Huff and Puff stabiliser
- Several snippets!

very much for your kind wishes and please still keep your fingers crossed!

Kit Developments

Pressure of semi-normal daytime work has kept me away from the electronics ‘laboratory’ but I have been mentally working up a new simple 80m 5 Watt CW DC rig - the **Highbridge**. I am just about to lay out the PCB. It will have a strong commutating mixer as product detector with a Polyvaricon tuned ceramic resonator covering most of the CW section of 80m. It will be in the small upright format and should sell for £39 complete. The TX stages will be digital (like the Chinnock - see last time) and supply voltage will be 9 volts upwards to help keen /P operators. The design should allow operation on other higher frequency bands but it will then have to be crystal controlled as higher frequency ceramic resonators are too prone to temperature induced drift. This is a much improved version of the Wedmore with some features from the Sparkford. The expected price is still lower than it was for the Wedmore! Give me a call if you would like to try an early model.

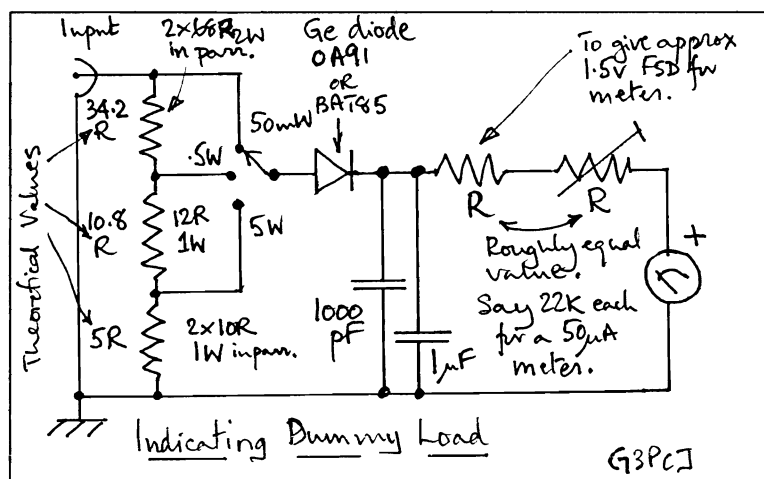
Many of you will have recently seen that Jackson Brothers had a news item in Radcom; they are now owned by Mainline Electronics who have most of the original products available. Always on the lookout for alternatives to varactor diodes to improve frequency stability, I asked about prices for new 150 pF bush mounting ceramic insulated variable C802 style capacitors; they were even worse than I expected at well over £15 + VAT for 100 off! The search for alternatives continues and you should definitely buy any in reasonable condition that you come across at rallies etc.. Sadly I cannot depend on that approach as a source for kit production.

Tim Walford. G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 or e mail walfor@globalnet.co.uk The Walford Electronics website can be seen at www.users.globalnet.co.uk/~walfor The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

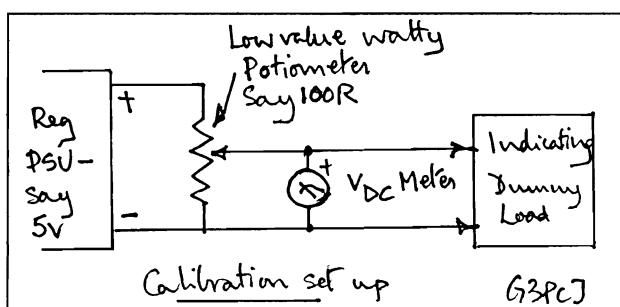
Indicating RF Dummy Load

I make no apology to those of you who have seen this circuit before - its so useful and simple that its worth repeating every few years for newer Members! It is prompted by a Member recalling how he set up CB rigs years ago! It combines the functions of a 5 Watt 50 Ohm dummy load with an output indicator. It has three power ranges, to 50 milliWatts, 0.5 Watts and 5 Watts RMS. The dummy load resistor chain is divided into three so that with the RF voltmeter part of the circuit tapped down the resistor chain, it gives the higher power ranges. Apart from the slightly unusual resistor values, this aspect only needs a three position slide switch! It works from hundreds of KHz to VHF if the layout is good! Since the RF voltmeter is working from a low source impedance it does not require a very sensitive meter, any full scale current up to about 0.5 milliAmp is fine. (The meter series resistor is chosen to give a full scale voltage of about 1.5 volts.) Another advantage is that it can be calibrated with DC from a stable adjustable supply using an accurate DC voltmeter. The meter circuit is simple and can be built on a small tagstrip mounted near the input connector, dummy load resistors and range switch. These latter components should be close together for best high frequency performance - perhaps on the inside of the front panel of a small diecast box together with the meter and RF voltmeter tagstrip.



Having built the circuit, calibrate it as follows. This is dependent on the RF voltmeter actually being a peak reading circuit which will show the same meter reading on DC as the peak of any applied AC voltage - the calibration relies on the applied AC voltage being sinusoidal - if it is not and has harmonics, the indicator may show a higher value corresponding to the tips of the waveform's actual (spiky?) shape. Connect your the dummy load to an adjustable DC supply - perhaps with a low value potentiometer as shown right.

Slowly increase the DC voltage to the dummy load to 2.24 volts and adjust the meter preset for full scale deflection with the slide switch set to the 50 mW range. Mark the scale FSD position 50 mW and or 17 dBm. Then reduce the DC input voltage to the dummy load and make markings on the meter scale as room permits using the lower values in this table. The other ranges will be automatically correct. The



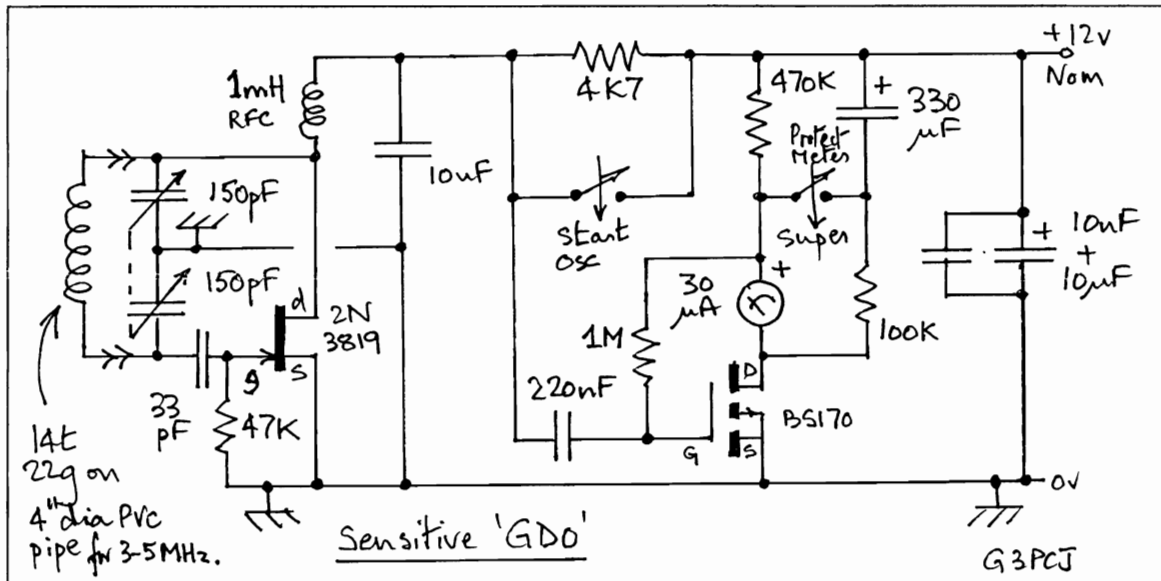
dBm figures are the RMS power (being dissipated) relative to 1 mW (0 dBm) into 50 Ohms. The higher ranges each increase power by a factor of 10 which corresponds to a 10 dB increase giving FSDs of 27 & 37 dBm or 0.5 & 5 Watts. The maths behind the calibration is $V_{DC} = \text{sq.root}(2RP)$, where $R=50$ Ohms & P = power in watts.

Tim G3PCJ

Input DC volts	milliWatts	dBm	Input DC volts	milliWatts	dBm
0.316	1	0.0	1.00	10	10
0.447	2	3.0	1.41	20	13
0.547	3	4.8	1.73	30	14.8
0.707	5	7.0	2.00	40	16
0.836	7	8.5	2.24	50	17

More on Grid Dip Oscillators!

Last time I mentioned the QRP Convention Challenge which was to build the most sensitive GDO. It was won by Peter G3OFX who achieved a distance of 21 cms against the test circuit set to near 4 MHz. For various reasons I felt I should not enter my own offering but it did prove to be pretty sensitive and readers might like to see the circuit. It hardly qualifies as a normal GDO since it has only a limited tuning range but that could be altered with plug-in coils. The starting point is a large oscillator coil for best coupling to the test circuit - I know 4" inch PVC pipe is not very practical but the bigger the better! Thereafter one should also use the oscillator transistor as a DC amplifier; often the meter in a GDO is associated with the gate of the FET (or grid for valves) but measuring the change in standing current through the device will also utilise its DC gain. In this case it is done across the 4K7 drain DC load resistor. (As this resistor is quite large, the device may not burst into oscillation without first shorting this out, hence the start button - alternatively use a lower drain resistor or higher supply.) As the device current often changes appreciably across the oscillator frequency range, the 'indicator' should be AC coupled so that it only shows the sudden change in current as the oscillator frequency sweeps through that of the test circuit. (This requires a slightly different technique of use where the tuning is swept at a constant rate - the indicator will not give a 'dip' if left stationary at the test circuit's frequency.) I tried all of the oscillator circuits mentioned in Hot Iron 31 but this proved the most sensitive and it should have a wide frequency range with suitable coils. The Challenge allowed a second device so I used a BS170 MOSFET as a further amplifier for the low frequency current changes. (The second switch prevents meter damage due to switch on transients.) G3PCJ



Somerset Homebrew Contest

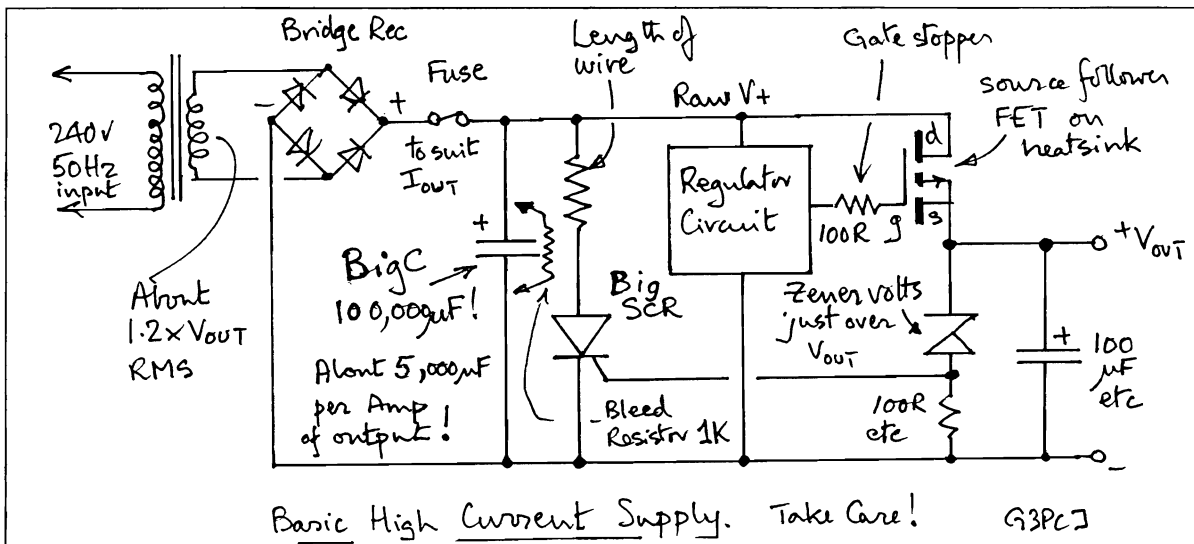
This event was kindly organised by Peter Barville G3XDS of the QRP Club on March 25th. Entrants had to use either a homebrew RX or TX (or both) for 3 hours on 40 or 80m. I pleased to report that Alan Burgess G4GLV won the first prize £50 Walford Electronics voucher using his Bruton TCVR. There were also several other 'brands' of rigs - both kits and completely home designed. Well done Alan and watch out for it again next year. Details will be in Hot Iron and Sprat.

Bristol Frequency Stability

Generally, builders have reported very good frequency stability especially on receive after a few minutes warm up. However, one or two builders have noticed a slow frequency drift after going to transmit. I have searched for a possible cause for this and eliminated all potential culprits except thermal effects! Actual frequency is highly dependent on the varactor tuning supply voltage from the LM317L regulator, these have excellent load and line voltage regulation - much better than the common 78L0X fixed regulators - but output voltage is prone to temperature influences. The 317 regulator is located near the output stage heatsink so is slightly warmed up after going to transmit. I wondered if heat might also be altering the main regulated 9 volt line to the RIT circuit but this is insignificant. The solution is to keep the 317 cool, either with polystyrene insulation between heatsink and regulator as suggested in the Manual, or a fan blowing the heat away from the 317. G3PCJ

High Current Power Supplies

In correspondence with Joseph Bell, G3DII, he mentions the care that should be taken with over voltage protection circuits for high output supplies. His own design had a 100,000 μF reservoir capacitor feeding the regulator stage. This normally holds a lot of energy! (Don't drop your screwdriver across it!) It needs to be discharged quickly in a controlled manner in the event of regulator failure or other causes of excess output voltage. The usual solution is an SCR crowbar circuit across the big capacitor and triggered by an over voltage detector at the output which also blows a protective fuse to prevent things melting. You need to be careful that the when the SCR fires, which you never want to happen anyway, that it does not destroy itself before blowing the fuse! The suggestion is that you should use some thickish wire in series with the SCR's anode to act as a low value resistor. I have sketched the main parts of a simplified supply below.



Joseph also mentioned strange heating effects in his main output device which happened to be a large FET operating as a source follower. It was getting hot when passing a very low output current! FETs have a well known tendency to oscillate (often at UHF) when used as source followers with a capacitive load. (An FET source follower fed from a long time constant used to be used in many computer supply 'reset' circuits until someone twigged this point! I have also spent hours chasing finger sensitive audio filters using source followers for the same reason!) In a power supply situation there is often 10 to 100 μf across the output to provide low output impedance for high frequency load currents which are too fast for the regulator circuit - so everything is there for an oscillator! The cure is simple - add a 100R gate stopper resistor! Older style regulators using bipolar transistor pass devices such as 2N3055s do not suffer from this problem!

Incidentally, recent EU regulations effectively prohibit such simple commercially made supply circuits because they introduce very nasty current spikes in the supply mains on each cycle as the big capacitor charges. Switch mode supplies are designed to avoid this - but they radiate instead! G3PCJ

Contributions!

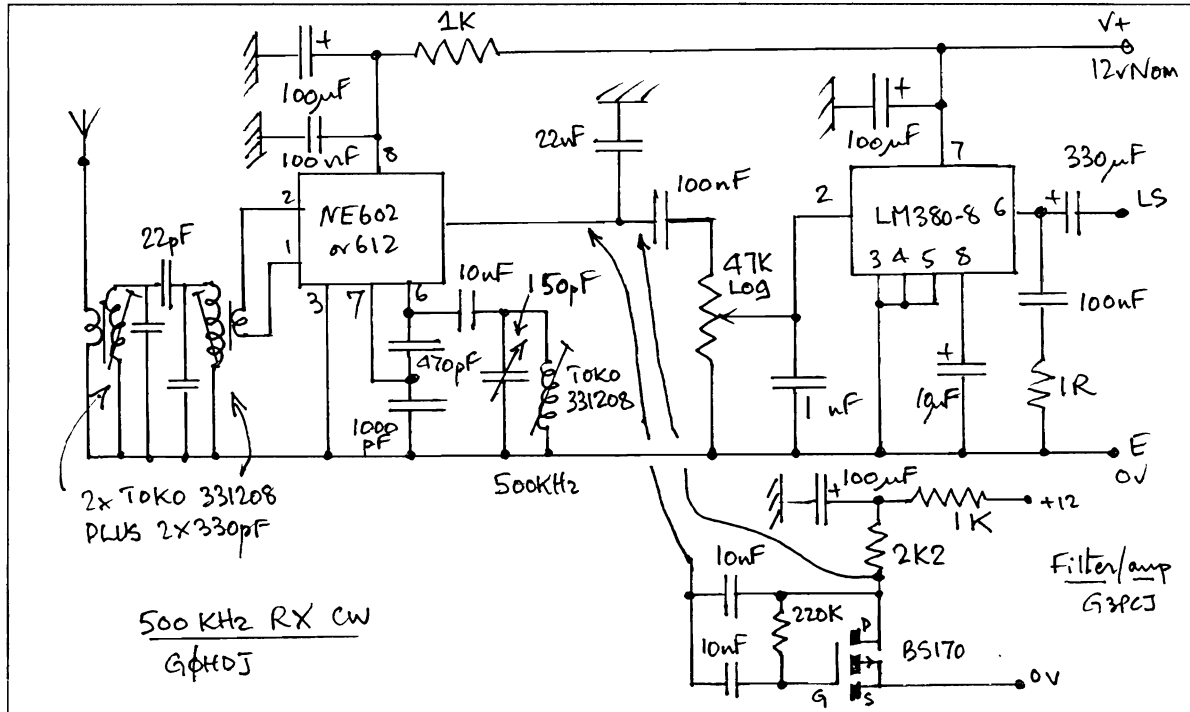
You can have hardly failed to notice that most of this issue is my prose with a few ideas suggested by others! I know you will get tired of this so please get writing! I know many of you do write quite happily because you correspond with me and others who I see occasionally in print elsewhere. Even if you feel unable to do all of an article, I am always pleased to have suggestions or questions because I have great difficulty thinking up new and interesting things!

PME and Radio!

Recently I completed the mains wiring of some barns needing new incoming single phase supplies. I had installed the distribution units with current operated earth leakage trips, known as RCDs; when Western Power came to install the meters etc. the man asked why I was not using PME - protective multiple earthing? I explained that I did not like being dependent on their neutral wire for safety earthing especially if there was any chance of touching mains earth and real earth at the same time. He agreed with my caution - it is especially relevant to radio shacks. Radio and PME don't mix!

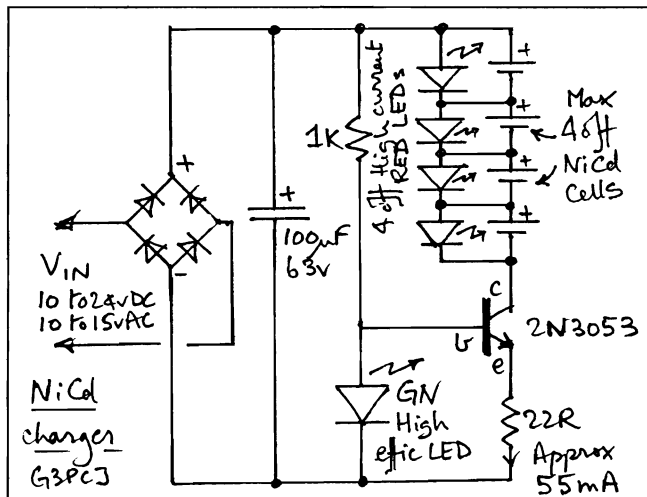
Maritime CW on 500 KHz

Craig Douglas G0H DJ sent me details of a simple receiver for this band based on the Sudden concept. The circuit below is his with a few minor alterations. It is a simple direct conversion receiver using the oscillator section of the NE602/612 mixer chip actually as an oscillator, followed by an audio output power amplifier stage with a voltage gain of 50. So overall it is not a particularly sensitive receiver but with a long wire antenna it should be able to find the maritime beacons and other signals near 500 KHz. If you want more sensitivity, you can add an RF amp or, perhaps more easily, an extra audio stage before the AF gain control as sketched in the corner. This arranged as a CW filter because the RX is also bit short on selectivity!



Nickel Cadmium Cell Charger

The circuit shown right can be used to charge any number of AA sized cells up to four. The green LED shows the supply is on and also acts as a simple zener diode for the constant current source. The red LEDs go out when a flat cell is inserted and tend to glow slightly when the cell is charged or shine fully when a cell is absent. The red LEDs will go out when the cell is inserted either way round so do get the polarity correct! You do not need to short out missing cells. The use of a bridge rectifier plus smoothing capacitor at the input means it can operate off AC or either polarity DC quite safely! I found this circuit invaluable for charging walkman batteries for the kids when doing long car trips abroad! G3PCJ

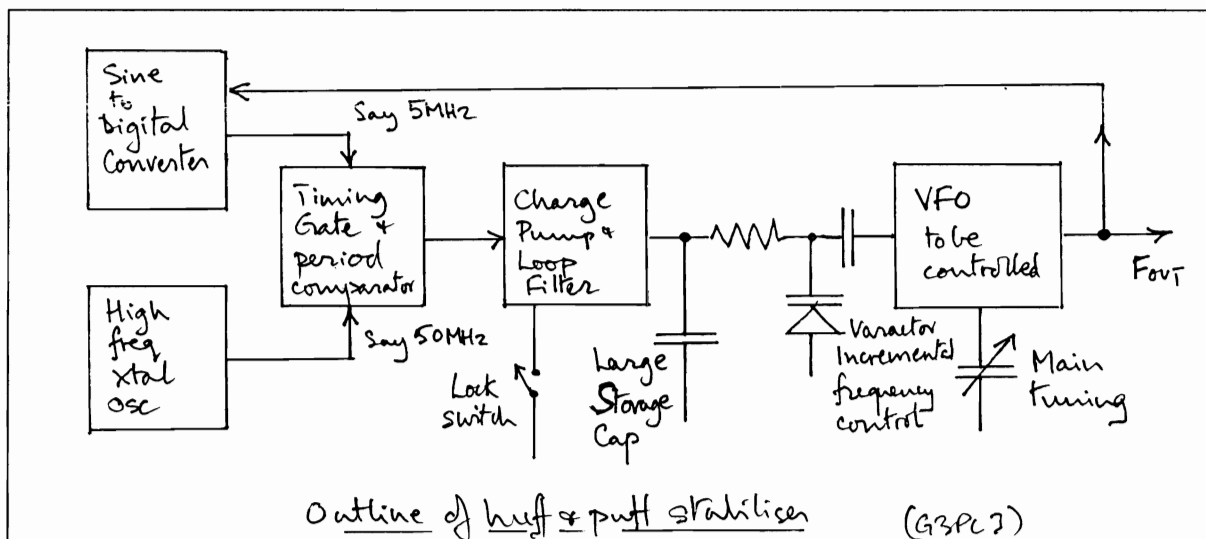


Subscriptions!

Yes, I am afraid its that time of year again. Assuming you wish to continue receiving Hot Iron, let me have your cheque for £6 please by Sept. 1st please. If you are like me and inclined to forget such deadlines, its as well to do it while fresh in the memory - i.e. now! You only need send me the cheque and your name and address. Don't forget to include any questions or articles etc. - preferably by e mail to walfor@globalnet.co.uk Don't worry about polishing up the final version - I can do that!

Huff and Puff Stabilisers

David Proctor G0UTF asks me to explain this concept. What a question - its far too difficult and I am not sure I fully understand it anyway! However - here goes! It is the slang name given to a relatively simple circuit used to stabilise the frequency of a conventional free running VFO. Although it uses the negative feedback principle it is not as complicated as phase locked loops. It was made practical by a Dutch Ham a few years back and has been the subject of several articles in Radcom's Technical Topics series. Our member Derek Alexander G4GVM uses a recent version with his Yeovil's 5 to 5.5 MHz VFO. It is not easy to explain but I think it helps to regard the circuit as being similar to a frequency counter but without the displays! It is a lot simpler too! I don't have a full circuit that I can sensibly include here so I will only describe the general concepts. In a conventional frequency counter, a relatively long period reference timing waveform (often divided down from a crystal) opens a gate for a defined period during which the counter counts up (and then displays) the number of cycles of the unknown signal. For example, a simple 5 digit counter using a gate open period of 1 mS would have a least significant digit showing the KHz of the incoming signal with a maximum of 99.999 MHz. (Beware that often a prescaler is used to increase the upper frequency limit requiring a longer gate period for the same resolution - my 5 digit counter uses a divide by 10 prescaler and a gate period of 10 mS.) For very low frequency signals the process is reversed to measure the period of the unknown (and then calculate the reciprocal to determine the frequency). In such situations, the counter instead measures the number of cycles of the accurate reference which occur during the much longer period of the unknown. For example, the reference might be at 1 KHz so that five digits would give a maximum period of 99999 milliseconds for which the reciprocal gives a frequency (lowest) of 0.01 Hz. It is perfectly feasible to compare the displayed unknown period with a desired value and apply a correction to the VFO being measured - this can be done manually or electronically with a device which compares the measured and desired values and then alters the VFO tuning in the direction to make the values equal. The Huff and Puff stabiliser shown in block diagram form below operates in a similar manner but without the displays.



In this arrangement the high frequency crystal reference is used to 'measure' the period of the desired VFO output - however, only the least significant digit of the counter is present - the slower more significant digits of the counter are missing as they are not needed. If the frequency drifts up (say), the output of the single bit comparator will become a logic 1 more often which is arranged to drive the VFO down by means of the long time constant filter connected to the varactor diode. If the frequency goes down, the comparator output will spend more time being a logic 0 so that the control circuit tries to bring the frequency back up. When the frequency is spot on, the comparator spends an equal time at logic 1 and at logic 0 so that the net effect is zero. An actual huff and puff circuit uses at least a crystal oscillator, a couple or more digital chips, a few transistors and an op-amp. The frequency control range of the varactor is usually quite small and the oscillator has to have good short term stability so that they invariably depend on air variable capacitor main tuning. Quite often the circuits need to settle for a minute before they can be turned on with a 'lock' switch. It is also quite difficult to make them change often and suddenly between two defined frequencies such as is required of the LO in generating the 800 Hz offset in a CW transceiver. Injecting a keyed CW tone into a phone rig avoids this problem. Derek - is this about right? Tim G3PCJ

Hot Iron

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Autumn 2001



Editorial

I should be harvesting now but it is raining fairly steadily and that will keep the combine in the shed for 2 days at least so I had better start on this issue, the first Hot Iron of the new subscription year. Many thanks to all of you regulars who have renewed for several years now. Days like this are good for pondering new ideas for kits or projects but increasingly I find that designing down to a price bracket is impairing what I think is good value for money. In real terms, the price of factory made kit is lower than ever, and it makes it unattractive to spend say half the cost of a new 100 Watt all band rig on a well equipped upmarket kit - but this doesn't acknowledge the real pleasure of operating home built gear! Hoping that price is not everything for my customers I shall not attempt to duplicate the very simple and low performance designs that appear from time to time. As in most walks of life, you get what you pay for! For kits, the basic hardware and PCB - even in my 'open' style of construction - usually account for well over half the costs so adding a few extra parts or stages only increases the price by a smallish amount. I know that many builders have great pleasure from using extremely simple rigs

but seldom can they seriously compete under difficult conditions so I think my efforts should be directed further up the complexity scale while still pursuing performance for cost considerations. Do please tell me what you think and what you would like to build which is not currently available from any supplier. I have great difficulty deciding what sort of rigs are best/wanted in this middle ground!

Kit Developments

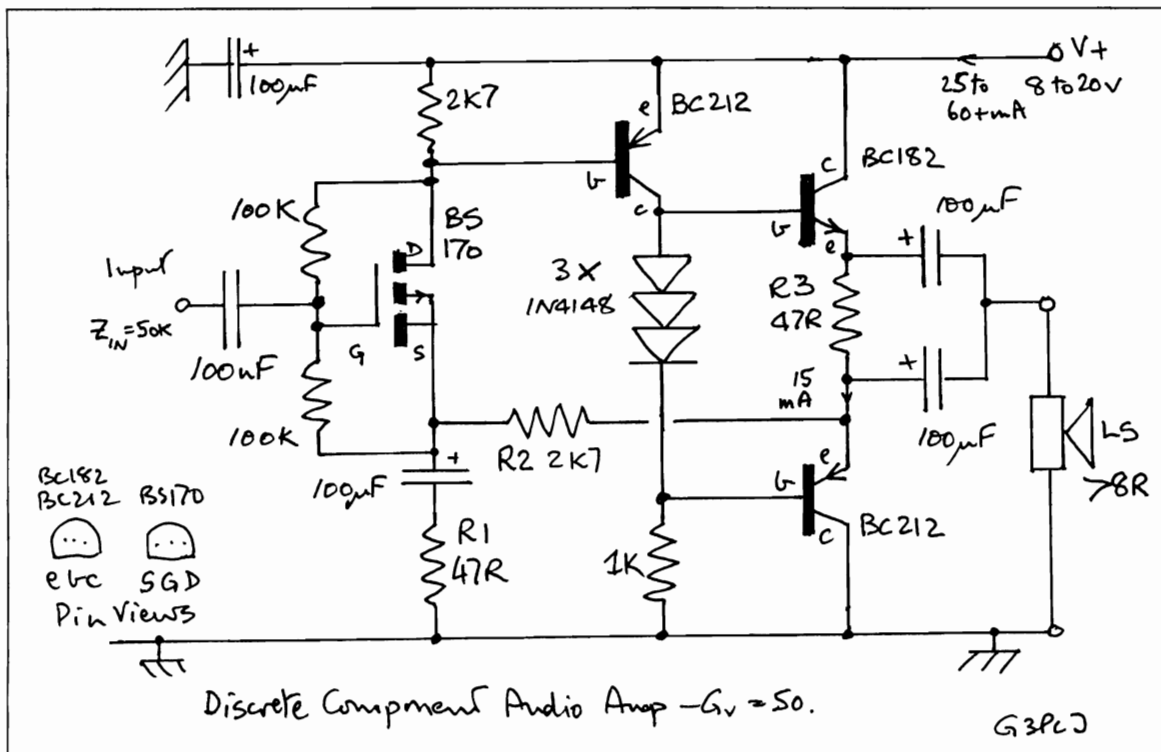
The first **Highbridge** CW TCVR is now working well but has needed extensive modifications to get the mixer and ceramic resonator VFO right. It is designed for 80m in its simplest form but, with a mixer kit for the VFO, it should perform equally well up to 20m. It runs on 8 volts upwards, with good sensitivity, so is suitable for /P operation and produces 5 Watts on 13.8 volts. It has full break-in operation, low pass RF filters, sidetone etc.. The main audio filters are bandpass fifth order centred on 750 Hz for CW, with output for phones or LS. It has Polyvaricon tuning of the ceramic resonator pullable VFO; the prototype will cover all of the CW section but that makes tuning very critical so it is usually restricted to near 3.56 MHz. The kit includes all parts for the 'small open style format'. I have altered the track masters and text so would like to have a few early builders. Anyone interested? Normal price will be £44 but only £39 (plus £1 P & P) for the early birds!

Other projects being considered are a 20, 40, 80m regen TRF and matching 1.5 Watt CW TX and an improved single band DC RX. What about DSB phone transmitters? Tim Walford. G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 or e mail walfor@globalnet.co.uk The Walford Electronics website can be seen at www.users.globalnet.co.uk/~walfor The Copyright of all material published in Hot Iron is retained by TRN Walford. ©. Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

Discrete Loud Speaker Driver

A future project needs an output stage capable of driving a loud speaker but to be in keeping with the rest of the rig, it has to avoid using an IC. The traditional approach is to use a transformer to drive the low loud speaker impedance from the relatively high output impedance of an amplifying stage - but they are expensive, bulky and difficult to mount! A Class A design would draw an undesired heavy standing current so it has to be two output transistors operating in nearly Class B. Often an audio amplifier is arranged as a low level voltage amplifying stage(s) driving a 'unity' voltage gain 'totem-pole' emitter follower output stage consisting of a pair of npn and pnp devices working in near Class B. A small standing current through these devices reduces cross-over distortion, which occurs during the signal 'zero-crossing' when one polarity of device takes over supplying the load current from the other polarity device - it is also dependent on their finite base to emitter voltage. The higher the standing current, the less the cross-over distortion because the stage is increasingly acting in Class A where ultimately the standing current would be at least as large as the peak signal current. Apart from flattening the battery more quickly, a high standing current will require bigger (expensive) devices and heatsinks (even more expensive!); thermal runaway also needs consideration to prevent the heat changing the bias conditions in a manner which increases the dissipation! The usual arrangement for setting this small standing current through the output devices is an extra 'Vbe' multiplying transistor and a preset at their bases. Instead I have used three silicon diodes to set the voltage between the bases of the output transistors so that a single resistor between their emitters can define the current. Two capacitors then couple out to the load. The rest of the scheme (below) uses a MOSFET input stage for high input impedance and easier biasing. This drives the second voltage amplifying pnp stage. The whole is enveloped in negative feedback to stabilise the DC operating conditions and determine overall voltage gain. It is insensitive to changes in supply voltage between 8 and 20. The centre of the 'totem-pole' settles at about 5 volts below the supply voltage. The open loop voltage gain is over 500 but the closed loop gain (as drawn) is reduced to about 50 (determined by the ratio of R2 divided by R1) to help minimise distortion etc. It produces 0.2 Watts RMS into 8 Ohms on 13.8 volts drawing 60 mAmps without any heatsinks which is enough for most applications. No signal supply current is about 25 mAmps. For medium impedance series connected walkman type phone use, R3 can be doubled for a saving of about 7 mAmps. Halving R3 will increase no signal supply current to about 35 mAmps but with less distortion at full output. Its cheaper than a LM380 with its associated components but it does use more board space! G3PCJ

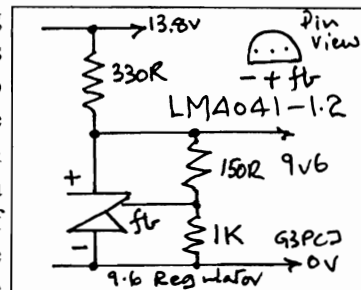


Spares!

Don't hesitate to ask if you need any spares; I have them for nearly all rigs ever sold! Payment is easiest by first class stamps for small orders. Please let me know your needs - preferably by e mail.

Bristol Updates

Drift on transmit Tests have now pinned this down to warming of the 317 regulator by the heatsink in those rigs where there is inadequate cooling or lack of insulation between them. I have also tried out using a temperature compensated reference diode successfully. Circuit alongside. You can either add this circuit or even repeat the existing 9v6 regulator using another 317L located in a cooler spot. The easiest things to do if you wish to include either of these modifications, is to leave the rig PCB unchanged and feed the main tuning control alone from this new supply instead of from the rig's 9.6 volts. I have some of the reference chips (or extra 317Ls) at 50p plus 50p postage in stamps.



Supply range A reluctance to work properly on over 15 volts on transmit is due to restricted bias conditions around TR306/7/8. I regret there is no easy cure except to stick to under 14.5 volts! If you wish to reduce the *minimum* voltage that the rig will work on, place 10K in parallel with R122.

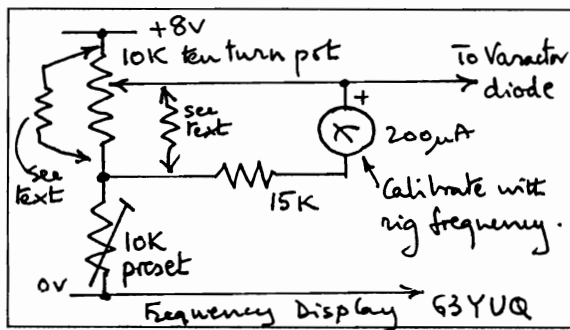
Birdies! Page 12 of the Manual mentions the birdy from the SCF clock, experience suggests that a little careful shielding of the clock generator chip IC110 helps - try a little insulated foil.

AGC time constant If you wish the hold, or hang time, to be a little longer so that the AGC pumps less aggressively between gaps in sentences, you can try doubling C110 to say 22 μ F.

Use on 6m! Andy Howgate has had his on 6m with a special band card. RX was all right (I think!) but RF output was low - as expected. Not sure how low but my guess is about a Watt output! More tests are planned later. G3PCJ

Single Control Varicap Tuning Display

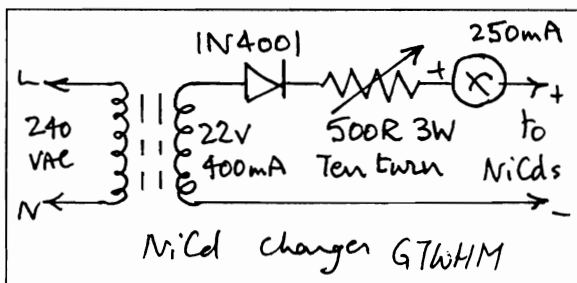
This scheme has been forwarded by Eric Elsley G3YUQ who devised it for his Bruton but it could be used on any Somerset Range rig with varactor tuning. He has changed the Coarse tuning pot for a ten turn type, without any Fine pot, so had to devise a means of showing frequency. He did this quite easily with a sensitive moving coil meter and appropriate resistors. The meter is calibrated afterwards and should not be less than about 200



micro-amps with a series resistor of about 15K to avoid seriously loading the 10K ten turn pot. A lower value will work but it will upset the frequency calibration more. For the LF VFO end, the meter will always read zero; for the HF end the meter series resistor can be adjusted (perhaps with a preset) to give full scale. Eric restricted the band coverage by placing an extra resistor across the ten turn pot - an alternative approach is the tune the associated VFO TOKO core for the VFO HF end, with the ten turn pot set for its most positive output, and then crank the 10 turn pot to the LF negative end and adjust the VFO LF end with the 10K preset. Adjust the meter series resistor to give FSD at the HF end and calibrate the meter using a counter measuring rig transmit frequency. The settings will be interdependent so there is a little trial and error required. You can add a resistor from the pot slider to its negative end, to shift the VFO central section down in frequency without affecting the end stops.

Charging Nickel Cadmium cells

Andy Howgate found out the hard way that the cheap NiCd chargers that come with many products from radios to power tools leave much to be desired. The most common fault is that they charge far too quickly and cook the cells. He suggests that you break open one of the larger 13 Amp plug type chargers and salvage the transformer, then couple it to just three other parts! The ten turn pot does need to be rated at 3 watts or more and the meter is essential for setting the charging current. He used a cheap multi-meter mounted on a box containing the transformer, pot and rectifier. The important point is that the charging current in Amps should be one tenth of the cell(s) amp-hour rating. If everything were ideal it would be charged in 10 hours, however because there are losses, you should increase the charge current or time by 10% to make sure they are fully charged. This scheme will work with either single or multiple cell battery packs. Its a good habit to set the resistor high after each charge to prevent damage on the next cell!

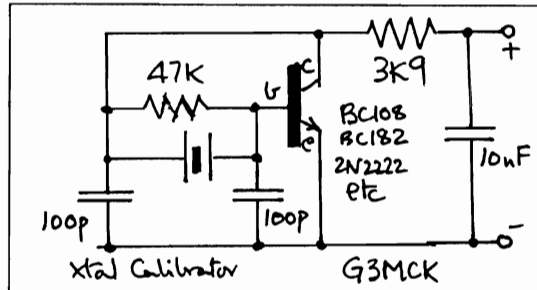


A trivial project to encourage very new constructors!

(I am delighted to welcome Gerald Stancey, G3MCK, as a new contributor - he warned me that this article would be too simple but I think it is just right! Ed)

This project is trivial but useful. It does not take much skill, time, or money so it is a good thing for the novice constructor to cut his teeth on. Please note that when I say his, I also mean her as I believe lady amateurs are honorary chaps. If that upsets you that is your problem not mine. PC does not exist in my QTH, the XYL doesn't allow it.

Now back to radio which is where we started. Anyone who plays about with receivers has the need for some sort of signal generator. Such a device will tell you that the receiver is working, that it is receiving on a particular frequency and it also gives you some idea of how well the receiver is working. Signal generators come in many shapes and sizes varying from the ridiculous to the sublime. This project falls into the first category. The circuit diagram right shows a simple oscillator that can be run from a 9 volt battery or a 13.8 volt PSU. You can build it in any way you want, from ugly construction to perf board. Etched PCB is far too complex but veroboard is a good bet. The choice is yours.



There are no hard to find bits. Crystals can either be bought for the job, the QRP frequencies are readily available or for the more financially challenged, the colour TV crystals on 3579.4 KHz can often be yours for the asking. At most rallies it is possible to buy crystals for pence. These may appear to be useless frequencies but a handful of non-amateur frequencies can be helpful when making general coverage receivers. Also near and non-favoured frequencies in the amateur bands can sometimes be found; for example at the Yeovil QRP Convention I bought a 3596 KHz crystal, in the band but not much use for transmitting and a 3484 KHz crystal, which is OK for setting the low band edge of a receiver.

Just wire up the oscillator, apply power and drape a bit of wire from the receiver aerial terminal over the unit. When the receiver is tuned to the appropriate frequency, you will hear a loud clear signal. The signal strength depends on how tightly you couple the receiver to the oscillator. Check the strength on a known receiver, then substitute your home brew receiver and see how it compares for gain. This is a bit iffy but at least it does give you some idea.

Next issue, we will look at boxing the unit, getting consistent output and attenuators, all simple kitchen table stuff and no maths.
Gerald G3MCK

Post article note!

Member David Proctor G0UTF has asked about inductance and capacitance values to pull crystals; since I think this follows on from Gerald's note I have asked him to address this topic at some time in the future.

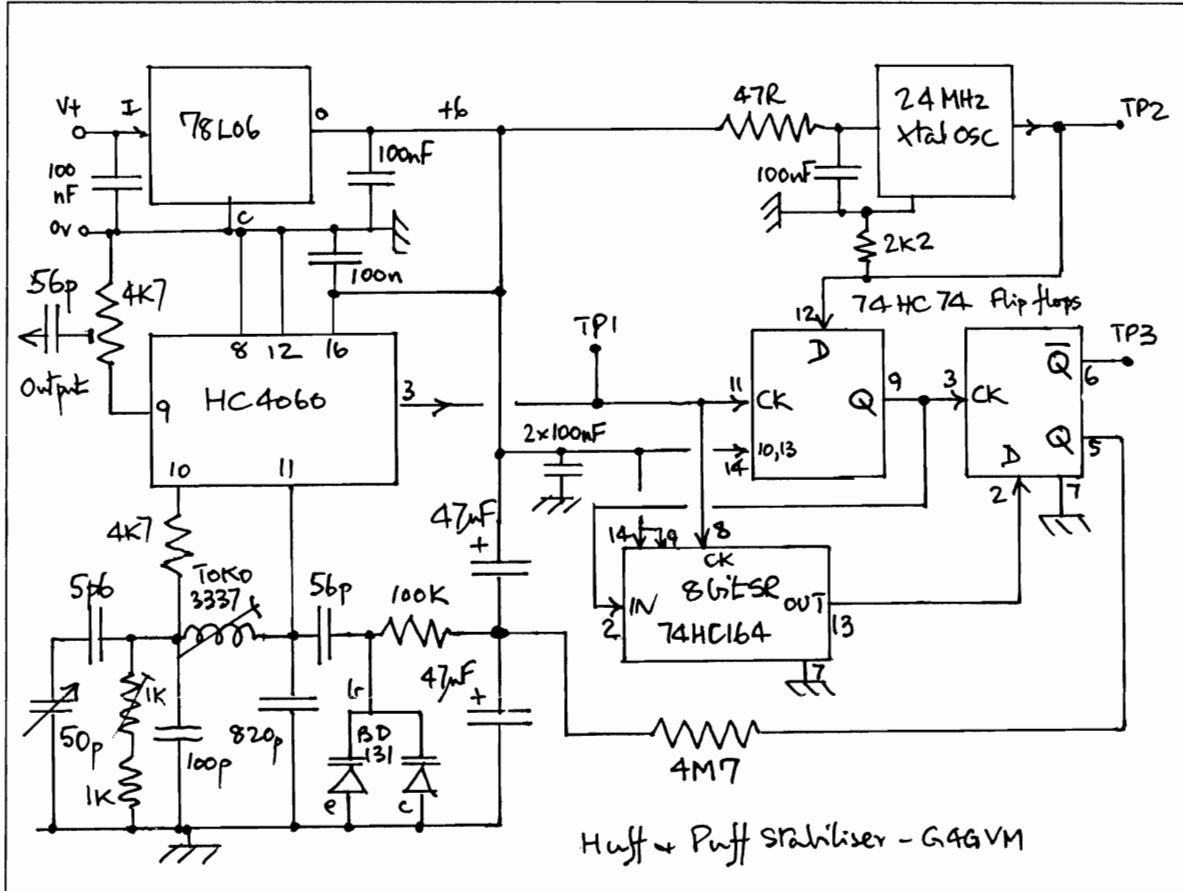
In the meantime, I offer the practical comment that *ceramic resonators* can be pulled very much farther in frequency than crystals due to their lower Q - in thousands as opposed to perhaps up to 100,000 for a good crystal. Most common ceramic resonators, such as those for 3582 KHz are designed for a 30 pF parallel load capacitance from the rest of the circuit. Increasing this capacitance can pull them a long way down! They have a wide initial tolerance (0.5%) but will often go down to 3500 KHz with around 150 pF across them. They are very cheap and great for experimenting - they will work in the above circuit! Their drawback is relatively poor temperature stability. This effect gets worse as the operating frequency increases - however they are quite useable for most purposes on 80m with shortish QSOs and the necessity to retune from time to time to find new stations.

Mixer kit

An interesting possibility arising from the above is to use a 4 MHz ceramic resonator VXO, mixed with a 11 or 18 MHz crystal to provide a LO output for a DC rig on 40 or 20m. I have laid out a versatile new **Mixer** kit to do just this - it has many advantages over a VFO running at transmit frequency because it prohibits chirp and is likely to be much more stable. The design also allows for it to act as a *receiving converter* for one or two bands under relay control. If the same crystal can be used for both bands, eg. 20 and 40m converted to 80m, then not even the relay is required! The flexibility is achieved by permitting the double tuned RF bandpass filters to be connected either, in front of the mixer for a converter, or after it for a mixing VFO scheme. Size is 53 x 100 mm, supply 8 to 18 volts.

Huff and Puff Frequency Stabiliser by Derek Alexander G4GVM

The name derives from the operating sounds made by the constant speed governor system used on steam engines in Victorian textile factories. Decreasing shaft speed caused the governor to open the steam valve more so increasing speed and vice-versa. This form of negative feedback is applied to the VFO frequency control voltage by a device which assesses changes in frequency by comparing it with a crystal based reference frequency. The idea was first suggested by Klaas Spaargaren PA0KSB in 1973 but has since been simplified, notably by Charles Fletcher G3DXZ, who has published notes in RadCom from 1996 onwards. It is still developing and the circuit below is my latest version. As a matter of principle, I use a dedicated 6 volt regulator to feed this system.



VFO & Divider chain Most chips with built in oscillators are for crystals rather than for VFOs; the 4060 can use either or you can use its oscillator gate as a buffer driven from an external VFO. I have been unable to make varactor main tuning work so I use an air variable capacitor with a 3337 TOKO coil for a nominal 5 to 5.5 MHz VFO. The 4060 has a divider chain arranged to produce the A output (TP1) at about 300 Hz for mid VFO frequency. Extra dividers are needed for higher frequency VFOs.

Crystal Ref Oscillator The other input component is the crystal frequency reference B (TP2) against which the VFO is compared. The reference frequency should be as high as possible (over 20 MHz) and is most easily provided by a crystal oscillator IC. They need 5 volts so a supply dropper is used.

Comparator This uses a HC7474 dual D flip-flop and a HC164 shift register. The A divider output is fed to the clock input of the first flip-flop and that of the shift register. The first flip-flop Q output feeds the clock input of the second flip-flop and the serial input of the shift register. The delayed output of the shift register feeds the D input of the second flip-flop whose Q output feeds the integrator via 4M7. The Q bar output (TP3) has a frequency which jumps around from 0 to 20 Hz.

Integrator The integrator 'capacitor' stores the mean voltage controlling the capacitance of the varactor diode; the voltage is nudged up or down by the pattern of pulses from comparator circuit. Two capacitors are actually used so that at switch on, the control voltage rises automatically to mid supply. Using a 6 volt supply provides a larger maximum control or capacitance range for dealing with drift in the VFO. An effective substitute for rare varactors like the BB212 is to use a reverse connected BD131. The desired scaling is about 4 KHz per volt giving 12 KHz either side of the starting point. This can be adjusted by varying the value of the small capacitor linking to the VFO from the varactor.

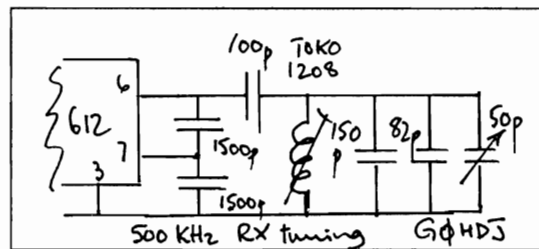
Notes - pros and cons The accuracy is astounding. On mine, for 10 minutes after switch on it drifts some 6 or 7 Hz, then not at all in the next 6 hours before I stopped measuring! At switch on, the frequency will be within a couple of KHz of that at the previous close down, due to drift correction during the previous use. The system locks up at intervals of 10 Hz and cannot be set in between. This is quite good enough for copying SSB. The interval is dependent on the frequency of the reference oscillator; the interval can be reduced by using a higher crystal reference up to 40 MHz maximum when loop instability problems arise. The test point values are not rigid but give a good guide as to what to expect.

You can use IC holders which eases the layout and facilitates changing chips. I have done a track layout etc. which is available from me. Best of luck, Derek!

500 KHz Receiver Tuning Range

Craig Douglas G0HDJ has found that a reduced VFO range is desirable for the receiver that he outlined in the last Hot Iron. The revised circuit is alongside and now covers 485 to 520 KHz. He has yet to hear any CQD calls!

Craig also asks about coupled resonant circuits, so here follows a little light maths!



Coupled Resonant Circuits

Two resonant circuits, usually in the parallel format, can be coupled by either a 'top' capacity between the hot ends of the resonators or a 'bottom' inductor between the two inductors as shown right. The size of the coupling components is determined by the desired bandwidth for the circuit. The bandwidth B_w is defined as the difference in frequency between the points where the response is 3 dB down. The resonant frequency F_0 of each resonator is given by the familiar formula:-

$$F_0 = \frac{1}{2\pi\sqrt{LC}}$$

The loaded Q of the whole circuit is then:-

$$Q_L = F_0/B_w$$

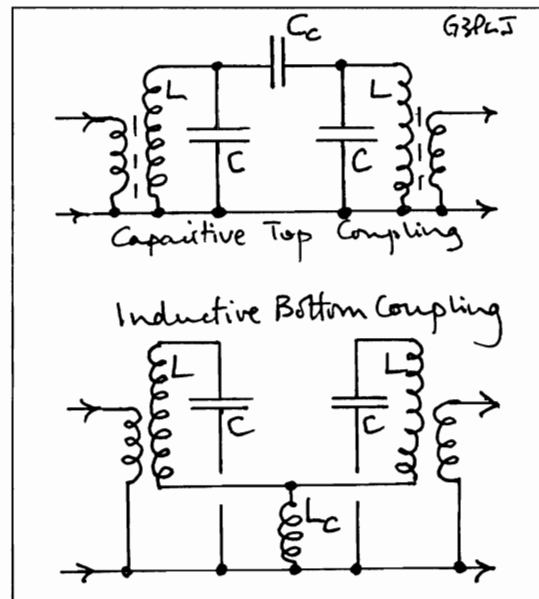
For an identical pair of capacitively top coupled resonators, the small coupling capacitor required to achieve this Q is related to the resonating capacitor by:-

$$C_c = \frac{C}{\sqrt{2} Q_L}$$

Similarly for bottom coupled resonators, the small coupling inductor is related to the main inductors by:-

$$L_c = \frac{L}{\sqrt{2} Q_L}$$

As a very rough rule of thumb, for most amateur band use, these coupling components should be about one twentieth of the either the resonating capacitor or inductor. The circuits above have been drawn for inductive link input and output connections; they could alternatively be done by either capacitive or inductive tapping but in all cases the source or load impedance of the outside circuits must not seriously load or degrade the Q of each resonator. (This is all actually a bit simplistic but is a good basis for experimentation!) G3PCJ



Finally, I must apologise for this issue coming out a little late - its been poor harvesting weather!

Hot Iron

Issue 34

“Journal of the Constructors Club”

Winter 2001



Editorial

Since last time the Radio Authority's proposals for the new Foundation Licence have been published together with the so called 'road map' towards a new structure for all amateur radio licences. I welcome the intention to simplify the overall structure by having three grades in the longer term; if I understand it correctly, they will be the Foundation, the Intermediate based on the current Novice concepts and the Full Licence. There have been many critical comments that morse should no longer be an entry requirement but just at the present, the UK Government cannot totally remove this condition as they are limited by existing International Regulations; in the meantime they have indicated their desire to move in this general direction. The RA have also taken on board the wisdom of a more practical approach to gaining the various certificates - the syllabus for the Foundation Licence includes such things as operating techniques and the Novice Licence already requires some simple equipment construction. In my own recent discussions with the RA, they have indicated their desire to encourage practical equipment building and they expect to be undertaking some sort of 'badging' process to indicate suitable equipment. This has to be welcomed by all concerned but just how it will work and be incorporated in the limited time available for each syllabus remains to be seen! The Foundation Licence course is supposed to be completed in about 10 to 12 hours. I will keep you informed!

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Kit Developments

Its been a hectic few weeks with many new developments, which I have just incorporated into the latest sales leaflet. (Send me a SSAE if you want a copy - at the time of writing I have yet to update the website.) I am getting good reports from the early **Highbridge** 80m CW TCVR builders and the version using the additional Mixer kit for 20 or 40m is also proven. The 80m version costs £44 or £64 for 20/40m. I have also introduced the **Wurzel** which is a 20/40/80m regenerative TRF RX with restricted range Polyvaricon tuning for ease of use. It is supplied with all hardware for small upright format at £37. The next introduction is the **Compton** DC RX for 80m using two switch selected ceramic resonators for the bottom of the SSB section or the top of the CW section. It has switch selectable phone and CW audio filters with drive for a loud speaker. This is an easy to set up RX capable of serious use. Again it comes with all hardware for the small open upright format and costs £39. The Compton can also take the Mixer kit (£20) as a receive converter to add 20 and 40m CW; it can alternatively take the Mixer kit (still £20!) to convert it for 80m CW superhet operation! All these RXs can work with the 1.5 Watt **Dundon** 'crystal' controlled CW transmitter which has semi break-in antenna changeover included for £19 or for £24 if it is to work on 20, 40 and 80m!

Plenty there for you to build! All the best for Christmas, Tim Walford G3PCJ, Editor

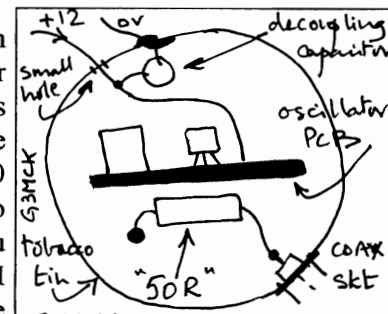
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A Useful Crystal Oscillator - Part 2

In the last issue I described how to make a simple crystal oscillator that could be used to provide a signal when checking out a receiver. However one drawback was that the strength of the signal you detected was a bit iffy. This issue's project shows how to overcome this drawback.

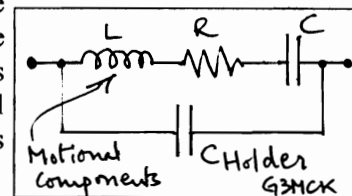
First of all put the oscillator in a metal box. Anything will do but a tobacco tin is great as they are cheap and you can solder to them. Solder the oscillator to the tin, a piece of 16 SWG wire is all that is necessary. Drill a small hole to take the DC input wire; if you want to do a better job, bypass the lead at the hole, 0.01 mF (10 nF) will do, or better still use the biggest feed-through capacitor that you have and put a 1K resistor between the feed-through and the oscillator board. Mount a coax socket and solder a 50R resistor from its pin to earth. You won't have a 50R resistor in your junk box and neither did I so use anything in the range 47 to 56 Ohms; this is real ham radio. Align the body of the resistor parallel to the oscillator board about 1/2 inch away from it. See right.

You now have made a signal generator that has a 50 Ohm output impedance and an output level that is the same for all your rigs. From experience I have found that I get S9 +/- 10 dB from this sort of set up. S9 being 50 micro-volts PD across 50 Ohms. The level can be altered slightly by changing the spacing between the 50 Ohm resistor and the oscillator board. If you can find someone who can calibrate it for you, so much the better. If not, then at least you have your own standard for comparison purposes. At this point, I was going to say something about attenuators but Tim requested me to write on pulling crystals!

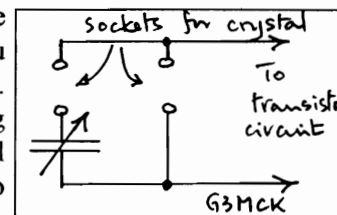


Pulling Crystals or VXOs

First of all, let me say this is a black art. Theory is useful but in the end it is suck it and see. There is also an attitude problem to face. Do you want to make a crystal behave like a VFO or do you just want to be able to dodge a bit of QRM? If the latter, you are more likely to be pleased with your VXO. Now to some theory. A crystal is a very stable high Q device, that is why they are used for providing high stability frequency control. When we pull them we degrade their performance, only an amateur would want to do this! Electrically they can be represented by the simple circuit right. In a crystal oscillator the circuit elements within the crystal provide the major frequency determining elements. However external reactance does have some effect and it is by changing these external reactances that a crystal can be pulled. Crystals can be resonated in either parallel or series mode. As most amateur circuits use the series mode, this is what I shall consider.



Firstly, putting capacity in series with the crystal will raise the frequency. I find that a 50 to 100 pF variable is a good value. Once you get to a certain maximum value there is no further pulling. At low values the oscillator may stop. In this case either remember that this happens or put a small capacitor, say 2p2, across the variable. Adding a second crystal socket as shown right can sometimes give a slightly lower frequency than can be obtained from the one with the capacitor. The amount of shift that you will get is unpredictable. Large crystals, like 10X, seem to give zero shift. Small crystals are best and I have got from 1 to 3 KHz at 3.5 MHz using miniature crystals in the same circuit. It depends on the cut of the crystal and exactly how it is mounted. These are things over which you have no control or knowledge so just accept the shift you get!

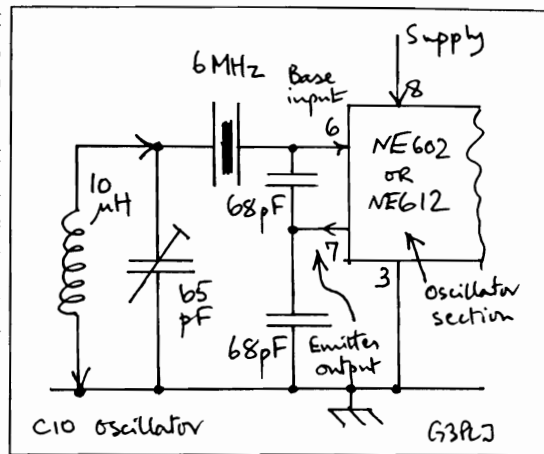


By putting an inductance in series with the crystal the frequency will be lowered. However this is much more tricky than using a capacitor. The kind of inductor that you use is critical. Some do not have any effect - some will give enormous shifts but at the expense of stability and ultimately you will get a free running oscillator. It is a matter of such it and see. I have found the following to work: TOKO 333xx, TOKO 100 uH RF choke 187LY101, and various other RF chokes of values between 22 to 47 uH. Sometimes better results can be obtained by putting several small RF chokes in series rather than using one large one. You can put a variable capacitor in series with an inductor. This will give you both HF and LF swing about the crystal frequency.

To summarise, it's a black art where minimising stray capacity is important and that experiment will be amply rewarded! Try adding capacity first. Higher frequencies will shift more. Gerald G3MCK

IF filter Sideband crystals

Many years ago when I first discovered that crystals could be pulled a useful amount, I gave up buying special expensive 'sideband' crystals for the 9 MHz filters that I was then using in superhet RXs. Even at 6 MHz you can obtain more than sufficient shift for either the upper/lower sideband which would normally be about 1.5 KHz from the nominal centre of a IF filter intended for phone use. The circuit right shows the main elements of a Collpits oscillator such as might be used with the oscillator section of a NE602/612 mixer. Without the inductor connected, the common and cheap 6 MHz 'computer grade' HC49 crystals can be pulled up to 6001.5 KHz easily. Connect the inductor and they will go down to 5998.5 KHz comfortably!



Below about 25 MHz, HC49 crystals are usually labelled with their parallel resonant frequency when operated with an external 'load' or circuit capacity of 30 pF. For higher frequencies, the series resonant (SR) value is often quoted. Also beware of 'overtone crystals' above about 30 MHz designed to work on an odd harmonic (usually 3OT or occasionally the fifth) of its fundamental resonance - these require special care to prevent them working on their fundamental. Any particular crystal can be used in either series or parallel mode but the series resonant frequency will always be slightly lower. Low frequency crystals used in 'quartz clocks' are often designed for a 22 pF load. When asking a supplier for a specially made crystal be sure to specify the circuit conditions! G3PCJ

Floor Planning!

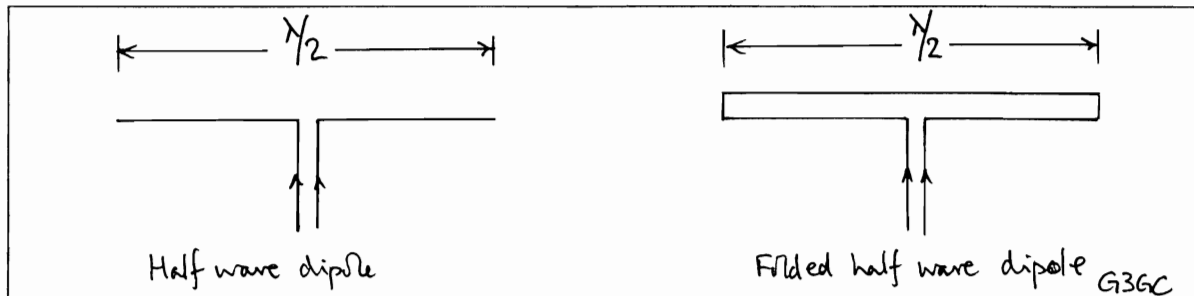
No, this is not about how to cram your radio bench into the spare room! I am advised it is the centrepiece of virtual prototyping! Still no wiser? Its actually about laying out printed circuit boards! For very fast circuits such as in most computers, the length of PCB tracks within a board is now terribly important. This is because the rise and fall time of the digital signals are so quick that a track of only a few inches maybe acting as a transmission line, and - just like our antenna feeders - if it is not terminated in the correct impedance there will be reflections which cause circuit malfunction. In the digital case, these reflections take the form of small voltage steps (up or down) superimposed on the wanted signal. The amplitude of the unwanted disturbance depends on the impedance mismatch while their duration depends on the length of the PCB transmission line. Broadly speaking, if the rise time (or fall time) is shorter than the time the signal takes to move from one end of the PCB track to the other end, then reflections and hence signal distortion may occur. The cure is to terminate the line with an impedance at each end equal to the impedance of the transmission line so that reflections do not occur. Nowadays designers use a Computer Aided Design package to help place the various circuit elements on a PCB because they have many cross interconnections - we would recognise the wisdom of laying out relatively simple things, like the functional blocks of a RX, in a straight line!

When designers were using TTL digital logic, clock speeds were up to 50 MHz with rise and fall times of 5 nanosecs or less; converting these at the speed of light (roughly 6 inches per nanosec) gives a signal 'edge' length of 30 inches. Thus when tracks or signal routes exceeded this length, trouble could arise - fortunately 30 inches covered most situations but it is different now! Cooling was also not too critical because the density within chips was also relatively low. Not long afterwards, the use of ECL (emitter coupled logic) upped the speeds and termination became almost routine because the packing density had not gone up by a similar amount. Nowadays, clock speeds are routinely over 1000 MHz with edge speeds of below 200 picosecs (0.2 nanosecs or 200×10^{-12} secs) so that track lengths of only 1.2 inches are critical! However, the packing density within chips has increased a great deal so that the number of connections going outside the chip has decreased relatively. It is not always realised that even if the clock speeds are much lower, the misreading of signals due to using high edge speed logic may cause malfunctions - particularly in sequential logic; such errors may propagate throughout the whole design. Hence it becomes terribly important to plan and asses the layout of functional blocks within the area of a proposed PCB to minimise track lengths - this is what is called electronic 'floor planning'! In practice a modern CAD package to do this would also include many other topics that are location dependent such thermal dissipation. G3PCJ

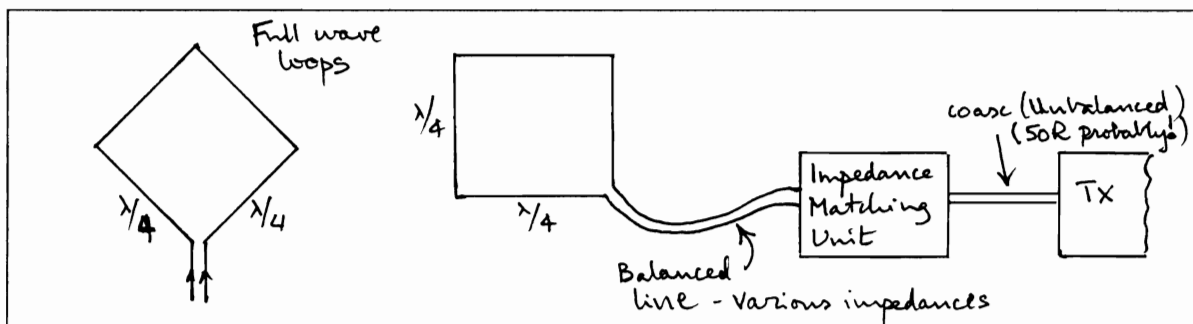
Antennas for small spaces

Andy Howgate asks 'What HF multi-band antenna would you suggest for a garden about 60 feet long?' I swiftly passed this to my antenna guru, Eric G3GC, whose answer is:-

Aerials, particularly those covering more than one band, for use in limited spaces are always a problem and the usual solution is to use an end fed wire which is as long as possible. However these always present the problem of effectively earthing the transmitter or the whole station and the AC mains often become part of the aerial. The usual solution for this is to connect the transmitter earth terminal to some form of counterpoise. It is far better to try to use an aerial which is nominally balanced, thus avoiding the earthing problems. However whatever aerial is used it will be essential to have a impedance matching unit capable of covering a large range of impedances.



The halfwave dipole, left above, is a balanced system and a derivative of this is the folded dipole, right above. The main effect of the folding the dipole is to increase its bandwidth and to change the centre input impedance. If the wires are all of the same diameter then the input impedance is increased by a factor of four which is why VHF/UHF Yagis always use a folded dipole radiator. However I am diverting from the subject, the folded dipole can be drawn out from the centre of its two sides to form a four sided square loop, left below. If this is made for 40 m then the sides should be 33 ft long with a diagonal of 47 ft and of course the total length of the wire will be a wavelength. This will require a garden only about 50 ft long but unfortunately the height at the top opposite the feed point will have to be about 50 ft high with the feed point some 3 ft off the ground. This may or may not be practicable depending whether a 50 ft pole can be accommodated or there is a convenient tree. If the aerial is made for the 20 m band then the dimensions are halved and the loop becomes more manageable. The sides are now 16 ft long and the diagonal about 23 ft. So a pole of between 25 and 30 ft is now required and the garden may be as short as 25 ft. The loop may be rotated through 45 degrees so that the sides are horizontal and vertical as shown in the middle below.



As with all balanced aerial systems some form of transformation from balanced to unbalanced is required before the system is connected to a concentric feeder, such as the output from a transmitter. Baluns are made for this purpose but have the disadvantage that in order to work correctly they should be terminated with the appropriate resistive load. Whilst this may be possible on one band, the terminating impedance on other bands is likely to vary wildly from that required. It is therefore far better to use an impedance matching unit such as the E-Zee Match to do both the matching and balanced to unbalanced transformation as shown right above.

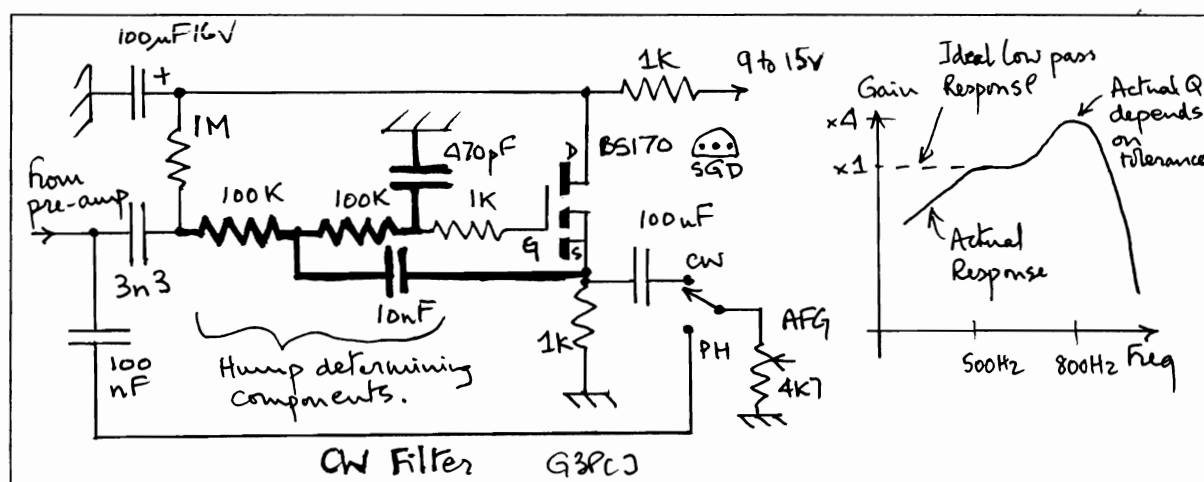
Erecting a loop in the vertical plane as above may require a support some fifty feet in height which is not always practical. A possible solution to this is to make the plane of the loop slant at some angle across the garden. This will lower the effective height of the aerial but may be an acceptable compromise. Sloping it at 45 degrees will reduce the required height to around 36 ft for a ground

clearance of about 3 ft. This will obviously need a garden around 35 ft wide which is rather more than most suburban gardens and so some compromise between the vertical and 45 degrees will be necessary. Many amateurs put up a loop of wire a wavelength long and just spread it around any supports without regard to keeping to the strict geometrical shape. These work surprisingly well and confirms the old adage that the more wire, within reason, you can get up the better. As ever, a good Antenna Matching Unit is essential, particularly for multiband working.

With the proliferation of Japanese black boxes, aerials are one of the few things in amateur radio with which we can experiment, so go out into the garden and have a go at something even if the mathematical analysis of it is virtually impossible. Eric Godfrey, G3GC

Simple audio filter for CW

Often a simple receiver, frequently of the direct conversion type, is designed to have an audio bandwidth wide enough for passing phone signals - typically 300 Hz to 3 KHz. While this can be used for CW, it will pass many unwanted signals so it is desirable to restrict the bandwidth for CW to a few hundred Hz centred on about 800 Hz. The circuit below can be easily added to a RX having an excessive bandwidth for CW. The output from the normal audio pre-amp stage or this filter, are selected by a switch feeding the audio gain control and output power amplifier. The principle circuit elements below (drawn bold) would normally produce a humped low pass filter with a small voltage gain on the 'nose' of the hump; however, in use such a filter appears to behave like the desired bandpass filter where the gain falls off on both sides of the central 'hump' frequency. The actual response of the full circuit shown does fall off below about 500 Hz due to the input coupling capacitor. The Q or sharpness of the hump can be altered with the two capacitors drawn bold. Decreasing the small one and increasing the bigger while still keeping the product of their values constant, will keep the hump on the same frequency but increase the Q - do this too far and you will create an oscillator! The Q, which is also the nominal voltage gain at the hump centre frequency, is theoretically the square root of their ratio (4.5 as drawn)! The resistor and capacitor on the FET drain are convenient ways of providing a decoupled bias supply for the gate. G3PCJ



Disposing of spent Ferric Chloride

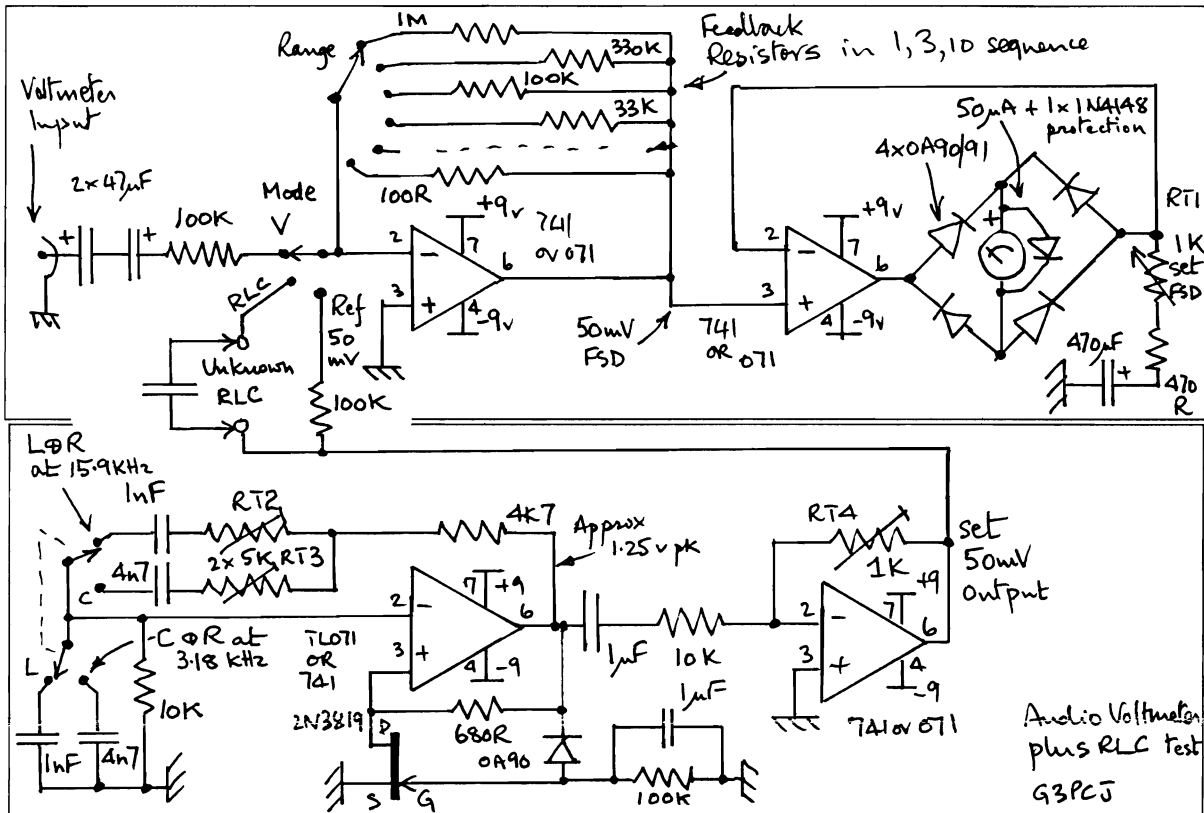
Craig Douglas G0HDJ has found the following advice for safely disposing of spent etching solution. The spent ferric chloride solution should be slowly added to 10% sodium carbonate solution which is more commonly known as washing soda. After leaving overnight, the liquid can be drained off and flushed down the foul water drain (sewer) and the solid placed in the normal refuse inside a suitable container.

Future date for your diary!

The 18th Yeovil QRP Convention will be on Saturday April 21st 2002 in Sherborne. There will be a Dinner the night before and the Construction Challenge is to build the widest stable frequency range crystal oscillator. The organisers will provide the 7.03 MHz crystal (30 pF parallel resonant). Not more than 15 components to run on a provided 9 volt supply. Start thinking about it now!

Audio Voltmeter with RLC measurer!

I built this gadget nearly 20 years ago but it still gets use to measure those difficult to read capacitors! The circuit in the top box below is a switched variable gain (audio) amplifier which feeds a detector using diodes enclosed within a feedback loop to make them effectively into perfect diodes! This part is scaled to show full scale deflection for an input of 50 mV so that, with the variable gain part adjustable from times 10 to divide by 1000 (in 1 - 3 - 10 sequence), it gives the instrument linear scales of FSD 5 mV to 50 volts with an input impedance of 100K. It actually reads the average value of the input waveform. (For a sine wave, the average is 0.318 times pk-pk value.)

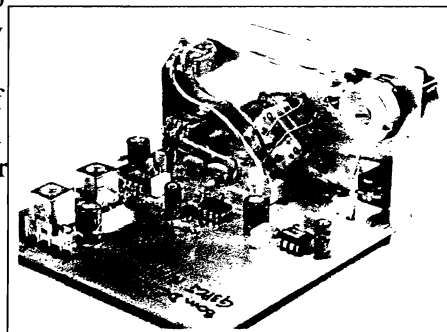


If the circuit of the lower box above its added, it can indicate RLC values. It provides a set 50 mV output at two frequencies to make the scales come right. The C values will be linear in a forward sense with a FSD range of 50 pF to 0.5 μF when the oscillator is running at 3.18 KHz. The R and L values will be 'reciprocal' - reading backwards with no indication for high values - with FSD ranges of 100R to 1M and 1 mH to 10 Henry when the oscillator runs at 15.9 KHz. The setting up procedure is to first set RT1 to give the correct reading for a known input voltage. Then set the two oscillator frequencies with RT2/3 and finally adjust RT4 to give the standard 50 mV test signal on the common unknown component terminal using the rest as a voltmeter. Also test known parts. In tabular form:-

R feedback	Gain	V in FSD	X in for FSD	Cfsd @ 3.18 KHz	Lfsd @ 15.9 KHz
1M	x10	5 mV	1M	50 pF	10H
100K	x1	50 mV	100K	500 pF	1H
10K	/10	500 mV	10K	5 nF	100 mH
1K	/100	5 V	1K	50 nF	10 mH
100R	/1000	50 V	100R	500 nF	1 mH

This is a bit terse for quite a complicated circuit so please ask if you need any further information on it. Originally I used 741 op-amps but nowadays I would use 071 or the dual op-amp 072 ICs. So, for a little light relief I add this photo of the back of a Compton 80m RX. (I have just been lent a digital camera and I can't resist playing with it! I wonder if Father Christmas will oblige!)

Happy Christmas to you all and the very best of health for 2002! Tim G3PCJ

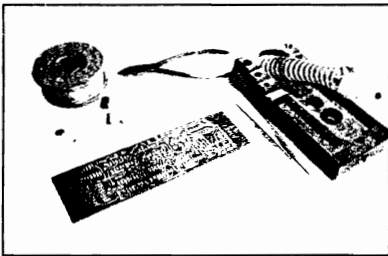


Hot Iron

Issue 35

“Journal of the Constructors Club”

Spring 2002



Editorial

A new computer and digital camera - hence a vast number of hours finding out how to do simple things! Just too many knobs – rather like modern black box rigs! I just hope that the image on the left photocopies all right! I told my wife that I had to buy these gadgets so as to be able to send out sensible press releases etc. - that produced an instant demand that I photograph her topiary, which is one of her interests – far too difficult and needs good weather! It is extraordinary how we now take for granted all sorts of gadgets that seemed really quite revolutionary not all that many years ago.

The same applies to radio gear. I have been trying to simplify some of my designs, being conscious that some competitors seem to sell very much simpler kits successfully. I keep coming unstuck though because I reckon that most of us consider things like receiver sidetone in a CW transceiver as almost essential – I know years ago it would have been considered an unnecessary luxury! Having decided to incorporate it, then it has to be free of nasty clicks or thumps every time the key is open or closed, be of a good pure note, preferably with adjustable audio level also! Despite many tens of hours addressing this specific requirement, and all

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- Semi-trap vertical
- GSM Radio System
- VFOs & digital pots

sorts of experimental circuits, I still don't feel entirely satisfied with my current design! It has also to use standard low cost components, preferably values that are used elsewhere within the kit so as to minimise the total number of different parts. My current circuit uses two small MOSFETs and about a dozen capacitors, resistors and a preset to set the level – it seems far too many! Clicks and clunks are particularly difficult to avoid - clicks often come from too sharp rise and fall times of a signal's envelope, whereas clunks often come from changes in DC levels in the audio path between key up and down. It is often quite tricky to find out the source of such clicks and clunks and other transients due to transmit/receive changeover!

Kit Developments

I have tested a new version of the 5 digit counter to replace the existing design which is showing its age! The original is my longest running kit ever – the text talks of rigs long since retired! The PCB size is unchanged but the new layout permits one end to be cut off if space is tight and you only wish to use three display digits. It will now also work with a supply down to 9 volts. Practically everything else is unchanged. The normal price remains £49 for 5 digits or £40 for 3 digits. Would anyone like to build one?

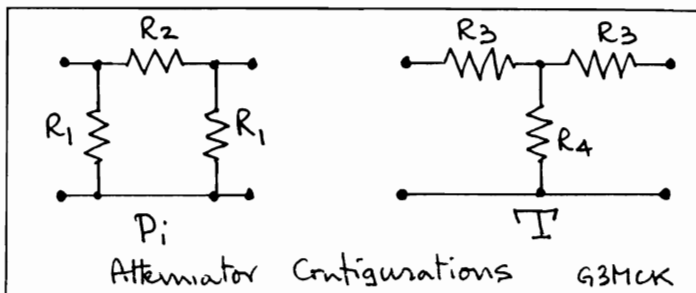
Somerset Homebrew Contest

Thanks to the good offices of the GQRP Club and Peter Barville G3XJS in particular, this contest will be held again this year with a first prize of a £50 voucher for anything from the Somerset Range. It takes place from 0900 to 1200z on Mar 24th on 40m. With the emphasis on homebuilt gear, you have to use either a homebuilt RX or TX or both. You do not have to have built them yourself. Full details in Sprat 109. Logs to G3XJS. Given the small number of entries, your chances of winning should be high! Tim Walford - Ed

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics always wanted. Please send any correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport Somerset TA10 9NJ. Tel 01458 241224 E mail walfor@globalnet.co.uk Subscriptions £6 per year for UK (£8 overseas) from Sept 1st

Attenuators by Gerald Stancey – G3MCK

These useful devices are used to introduce a known loss into a matched transmission line or as lossy matching devices. Let us look at the first use. Here two configurations are available; the Pi and the T forms – see right. In practice which one you use depends on what you have in the junk box! The values for R_1 and R_2 depend on the attenuation needed and the impedance of the line. Formulae for calculating them and tables of suitable values can be found in text-books but for use with 50R coax the table on the right give suitable resistor values in Ohms.

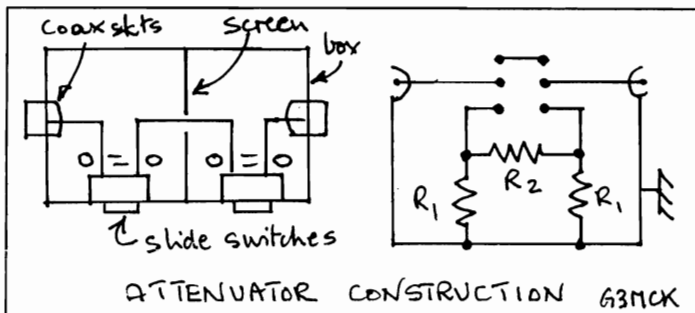


For attenuators that are used with a signal generator, 1/8th watt 5% resistors are suitable. The table covers most likely needs. If you need more attenuation, or other values, then connect two attenuators in series. Construction is easy – see right; simply mount two coax sockets on a piece of PCB or build it in a tobacco tin. They can be bypassed by a simple two pole slide switch. A set of attenuators can be built into a single box provided it is divided into separate compartments to prevent signal leakage from one section to the next. All leads should be kept as short as possible with the resistors being fitted direct to the switch tags. Where the table calls for non-standard resistor values (shown in italics) use either two in series or parallel to obtain the desired figure.

Attenuation	Pi form		T form	
	R_1	R_2	R_3	R_4
3 dB	300	18	9.1	150
6 dB	150	39	16	62
10 dB	91	68	27	36
20 dB	62	240	39	10

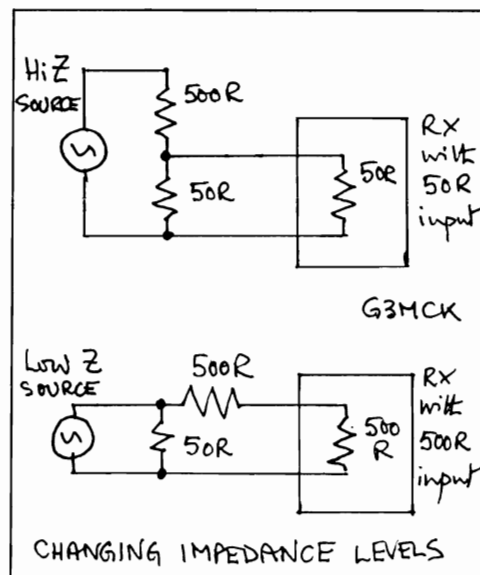
S Meter Calibration

This is straightforward if you have signal source of known strength and a set of attenuators. Set the signal generator to a suitable output level, switch in suitable attenuators and then note the S meter readings. Take S9 as 50 micro-volts PD across 50R and one S point as 6 dB. However if you only have the signal standard described in Hot Iron 33 don't despair! Proceed as follows. Make a 6 dB attenuator, preferably with a bypass switch. Feed a signal from the standard into your RX with maximum RF gain and note the S meter reading. This will be your standard against which all signals are measured. Insert 6 dB of attenuation and note the new reading S_A , remove the attenuation and decrease the RF gain until the meter reads S_A again. Insert 6 dB attenuation again and note the new reading S_B , remove the attenuation and decrease the RF gain till the meter reads S_B again. Repeat as often as you wish. You now have an S meter calibrated in S points against your standard and you can now give realistic relative signal strength reports. Its not a lab method but will give much better results than relying on typical S meter readings.



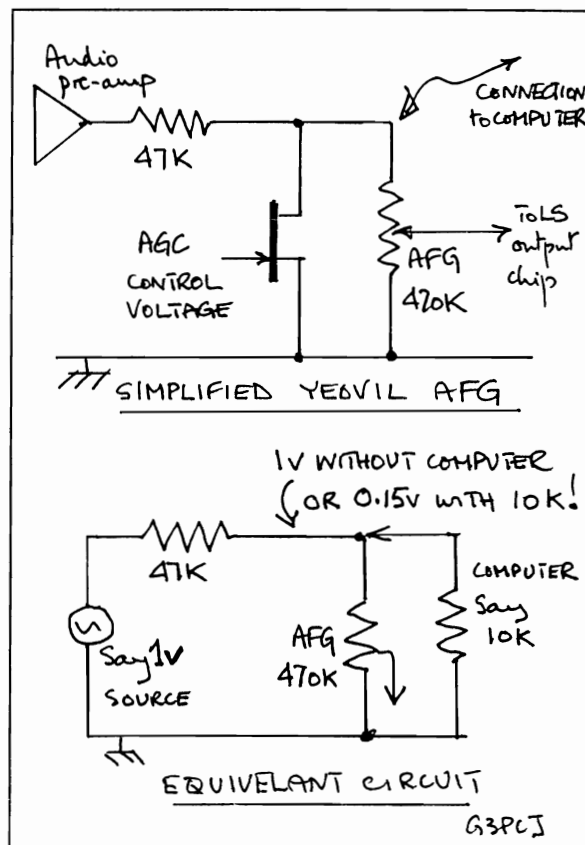
L Section attenuators

The box right shows a signal source that has a medium to high impedance output connected across an L type 13 dB attenuator – the 500R and 50R resistors. The Signal source will see a load of 525R and the RX will think that it is being fed from just under 50R. You can add 50R attenuators between the L network and the RX. This arrangement can be used to make a signal generator from a BC221; in practice 47R and 470R resistors are suitable. With my BC221, output is reasonably constant over 2 to 4 MHz and can be considered flat for small frequency changes (but do check yours). Using your signal standard and attenuators you can measure the BC221 output plus the L network in terms of your standard. The circuit can also be reversed as shown in the lower part for matching into a 500R load such as RXs like the HRO.



Output Impedance and Loading

Recently one of our members was trying to connect his Yeovil to the sound card input of his computer so that he could explore PSK31 etc. He found that, when he made the connection across the AF gain control (to avoid the level changing with AFG setting), the Yeovil's normal audio output was decimated! The explanation is fairly simple! It so happens that the circuit driving the Yeovil's AFG pot has a relatively high output impedance, roughly 47K to enable the rig's AGC to work on this point. This is why the AFG pot has an unusually high value (for modern rigs) of 470K. With no AGC action (full gain) the 470K pot does not attenuate the output through the 47K series resistor; however when reduced gain is required on strong signals, a FET is turned on across the AFG so that the 47K is now in series with a much lower effective value across the AFG. This forms a variable attenuator! (See previous article.) The computer input impedance is likely to be of the order of 10 to 50K, so even at the higher figure, it will halve the signal at the AFG due to the rig's series 47K resistor. If the computer's input impedance is even lower, the attenuation will be even more. The moral is that if you are to avoid unwanted attenuation, the load from any 'additional' device should be at least 10 times the source impedance at that point. This principle applies at any frequency and is equally applicable when connecting test gear to equipment being investigated. (At high frequencies extra stray capacitance becomes important and may make the above approach impossible so that low impedance matched connection to loads is necessary. In this situation, the open circuit voltage is often twice that registered when the load is connected - think of this situation as an attenuator.) Tim G3PCJ



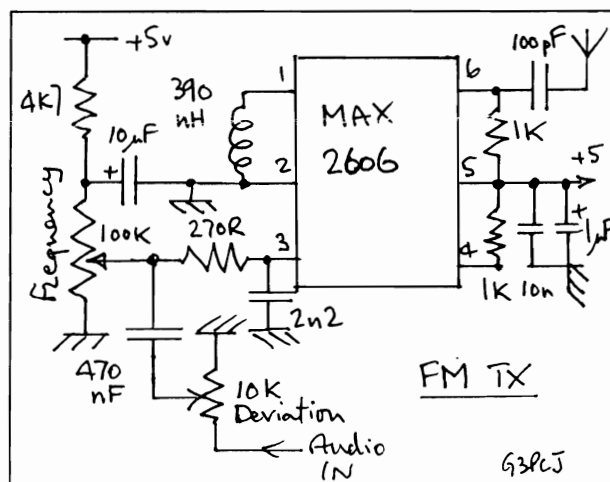
18th QRP Convention – Digby Hall, Sherborne April 21st 2002

Yet again a full programme of talks, displays, trader's stalls, morse tests on demand, QRP Forum, etc. etc. Make a note in your diary now! Steve Hartley, who writes the Newcomer's News in Radcom, will be amongst the speakers. There is a dinner the night before which is usually a very sociable affair! I am sure that you will all have already started on your entries ready for the Construction Challenge! The task is to build a stable 40m VXO with the widest useable frequency range. The 9 volt power supply and 7.03 MHz crystal will be provided by the adjudicator. There is also the Fun Run for CW contesters wanting to pass the time of day in a leisurely manner - between April 1st and 4th inclusive on 40 and 80m. Overnight accommodation can also be arranged. Full details of all these events from George Davis G3ICO QTHR.

Single chip FM transmitter

I spotted this design in some recent Maxim literature which suggests that most countries allow such low power unlicensed transmitters. They suggest you can listen to your favourite CDs at the bottom of the garden (with a portable domestic FM RX) by connecting your Hi-Fi audio output to drive this TX! The chip contains a voltage controlled oscillator using an internal varactor diode. Carrier output is -21 dBm into 50R on a 5 volt regulated supply. Use a 75 mm rod as an antenna. Tune it to a blank part of the 88 to 108 MHz band with RV1 and set the deviation for comfortable received audio level with RV2. (The audio input should not exceed 60 mV). G3PCJ

Check the rules before radiating!

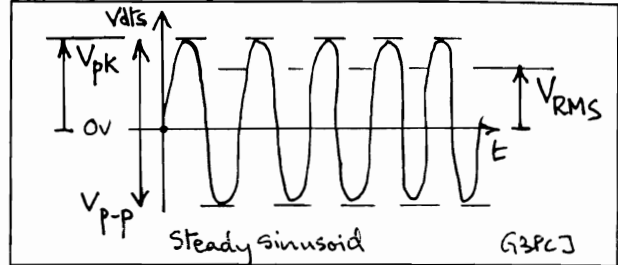


Measuring RF Power

The DC power going into a resistive load is the product of the current through and voltage across the load. For an AC sinusoidal signal, the power is the product of RMS current and RMS voltage. Using Ohm's Law, it can be re-arranged into the more useful form as $(V_{RMS})^2/R_L$ where R_L is the load resistance.

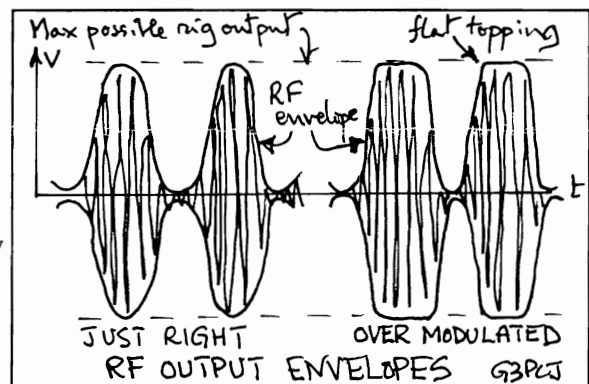
For these sinusoidal signals, such as that shown right, there is a simple relationship between RMS voltage and the more easily measured peak voltage. The peak voltage is $\sqrt{2}$ times the RMS voltage, so with a little juggling and squaring:-

Power = $(V_{pk})^2/2R_L$ where V_{pk} = peak voltage.



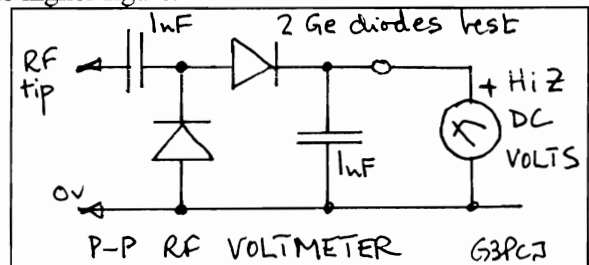
For most transmitters, under no signal conditions, the output devices will have the rig's supply voltage on their collector or drain; when these devices are turned on by the input signal to give maximum output, they conduct fully, drawing the collector or drain to as near 0 volts as they can. Hence the instantaneous output signal starts at the supply volts, goes to 0 volts (or very nearly in a practical rig), and then because it is driving some sort of tuned load, the signal on the collector/drain will go on up to a maximum value which is twice the supply voltage and then back down again. This leads to the common expression for the maximum output of a transmitter being $(V_{supply})^2/2R_D$ - note that here R_D is the load on the device's collector/drain which may or may not be 50R. This tells us the maximum RF power that the rig can produce under any (sensible) conditions - either steadily for CW or momentarily for SSB. If the rig is producing CW, it will be what a commercial RF power meter would indicate. It can be easily measured with a scope or RF voltmeter since the RF envelope is nice and steady like that above. It will also be the maximum that it can produce on modulation peaks if it is an SSB (or AM) rig, and will be the peak envelope power or PEP figure. Note no doubling of figures here!

The best way to set up a SSB transmitter uses a 'two tone' audio signal to modulate the rig with the RF envelope then being observed on a scope. This makes it easy to see when it is being overdriven leading to the undesired flat topping of the modulation peaks which causes that horrible splatter either side of the nominal carrier frequency. The two tone audio signal is made up of two unrelated audio frequency signals with equal amplitude. The envelope of the resulting RF signal should be a nice sine wave at the difference of the two audio frequencies as shown right. Most mechanical RF power meters would not give the correct figure on this



complex waveform because it is not a steady constant amplitude signal. The modulation peaks can be measured with the scope but historically, the easiest way was to turn off one tone leaving the other producing a nice steady signal which could be measured. Since the peak with both tones on is twice that of each tone alone, the PEP figure is twice the steady power out which each tone would produce on its own whereas together they just cause limiting. This is the origin of the myth that the CW output figure should be doubled for SSB! It should only be doubled when it is the CW power out of either single tone of the limiting two tone combination. The rig is however able to produce CW up to the higher figure.

An easy way to measure the RF power of a steady CW signal uses a diode detector and high impedance DC voltmeter. The circuit shown right measures the peak to peak voltage of the RF so it is important to use it on steady sinusoidal RF signals. (It will give funny values on spiky and complex waveforms such as the two tone signal.) Since the peak to peak voltage is double the peak voltage the formula becomes Power = $(V_{pp})^2/8R_L$

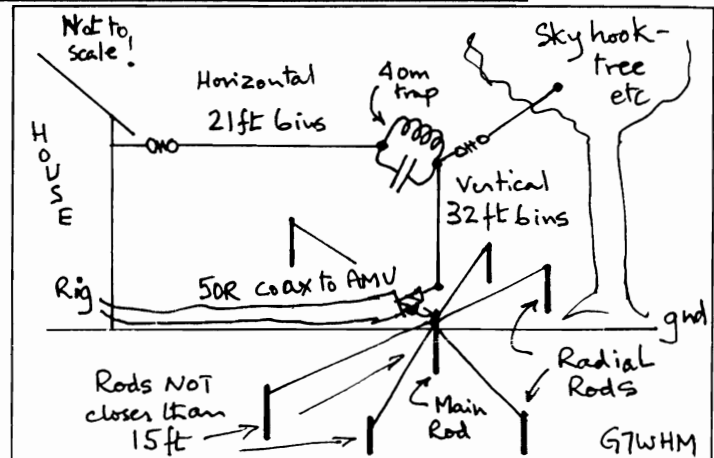


If you are measuring the power from either single tone alone of a limiting two tone signal you may then double it for the rig's SSB PEP figure! If it's the maximum steady CW output that it will sensibly produce, then it is also the PEP figure!

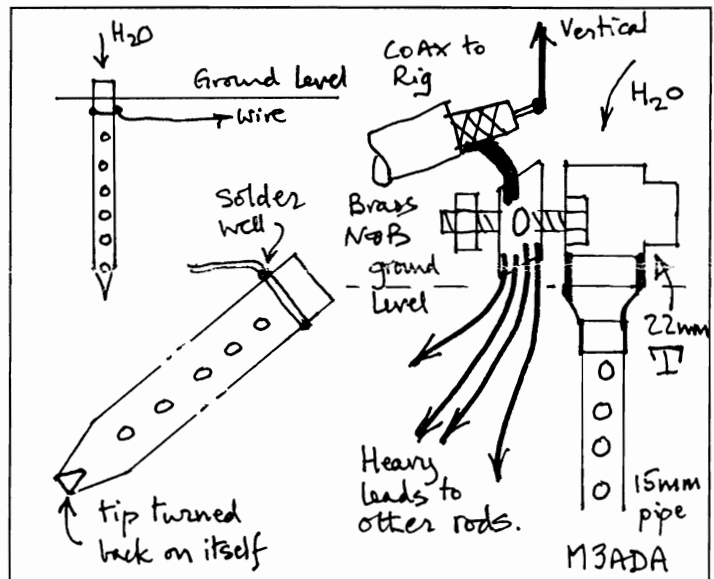
Tim G3PCJ

The Semi-vertical Trap antenna – Andy Howgate G7WHM and M3ADA

I found this design by G3RNL in a book called the HF Antenna Collection. My wish here is to particularly describe the 'earth' system; this is most effective but does NOT require the whole garden to be dug up and should be more acceptable to those members of the family less directly involved with radio! As can be seen right, the antenna has a vertical section over a good earth system, then a 40m trap and a further horizontal section. In essence it comprises a quarter wave radiator over a ground system for 40 and 80m. Consequently it should have a lowish impedance on these bands at the feed point and so present a fair match to the coaxial feeder. It will radiate on other bands but needs a good AMU and coax losses maybe high. I have laid mine out with the vertical section furthest from the house to get it away from house wiring and to make the 'earth' aspects easier. That also reduces the chance of you puncturing some vital buried service like gas, water, electricity and drainpipes to soakaways with earth rods near the house. Like most unbalanced antenna systems, it needs a good RF earth, which I achieved by a central ground 'rod' connected to several earth



radials each terminated in a ground rod(s). For the radiating and earth wires, use the thickest plain copper wire that you can obtain (with or without insulation) or which the tree etc. will support! The trap is made of 23 turns of 18 gauge enamelled wire on a 1.25 inch diameter former resonated by 50 pF in parallel. It is adjusted to resonate at 7.1 MHz with a GDO by squeezing or expanding the turns along the former. Use a good quality high voltage capacitor and, after adjustment, fit inside a weather proof container. Use as many additional ground radials and rods as space or effort will permit – you can put two rods on a radial but allow at least 15 feet between any two rods. The original article suggested 3 ground radials but I fitted 6 and don't regret the extra work at all!



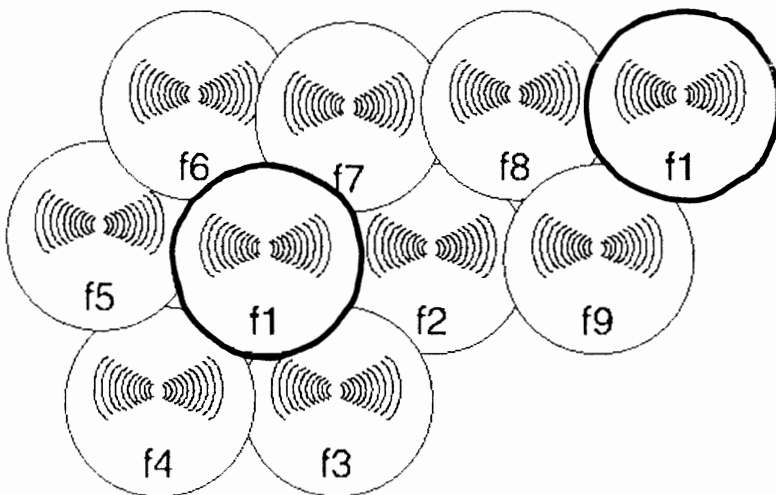
I decided against using the commonly available 'mains' type earth rods and made up specials using 15 mm copper water pipe. Make them as long as you think you can drive into the ground with the help of a pilot hole made by a very long slightly smaller old masonry drill or suitably pointed steel rod – not less than 3 ft! Don't attempt to make the pilot hole in one go, rather you should drive the rod down say 6 inches, rotate it and withdraw, then down another 6 inches etc.. Drill ¼ inch holes in the copper tube every 6 inches to let the water out that you will later pour down the tube to improve contact with the ground. The tip of the tube should be doubled back and formed into the shape of wedge. The earth wire should be generously soldered to the top of the tube and then the tube driven down with a rubber mallet till the top is just above ground level. The radial earth wires can be just buried within the lawn by making a small slit with a spade. The main or central earth rod requires a more elaborate connection scheme to join up the coax outer and the several earth radial wires. I used a 22 mm equal T pipe fitting soldered to the top of the 15 mm tube with a Yorkshire style 22 to 15 mm reducer. A hole for a large brass nut and bolt is drilled through the back of the T piece. This takes a copper (flattened off cut of 22 mm pipe) or brass plate to which the coax outer and radials are soldered. After tightening apply a generous covering of lithium grease. It took me 3 hours to make 7 rods, an evening for the above ground parts and a good day to install and bury some 90 ft of wire! I can always add more if necessary, I don't have blisters or back problems and the wife is happy because the garden looks the same! I wonder if she will mind if I ask her to water the earths as well as her plants (perhaps not). I would love to have some comments from other members on this scheme and how they think it could be improved etc.. (Get your pens out please! – G3PCJ)

The GSM Radio System – by Paul Tuton G0UBV

For a while now, I've been promising Tim a GSM overview. It's actually quite tricky. The GSM specification amounts to at least 6000 pages and almost every GSM fact has ifs, buts and maybes, all depending on... So in order to keep it to a sensible length and digestible, I've taken a few liberties with the details. As you get deeper into how GSM really works, the astonishing thing is that it works at all, so here are some of the key principles.

There are two frequency allocations for GSM, in the region of 900MHz and 1800MHz. I'll focus on 900MHz though principles are much the same in both bands. Base stations (the masts you see all over the place) transmit to the mobiles between 935MHz and 960MHz, and the mobiles transmit to the bases on corresponding frequencies that are 45MHz lower. So we have a 25MHz bandwidth that is shared between the network operators. Analogue speech is sampled and digitally coded into a 13Kbit/sec data stream. The carrier is frequency modulated with this data using a two-level digital modulation called Gaussian Minimum Shift Keying. GMSK was designed specifically for GSM, and it has a near-optimum combination of several desirable properties. These include small bandwidth and resistance to interference.

GSM carriers are spaced at 200KHz so there is capacity for 125 carriers, though one frequency is unused in order to provide a guard at the band edges. All traffic takes place on one of 124 paired carrier frequencies (for the mobile & the base station). A significant advantage that GSM provides over the earlier analogue systems is an increase in capacity. GSM achieves this by digitally 'dividing' each carrier into 8 time slots. When you make a call, the GSM system allocates a pair of carrier frequencies and a time slot within the carriers so the latter can be shared with 7 other users. Ignoring system control traffic, in principle a single base station could support $124 \times 8 = 992$ simultaneous users. To increase the number of actual users, we reduce the transmitter powers so that ranges are limited, and divide the required geographic coverage area into cells. Each cell has a base transmitter with a limited number of carrier frequencies. The same frequencies will be used in other cells, but a 'frequency reuse' plan ensures that the potentially interfering cells are far enough apart to avoid problems. The diagram illustrates the principle:



In rural areas, the cell radius might be anywhere between 5Km and 20 Km. In dense urban areas this can reduce to 500m or even down to 50m. Where users tend to congregate (railway stations, airports etc) more / smaller cells are required. A typical cell might be allocated 4 carrier frequencies. That means we have 32 timeslots of which 2 will be used for system traffic (SMS, 'ringing' a mobile etc) so it will support 30 simultaneous users.

Now comes the interesting part. What percentage of users will be active at any one time? This, of course, determines the service level and you will not find it easy to get 'actual' figures! Some of the figures that I have seen surprised me. 1 in 25 for example. No wonder you can never get through if you're in a traffic jam. Our 30-user cell can support $30 \times 25 = 750$ potential users. We just have to hope that only 1 in 25 of them wants to communicate at any given time.

The transmitters in the individual cells must be controlled, interconnected with each other and also to the public telephone network. The mobile network has a number of interconnected 'Mobile Switching Centres' (MSCs) which are rather like conventional exchanges. The 'main' MSC has a connection to the public telephone network. A central database contains details of all the subscribers to the network and each

MSC maintains its own database of mobiles that are presently active within its area of control. Each MSC controls several Base Station Controllers (BSC) which in turn control several Base Transceiver Stations (BTS) or individual cells. Each BSC manages the radio resources (mainly carrier frequency and time slots) for all the cells that it controls. So there is a hierarchy of MSC / BSC / BTS with interconnections at each level. The MSCs and BSCs are software-controlled switches and computers. They provide intelligence and control while the BTSs provide the radio connections. The MSC knows about subscribers and where they are, a BSC knows about the radio resources that its BTSs are using, and a BTS does what it is told by its controlling BSC. The whole agglomeration of MSCs, BSCs and BTSs forms a "Public Land Mobile Network" that is owned and managed by its operator.

When you switch on your mobile, it sniffs around and picks up broadcast channels from BTSs in the vicinity. After some discussion, the mobile and the system agree on the best BTS to use and the mobile associates with it (for the moment). The fact that the mobile is now 'on' is recorded by the MSC that controls the area. The MSC accesses the central mobile / subscriber database, locates the record for this mobile / subscriber and updates the 'location' entry to indicate that this MSC is where this particular mobile can be found. At the same time, the MSC reads (from the central database) subscriber details that are essential to authorise and control calls (e.g. details of subscribed services). The MSC stores these details in its own local database together with the present location of the newly-switched-on mobile.

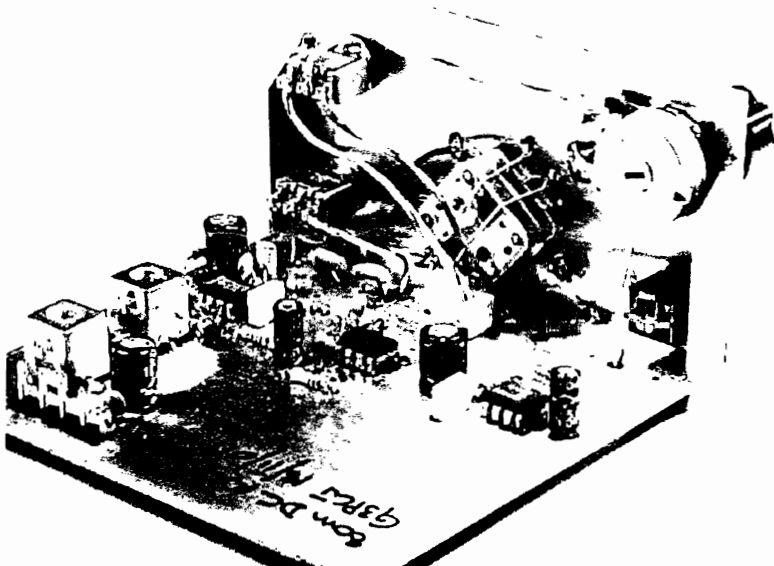
At one extreme, an MSC could record the finest detail of the actual cells for all mobiles in its area. This has the advantage that when an incoming call arrives at the MSC, it already knows exactly which specific cell it should page¹. But this approach would generate an impractically large number of location updates as mobiles move from one cell to the next. At the other extreme, when a MSC receives a call for a mobile that could be anywhere within its area, it could page all its cells to find the specific cell containing the wanted mobile. Since an MSC might control an area the size of Wales this is also impractical! In reality the MSC records a mobile's position by "Location Area" - a cluster of adjacent cells. A location update is needed only when the mobile moves out of the cluster. In view of the extreme range of cell sizes, this is one of many factors that are adjustable in order to maintain an acceptable overall level of service.

Clearly the system depends on very complex computing systems and communications networks without which the actual line of sight radio equipment would be useless!

¹ Paging is a message that says 'are you able to take a call' and it is directed to a specific mobile. A mobile in the standby state has not yet been allocated a carrier / timeslot for the call, so the page takes place on one of the cell's 'common control channels'. These channels are monitored by all mobiles in the cell, at all times when they are in standby. When the mobile indicates a willingness to accept the call, carrier frequencies and timeslots are negotiated, the ringer sounds and so on.

New Rigs!

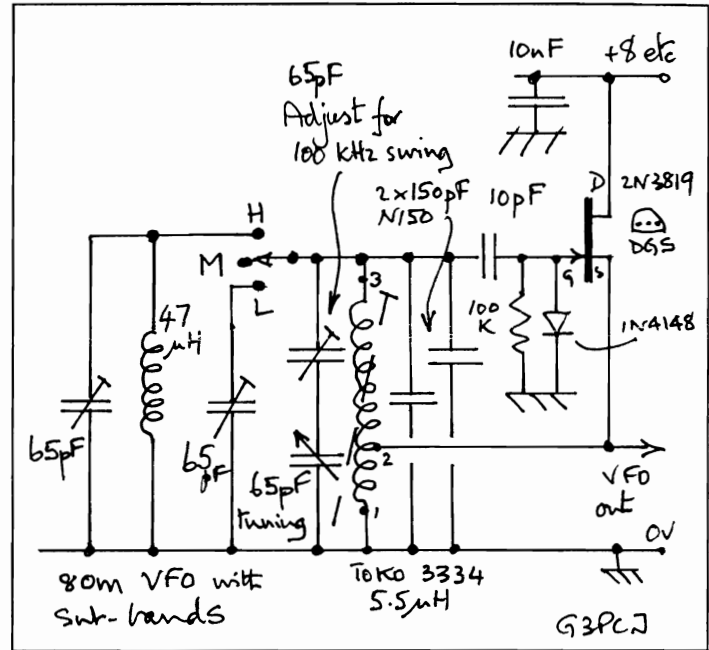
Since we have an extra page this time, I thought you might like to see a photo of the Compton.



Just to remind you, it is a serious 80m direct conversion receiver with audio filters for phone and CW. Able to drive a LS. No need for a counter to set the VFO since it uses two ceramic resonators selected by a switch giving coverage from about 3.52 to 3.7 MHz. Double tuned RF filters. Three integrated circuits only. Very easy to get going with the minimum of test equipment! It costs £39 for everything to build it as shown, plus £1 for P and P please. You can even add a Mixer kit working as a receiving converter to add 20 and 40m! The Dundon is the matching CW transmitter.

VFO with sub-bands

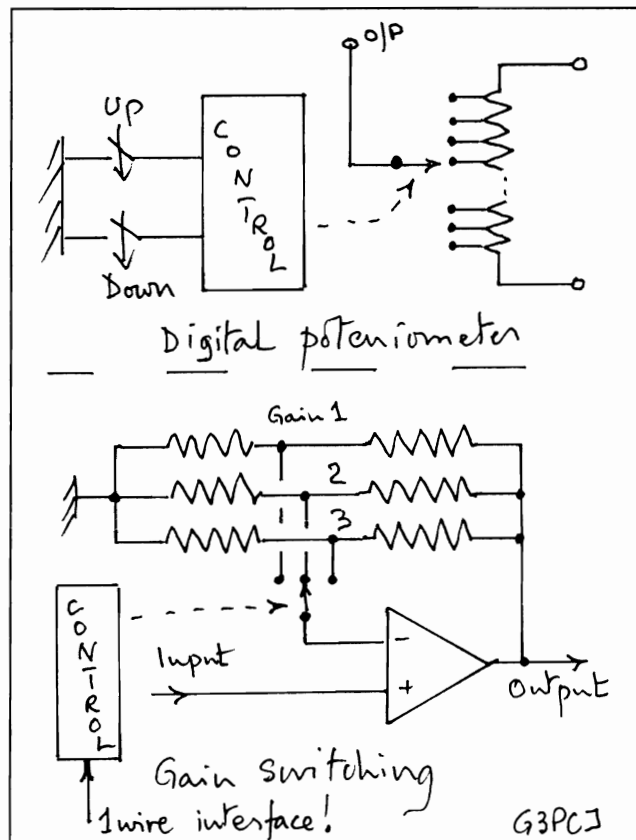
In an effort to improve frequency stability, it would be nice to avoid using varactor diodes. Their drawbacks are the need for a highly stable tuning supply voltage and an uncomfortable relationship between their temperature and capacitance. Varactor diodes suitable for HF VFOs are now also becoming like hen's teeth! Air variable capacitors are out since their cost is exorbitant! Instead, the style of variable capacitors known as Polyvaricons, are cheap and effective but they only have a 180° shaft rotation. Without using an expensive and difficult to mount reduction gearbox, the maximum frequency swing that is practical is about 50 to 100 KHz. For full coverage of a band like 80m, there is a need to have at least three sub-bands of about 100 KHz each. Adding some extra capacitance for one sub-band is easy with a toggle switch and a trimmer. The challenge is to get another sub-band using a centre off toggle switch, where the third sub-band has a higher frequency than the central off position. I have not actually tried the scheme shown above but I am confident it will work. By switching a further coil in parallel with the main one, the resonant frequency will increase; providing it always goes beyond the minimum increase required it can then be brought back down again with a trimmer. Although the actual frequency range on each sub-band will not be identical, they will be sufficiently close to allow a common incremental calibration – say 100 KHz segments for each sub-band. The values shown should be suit an 80m VFO for a DC RX. G3PCJ



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Digital Potentiometers!

Equipment designers have long disliked mechanical devices like conventional pots as their cost is out of proportion to the rest of the electronic components. (Knobs are my pet example of excessive prices for what they are!) Chip designers have come to their rescue by integrating resistor chains on the same die as a series of electronic switches which connect the 'pot' output terminal to the desired tapping point. The same approach is now available for setting the gain of an op-amp under remote control by a micro-processor. There are many versions of such devices, often with very simple control methods such as simple up/down buttons to adjust the 'pot'. There are even versions which have a non-volatile memory of the output tap position! Needless to say they are all extremely small with surface mounting onto the PCB! They are excellent for tasks such as an AF gain control. I pondered if it might be possible to use such a digital 'pot' as tuning control for a varactor diode controlled VFO. Despite such 'pots' commonly having 256 tap positions, the resolution is nothing like small enough for tuning purposes. It emphasizes the challenge of making a VFO which has to be controlled within about 10 Hz over a range of 300,000 out of 3.5 million (for 80m) and not drift thereafter! G3PCJ

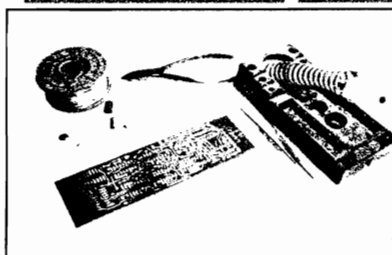


Hot Iron

Issue 36

“Journal of the Constructors Club”

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Editorial

Firstly I must apologise for being late in getting this issue out to you. We had a little bit of a domestic crisis which I am pleased to say is now all over and dealt with satisfactorily! It has also been a bit hectic since I have been involved with the Royal Bath and West Agricultural Show for many years and, due to last year’s foot and mouth epidemic we badly needed a good event; the weather did its best to spoil it again for 2 days!

Many of you will also have seen that I have had a fair bit of publicity recently! In Sprat with a special offer for the Wurzel 20/40/80m regen TRF RX for £35 – I am pleased to be able to make the same offer for Members of the Constructors Club. The Dundon 1.5 Watt CW transmitter will work with it and can be made to do all three bands with a little bit of ingenuity! £29+£1 The Compton 80m DC RX has had a review in Radcom by Steve Hartley G0FUW who writes their Newcomers column – to quote ‘Having built a good number of DC RXs, this is one of the best that I have come across.’ I didn’t expect it to, but the Compton even survived a reversed supply! And the last piece of publicity is a ‘construction experience’ article by Rob Mannion in PW on his building of the Wurzel – also very positive! Hence my etching tank has been pretty

busy as well! My apologies for the delay.

Kit Developments

Spurred on by Steve Hartley, I have developed a phone double sideband suppressed carrier 1.5 Watt transmitter called the Butleigh to go with the Compton DC RX. This will do any single band of 20, 40 or 80m and uses the VFO facilities of the Compton. Although the Compton is normally 80m only since its VFO is based on two ceramic resonators, by adding the Mixer kit with a normal VFO, it can be made to do any band to 10m! Furthermore, the Mixer kit fitted with a 6 MHz IF filter and VFO, turns the Compton into a superhet – for any band up to 20m! This can then use the new Kingsdon 5 Watt SSB phone and CW transmitter, this is intended primarily for use with the Midney superhet RX but will work with the Compton when converted to a superhet! The Kingsdon replaces the earlier CW only Kenton transmitter. Since I am working up a new single bander superhet phone TCVR which needs an adapter kit to make it do CW – I have made this CW kit also suitable to convert the Butleigh so that it will do both phone or CW! I also decided that a new harmonic marker kit would be useful – this one has markers throughout the HF spectrum based on odd and even harmonics of 5, 1 MHz, 500, 100 and 50 KHz from a crystal and 3.58 MHz pullable from a ceramic resonator. These options are a bit complex so please don’t hesitate to ask!

Somerset Homebrew Contest

This event took place on Mar 24th and was won by Dan Taylor GW0EGH with an unusual home designed rig. As ever, my thanks go to Peter Barville G3XJS and the GQRP Club for organising this event. We have decided that it is time for a change in format and are mulling over future ideas. If you have any suggestions about how to encourage the use of homebuilt gear do let Peter or me know.

Tim Walford - Editor

Operating Techniques Over The Years by Eric Godfrey G3GC

The amateur of today operates on a press of the key, press to talk or even to just talk to change from receive to transmit. This is of course very convenient but is a far cry from the techniques employed by the early experimenters and amateurs. It is just a hundred years ago on 12th December 1901 that Marconi made his first radio crossing of the Atlantic but it was not until the early twenties that the first two way Atlantic contact was established by amateur radio.

In the twenties and thirties virtually all amateur transmissions were crystal controlled. In fact to get a licence in this country you had to produce a 'Crystal frequency Certificate with your application to the GPO for a licence. Most people had only one crystal when first starting in amateur radio but as time went on a second or perhaps even a third might be acquired. The fact that the transmitter was on a specific frequency in the amateur band, necessitated the use of different techniques from those used today. Assuming that you put out a CQ call on 40m, then it was most unlikely that anyone hearing your call would have a crystal on the same frequency. So you would have to search through the whole band from 7 to 7.3 MHz (although they were Megacycles per Second in those days) until you came across someone calling you. Then he, after having given you sufficient time to find him, would send 'K' at the end of his transmission and you would call him on your own crystal frequency and thus a contact would be established. Today we would call this split frequency working. It is obvious that to search through the whole 300 KHz took quite a long time and so a series of unofficial 'Q' codes were used to indicate how you would be searching the band. They were QLH for the low frequency end to the high, QHL for high to low, QLM for low to middle, QMH for middle to high, QHM for high to middle and QML for middle to low. The use of the latter four codes effectively halved the bandwidth to be searched but put a restriction on those who did not have crystals in both halves of the band. Crystals were not cheap and in 1937 one from the Quartz Crystal Company (QCC) with a frequency certificate would cost fifteen shillings which was about three-quarters of a weekly wage. As an aside it might be worth pointing out that British stations were not permitted under the terms of their licence to call 'CQ'. This was because we were not licensed by the GPO as 'Amateur Transmitting Stations' but as 'Experimental Transmitting Stations'. We got round this by calling 'Test de G***' but everybody round the world knew we meant 'CQ de G***' and responded accordingly.

In the late thirties, with the introduction of pentode valves having a low anode to grid capacitance, it became possible to make reasonably stable oscillators, allowing amateurs to wander about the band rather than being 'rock bound'. Wander about is an appropriate description as the oscillators tended to drift due to the fact that there was a considerable amount of heat from the valve's heater and also the heat, and thus the temperature around the oscillator, increased when the key was down. Nevertheless they were a great advantage over being crystal controlled. The advent of this freedom meant new techniques were used to get contacts. Obviously you could tune to the frequency of the station calling 'CQ' but how did you know when you were on his frequency? Well the answer was for you to be able to hear your transmitter oscillator frequency whilst still listening to him. You then adjusted the frequency of your transmitter oscillator until you heard the beat note, this was then tuned for zero beat. However this meant that your transmitter frequency differed from the received station's frequency by the pitch of the beat note. In fact this was not a problem since in those days most receivers were wide open with a bandwidth of many KHz. After the war when proper IF filters were coming into use, you then had to adjust the beat note of your oscillator to be the same as the frequency as of the beat note of the incoming signal. It was also necessary to be sure that you used the correct sideband. Since those days much progress has been made by the manufacturers of black boxes so that now you always transmit and receive on the same frequency unless you specifically intend not to do so. The most modern equipment even have memories so that you can instantly change frequency. It may be worth remembering that the crystal controlled transmitters with the consequent searching of the band were still in use on 2 metres in the sixties and early seventies. I was crystal controlled on 2 metres until June 1970.

In my opinion it is an unfortunate fact that progress has taken away much of the skill, pleasure and sense of achievement from operating an amateur radio station.

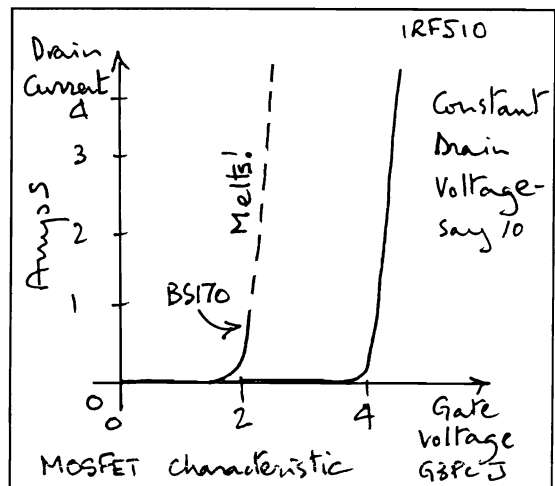
Eric Godfrey G3GC

The MOSFET Pair

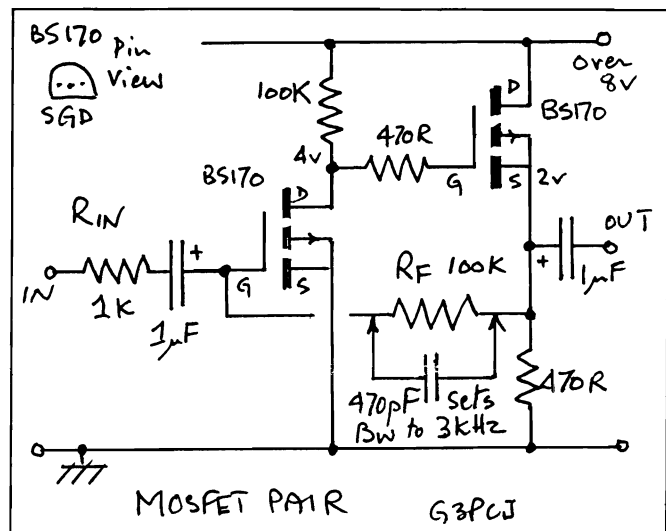
Field effect transistors (FETs) are very useful devices and come in many forms. They are characterised by the gate to source *voltage* controlling the *current* through the device. Many experimenters will be familiar with the depletion mode junction FET such as the common 2N3819 – it is said to be a depletion mode device because with zero gate bias voltage there is still a useful current flowing through the device from drain to source and the normal bias arrangements tend to decrease this zero bias current. They are available in both polarities.

Metal Oxide Semiconductor field effect transistors (MOSFETs) usually have no significant current flowing through them with zero gate bias voltage; they require a significant gate voltage with respect to the source to make a useful current flow from drain to source - hence are said to be enhancement mode devices. This 'forward' bias is typically in the range of 2 to 5 volts depending on type. Again they are available in both polarities with a huge variety of power ratings. 'n' type devices where the drain and gate are normally positive with respect to the source are the most common and usually cheaper. The low power type BS170 is one such device which requires about 2 volts on the gate to turn it on – see below. The IRF510 is another.

The gate terminal of a MOSFET looks like a capacitor so has a very high input impedance; for the BS170 it is typically a few tens of pF and draws effectively zero gate current. This makes biasing very easy! In the simplest common source amplifier arrangement, a single high value resistor from drain to gate will suffice – this makes the current through the drain resistor adjust till the drain DC voltage, and hence gate voltage, is equal to just over 2 volts which is that required to turn it on. The drain resistor can be chosen to give the desired gain (and current) bearing in mind circuit capacitance and hence realistically achievable bandwidth. Note that increasing the supply voltage will increase the drain current but the drain voltage will remain pretty close to 2 volts since only small changes in gate voltage cause large changes in drain current. The device is also highly suitable as a buffering source follower with unity voltage gain. Since the device bandwidth is very large (well into VHF) there is the potential for unintended oscillation unless a 'gate stopper resistor' is added – this need be only a few Ohms but can be higher depending on the desired actual bandwidth.



By combining the common source amplifier stage with the source follower in a feedback pair, as shown right, we have a very versatile arrangement usable from audio to high HF! It provides voltage gain and a low output impedance. The amplifier stage drain voltage will be just over 4 volts DC, so giving a buffer stage source voltage of about 2 volts to turn on the amplifier stage; this will therefore allow a signal swing of up to plus or minus 2 volts peak. Normally one would try to keep the signal levels well below these limits. (This signal excursion range can be doubled by adding another resistor, equal to the feedback resistor, from amplifier gate to ground so that they act as a voltage divider.) The amplifier stage drain resistor needs to be low enough to drive the capacitance of the buffer stage at the desired frequency and extra resistors/capacitors maybe added for decoupling and or to reduce device dissipation in either stage. The circuit shows a speech amplifier circuit for a microphone where the pair of devices are actually acting like an operational amplifier – the effective voltage gain is the value of R_F divided by R_{IN} as long as this is below the open-loop gain of the pair of devices. In this example, used in the Butleigh phone TX, the voltage gain is set to 100 for the speech amplifier. A similar arrangement (with different device currents, gains etc.) is used for the Butleigh's RF driver stage. A very useful circuit configuration! G3PCJ

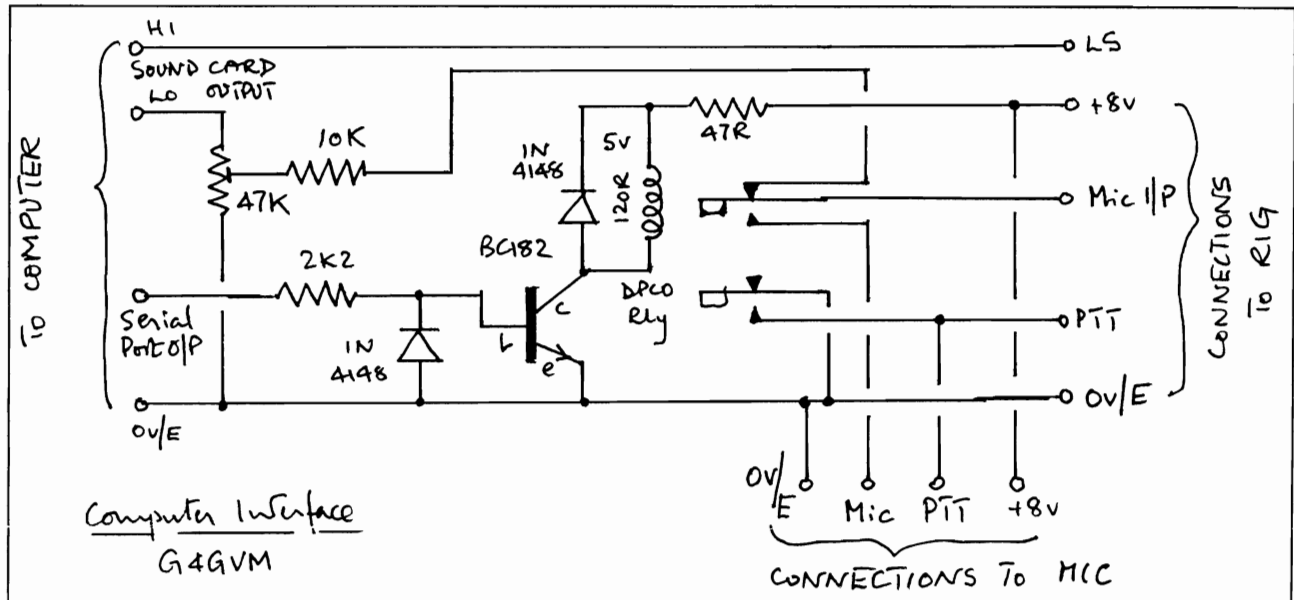


Computer Interface for SSTV and PSK31 by Derek Alexander G4GVM

I suppose there are a number of circuits available, two of which I have seen published, one with the PSK31 (DigiPan 1.6) program itself and the other in SPRAT 106. They all require a certain amount of adapting with plug and socket arrangements to suit one's particular Rig.

I use home-brew equipment (the Yeovil) where it is necessary to unplug the microphone to gain access to the mic input circuit. In order to speak between pictures without a deal of re-plugging during the QSO etc, a more comprehensive design was needed. The circuit to be described automatically allows a microphone to be used when the computer is not actually sending.

I have not found it necessary to isolate the Rig from the Computer with transformers; indeed I found the matching of impedances a problem. Others may not of course! G4GVM.

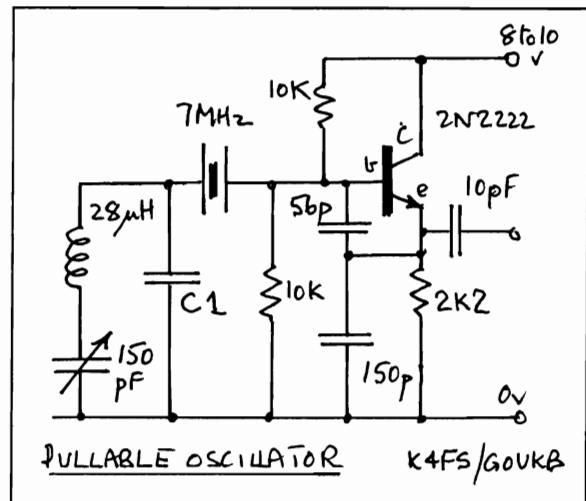


Pulling a crystal oscillator

You may recall that the Construction Challenge at this years QRP Convention was to obtain the largest pulling frequency range of a nominal 7 MHz oscillator. The winner was Brian Jones G0UKB who used some ideas which he saw in a 1998 QRP Quarterly from the USA. He kindly forwarded me a copy of the article by K4FS who did many experiments. Brian managed to get a truly remarkable pulling range for a crystal oscillator such that I wonder if it can really be called a crystal oscillator!

It is based on an ordinary Collpits crystal oscillator which has inductance added in series with the normal trimming capacitor – so far nothing unusual! However the original author added some small extra capacitance C1 across these 'normal' frequency trimming components as shown below.

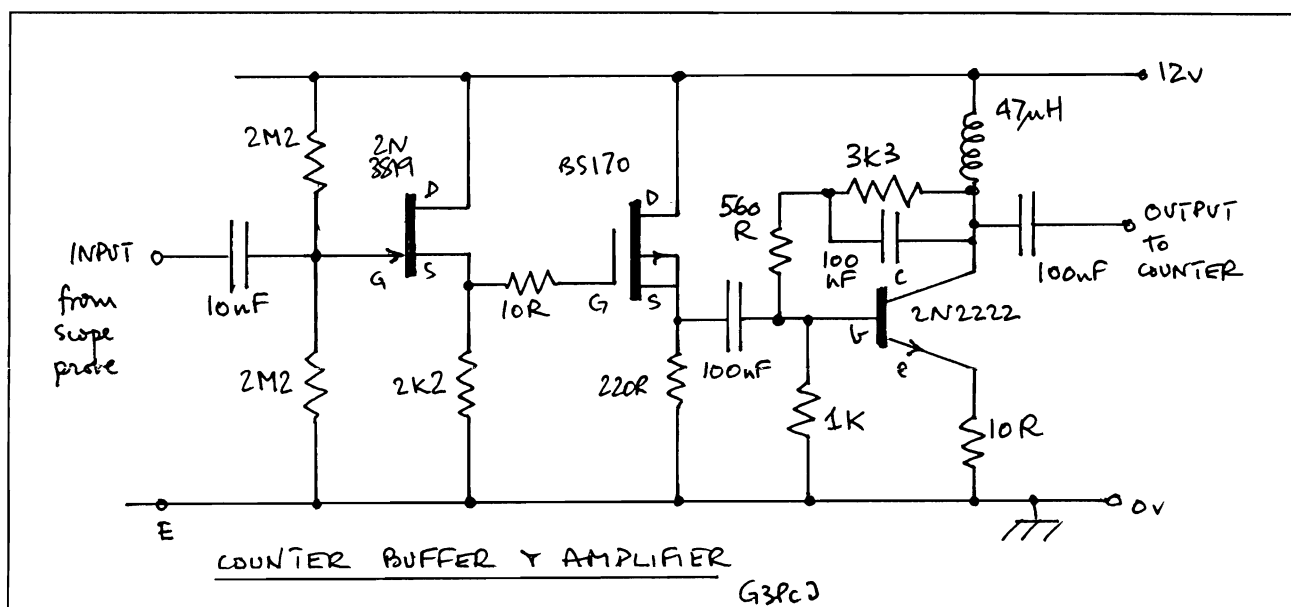
The technique can be used in most bands but for simplicity I give his findings for 40m. K4FS used a 150 pF trimmer and a 28 µH inductor actually made up of two in series to avoid unwanted resonances. With C1 omitted, the pulling range was just 5 KHz as one might expect. K4FS found that adding 6 pF for C1 increased it to 11 KHz but using 10 pF for C1 enabled 33 KHz. Brian reports that he later managed to get his 40m version to go down 300 KHz but he didn't tell me the circuit. He does comment that there is now some small drift and chirp when switched on! I am pretty confident that with that coverage it is not the crystal that is defining the frequency but the other L and Cs! Nevertheless a good experiment – well done Brian! G3PCJ



Counter Input Amplifier

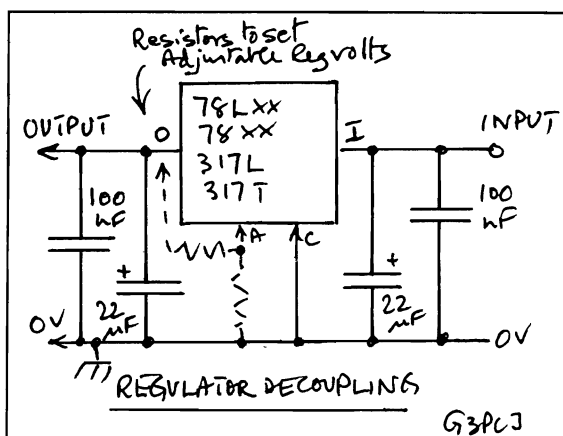
Craig Douglas G0HDJ writes that he has difficulty connecting a slightly insensitive counter to various oscillator circuits, and that when adding a scope probe for buffering purposes, it could only be driven by a signal generator! Clearly more gain was needed but Craig's experiments with two other 'amplifier' circuits did not provide the solution. Had he used both of them (almost literally) it would have done the trick!

The input circuit of the counter had an input impedance of around 1K so connecting it direct to the circuit under test would be quite likely to load it and probably stop it oscillating. The first amplifier that Craig added could easily drive this load but this amplifier had an even lower input impedance, intended for use with a 50 Ohm output impedance circuit! Hence it killed everything it was connected to. Adding the scope probe in front of this increased the load on the oscillator so that it now worked; however the scope probe needs to work into 1M typically so its attenuation was almost total and hence no joy! Craig tried a buffer circuit on its own but there was still insufficient sensitivity in the counter. The solution is to use a buffer circuit after the scope probe and then to amplify the signal to recover that lost in the probe (and maybe more for an insensitive instrument) ready for the normal input stage. Most scope probes attenuate the signal by factor of ten. They have an input resistance of 10M shunted by a few pF typically and expect to have a load on them of 1M and 30 pF – typical of the input of an oscilloscope. Scope probes are practically useless when set to x1 - if they can be! The following circuit should be cheaper than buying a new counter! G3PCJ



Linear Voltage Regulators

Craig Douglas G0HDJ prompts me to explain the decoupling requirements for 78 series devices. These should be decoupled on their input and output by at least 100 nF capacitors – see circuit right. This applies to all versions – irrespective of power rating, polarity or voltage. They need an input supply that it is at least 2 volts more than the desired output. It is quite permissible to use much bigger capacitors (in & out) to give better transient performance. All of the above comments also apply to the linear adjustable regulators of the '317' series. Where excellent regulation is particularly important (e.g. for tuning diode voltages), use the adjustable ones – they are about 10 times better! The more modern Low Drop Out (LDO) regulators can tolerate a lower incoming supply for a particular output voltage but their regulation is not really good enough for tuning purposes. They do however nearly always need an actual minimum of 10 μ F on their output, so one should use 22 μ F to allow for the wide tolerance of electrolytic capacitors. Often other parts of the circuit might need big capacitors on the supply rail – so the general advice is 'use plenty of capacity on input & output!' Switching regulators are best avoided in radio equipment because they are likely to generate unwanted hash or birdies.



Digital Radio Mondiale (DRM)

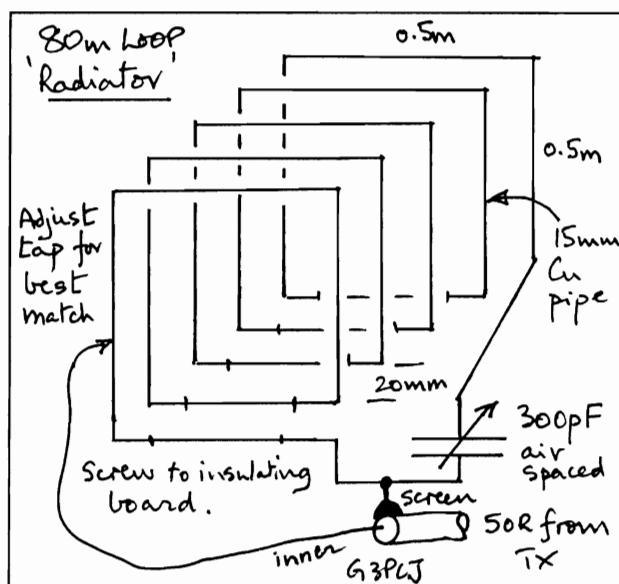
This is a new internationally recognised system for broadcasters that is intended to re-invigorate the broadcasting bands below 30 MHz! Despite the possibilities with satellites, the use of the traditional HF bands for broadcasting has many attractions, mainly associated with the coverage that can be achieved with simple systems for transmitter and receiver – the snags to be overcome are poor audio quality and lack of user friendly facilities! Inevitably, the solution to improving these aspects is the use of digital technology – both for encoding the signal to improve sound quality, and for control to make it more convenient for users.

Given that existing Amplitude Modulated (AM) transmitters will operate alongside DRM ones for many years, they have to be compatible with each other. Hence the new system has to fit within the 9 or 10 KHz channel spacing that is now used worldwide for LF, MF and HF frequency allocations. This is a severe constraint for a digitally encoded audio signal aiming for 15 KHz CD like quality! It can be done apparently using a mixture of Advanced Audio Coding and Spectral Band Replication - these are techniques that have been developed for audio and video compression already (DAB/MPEG4 etc.). They eliminate the redundancy in conventional sound and use the time freed up by this, to send the other helpful command information. Each transmission will have its own station identification and lists of alternative frequencies carrying the same service so that the intelligent (complex!) receiver will be able to automatically retune and select the best source for a particular programme. Despite such radical alterations, an objective has been to minimise the changes required in the expensive high power RF sections of an existing transmitter. A complex form of modulation is used with many sub-carriers conveying different aspects of the audio & control information. Inevitably a Fast Fourier Transform processor features in both transmitter and receiver with a need for very high accuracy of the clock oscillators in both, together with a beefy dedicated micro-processor! Within the entire LF to HF spectrum, the range of signal levels currently exceed the dynamic range of available analogue to digital converters that will be required in the RX. Luckily the very strong LF and MF signals can be reduced somewhat while still allowing adequate signal to noise for the more needy top end of the HF spectrum. The aim is for the RX to cost below £100!

No good for your HF crystal set! Will it replace the 2 billion AM receivers in use now? G3PCJ

The 'Radiator'

My 80m loop antenna always generates much amusement because it looks a bit like a water heater of some sort! Originally designed for a QRP Construction Challenge, it is a five turn loop made up of malleable 15 mm copper water pipe. This can be obtained from good plumbers merchants. I bought a 10m length and bent it by hand around some sort of former with a side of 0.5 metres. The turns should be spaced at least 20 mm apart to reduce self capacitance and the whole resonated with an air variable of around 300 pF with a good insulating knob! There is no need for an AMU since the feed can be tapped around the loop, usually within the first half turn, to effect best match. There is nothing special about these dimensions, just use what you can get hold of! Great for QRP and fun – not really for more than about 25 Watts due to arcing of the capacitor. Less turns for 40m etc.! G3PCJ



SUBSCRIPTIONS!

I regret it is that time of year again! I shall not be sending any further reminders out, so if you wish to continue receiving Hot Iron, hopefully on time, then please send me your cheque for £6 straight away while its fresh in your mind!

As ever, please do tell me if you have any comments, suggestions or queries – I will do my best to get them answered – your ideas are what will make interesting reading! Many thanks to all of you for your support throughout the year, Tim Walford G3PCJ

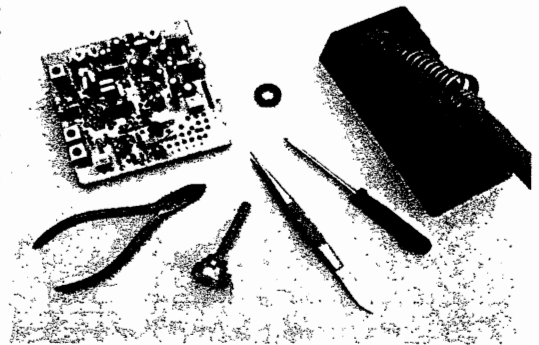
Hot Iron

Autumn 2002
Issue 37

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Editorial

All change thanks to complex technology! A few weeks back, my computer suddenly said it had an 'unmountable boot volume' and died! Getting it going again lost everything that was not properly backed up and that included my last style version for Hot Iron. I spent nearly an hour trying to make Word do what I wanted and failed hopelessly so this is with MS Publisher—keep your fingers crossed!



Time and again, kit customers say they most enjoy operating with simple rigs. Interestingly, a later article about PSK31 laments the character implicit in simple forms of communication. Because things can be done with many variants and high degrees of sophistication, it does not always mean they give more pleasure nor are they always easier to use! I am certain that if I spent more time at it, I would come round to these benefits but just at the moment I long for a blank sheet of paper and a pen! Wish my writing was more legible!

Kit Developments

A relatively minor addition has been an **audio amplifier**. This has two sections, the first which can act as a speech amp, drives a PCB mounted shafted preset which is followed by an LM380 power amplifier. Uses include driving a loud speaker instead of phones or as a low power modulator for an AM rig. More on that later I hope!

The next major new project is the **Fivehead** transceiver. This has portable operation as a theme. It is an any single band phone superhet producing nominally 1.5 Watts (on 13.8 volts) for any band to 20m by direct VFO injection. There will be several options for enhancements; higher bands using the **Mixer** kit—hopefully to 10m, semi break-in CW with the **CW** kit, S and Power out/reflected readings (and AGC) with the **Meter** kit, 5 digit readout with the **counter**, **speech processor**, and a forthcoming 10 Watt **Linear** amplifier. Target price is near £85 without the extras! Sorry I can't throw them in! I have a prototype nearly working on 80m and could do with some early builders if anyone is interested. The main PCB is 100 mm square and is a bit full—its actually the one in the picture above—with the output LPFs yet to fitted! I have to add some parts to the layout to improve the muting (see later) and do several other tests so it is not quite available yet! Let me know if you are interested. Tim Walford G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £6 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

PSK31 AND ME

Some time ago "PSK31" was introduced to the Yeovil Amateur Radio Club by G3TSK and M5EVT with a talk and demonstration of the mode. This was followed up by an article by G3TSK in Yarcnews and a demonstration set up at the 2001 QRP Convention by both of them.

Before the talk I knew nothing about the mode and gleaned that it was a CW mode with the letters in PSK31 standing for Phase Shift Keying and the figures for the bandwidth of the system, namely 31 Hz. This is a remarkably low bandwidth and the consequent reduction in noise level allows stations with very low strength signals to be resolved. The mode uses transceivers running in SSB (usually USB) mode and the CW Morse is derived from the modulating audio signal with phase shift keying. The RF operating frequency is the absolute frequency of the audio signal which in the USB case is added to the carrier frequency. As far as I know the nominal RF frequencies are universally agreed for each band and for the twenty metre band it is 14.070 MHz. As you might expect all this is done under computer control for which there are a number of free programmes available, the most common being "DigiPan". The bottom of the screen of the computer shows a "spectrum analyser" display of the SSB band with the incoming PSK31 signals clearly displayed against a horizontal frequency scale. Above this are two windows, one for decoded incoming signals and the other for the out going message(s) either transmitted or to be transmitted in Morse. Whatever message is held here, it will be transmitted when the system is changed over to transmit.

All this was very intriguing and so recently I decided to have a go myself and find out what it was really like to operate in CW without using a key. One of the things that was very apparent when listening (perhaps I should say viewing) incoming signals was that most seemed to be of a standard format which was precisely repeated for different QSOs except for the callsign of the station being worked or the operator's name. This standard format does not seem just apply to a particular station but is common to different stations, the only changes being the personal ones such as the name and the QTH. This is obviously due to the same software being used together with the standard formats of messages that comes with the software. Another thing is all signal reports seem to be 599 but as the signal strengths are well below that normally attributed to S9 this is even more ridiculous than that commonly heard on CW, the "599 please repeat" report. Further as the signal cannot be normally heard how do you know it is T9? It seems to me that the only valid report that can be given is "your signals are R5, R4, R3 etc.". Another problem is that if you want to have a non-standard format QSO then you have got to be able think what you want to say and to type fast enough to keep the text flowing. To the majority of us this is just not possible and so the QSOs are punctuated with long pauses whilst the operator thinks what he wishes to say and then starts to type it on the keyboard. In a normal CW QSO there is often a pause for thinking but the operator, without intruding on his train of thought, will normally send AS or BT to let the recipient know that he is still there.

Were the QSOs I had worth while? The answer is "NO!". There was no "job satisfaction" using the keyboard with the whole QSO seeming to lack any life and I did not feel that I was working a living individual. Compare this with real CW when one can converse back and forth using the "BK" method where the callsigns only have to be sent once every quarter of an hour to satisfy the licence conditions.

So at the end of the day what do I think of PSK31. The answer is not much. I have great admiration for the technicalities of the mode and recognise that it is a great step forward over the old RTTY modes. However in my opinion it is not a "living mode" and it gives me the feeling of working in a graveyard.

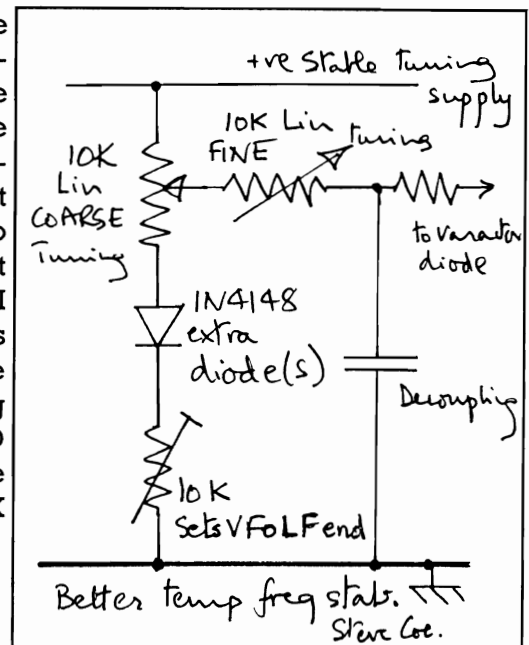
No, give me a pair of phones connected to a simple transceiver, a well tempered resilient morse key, a spot of QRM and I shall be pounding brass as happy as the proverbial pig.

Eric Godfrey, G3GC

Rig Updates

Midney RX Steve Coe has added an extra diode to the tuning arrangements of his Midney which improves its frequency stability under varying temperature conditions. See right. The diodes are connected in series with the negative end of the main tuning pot; their diode drop voltage decreases with increasing temperature so helping to counteract the effects of changing temperature which are mainly due to the varactor diode. He has tried up to three extra diodes, but the more you have, the lower the available tuning range. I suggest that in most situations a single diode connected as shown right is the best compromise. After adding a diode you will need to reset the lower frequency end of the tuning range with the preset in the tuning voltage chain. The VFO HF end should not be affected. It should also work if you have changed the normal 10K Coarse/Fine pots for a single 10K multi-turn pot.

Note! This scheme might also benefit the **Bristol** and other rigs with varactor tuning for their main tuning control.



Bristol TCVR Over the years, some builders have found that aligning the 20m LO BPF is rather tricky to get the best compromise between LO signal amplitude and purity. The cause of this difficulty is that, on 20m, the LO crystal frequency is 4 MHz and the desired LO is nominally 8 – 8.5 MHz after mixing with the 4 to 4.5 MHz VFO; hence the second harmonic of the crystal is likely to be right on the wanted LO band edge so the LO BPF cannot remove it. This harmonic is sometimes uncomfortably large and leads to lots of 'fuzz' on the tips of the LO signal if viewed on a scope. This makes it a pretty hard waveform for a scope to trigger on properly hence the confused display. Another symptom is that the fuzz's characteristics change quite rapidly with small changes in VFO frequency. This is because the frequency difference between the wanted LO frequency and the crystal's second harmonic is changing rapidly. Following discussion with Simon Bea G7CPN/M3BGA whose Bristol was particularly troublesome, we found the best solution is to reduce the amplitude of the 4 MHz crystal oscillation and hence also its harmonics. This can be done quite easily by adding a 1K resistor directly across the 4 MHz crystal. Note this has to be done on the band card so that it affects only the desired bands. Simon also applied the same modification for the 30m band. Note! This suggestion applies other rigs (**Taunton etc.**) using the same frequency scheme.

Electrical Safety

Prompted by reports of an accidental death while someone was using a sander to complete a job for a friend, I surmise that the premises concerned did not have an earth leakage trip or residual current device (RCD). I do urge all readers to **CHECK NOW** if you have a residual current device (RCD) protecting your electrical installation (assuming you do not already know the answer). RCDs can be installed to protect individual sections of your electrical installation, such as a ring main serving several 13 Amp sockets, or the whole installation. You can also obtain 13 A sockets which have their own RCD within their body. The modern RCD works by sensing inequality between the currents in the two principle conductors of the mains supply, any difference between them means that some current is escaping to earth in a faulty manner so it turns itself off. There are various sensitivities for different applications. All RCDs have a test button which applies a small fault current; they should be tested every 6 months or so to check operation. The smaller the trip current rating, the better the protection but this can lead to nuisance tripping for large 'circuits'. 15 mA is often used for personal protection and 30 mA for general work. Your shack mains supply should certainly be protected by an RCD but I would strongly recommend that your whole electrical installation should be so protected. If you have the older style of voltage operated earth leakage trip, they are better than none, but not as good as the modern current operated RCD.

On a separate point, real RF earths of antenna systems and mains earth must NOT be connected together - especially where mains earthing is by protective multiple earthing (PME). G3PCJ

One off construction methods

Andy Howgate G7WHM/M3ADA tells me in an e mail about how he is building a new small transceiver based on the Compton and Butleigh circuits.

"I suppose the technique could be described as ugly bug—not sure what you would call it—it uses a single clad PCB with the copper side acting as the ground plane which allows all earthy connections in close proximity to the individual components. The copper clad side is counter sunk where non earthy component leads pass through the PCB, these are then folded over on the insulated side and routed as if they are the circuit tracking. This allows build as you go, using a pin drill and countersink bit and hence allows for extreme miniaturisation. Component size is not so critical and one can use what is to hand and fits into available space and thus no great forward planning is required or any special pc programs or messy etch stuff. Not suitable for a repeatable product, but for my needs, perfectly suitable for a one off.

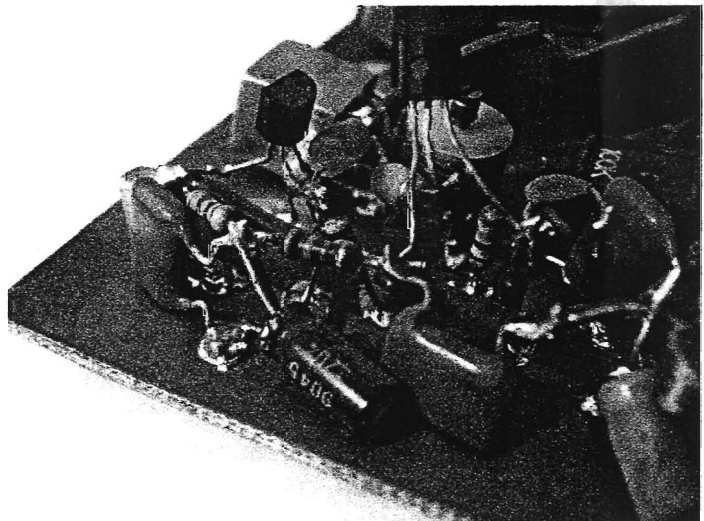
The track or wire side does not look so neat as an etched PCB but the ground plane side with components looks smart. The supply lines are linked from one point to the next with insulated wire and all ground or 0 volt connections are made directly to the ground plane. When completed, the wired up side can be brushed over with lacquer which will bond the whole lot together and offer insulation etc and ensure rigidity. Looking at the top-side, you would be hard pressed to tell the difference between a properly laid out PCB and this one! Removal of a component is probably not so easy, especially with items like a chip, but in certain applications one can use a DIL socket— audio circuits are ok but RF devices maybe risky. It depends on what one is building, transistors and two wire devices are easy to remove either by cutting the longish wires or de-soldering and using a spring hook to detach the wire from that particular joint. Its not perfect but in my opinion better than island pad or 'dob' boards and spending hours track drawing, etching & drilling. The whole process of assembly is completed in one operation - find suitable location then drill component holes, add countersinks, fit component, bend and route wire ends to suit, solder them to the next part & solder any earthy points on to the ground plane direct. It sounds time consuming but in reality very little time is taken, about 45 minutes from cutting my PCB to size, cleaning copper, finding suitable components from my part bins/junk boxes, drilling and fitting them. About an hour to have the LM380 audio chip up and running. One is working from the circuit diagram direct.

I think the technique is perfect for trying ideas before committing to a full PCB layout, and then finding out you have to start again because your design does not perform as you would like! This method does allow changes to the layout as you progress. If you use paxolin copper coated material, it is cheap by comparison to double sided fibre glass PCB. It is really much like using perforated board of days gone by, but the clad side is your screen and earthing point. The tools needed are simple pin drill, track cutter or battery powered drill, pointed pliers for bending leads, side cutters, solder and an Iron. Oh! And a paper clip straightened out with a small hook bent on the end (spring hook) - this being used to pull a wire from a connections when heated with the iron for component removal. Much quicker than designing a PCB, etching it, getting your friend to do the drilling, collecting, building, and then doing a Mk 2 after debugging! But a steady hand is needed!"

I had sent Andy some components for this rig and he comments that he will have them in and working 20 minutes after unpacking! I have often used another version of this style of building which I know as 'dead bug' construction. This does not involve any drilling—it has all components mounted only by their earthy leads direct to the copper ground plane. Connections are then made direct between individual parts, with plenty of extra 10 nF decoupling capacitors are used to anchor the supply lines. Chips are mounted upside down with their legs in the air—hence its name! If really necessary, 10 M resistors can be used to anchor other nodes and are unlikely to affect circuit impedances. See photo below for one of mine! G3PCJ

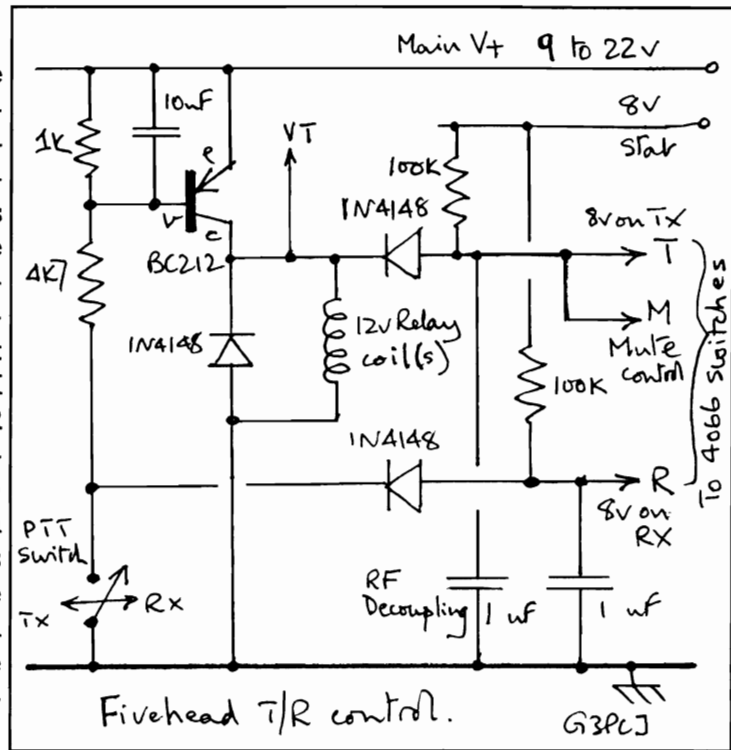
Correction!

Derek Alexander G4GVM points out that I made a mess of his computer interface circuit diagram in Hot Iron 36! "When at rest the relay should allow the mic to operate the rig, and the mic's PTT to make the rig go to transmit. Only when the computer operates the relay, is its o/p connected to the rig mic I/ p and its PTT circuit can then put the rig into transmit." The top set of relay contacts in the published diagram need reversing. My apologies— please ask me or Derek if you need any further information to make it work properly, Tim.

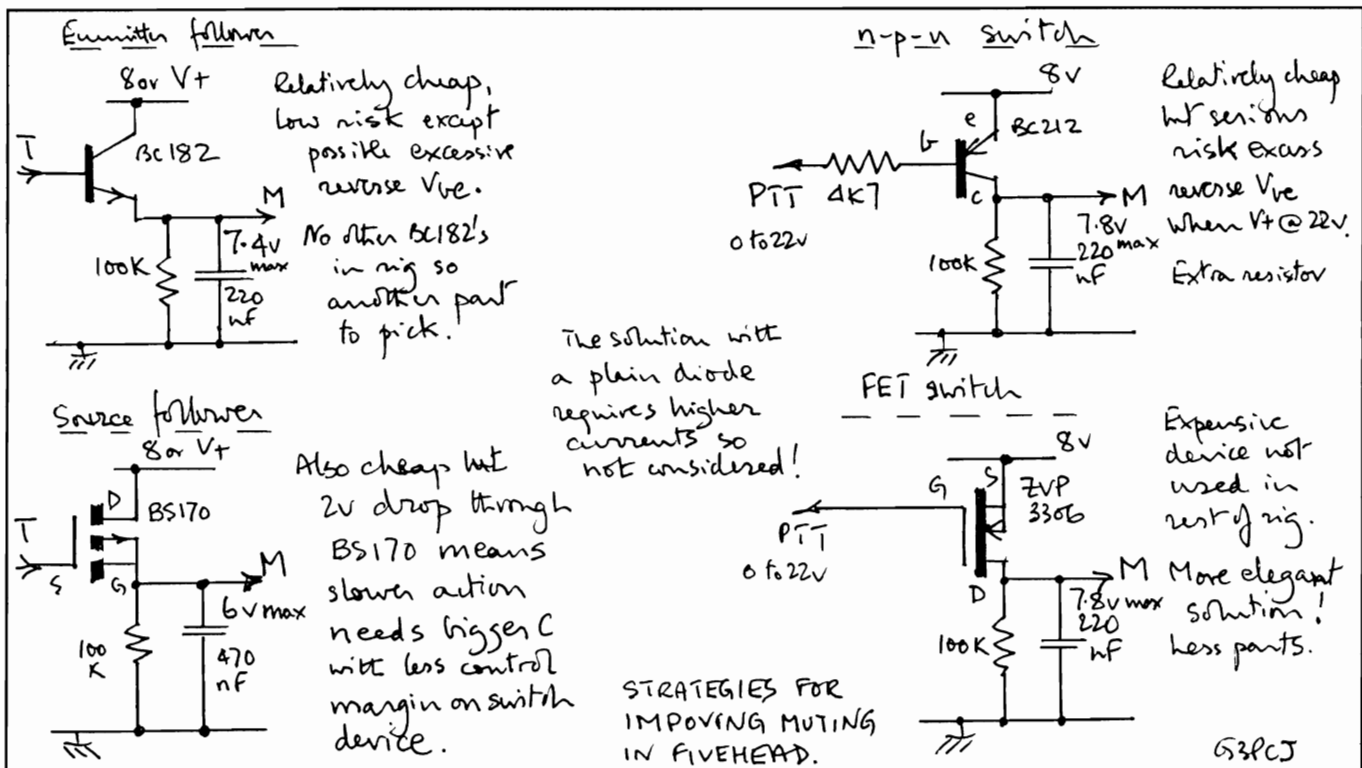


Design Choices!

You might be interested to see some of the considerations when I find that modifications are needed to a rig during its prototype testing! In this case, I found that the muting of the **Fivehead** was poor allowing clicks to come through the receiver audio on the change over both from reception to transmission and vice versa. Not only is this uncomfortable when using phones for CW, but these clicks would also desensitise the RX AGC loop if a Meter kit were fitted. (These TR clicks are a different problem from the potentially annoying clicks due to CW key action.) The requirement is for the muting to turn on very quickly, before the TR relay changes over to transmit, and to go off slowly after the relay has reverted to reception—the intention being to mask the transients caused by the swift changes of the high relay current flowing in the inductive relay coil(s).



The original design shown above did not hold the muting beyond the TR relay supply voltage being removed —this means that at least a diode and CR time constant has to be added — about four more parts. The Fivehead's muting uses one section of a CMOS switch chip to place an audio short across a high impedance point in the audio path prior to the AFG pot. Other sections of the 4066 switch chip route the signals between the IF filter and the two mixers. These chips use an 8 volt supply but their control signals are related to and derived from the rig's main positive supply which can be up to 22 volts! Thus their control signals (including that for muting) have also to be limited to 8 volts. The diagrams below show four possible approaches using different transistor technologies to derive a fast attack and slow decay of the mute control signal. The pros and cons are noted for each. Space is very tight on the PCB so that I fear I shall not be able to squeeze in even these few extra components for any of the solutions without a wire link. You will have to buy a Fivehead to find out which I will eventually choose as I have yet to make that choice! G3PCJ



A Wurzdun or Two

I recall exchanging e mails with Tim some time last year regarding a very good friend of mine (Dave Buddery G3OEP) and his tireless efforts to promote Ham radio. The main subject was that another friend Bob and I fancied assembling a rig as a gift for Dave. I had explained to Tim that Dave rather liked some of the old equipment such as regen receivers and that he still regularly used an ex German war department receiver which happened to be a regen. I am unsure if this was the inspiration for the Wurzel design or perhaps it just turned out that the receiver was on the drawing board already, it didn't really matter too much but only that a design was available.

The final realisation was a three band radio with a matching crystal/resonator controlled transmitter on the QRP frequencies. The Wurzdun, as I called it, had several additions as I plodded along trying to make this transceiver into what I thought would be a nice gift. The Wurzdun would be used by an 80 year old whose hearing was not what it should be, so with Tim's help and advice and the supply of additional parts, the Wurzel gained an audio amplifier and CW filter so as to drive a loud speaker or phones with a higher output level. The matching CW transmitter had provision for one LPF so an additional PCB was assembled with the extra LPFs and switch used to select both appropriate crystal and filter. The Wurzel retained its normal band switching scheme. The transmitter, known as the Dundon, had no side tone so a simple system using a peizo sounder and steering diodes was fitted which worked very well. By experimentation, by far the best way to silence the Wurzel, and remove key thumps during transmit, was to disable the regen potentiometer and remove the audio output from the audio output jack using the spare contact set on the Dundon's relay.

So as to give as many operating parameters as possible, a switch was fitted to enable operation of transmitter with out the Wurzel so that another receiver could be used if desired. Since the Wurzel and Dundon are separate units, Tim had provided a netting switch so that the selected local oscillator in the transmitter could be tuned into by the receiver to check that the two were operating on the same frequency. Finally the rig was boxed and lettered and we waited for our special event.

Dave, who had now been presented with his rig, phoned me two days later to inform me that he was having an awful lot of fun and had had several excellent contacts with good reports and he was now planning a day out working portable. The regen principal has been around a long time, for much of Dave's life, as he is almost 80 years of age! Later on, Dave was formally presented with his rig by the Lowestoft Club at a special barbeque event in recognition of his contribution to amateur radio over many decades by their Chairman G3IWC, see the colour photo in the Sept 2002 Radcom page 74.

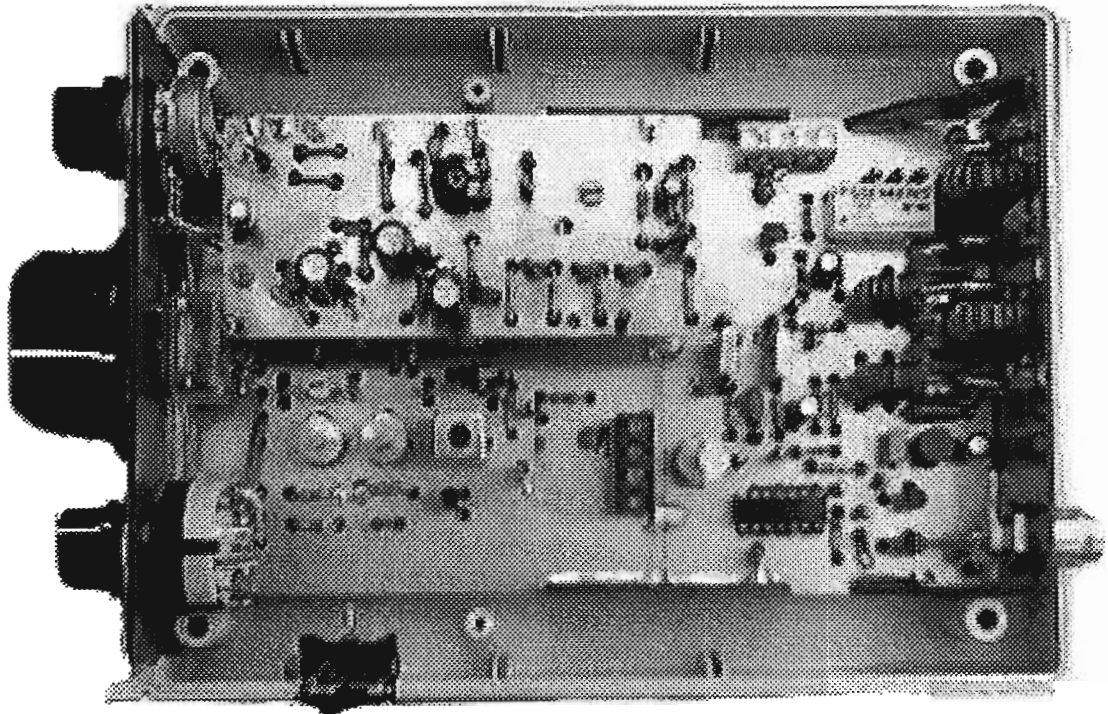
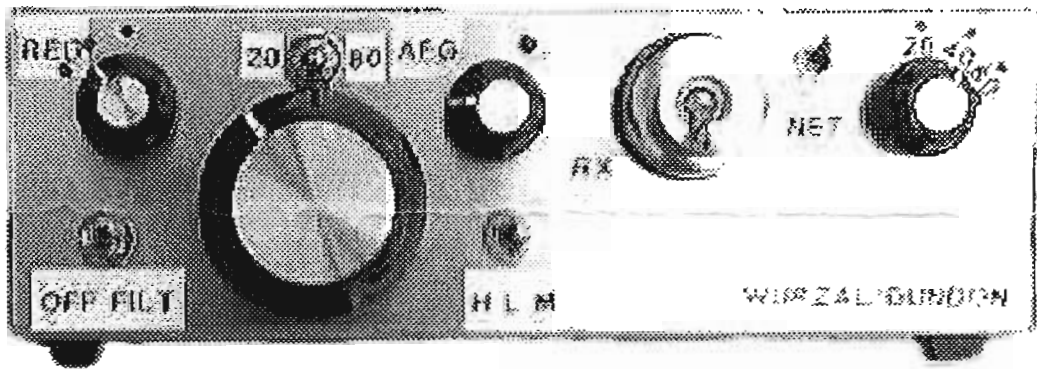
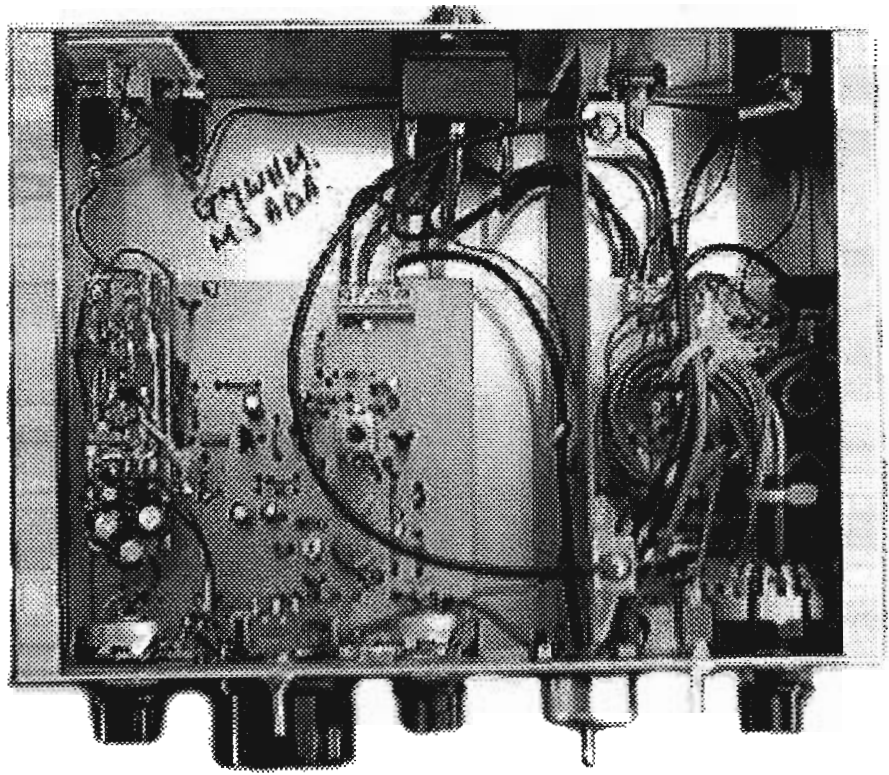
I now had a problem! My work bench was now empty of a project and I kind of missed the Wurzdun so it wasn't too long before a Wurzdun Two was under way; experience gained on the mark one resulted with the mark 2 being a little smaller, a little neater in appearance, with a proper side tone working into the audio output and a variable antenna attenuator control for the receiver made an even better rig but that is another story and I will not be parting with this rig!

My thanks to Bob M1CQR who helped with construction of the Wurzdun and The Lowestoft radio club for the financial assistance and organisation of the event.

Andy Howgate G7WHM/M3ADA

Editors Note! I was very pleased to be able to assist in this project since Dave B (as I know him!) has been a long standing customer and enthusiast of my simpler designs. Latterly he has kindly written up some interesting notes about very early DF work and the 'Hippersly Hut' which existed in East Anglia and possibly another in Somerset during the First World War. After a little more local research I hope to put this material in a later Hot Iron.

I must also thank Andy very much for taking the following photos of the Wurzdun and also for getting them copied. For those interested, the Wurzel is a simple regen receiver for the 20, 40 and 80m bands which normally drives Walkman type phones. I can supply it at the special price of £35 for Construction Club members. The Dundon is a 1.5 Watt 'crystal' controlled CW transmitter that can also be made to work on 20, 40 or 80m. Tim G3PCJ



Hot Iron

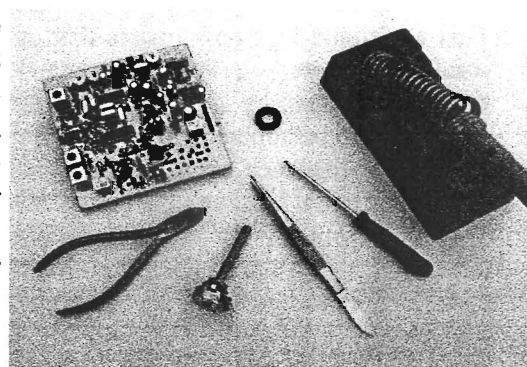
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Editorial

Recently, at the Yeovil ARC, we had a talk by Steve Hartly (Newcomers columnist in Radcom) about the forthcoming licence changes. Next year, all people wishing to become radio amateurs will have to first take the new Foundation Licence, then the Intermediate and finally the Full licence if they wish to be able to use all the facilities available to radio amateurs. It will be possible to stop at any stage through this process. The scope of the courses is much wider than the old C and G RAE, there is a strong element on operating practices, with a good piece of circuit construction being regarded as essential. These changes can only be good for the hobby as is already shown by the number of new licences issued. Already a few thousand new licences have been issued compared to just a few hundred of the older Novice ones. There is now a strong new flow of blood into the hobby. The old chestnut of CW is being addressed; for the present the Government has to still require it due to International Law but it is likely to be dropped soon. Plenty of people will still use it though – especially for QRP since it allows simple gear to be made. Good news all round!



Kit Developments

The **Fivehead** transceiver is now available after testing by members Geary and Howgate. To remind you, it is an any single band phone superhet producing nominally 1.5 Watts (on 13.8 volts) for any band 20 - 160m. It is small (open upright format with 100x100 main PCB) and pretty dense for /P operation. Many optional extras but the 10 Watt Linear is likely to be often paired with it. Prices are £79 for the Fivehead and £23 for the Linear.

I have also completed the layout of a new **QRP Antenna Matching Unit**. The latest version is a T match with resistive matching bridge and LED indicator. For all bands 10 to 160m, and all likely balanced or unbalanced loads. Small open upright format (100x100 base PCB). Normally £29 but £27 for Con-Club members - available in about two weeks when the text is completed!

The next project is the **Triton!** A 1.5 W direct conversion CW TCVR for 20, 40 and 80m. This will use a ceramic resonator VFO and should be pretty small! Some work still needed!

By mistake I have just bought a second copy of a book that I already have, **Radio Frequency Transistors** by Helge & Granberg—anyone interested? And finally, since it is just December as I write this, **A VERY HAPPY CHRISTMAS** to you all, Tim Walford G3PCJ.

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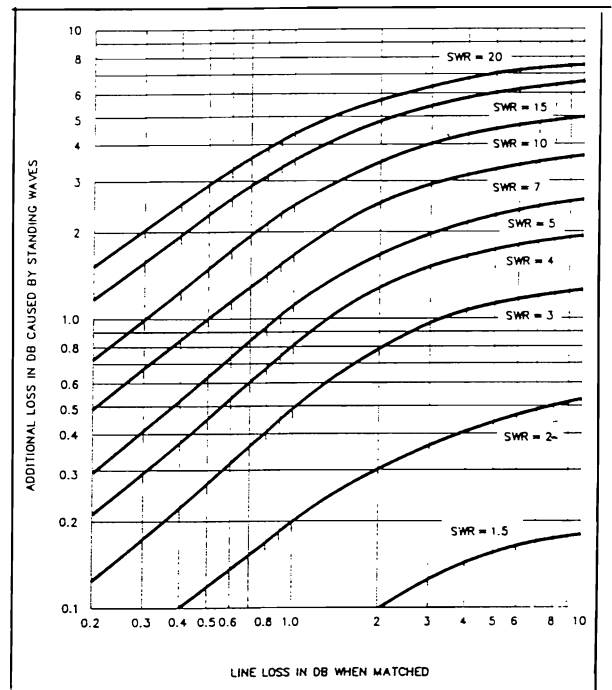
SWR and Effective Feeder Losses by Eric Godfrey G3GC

Most amateurs know that the effective loss in a feeder connecting a transmitter to an aerial is increased when the SWR is more than 1:1 and that this effect increases with an increasing SWR and higher initial feeder losses. Since the loss in a feeder always increases with frequency this is more likely to be a problem at VHF and above. These frequencies do not normally concern "Hot Iron" which generally leans towards HF matters. However a short note on this might be of interest to readers, many of whom no doubt operate on VHF and at the same time perhaps put the skeletons of a few misconceptions to rest.

The graph on the right shows how much additional feeder loss has to be added for various values of SWR and initial feeder loss. You will see that even with an SWR of 2:1 and an initial feeder loss of 1 dB, which is quite high with only 79% of the transmitter power reaching the aerial, that the amount to be added is only 0.2 dB making a total of 1.2 dB. This additional loss now means that only 76% of the power reaches the aerial. This additional loss only reduces the transmitted power by a further 3%. Such a small difference is unlikely to be apparent at the receiving end. If the feeder is a coaxial feeder then one of a larger diameter would not only reduce the initial loss but also reduce the amount to be added.

The loss in any coaxial feeder, which will have an inherently a low impedance of around 50 to 75 Ohms, is made up of "copper" losses and "insulation" losses. In a coaxial feeder the copper losses can be kept to a minimum by using as large a diameter feeder as is possible. The best insulator to use is either dry air or nitrogen. However these are impractical since some rigid support is required to hold the inner central with the outer. This forms the insulation and the losses are kept as low as possible by using as little of the highest quality insulator as possible. Most coaxial feeders used by amateurs have solid polythene insulation although for UHF some amateurs do use feeders where the support of the inner is from a continuous helical polythene membrane. However this type of feeder has the disadvantage that one has to ensure that the air inside is absolutely dry or the losses will be higher than the specification and under certain circumstances, could be worse than solid polythene. Some amateur HF installations use pair line open wire feeders particularly to feed multi-band aerials. These are inherently high impedance feeders usually between 200 and 600 Ohms. The copper losses now are from the two wires and the insulation losses from the method used to hold the two wires apart. Commercial feeders use a continuous length of thin polythene between the wires to hold them in place about centimetre apart. Some have slots or windows cut into the polythene to reduce the amount of insulation and thus reduce the loss. However it is not unusual for these high impedance feeders to be home brew with 16 SWG or thicker copper wire spaced about six inches apart with spreaders every 2 feet or so. This type of feeder will usually be around 600 Ohms whereas the commercial polythene insulated feeder will be around 300 Ohms. The spacers for the home brew feeders were made in the past from either wooden dowels that had been impregnated in either molten paraffin wax or polyurethane varnish. Today it is possible to make them from plastic which can be obtained from DIY stores in either circular or rectangular sections. Plastic knitting needles have also been used by some amateurs. However whatever plastic is used it should be checked to see that it is not lossy by putting it in a microwave oven for a few moments. If it gets warm or melts it is lossy and should not be used. Since there is very little insulation associated with these feeders then provided the spreaders are kept in good condition, they have a very low loss. The wires are responsible for the copper losses and these will be kept to a minimum making the wire as large a gauge as possible. Wires of 16 or 14 SWG are commonly used. High impedance open wire feeders are commonly used to feed multi-band HF aerials where the impedance at the aerial terminals can be either low around 50 Ohms or high around 1,000 to 2,000 Ohms depending on the band in use. Since any of these impedances will automatically give a high SWR on the feeder, the high impedance low feeder loss will be beneficial.

Perhaps a few words about impedance matching units (commonly but incorrectly called Aerial Tuning Units or ATUs) will not be out of place here. An "ATU" in the shack connected to the input of the feeders feeding the aerial will never make any difference to the SWR on the feeders between the "ATU" and the aerial even though the "ATU" has been adjusted to give an SWR of 1:1. The only way to adjust the aerial to the correct impedance is by cutting it to resonance when the value of the reactive component will be zero. However the resistive component may still not be the same as the feeder impedance in which case there will still be an SWR even though reduced. The only solution left is to transform the aerial impedance to match to the feeder impedance using some form of matching network at the **aerial terminals**. Once again nothing can be done at the input to the feeders to reduce the SWR on the feeder.



Rig Updates

Bristol TCVR Last time I mentioned the particular aspect of the Taunton and Bristol's 20m LO scheme. My suggestion of damping down the amplitude of the 4 MHz crystal oscillator didn't actually work very well! After extensive tests I eventually found that M3BGA's rig was not behaving properly due to a mixed up 1K and 10K resistor in the LO BPF buffer driver. This cured his rig but there is another solution - just change the crystal frequency to 12.5 MHz so that the LO mixer subtracts on 20m - this makes the band tune backwards like 12, 80 and 160m. Nothing else should need changing. I hope this won't be necessary for future designs but it is an option! Janos Ladvanszky (see below) has also examined this. He found that adding LF rejection to the LO BPF driver helped to prevent interaction between VFO and crystal when their frequencies were almost the same.

Some mods of the Bristol by Janos Ladvanszky HA7XN

Greetings to the readers of Hot Iron. I am a Hungarian radio amateur, licensed since 1970. Some months ago I studied the webpages about QRP transceivers and I found a very good report about the Bristol at www.eham.net. Soon I decided to buy the kit, with all options and four two-band cards. Presently my Bristol is almost ready, only the last half of the S-meter kit has not been built yet. My impression is very good, especially if the system concept is concerned. Also, construction of Bristol offers a wide room for experimenting that I fully exploited. Below I would like to describe some modifications that may be interesting for other builders.

At first two facts are summarized that led to the mentioned modifications. When the LO resonators were tuned in the original setup, I saw that the effects of the two resonators on the filter characteristic are different: The resonator nearer to the LO buffer showed only a little effect. When the frequency meter was built, I measured 170mVpp sensitivity for channel A, and the corresponding output voltage from the receiver was only 50mVpp at the band edges. A trivial solution is a small amplifier inserted at the input of the freqmeter. But another placement of the amplifier is also possible: The LO buffer could be replaced by this amplifier and this way some improvement of the receiver performance was expected.

First I removed the LO buffer FET and its source resistance. I built the amplifier shown alongside. This is a common emitter stage with voltage gain of $4.7k/680$, that is, about 7. This gain offers a freqmeter sensitivity of about 25mVpp, far enough in this case. Coupling capacitor at the collector is included in the original circuit. The amplifier is realized on a 5x15mm pcb attached to the main panel near the placement of the former buffer. Introduction of the amplifier has the following advantages:

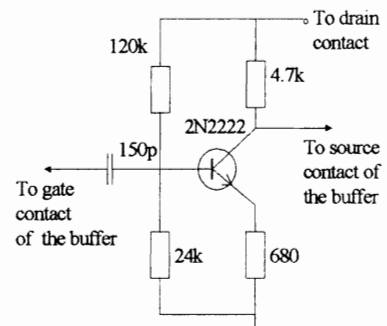
1. Freqmeter sensitivity problem is solved.
2. Receiver sensitivity is increased.
3. Large signal properties of the receiver are improved.
4. Q of the second LO resonator is greatly improved.
5. It is easier to obtain 5W output on any bands.

There is a disadvantage! Some spurious signals occurred at the low end of the 14 MHz band. I eliminated this by changing the input of the LO mixer IC (IC 104, pin 2), it was grounded by a 33pF capacitor, forming a 3.3pF/33pF capacitive divider. As far as the advantages are concerned, point 4 may need some explanation: The output impedance of the amplifier is higher than that of the buffer so does not load the tapped resonator.

A hint: When I started experimenting with Bristol, first I used an energy saving bulb in my lamp. It turned out that this bulb produces a 20kHz signal with very rich harmonic content that can be detected in the lower bands (up to 7 MHz). So please take care if you use energy saving bulb.

Finally I wish similar success to those who perform the same modifications. Please feel free to contact me at Ladvan@axelero.hu if you wish.

Janos also provided details of his display LED arrangement but I will leave that to the next issue. G3PCJ



Cdr Bayntum Hippisley

I mentioned last time that Dave Buddery G3OEP, had noted the existence of a First World War listening station in East Anglia with Somerset connections! Based on information from Dave and other sources, it appears that Hippisley, whose family had lived at Ston Easton House near Shepton Mallet since the dissolution of the Monasteries, was the very early radio amateur HLX before the First World War. He had been apprenticed with Thorn Engineering and was later in the North Somerset Yeomanry and later still became G2CW. He was a Justice of the Peace and was High Sheriff of Somerset in 1907, eventually being made a Commander in the Royal Naval Reserve with an OBE and later a CBE for his distinguished career, mainly in intelligence matters. The Somerset Local Studies Library has kindly produced a transcript of an interview with a Mr Victor Foster who knew Hippisley well. Apparently Hippisley was on duty in 1912 at a wireless station on the Lizard (Poldhu presumably) when he heard the distress calls from the sinking Titanic! Later in Oct 1914, he began picking up coded Morse messages of 5 figure/letter groups. With other radio friends, including Russell Clarke THX of Abergavenny, they were mystified! To obtain more information they resorted to a longer aerial, consisting of an unused private telephone line (single wire with earth return) that he had from Ston Easton to the neighbouring village of Cameley where his cousin had been rector. Not being able to interpret these messages he eventually sent them to the Admiralty in London who were not able to do any better! Russia was also at war with Germany but nothing was being received via normal listening services from the Germans—just radio silence. On Oct 20th a German battleship was sunk in the Baltic by the Russians and a sailor was washed ashore clutching a codebook. Being unable to use it, the Russians sent it to London and this enabled Hippisley's indecipherable messages to be read as German Fleet orders. This persuaded Government to set up a purpose built listening station which they sited at Old Hunstanton on the Norfolk coast. This site and building is relatively well documented, although I could not find it recently when nearby! It was known as the Hippisley Hut and fed information from radio intercepts into the official intelligence organisation which came eventually to be known as Room 40. Charles Lambert G2ST was instrumental in setting up this organisation and recruited HJ Round from the Marconi Co to develop direction finding receivers. The Hut was initially run by Lambert who also wrote children's stories under the nom-de-plume AJ Alan! Lambert eventually became supreme head of MI6 in both Wars. Amongst many other successes, the Hut gave the Royal Navy a crucial 4 1/2 hours early warning prior to the Battle of Jutland by detecting a very small change in the bearing of the received German signals - indicating their fleet had left port.

When Hippisley departed to Norfolk, it is thought he may have taken a number of local radio enthusiasts with him since their previously well publicised activities in the West Country seem to suddenly cease! He had an extensive 'shack' in his cellar but little is definitely known about the actual radio equipment he was using. Foster noted very early 'servo' equipment in Hippisley's 'shack' for the transmission of shipboard angular information (e.g. relative wind direction) which was being maintained by Horstmanns of Bath - what we would now call Selsyns (resolvers/synchros) using 3 phase AC signals. When he left Ston Easton, the house was shut up and became neglected only to be refurbished many years later by the new owners, the family of William Rees-Mogg—later editor of the Times. It is reputed that local buoys found all the technical equipment when rummaging through the almost derelict house!

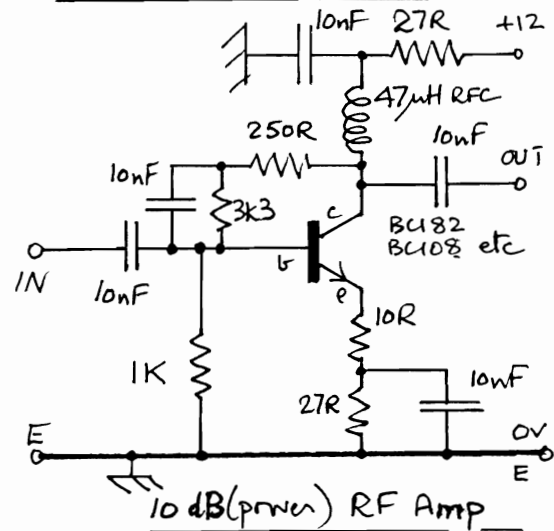
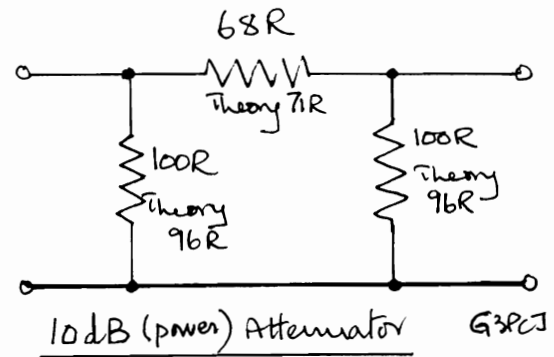
Dave Buddery thinks Hippisley may have formally set up a listening Hut in Somerset for the task of intercepting German radio traffic in the Western Approaches. I have not found any firm evidence for this. My opinion is that he performed these early intercepts using his own equipment installed at Ston Easton and that a dedicated 'western' Hut never existed. Information on the equipment being used by both sides of that war is patchy! In the early stages all would have been using rotary spark transmitters, probably with long wavelengths up to 2000m. A long wavelength increases the chance of a spark or kick in each RF cycle (of the simple damped tuning circuits defining the frequency of operation) so should improve the average RF output power. It is suggested that Hippisley's own spark transmitter would have been rated at around 500 Watts with shipborne sets of up to a kW or more. All the receivers would have been crystal sets using galena detectors at the start of the war, though later 3 stage valved sets with reaction were used by the services (certainly by the Germans), but most Navies are pretty conservative and spark transmitters, crystal detectors and low frequencies are likely to have been predominant till the end of the war.

The sources for this note are too many to list sensibly, but many thanks to Dave Buddery for prompting the investigation—it was most interesting. As a footnote, I suggested to the 'historic radio' section of the Yeovil Club that we should put a replica spark transmitter on air (with all the filtering etc to make it legal) but my suggestion was not intercepted! (I know others have tried!) Tim Walford G3PCJ

Useful Test Gear!

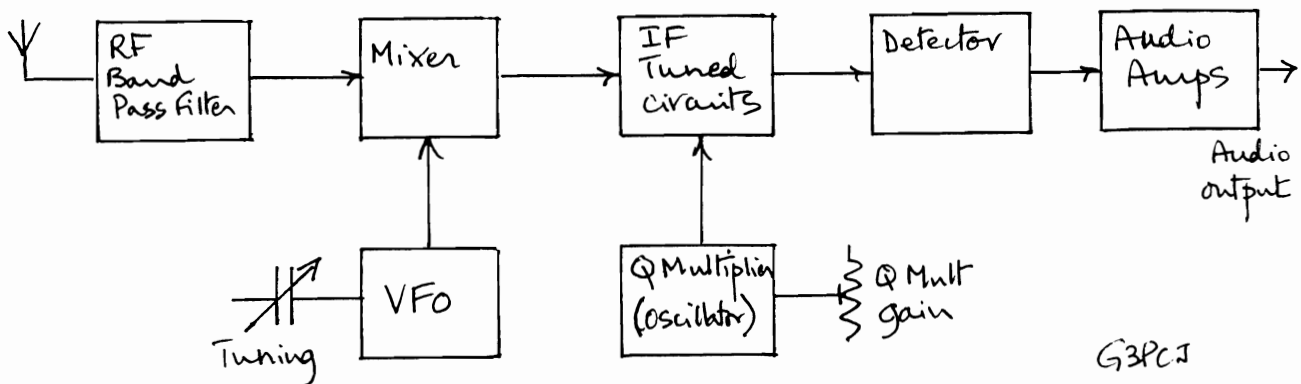
In RF work it is very common to find circuits using a 50R impedance for most signal lines. General purpose amplifiers and attenuators, with 50R in and out impedances, are most useful units to have available on your bench. They can easily be made broadband so can just be added, for example, ahead of a RX on a temporary basis to see if less signal will reduce BCI problems, or to add a bit of gain to compensate for a short receiving antenna.

Both circuits right are broadband and will cover 2 to 30 MHz. The attenuation is 10 dB power which implies a reduction in voltage by a factor of 3.3 when operating with matched source and load impedances. The gain of the amp is 10 dB (x10) for power or times 3.3 for voltage with matched 50R in and out. The supply is not critical but should be well filtered if amplifiers are cascaded. Maximum output will depend on the device standing current and should be around one tenth of a watt or +20 dBm for the values given. (Note. 0 dBm is one milliwatt into 50R, so +20 dBm is two lots of x10 power or times 100 compared to one milliwatt = 100 mW = one tenth of a watt.) Tim G3PCJ



Q Multiplying Superhets!

The key point about a superhet is that the incoming frequency is changed to another where narrow filtering can be carried out rather more easily. Hence the early single conversion superhets changed the frequency down because the lower IF had a smaller bandwidth for a given Q in the tuned transformers that were used originally. An alternative to the modern technique of using a crystal filter for really narrow bandwidths is to use a regenerative stage, this can raise the Q of a tuned circuit to 1000+ easily! The snag is that it becomes rather tender and not really tuneable! The solution is a tunable local oscillator driving the mixer for the down conversion. Then the high Q stage can be fixed frequency and less temperamental. As ever, you need to make certain that the right mixer product is being received so good RF filtering is required; this prevents the unwanted image at twice the IF from the LO getting into the mixer. Either sum or difference mixing can be used but if the LO is above the wanted RF there is less chance of its harmonics getting into the front end and causing birdies. This technique was used as an adjunct to general coverage RXs in the valve era - known as a Q multiplier. An almost oscillating extra IF stage was coupled to the original IF amp and could markedly decrease the IF bandwidth of a previously wide open RX! G3PCJ



Assorted Snippets!

PCB Material for VFOs. Charles Wilson forwards an article which points out that you need to wait several hours after building a VFO before measuring its frequency stability! This allows the parts to revert to ambient temperature and stabilise mechanically. It suggests that VFO stability may be improved by purposely ageing the board. Pack the PCB moist free in a plastic freezer bag and leave in the deep freeze compartment of your fridge for a couple of hours. Remove from fridge and allow bag with board inside to warm up to room temperature for an hour or so. Then put the bag on a hot central heating radiator for another couple of hours! Allow to cool down and return to the fridge. Repeat these extreme temperature cycles three times and with luck, the board will be free of mechanical stresses and give optimum stability! Its bad enough taking frequency readings for an hour after changing components for better temperature compensation, but this is seriously time consuming! It helps to emphasise that best VFO stability requires high quality parts with excellent mechanical rigidity. Charles doesn't like double sided PCBs for VFOs but I have not had problems.

Fuse cap heatsinks. Andy Howgate suggests that the end caps of (blown) mains fuses will fit snugly over TO92 shaped transistors; this allows you to solder on a loop of wire etc which can help to radiate the heat! Very useful for those rigs using BS170 MOSFETs in their output stage! A loop of wire is better than a small piece of sheet material since it will have less capacitance to whatever is nearby.

Reduced price kits!

I have two Boosters which are surplus to requirements. I am open to offers bearing in mind their normal price of £49! On the TX side, they need about 1 W drive to produce 20W on a 13.8 volt supply. They also include RF sensing with two TR relays, and a receive 10 dB broadband amplifier. Input and output to the four IRF510 FETs is by two sizes of ferrite rings. Full of goodies!

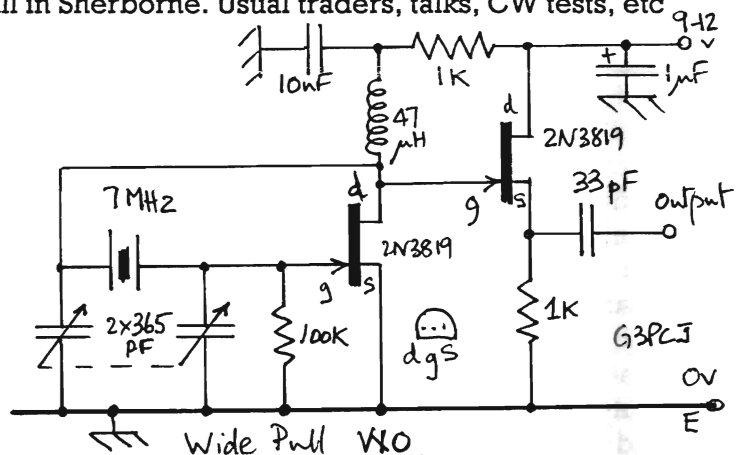
I am also expecting to receive a Bristol kit back from a customer who has decided it is too complex for him. I am assured it is untouched so should be complete. Let me know if interested.

New date for QRP Convention!

I am advised that the date has had to be changed again to avoid a bad clash of local events. The new date is June 8th 2003 at the Digby Hall in Sherborne. Usual traders, talks, CW tests, etc

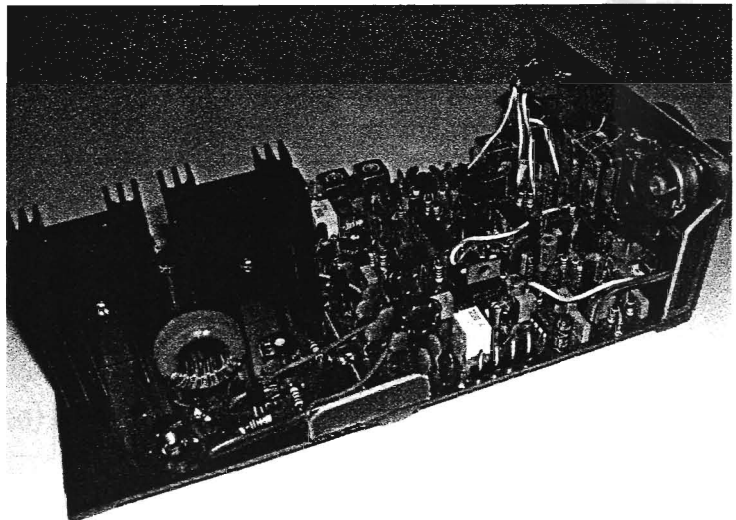
Simple Wide Range VXO

The circuit right has a reasonable pulling range without the need for extra rather temperamental inductors! It does about 6 KHz swing at 7 MHz with only a total of 15 parts including the buffer! If you only have a single gang variable capacitor, then replace the other missing section with around 100 pF; the swing will not be quite so large but still quite useful for dodging QRM! It can be used over the entire HF range



I end this issue with a photograph of my Fivehead with 10 Watt Linear attached. It uses two IRF510 FETs in a push-pull arrangement. Jim Gearey's Fivehead looks much better than mine but I don't have a photo of it with his Linear—not that he really needs it! His first contact and barefoot, (on 20m) was with DL6OCF, who gave him 5 and 5 which was rather pleasing, especially when the other station was running a kilowatt! Having now installed a counterpoise to stop RF feedback, he has added Poland, Lithuania & Italy.

My apologies for the slight delay in getting this issue out. Happy Christmas and a good building year to you all, Tim G3PCJ



Hot Iron

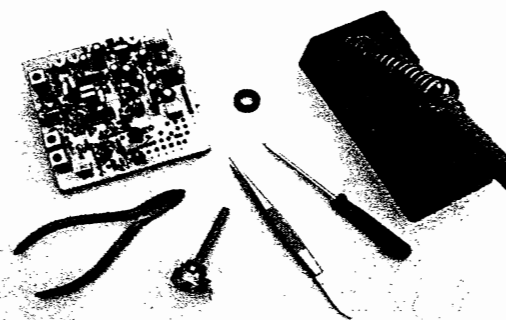
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Editorial

The days are getting longer, warmer and dryer—thank heavens! On the farming side we are at last able to do a little field work. But often this is also a busy time of year for kit builders for reasons which I cannot fully explain! I had thought it was catch-up time after the excesses of Christmas but maybe not! I am pretty certain its more to do with temperature and many builders having shacks at the end of their garden! I must admit that even here, in the main part of our house, that outside temperature does have an effect on my willingness to experiment—it certainly has an effect on my brain cells. The list of possible interesting projects never seems to get any shorter though; I suppose that is because its easy to think up the outline or specification of a project but quite another thing to be able to tick it off as completed! Having read an article recently about the K2 TCVR, having many of the processor based facilities found in much higher priced black boxes, I remain convinced that rigs and kits highly dependent on software are best left to others. I am sure most builders like to understand their rig and feel confident about mending it if required.



Kit Developments

The new **QRP Antenna Matching Unit** is now fully out. All bands 10 to 160m, and suitable for all likely balanced or unbalanced loads. It includes a resistive matching bridge which drives a LED matching indicator or an external meter. Normally £32 but £30 for Construction Club members. I have also **reduced** the price of the Wurzel, the Compton and the Butleigh to £35 each. The **Fivehead** superhet phone TCVR is now also working well on all bands 20 to 160m, £80

Last time I mentioned a new small CW direct conversion TCVR for 20, 40 and 80m - for various reasons I have had to change the name to the **Triwell** which was suggested by our member Andy Howgate; it reflects the three bands and lots of water of which there is plenty in Somerset! It is proving quite challenging to get right! Much head scratching over the best design for RF front end and AF filters. It's a little way off yet but let me know if you are interested.

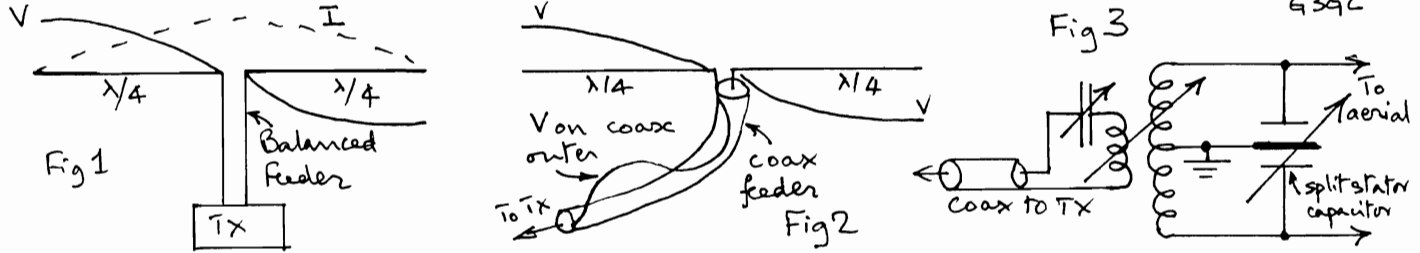
I am sad to note the 'demise' of Kanga. I use that word cautiously since I have not yet heard whether John Fletcher has sold the business to others or what has happened. I hope it is not the end since it is sad to see another UK kit supplier disappear. A variety of 'styles' is good for all of us and helps to keep competitors on their feet! Tim Walford G3PCJ.

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £6 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

Unbalanced TX outputs and balanced aerial inputs by Eric Godfrey G3GC

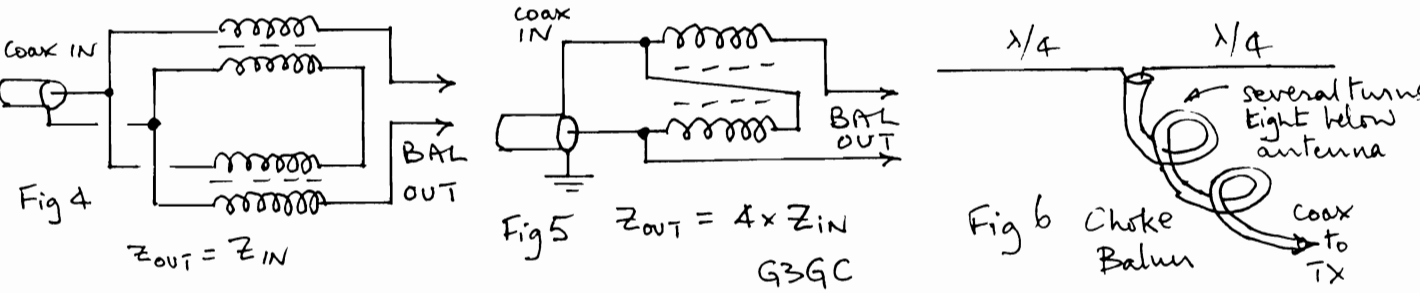
A fundamental principal in engineering is that any balanced system should not be connected to an unbalanced system, and vice versa, without some form of network transforming the balanced system to an unbalanced one. So often this principal is ignored by amateur radio enthusiasts with the consequent reduction in the expected performance. This particularly applies to the connection of an unbalanced transmitter (coaxial output) to a balanced aerial such as a centre fed half wave dipole.

Let us first look at the consequences of making a direct connection of the coaxial feeder to the balanced aerial. Fig. 1 shows the voltage and current distribution on the two arms of a half wave dipole properly fed with a balanced feeder/transmitter set up. Fig. 2 shows the voltage distribution on the same aerial but now fed with coaxial feeder direct from the transmitter. In the first instance because the feeder is balanced there is no (or negligible) radiation from the feeder and each side of the feeder forces similar currents in the two dipole arms with the consequent well known figure of eight polar diagram in the plane of a half wave dipole. Fig. 2 shows the distorting effect on the voltage distribution in the aerial caused by connecting the unbalanced coax to the balanced aerial.



In Fig 1 each side of the two wires, which carry equal and opposite currents, of the balanced feeder have the same length of aerial wire connected to them. In Fig 2, these two feeder wires are replaced by the coaxial inner conductor and the inside of the coaxial outer conductor. Thus the inner conductor current feeds one arm of the dipole whilst the inside of the outer conductor not only feeds the dipole's other arm but also the outside of the coaxial feeder to which the dipole arm is connected. Consequently the current on this side has to be shared between the dipole arm and the outer of the coaxial feeder, not only reducing the amplitude in the dipole arm but also setting up other undesired currents and voltages on the coaxial feeder from which they will radiate. How the currents are shared will depend upon many things and in particular the length of the coax. Consequently the radiation diagram of the aerial, although displaying some of the characteristics of the figure of eight, is virtually unpredictable. However, one thing is certain it will not be the theoretical figure of eight. The current on the feeder will cause radiation with random polarisation depending on its orientation at any particular point.

There are a number of different ways of achieving the change from the unbalanced to balance configuration and I will just mention just a few here. Probably the best way is by using a balanced tuned circuit connected to the aerial and link coupled to the unbalanced transceiver as shown in Fig. 3. This not only makes the change from balance to unbalance but also, by the adjustment of the various Ls and Cs, is able to match differing impedances. Further brownie points for this type of unit are that it uses a parallel tuned circuit at the operating frequency which will reduce the emission of harmonics on transmit. On receive this tuned circuit provides extra selectivity ahead of the receiver which can be useful on 7 MHz against the high power broadcast stations just further up the spectrum. Another approach is to use special RF transformers, often wound on ferrite, to make the transformation, Figs. 4 & 5. However there are a number of problems with these which include losses in the ferrite, a nominal fixed impedance transformation ratio and the fact that they only work properly when terminated by the correct load impedance. This is most unlikely particularly with multi-band aerials. A further approach is to coil up the coax feeder for a few turns just below the feed point to form a 'choke balun' - Fig 6.



Mounting Digital readouts

(I have held the following notes by Janos Ladvanszky HA7XN over from last time. I can also report that one or two UK Bristol owners have successfully tried out his suggested modifications to the Bristol's LO chain. G3PCJ)

The other modification I would mention is a tip for mechanical attachment of the LED display to the front panel. My objective was making a construction that allows an easy replacement of any LED ICs if necessary, and an easy removing the wires connecting the freqmeter to the display if necessary. The outline is shown in Fig. 2.

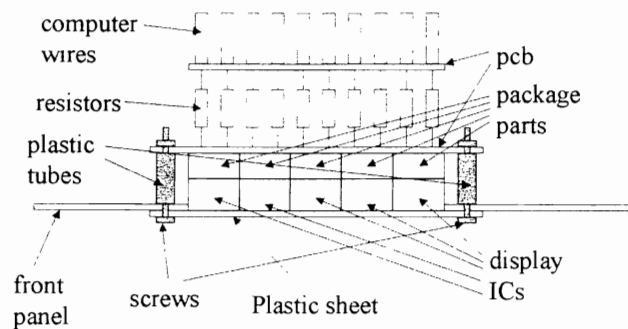


Fig. 2. Upper view of the display attachment

The face of the displays is covered by a plastic sheet that is fixed to the front panel by four screws. Display ICs are held by IC package parts that are made from a DIL 14 package each (In the UK we know these as IC sockets! Ed). These small packages are soldered to a PCB and this PCB is fixed to the inner side of the front panel by the same four screws previously mentioned. The 3.3k series resistors described in the user's manual of the freqmeter, are soldered to the PCB and their other ends are soldered to another PCB. To the other side of this last PCB, the connectors are soldered, to which a seven-wire computer cable is connected for every seven-segment ICs. One additional wire is necessary for the decimal point. I note that construction of this display attachment needs patience, especially cutting the DIL 14 packages.

A hint: When I started experimenting with Bristol, first I used an energy saving bulb in my lamp. It turned out that this bulb produces a 20kHz signal with very rich harmonic content that can be detected in the lower bands (up to 7 MHz). So please take care if you use energy saving bulb.

Finally I wish similar success to those who perform the same modifications. Other minor modifications that I made are available from me at the e-mail address Ladvan@axelero.hu

(There is another arrangement where the LED segment resistors are mounted directly on the counter PCB, one end being inserted directly into the PCB hole allocated for each segment wire. The segments are then connected directly to the tops of these resistors protruding from the PCB. In both cases, there is no restriction on the length of the wires, since they carry only DC. While the electrical scheme used for my counters does have lots of wires, it has one massive advantage over the approach often used for driving LEDs where the drive signals are multiplexed. That approach is often used with a microprocessor controller and the fairly low frequency LED drive signals have relatively sharp rise and fall times. These are full of harmonics from LF upwards and these are inevitably heard by the receiver without great care on layout and shielding! In my design the digital logic is CMOS and confined to the counter PCB; the reference oscillator frequency is also much higher with its harmonics outside any amateur band. G3PCJ)

Cdr Bayntum Hippisley- follow-up!

A friend of David Hunt has kindly done more extensive research in Norfolk and interviewed Mr Dyker Thew, a local journalist, who had observed Cdr Hippisley first hand. He reports:-

"Hippisley arrived in Hunstanton with several members of his unit at the beginning of WW1. Others joined them until the unit was about 30 strong. No local people were employed as civilian staff. All wore naval uniform and were billeted in the town, with the exception of Hippisley who took over a wooden summer house in Old Hunstanton as his quarters. This became known as the "Hippisley Hut". Hippisley moved between his various sites in his Humber car, which was the only transport available to the unit. Thew described Hippisley as dapper, lightly built, of medium height and very active. He looked invariably smart in his uniform, and was "in command", confident and outgoing. He was also entertaining and amusing. Held in high regard by the townspeople, especially the ladies, he was believed to work very hard. At no time was he visited by his wife or family during the war, nor was he known to have returned to Hunstanton after the armistice. Thew was convinced that the Hippisley Hut was not used for any part of the unit's work. He had passed it often throughout the war but had seen no mast nor wire aerial, nor was it guarded as were all the other unit sites as the war progressed. No unit designation was ever displayed on any of the sites, nor did one become common knowledge at any time. The unit personnel were referred to locally as "the wireless men".

While Thew never learned anything directly of the unit's work rumours often circulated in the town, especially after particular successes. He instanced the installation of a direct Post Office line to the Admiralty, and the first reporting of the Battle of Jutland. Some of the rumours were confirmed a few days later by reports in the national press. Although these official reports never mentioned the Hunstanton unit, the townspeople were satisfied that it was "their" unit which provided both signals intercept and direction finding to the Admiralty. They were also convinced that DF had been invented by Hippisley's unit. Relations between members of the unit and the townspeople were very good. Billeting allowances were generous and were paid promptly. In what spare time they had the men played football, both for and against local teams. They were also seen at concerts and the cinema.

INSTALLATIONS

On arrival in Hunstanton the unit established itself in the lighthouse, taking over the existing Marconi wireless station which had been installed in 1911/12. A workshop was set up with lathes, benches and other mechanical engineering tools, in a wooden building which had been the Professional's hut adjacent to the 9 hole golf course. Hippisley then took over the three cliff-top shelters, around each of which he formed a temporary building. A single slim vertical mast, some 50 or 60 feet high, was erected at each of these, wire guyed for stability. This appeared to be the only aeri-als, no horizontal wire aeri-als being visible. About a year before the end of WW1 a much larger site was established behind the town E of the Lynn Road, where more masts were erected and temporary buildings constructed. The earlier sites remained in use. Mr Thew could recall no details of the use or staffing of this later site. At the end of WW1 Hippisley and his unit dismantled all their equipment, restored the three cliff-top shelters and departed in a very short time. No intercept site was re-established in or near Hunstanton before, during or after WW2, as far as Mr Thew had been able to tell.

AIR DEFENCE

To counter the Zeppelin threat a number of Sopwith biplane fighters were deployed to an airfield at Sedgeford, a few miles SE of Hunstanton. In 1915 the Admiralty sent HNS Cricket, a "Monitor" gunboat, to the Wash where it was anchored off the end of Hunstanton pier. It remained there until the end of WW1, providing anti-aircraft fire to supplement the Sopwith fighters. There being no other obvious reason for its presence the townspeople concluded that these air defences were for the benefit of the wireless unit.'

MAP REFERENCES

Hippisley's Hut TF685422, Workshop TF681423, Lighthouse TF676420, Cliff Shelter TF674419/673415/673413

It seems that when I was there, looking for the 'Hut' expecting to find something with the radio equipment, I was actually looking for their mess room! I did find all the other buildings but dismissed them since they did not look like the beach hut with radio that I was expecting! G3PCJ

Transformers and matching!

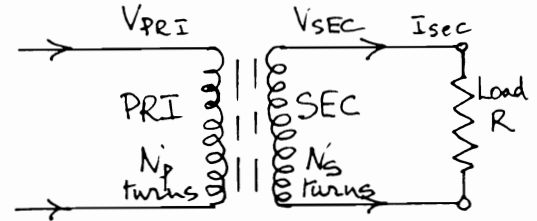
Andy Howgate asks about the toroidal version of these devices which are frequently used where a broadband RF transformation is required. Fundamentally they are like an ordinary laminated iron transformer for 50 Hz! The ratio of the number of turns on the secondary compared to the primary directly tells you the change in voltage. For example, if the secondary has half the number of turns that are on the primary, then the nominal output secondary voltage will be half that applied to the primary—this is just as true at 50 Hz (for the mains transformer) as for the RF transformer wound on a ferrite ring. Similarly, if the secondary has three times the number of primary turns, then the output voltage will be three times that applied to the primary. The power dissipated in a resistance R connected to the secondary will be $(V_{sec})^2/R$ but the secondary voltage is N times the primary voltage where N is the turns ratio, so the secondary power can also be written as $(N \times V_{pri})^2/R$. The power into the primary is $(V_{pri})^2/Z$ where Z is the apparent input impedance of the transformer (with the load R connected to its secondary). Assuming just for the moment that the transformer is perfect and does not have any losses, then in the power available from the secondary must equal that input to the primary. Hence the two power expressions must have equal values or $(V_{pri})^2/Z = (N \times V_{pri})^2/R$. This can be juggled around and V_{pri} eliminated to show that:-

$$Z = R/N^2$$

This tells us that, for our second step up example where N was three, the transformer input impedance is one ninth of the load on the secondary. For the first step down example where N was a half, then N^2 is 0.25 so that Z is four times the load impedance R.

A transformer works equally well in principle with the power flowing in either direction; thus what is a step up transformer one way is a step down one the other way! All of the above applies to any conventional transformer for 50 Hz or 5 MHz. For general RF work, the winding capacitance should be low and its inductive reactance many times (min 4) the circuit impedance connected on each side. This often requires a quite high inductance from small numbers of turns so the transformer core has to be made of high permeability material. For RF work in the 2 to 30 MHz range, the ferrite mix number 61 is suitable. Hence such transformers are often made with half inch diameter FT50-61 toroids. Sometimes the mix 43 material is used for broadband low frequency transformers.

Note! Ferrite cores are made of a dusty dark grey unpainted material. They should not be confused with painted powdered iron cores such as the red T68-2 or yellow T50-6 used in HF tuned circuits. Ferrite is generally not suitable for tuned circuits. Beware also that cores made of other ferrite material, e.g. those intended for low frequency mains filters etc, also look the same and cannot be distinguished just by visual examination. Only use cores that can be positively identified! G3PCJ



$$\text{Turns ratio} = N_s/N_p = N$$

$$V_{sec} = N \times V_{pri}$$

$$P_{LOAD} = V_{sec} \times I_{sec} \\ = V_{sec} \times \frac{V_{sec}}{R} \\ = V_{sec}^2/R$$

$$P_{LOAD} = \frac{(N \times V_{pri})^2}{R} = \frac{V_{pri}^2}{Z}$$

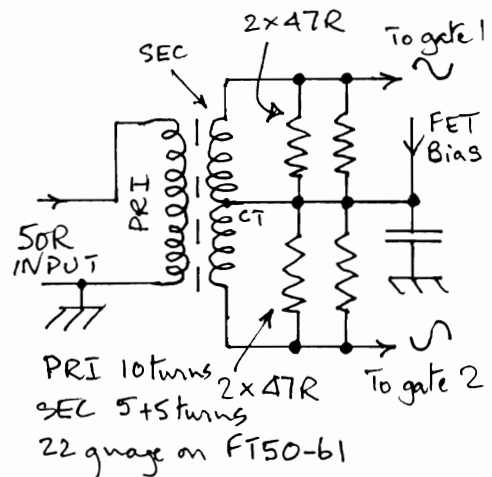
where Z = primary input impedance

Re-arranging & eliminating V_{pri} ,

$$\text{then } Z = R/N^2$$

G3PCJ

As an example, the circuit below shows the broadband input transformer of the new 10 Watt linear amplifier. The design requires opposite phase RF signals, hence the centre tapped secondary. The load presented by the transformer (with following resistors) on the preceding stage is nominally 50 Ohm.



INPUT OF 10 WATT LINEAR
G3PCJ

The Dundon top-bander - By Paul Tuton G0UBV

For the last two or three years, Tim's occasionally asked what kind of new kit I'd like to see and my reply must have become monotonous "...an AM top-band transmitter". Nothing much came of this until last year, when I'd acquired a Dundon kit more or less at the same time as Tim's regular "what kit" question. Following my predictable response, Tim finally caved in with a compromise. Why not modify the Dundon? So that's how it started. With some design suggestions from Tim and a bit of ingenuity from both of us, I now have almost 8 watts of high-level AM between 1960 KHz and 2000 KHz. Here's a summary of how it was done.

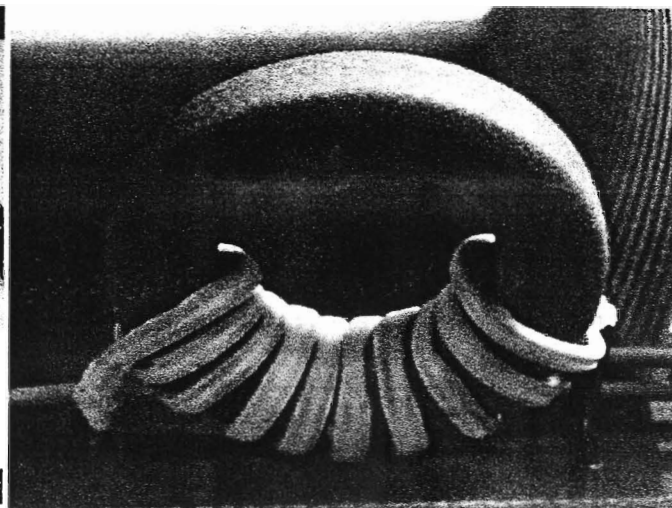
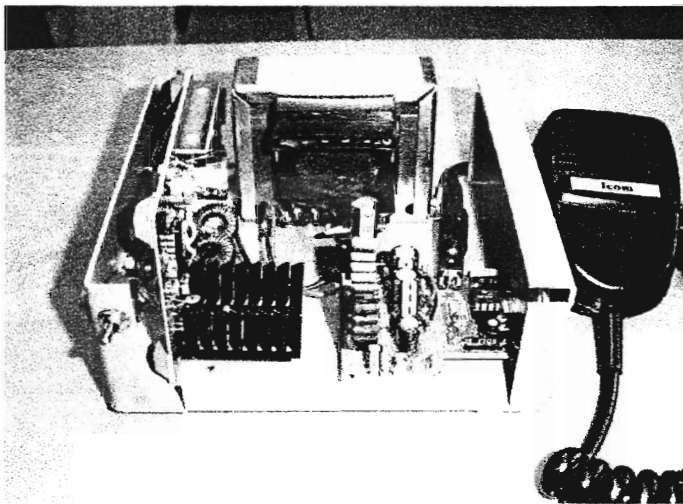
First of all, I got the basic Dundon working with an 1843 KHz crystal and an output filter to Tim's spec. Fine. About 1.5 watts output. I didn't really fancy applying high-level mod to the Dundon's 2 x BS170 PA and anyway, I was hoping for 5 Watts. So out went the BS170's, replaced with an IRF510. That meant changes to the bias and I pinched the design from the Highbridge, complete with drive-level adjustment. It meant a bit of track-cutting and fiddling with the heatsink, but was quite easy. It worked first time with the output up to around 3 watts on a 12 volt supply.

Coincidentally while I was building the TX, I'd been given a heap of old Practical Wireless magazines. The July 1979 edition featured a "VMOS Top Band Transmitter" much as I'd always had in mind. The specified modulator transformer was "A speaker matching transformer rated at 10 Watts, with a winding resistance of not more than 1 Ohm between the 0 Ohm and 16 Ohm taps." The PA power supply was fed through the transformer (0 and 16 ohm taps) with the modulator output applied to the 3 Ohm tap. The other winding of the transformer was not used. This was much the same as the design for the modified Dundon except that Tim suggested using a 230v to 15v-0-15v mains transformer. PA power being fed through the 15-0-15 secondary, with mod applied to 0v centre-tap. I didn't have either transformer type, so I took the plunge and ordered a 30 Watt line-matching transformer from Maplin. This hefty object exceeds the specifications in the P.W. project, and has secondary taps at 0 / 4 / 8 and 16 Ohms.

For the modulator itself, Tim sent me one his new LM380 audio amps. With the audio amp plus electret microphone, the Dundon and the transformer all lashed together on the bench, initial dummy load tests looked promising. Monitored audio in the receiver downstairs was impressive. Subsequent air tests confirmed the results, with astonished locals commenting on the excellent

Snippets!

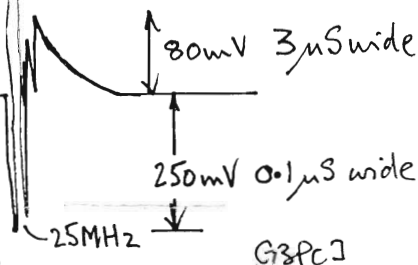
Paul Tuton has recently built one of the new AMU kits and recommends binding the two wires of the bifilar transformer together with plumbers PTFE tape before putting the turns on the toroid. An alternative is twisting the wires together. See the photo on right. His AM rig is on the left.



Both Paul and Andy Howgate have suggested using the 18 volt output 'wall-brick' type PSUs often supplied for laptop computers. Their small size makes them highly attractive! The sketch right shows the output ripple waveform when loaded to 3 Amps but somewhat to my surprise, it did not cause any interference on the receivers that I used with it! Clearly good L and C filtering of the incoming supply is important. The repetition rate of these spikes is not constant and varies with DC load. It also runs very cool! G3PCJ

18v DC switch
Mode laptop
Supply loaded
to about 3A.

Repetition
rate about
60 kHz but
not constant.



Somerset Contest

As usual the purpose is to encourage the use of home built gear! The first prize is a £50 voucher for Somerset Range gear. Peter G3XJS is again kindly doing the hard work on behalf of the GQRP Club. The rules have been changed to allow more bands etc. Either TX or RX or both must be home made. When: Sunday 23rd March, 0900z until 1200z. Mode: Any mode is permitted (including cross mode). Freqs: Around the normal QRP cw and ssb frequencies on 80/40/20/15/10m. Call: "CQ HBC Contest" (ssb) and "CQ HBC Test" (cw). Exchange: rst/serial/power (eg 579/SC021/3W). Serial must start with any random number of your choice, not less than 100, and increment by one throughout the Contest. Stations not in the Contest may send any serial (eg 001). Scoring: Any station may be claimed once per band. QSO's with QRP stations score 2 points. QSO's with QRO stations score 1 point. Final score is the total number of points (there are no multipliers), BUT deduct 25 points if you did not build either the TX or RX yourself. Entries to G3XJS by the end of April, with log sheets showing times, bands, stations worked, reports sent/received, and points claimed. Please supply details of equipment used, power and antenna(s), together with a declaration that your station was operated in accordance with the Contest rules. In the event of a tie, Tim will draw the winner from his hat!

Yeovil QRP Convention

Note the new date! June 8th 2003 at the usual Digby Hall, Sherborne. The usual attractions etc! Talks on the G5RV Antenna, Summits on the Air, and the Inside workings of the GQRP Club! There will be no formal morse tests this year but assessments (for M3 licencees) will be available by prior arrangement. The usual array of radio related traders and a large bring and buy stall. The Construction Challenge is to produce the highest output TX (on 3560 kHz) which runs off one AA cell. It should have no more than 2 active components, no i/c s. YARC will supply a 50 ohm dummy load and meter. In the case of a tie, the number of components will be taken into account. G3ICO

Megohmmeter by Gerald Stancey G3MCK

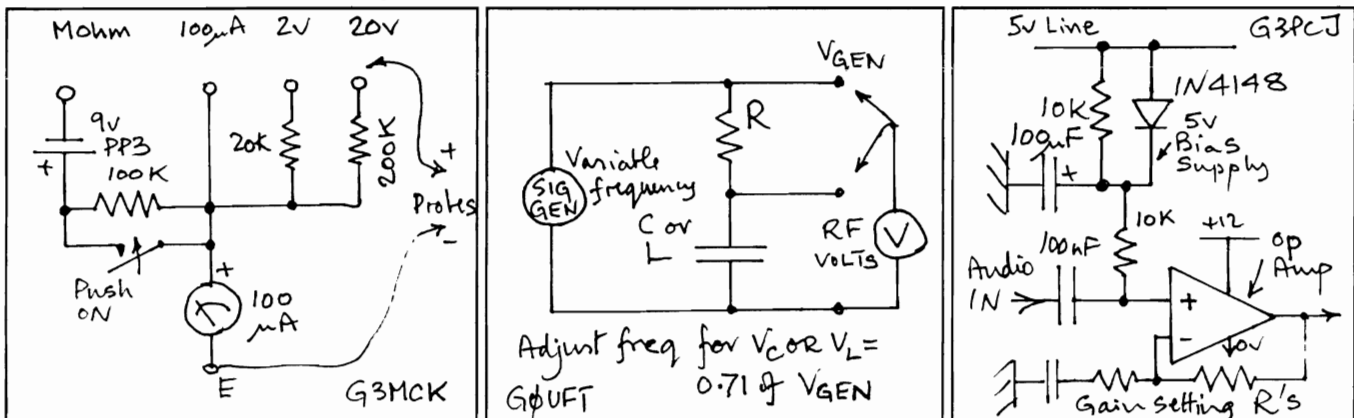
Recently I needed to measure, or to be more exact estimate, the values of some resistors that were in excess of 2 Megohms. What's the problem you ask. Well my DVM only goes to 2M. The solution was easy—a return to basics! I had a 100 micro-amp meter and a PP3 battery. Put them in series and 4.5 micro-amps will show on the meter (Ohm's law). Not much but enough to show that I wasn't looking at an open circuit. Higher resistances will show a proportionally lower current.

As it stands, this test set has one dangerous drawback. If the resistor being measured turns out to be less than 100K you will blow the meter! This danger can be avoided by putting a 100K current limiting resistor in the circuit. This resistor can also be used to check the actual battery voltage. I have found new PP3s up to 9.7 volts. You use the measured value in your calculation.

For example. Touching the test probes together show the battery voltage to be 9.3. When the probes are put across the unknown resistor 3 micro-amps flow. From Ohms law the total resistance is found to be 3.1 Megohm. Ignoring the internal resistance of the meter and battery, we reduce the calculated value by 100K for the current limiting resistor making the unknown 3 Megohm.

The basic test set can be improved by increasing these very small currents which make it impossible to make accurate Megohm readings. Either fit a more sensitive meter and or use a higher battery voltage. In either case, alter the value of limiting resistor to protect the meter. A minor improvement is to fit a momentary 'on' push button across the limiting resistor, this is only pressed if the initial reading is below full scale and it avoids having to subtract the limiting resistor after working out the total circuit resistance.

Having got so far why not add a few more sockets to the test set. One going direct to the meter, the others going to the meter through 20K and 200K resistors. (Use your present meter to select them.) You can now measure 2 volts and 20 volts and with access to the basic meter for other uses. Most amateurs have a multi-meter already but you will find a second analogue one like this very useful. They not affected by RF fields and you will find it much easier to observe changes in readings than can be done with a digital meter. Finally it's a simple low cost project which can be built with confidence and nothing succeeds like success! See the circuit left below.



Measuring C or L without a bridge by David Proctor GØUFT

See the circuit in the middle box above! Connect a signal generator across a known R in series with the unknown. Measure the signal generator's RF voltage and adjust its frequency f till the RF voltage across the unknown is 0.71 of that from the generator. Then the reactance of the unknown is the same as the resistor, hence for a capacitor $C = 1/6.3Rf$ or for an inductor $L = R/6.3f$. For example, if $R = 1K$ & $f = 235$ KHz, then $C = 680$ pF or $R = 2K2$ & $f = 3.5$ MHz, then $L = 100$ uH.

Quick charging of bias filter capacitors

DC receivers often have very large capacitors to filter the bias supply of the first audio op-amp stage to remove hum. They takes ages to charge up and often cause the receiver to squeal when first switched on! If the feed resistor is not part of a voltage divider, the solution is to put a diode across the R; this causes the capacitor to charge quickly to within one diode drop of the bias supply and then slowly rise with the full filtering to the full bias supply volts. In the example shown above right, an op amp running on 12 volts takes its op-amp input bias through the big CR filter from a subsidiary 5 volt line. The op-amp output is thus correctly biased to near mid supply. G3PCJ

Hot Iron

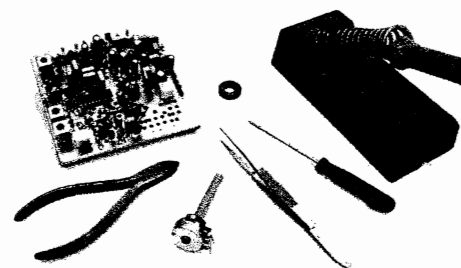
Summer 2003
Issue 40

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- FETs and biasing
- Supply filtering and earthing
- Tribant!
- Loop Antennas
- **SUBS for 2003/4!!!**

Editorial

The season for Summer rallies is now upon us and I trust that I will have seen some of you at this year's Yeovil ARC's QRP Convention. I have been etching away these last few weeks, making certain that I have a stock of all kits and trying to guess what will go well! One snag is that there are currently no stocks of PolyVaricon tuning capacitors in this Country! I have asked Maplin to find out if they can air-freight some from their far East supplier - their main shipment being en-route in a shipping container! I had naively thought everything goes by air nowadays!



Some of you may wonder why you don't see me, and maybe other kit suppliers, at rallies around the country - the reason is that it is quite costly in petrol and time attending an event some way off; you need to sell a lot to make it worthwhile. It is very much more effective to run as essentially a mail order business using the web as much as possible. This helps to keep the overheads of running the business down which helps you in the long run!

Kit Developments

It has been an active few months, especially with a most productive visit by Rob Mannion G3XFD, Editor of Practical Wireless. I had already agreed to supply him with one of the latest AMU kits for review by Tex Swann, this will appear in the July issue - it should be out by the time you get this. Rob also had a number of very useful suggestions for projects that we could work on together. The first is a new CW 2 Watt DC TCVR for 80m called the **SIDCOT** which I expect to write up for PW - see later. I have recently made the prototype; it is now working well and about to be tried out kindly by my CW adviser, Eric Godfrey G3GC. It is supplied in the small upright format and the price is £44. I am looking for a few early builders if any of you are interested in a discount! It is more sensitive and stable, with better selectivity than all my earlier designs aimed at that broad specification! It is of intermediate complexity and uses a ceramic resonator VFO. —

Rob also suggested a GDO project except that it will actually use FET's - not valves! To avoid the expensive meter, I am contemplating an audio approach with changing pitch for the indication. AC coupling of the squeaker circuit may obviate presets too! More later!

The tri-band CW rig, mentioned last time is progressing slowly but surely! Tim G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics—is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

Rig Updates

Bristol Andy Howgate reports a simple alteration to the wiring of his Bristol which has eased a problem in his rig with the switched capacitor filter (SCF) clock. The problem arises from the filter using a digital clock, actually running at 50 times the desired filter audio cut-off frequency; the radiation from the harmonics inherent in the digital clock signal can sometimes get into the front end. It appears as faint birdies spaced across the band which are extremely sensitive to the rig's tuning owing to the high harmonic number. It is present for all settings of the filter bandwidth but the birdies are stronger on the wider phone filter settings because the harmonic number is lower and hence stronger. Altering the fine tuning just a whisker will remove them but it can be annoying! Experience has shown that using screened leads for the two control signals going to the bandwidth selection switch will reduce the radiation - actually that from the unselected wire because the other wire is inactive due to the filtering in the supply line to which it is connected. Andy found that removing the wire completely between point S (for the phone position) and S101 helped greatly. This lets the clock run at a much higher frequency, with far less frequent harmonics, implying a filter bandwidth way above the desired normal audio upper limit of around 2 to 3 KHz. In consequence, the IF filter bandwidth now determines the rig's actual audio bandwidth - the IF filter bandwidth is about 3 KHz so the consequence is that phone audio has a slightly wider bandwidth than when the switched capacitor filter was acting normally for phone. The slope of the IF filter is also shallow than that of the SCF. With the other side of S101 left connected to point Q, as originally intended, the CW facility is unchanged with the preset RT101 still active to reduce the SCF bandwidth as required. The narrower CW bandwidth already means the birdies are hardly noticeable. I have not altered the Manual since it does not affect every rig.

Midney on 20m Several years back, I had a batch of TOKO 3335 coils whose temperature characteristics were worse than normal leading to drift problems with the 8 MHz VFO of the Bruton. The same circuit is used in the Midney and recently one or two 20m rigs have shown the same problem. (This particular TOKO is not used in the VFO on other bands.) I repeat the suggestion in Hot Iron 19 (Spring 1998) which came from Hans Puhlinger OE3HPU, of changing the troublesome TOKO coil to a powdered iron toroid. Without any other changes, a 12 turn winding on a red T50-2 toroid, tapped at 3 turns from the ground end for the 2N3819 source connection, worked very well. The inductance can only be varied by adjusting the turn spacing. So as before, set the tuning to highest VFO frequency, adjust the turns to set the upper actual VFO frequency limit, then swing to low frequency end of the tuning controls and adjust the preset to set the lower VFO frequency limit. I anticipate that it will not be long before I have to alter the Midney's tuning to use a PolyVaricon capacitor owing to existing BB212 varactor diodes becoming like 'hens teeth' - to use an agricultural expression! In fact, the comment also applies to most 'high' capacity varactors.

Somerset Contest Winner

As usual the purpose was to encourage the use of home built gear! Peter G3XJS (on behalf of the GQRP Club) again very kindly has done the hard work despite other very pressing matters. The first prize of a £50 voucher for Somerset Range gear was won by Dan Taylor GW0EGH. Well done Dan! Peter comments 'he submitted the log with the highest score (70), having used a 40m homebrew TCVR based on the Belthorn design ... 2 MHz VFO, 9 MHz IF and Club filter with a cheap dynamic mic. The aerial was a bent dipole at about 23 ft (specifically erected for the Contest), supported on various poles and bamboo canes. In the true spirit of the Contest'

The rules were changed to allow more bands etc. which did gain a couple of overseas entries. But the level of response has been poor for a number of years so we have decided to call it a day - shame - but something different is needed.

So - Ladies and Gentlemen - what sort of event or thing would you like me to sponsor?

The aim should be to encourage the building and use of more homebuilt gear? I don't mind if they are not kits - I just would like more people to enjoy the thrills of using their own creations! All ideas are welcome - please let me have any suggestions! G3PCJ

Driving a monopole antenna

Andy Howgate asked me what I thought about a scheme outlined in PW (April 2002) for feeding RF to a vertical monopole radiator. I was not too impressed so passed it to my antenna advisor G3GC for a proper comment! In essence the scheme uses a matching toroidal transformer at the bottom of a vertical radiator made out of twin feeder as sketched right below. I was told there is/might be a commercial version of this known as The Penetrator using a metal pole radiating element, hence it came to be known by us three as the P Pole! The more I think about it, the more I am convinced this was an elaborate April Fool article which certainly had me, and I gather quite a few others! I feel it is worth repeating Eric's comments as they are technically worth repeating to remind us of good practice. I have paraphrased them slightly:-

1. I can see no reason for having two in phase secondary windings since the two pieces of aerial wire could be attached to a single winding. As the article infers the two windings have equal in-phase voltages, so they may be joined together or left apart which would not make any difference. A single (heavier gauge) secondary wire with the same number of turns could replace the two separate secondary wires. The far ends of the two aerial wires attached to this single winding could still be joined together or not, with impunity.

2. Regarding the transformer, I view with grave misgivings the suggestion that if a T220/2 toroid is not available then a scanning coil toroid from an old TV may be used. These are for use around 15 KHz and would in no way be satisfactory at HF let alone up to 430 MHz. Whilst I do not know the characteristics of a T220/2 (intended for low/medium HF—G3PCJ), I very much doubt if it would also be satisfactory over this range of frequencies.

3. The article states that "My experience is that the matching on all bands is reasonably flat across the bands, though it may be a little higher than you would expect. (It is however tameable with a tuner)". Unfortunately there are no SWR figures given but if they are high then the change over an amateur band will be small since any difference will be swamped by the high standing SWR.

4. Another reason for the flatness of the SWR could well be losses in the toroid which, as I have said, I do not believe could cover such a large range of frequencies.

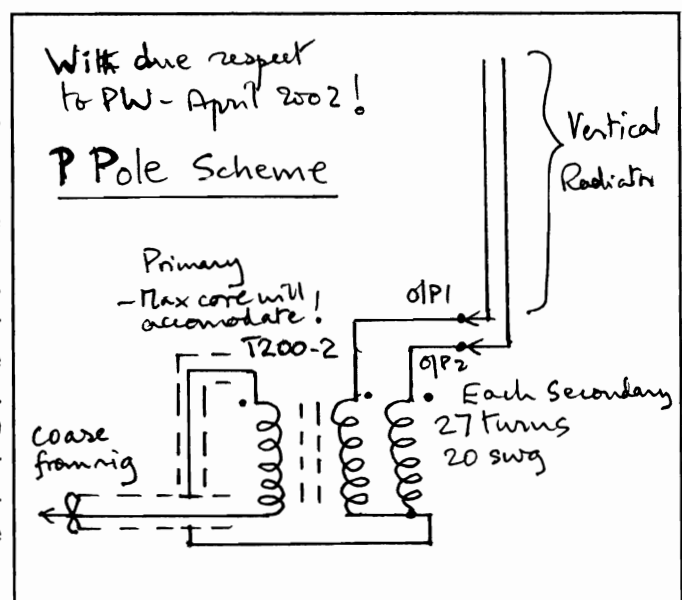
5. The design of the transformer is left wide open. The number of secondary turns is given as twenty seven but the number of primary turns is not given but simply stated to be the maximum possible.

6. A point which in my opinion should not be overlooked is the matter of earthing. As with all end fed aerials satisfactory operation is only likely when a counterpoise is used. The article suggests one is not required but I do not think this is likely to be always assured. In my opinion one should always play safe and have one.

7. A fellow member of YARC, who is an instructor for the new licences, has demonstrated that even a poor antenna will enable reasonable contacts to be made - he worked around the country with a few watts using a wire laid around his landing floor!

Snippet!

A recent note in the IEE's Electronics Systems and Software journal discusses advances in software radios. In such radios, nearly all the filtering and amplification is done in the software, leaving only the RX front end as conventional analogue circuitry. The signals are then converted in an A to D converter for digital processing in the RX's micro-processor. The technique is already widely used in Amateur Black boxes but what amazed me was the comment that 'rapid single flux quantum digital logic will operate to 250 GHz', I repeat 250 GHz! Staggering! Hence practically no need for front end down conversion to reduce the frequency/bandwidth of the signals that have to be digitised.

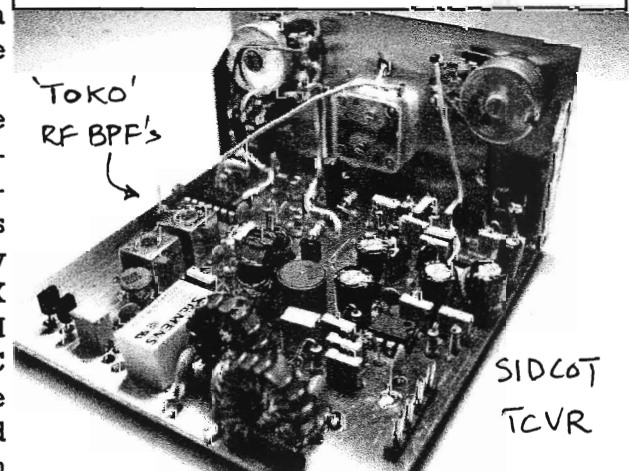
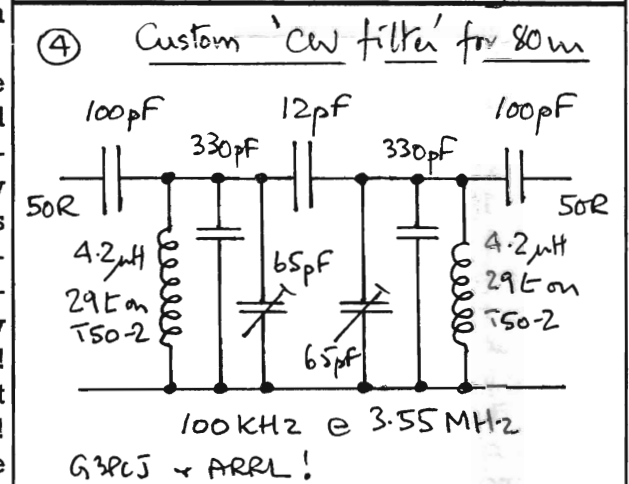
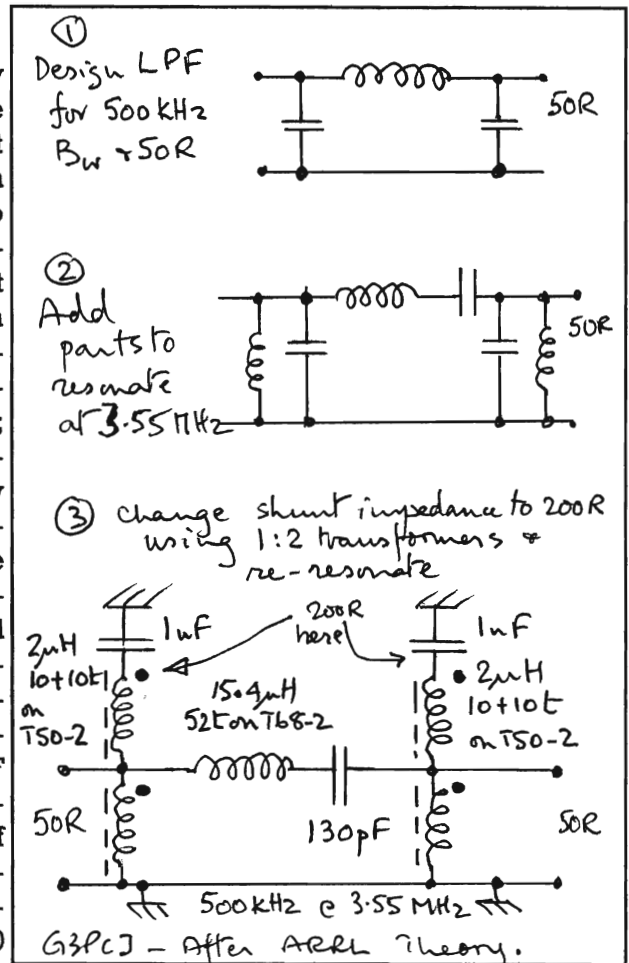


Capacitor types and RF filters

During recent development work on the new direct conversion CW rigs, I wanted to incorporate good RF filters to reduce the chances of broadcast station interference. However, as ever, space was in very short supply and a complex filter would also add appreciably to cost for three bands. I investigated several possible configurations, ideally without any trimming capacitors. One approach for a 'custom' bandpass filter is to design it first as a low-pass filter having a cut off frequency equal numerically to the desired bandwidth of the bandpass filter; this low pass filter is then changed to a bandpass design by adding series capacitors to resonate the low pass series inductive elements, and inductors in parallel to resonate the shunt low pass capacitors. These extra parts should have values to resonate at the centre of the bandpass filter. This can lead to impractical (large or small) values in a 50R system so an impedance transforming inductor can be used to make values more practical. The scheme right (500 KHz bandwidth at 3.55 MHz) above looked possible but the RF voltages would be high as it would be connected during transmission. I hoped to use the same style of small yellow high voltage (1 KV) disk ceramic capacitors that were intended for the TX output low pass filters. I soon realised that the desired bandwidths (100 KHz at up to 14 MHz) would not permit a solution without any form of trimming!

To keep the values practical, an alternative approach (shown right) seemed more sensible and this can also easily cater for differing input and output impedances. (Neither approach involves easy maths which I will spare you!) After extensive trials taking nearly two weeks on a prototype rig, I eventually came to the conclusion that all versions were acting like attenuators! This was swiftly confirmed by measurements on the filters with a signal generator! It took several more days to realise that there must be something funny about those HV disc capacitors! A quick change to silver mica capacitors (because they happened to be handy) changed the circuit to a filter! **CONCLUSION.** Those particular HV discs are just too lossy - avoid them in high Q resonant circuits!

It was not long after that I realised the three band rig was just too complex to fit into the small upright design format; two separate designs being better - the simpler single band SIDCOT 80m TCVR is shown right. The SIDCOT has semi break-in TR relay control (thus not inflicting transmit voltages on the RX RF filters) so it uses the easier conventional TOKOs. I am pleased to report the SIDCOT passed the G3GC tests with good reports! (The three band rig will have the custom better filters above with electronic TR and 5 W output so it will need a whole 100 x 160 mm PCB.) G3PCJ.

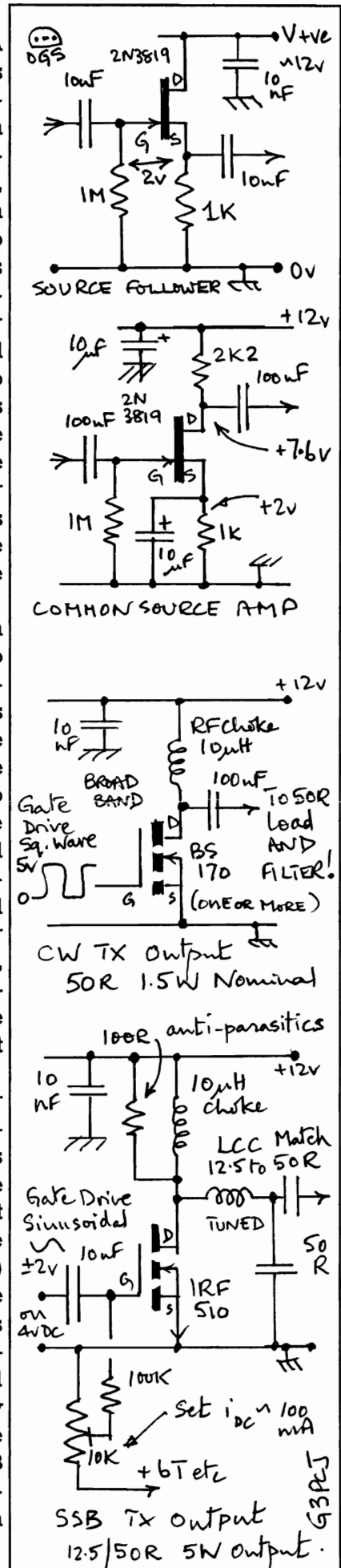


Field Effect Transistor (FET) biasing

A member has requested something on this vast subject! A simple point to note is that they are all voltage controlled devices unlike bi-polar transistors which have current control. Firstly *junction* FETs; these are usually depletion mode devices where even with zero bias voltage on the gate, there is significant current flowing between drain and source. In the case of the common 2N3819, the zero gate voltage bias current is between 2 and 15 mAmps! In most circuits this is too wide, so a negative bias is often applied to reduce the nominal and range of actual current. Often a resistance is put in the source lead; this makes the gate, if actually at 0 volts, appear negative with respect to the source - as shown right. The upper circuit right shows a source follower where the source is biased about 2 volts above ground so that it can handle signals of up to about + & - 2 volts peak. The reduction in current range also makes it easier to set the drain voltage relative to the source in a voltage amplifying stage - neither too high nor nearly zero when the device is said to be 'bottomed'. The source resistor would be bypassed for signal frequencies. Such devices are used for **linear** applications where the output should always have a constant relationship to the input - i.e. the same gain for all useful signal levels up to some value where the circuit starts to limit - on the supply rail or by bottoming.

The small metal oxide MOSFETs, like the BS170 that I use a lot, are enhancement mode devices. With zero gate bias, there is no current through it - so for normal linear use they have to have a positive gate bias to turn it on. The gate has to be more than about 2 volts above the source, then current changes rapidly with applied gate voltage. So depending on the drain load, this current may cause the drain voltage to dip close to the source voltage (bottoming) or to some intermediate value for linear operation. If the gate voltage goes on above the voltage at which it bottoms, the device is turned on for the maximum current that the drain load will permit - it is acting like a switch. This is **non-linear** operation and is typical of digital circuits. The gate voltage of these devices can go somewhat higher without damage. When used in the output stage of a CW transmitter, they can be driven like this from a digital logic signal switching between 0 and 5 volts. See middle diagram. The RF load defines the device actual current. Such stages have to be followed by sufficient filtering to remove the unwanted harmonics.

The larger devices like the IRF510 have somewhat higher gate turn on voltages - near 4 volts. They can be used in the non-linear mode (with 5 volt digital drive plus a small positive DC bias voltage) but I mostly use them in **linear** output stages for SSB phone signals. (If you put SSB through an overdriven output stage making it non-linear, the severe distortion of the signal will sound awful! The input and output are no longer directly in proportion to each other.) If any of these enhancement mode devices (large or small) are to be driven **linearly**, the maximum output will occur when the device is just starting to bottom. The peak gate drive signal may not be sufficient to turn the device on this far so it is common to apply a small DC bias which will provide a small drain current even without any modulating signal as shown right. This is Class AB operation. The bias is normally removed during reception. It is part way to Class B operation where two devices can be used in push pull with practically zero standing current when there is no modulating signal. It's a big subject so I hope this raises other questions! G3PCJ



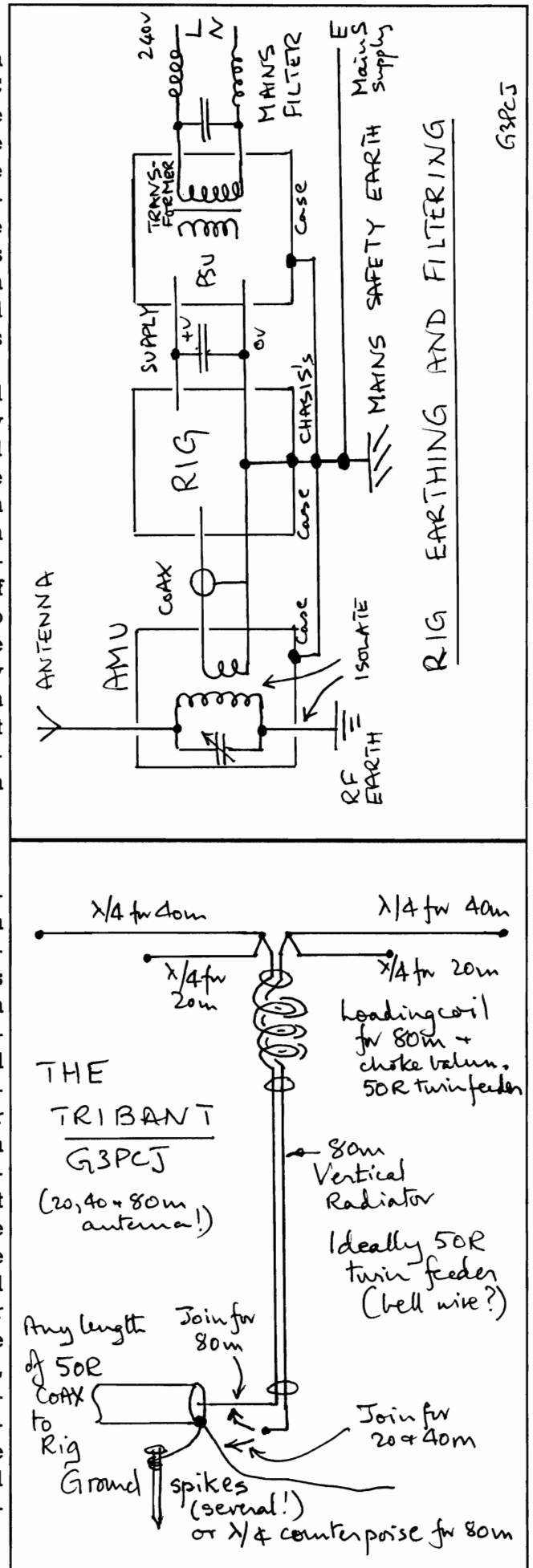
Supply filtering and earthing

Andy Howgate told me some while back of a peculiar problem that he had which caused his DC supply volts to appear between mains earth and the RF earth! In between finding this out, at least one PSU died and had to have a new set of rectifiers! The same supply also had a blown ceramic capacitor filter on the positive line! I regret I cannot recall the exact mechanism but this supply also had capacitors between both output rails and mains earth which was also connected to the chassis. One of these had gone short circuit and was putting the supply volts where it should not have been!

I have sketched right how the supplies and their filtering ought (I think!) to be connected. Any filter capacitors should be across the supplies and not to mains or RF earth. Mains earth must not be connected to RF earth, especially if your mains earth uses Protective Multiple Earthing (PME). The reason is that PME uses the supply neutral also as earth conductor, hence everything, cases and all, goes live if the neutral breaks. So you should not be able to touch real RF earth and mains earth at the same time lest there is 240v between them! Furthermore, any mains filtering should not have capacitors between either supply line and mains earth as the current through them will cause the earth leakage trip - properly called a residual current device and often set for 30 mA max - to turn everything off! G3PCJ

The Tribant!

No this is not a car! Its intended to be a tri-band antenna for 20, 40 and 80m - perhaps even suitable for /P use! Exact details have yet to be decided but the principle is to have a pair of dipoles for 20 and 40m connected in parallel and fed with twin close spaced low impedance feeder. The reason for the latter is that some of the feeder is wound into a 'choke balun' just below the centre of the dipoles. On 80m this balun acts as a loading coil for the vertical twin feeder section below the balun making use of the two HF dipoles acting as capacity hats above the balun loading coil. The amount of choke balun inductance required to achieve resonance on 80m will depend on the height of the vertical section. The vertical has to be worked against RF spikes/radials or a counterpoise for 80m. On 80m, the feed lines are strapped at the bottom of the vertical section; for the higher bands, the feeders can be connected by coax to an unbalanced rig or AMU output. At the bottom of the vertical section, the impedance on all bands should be low when properly adjusted, hence an AMU should not really be required. Its only an idea - more details later if and when I have tried it out! G3PCJ



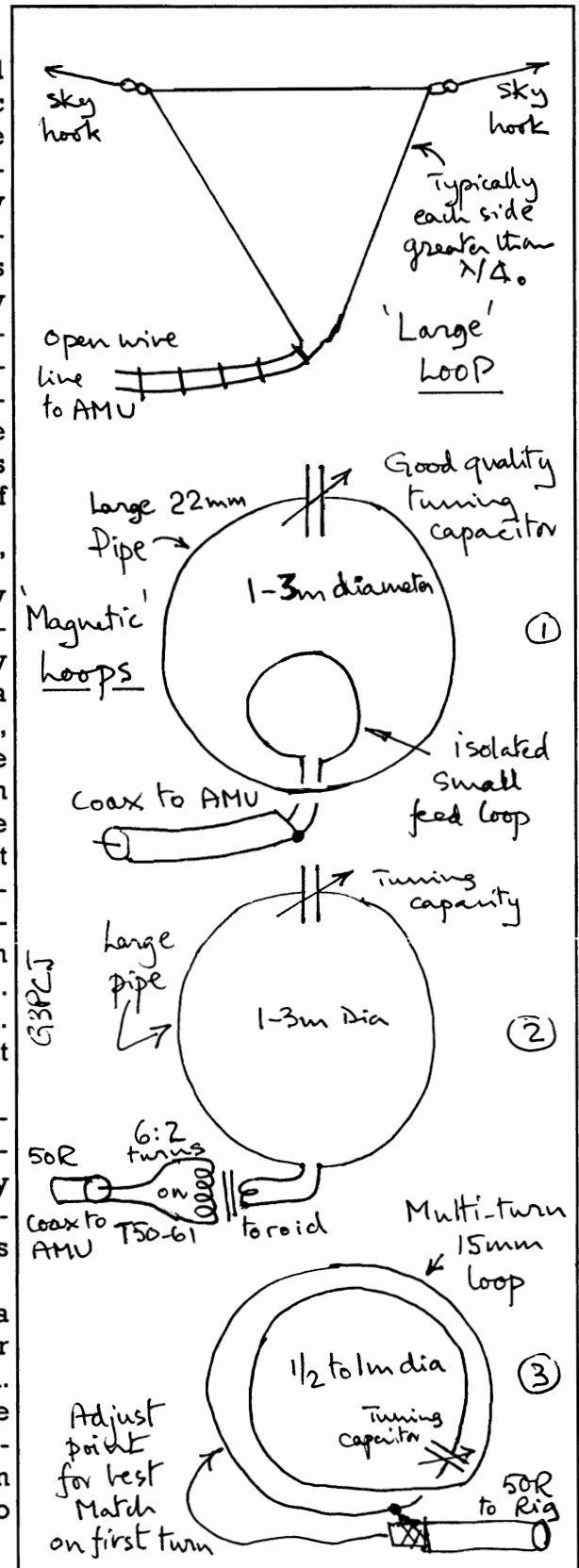
Loop antennas

Both Club members Andy Howgate & David Proctor have raised this broad topic which I hope Eric G3GC will address in due course; in the meantime here are a few thoughts. There are 'conventional' antennas formed into 'loops' where each nominally straight side exceeds roughly one quarter of a wavelength. They can be triangles, circles or squares mounted in the horizontal or vertical plane. Generally they do not have any loading coils or resonating capacitors. Input impedance at any break in the circumference will depend highly on actual length and frequency. Often it is best to feed them with open wire line and a good matching unit. The main advantage is usually some gain over a dipole and sometimes a bit of directivity. See right for an example.

Physically small loops are usually 'magnetic' loops and are brought to resonance with a good quality capacitor - because the high Q leads to very high voltages. Remote tuning is desirable to avoid hand or body effects. The loop circumference is usually well below a quarter of a wavelength. THE advantage is small size, coupled with reduced noise on reception. They can be any shape of single or multiple turns; due to the high circulating currents large diameter copper tubes are best to reduce losses. There is much debate about their transmit efficiency - see June 2003 Technical Topics Radcom! There are three main feed methods, depicted right. Any of these may have a Faraday screen to reduce pick up of unwanted local interference. Firstly with a small electrically separate coupling loop. I have always felt adjustment of this type to be a bit hit and miss!

The main loop can be fed with an input transformer; typically with a couple of turns on the secondary connected in series with the loop and physically half way round opposite the tuning capacity. The primary would have say three times the number of turns on the secondary. For QRP use a ferrite core FT50-6 .

My own preference is for direct feeding by a tap on the first (or only) turn. This is the circular equivalent of the gamma match for a straight antenna. For convenience, the feeder outer is connected to one side of the tuning capacitor but this can upset symmetry; the inner is connected part way round the first turn at a position which gives the best overall match. No AMU is required! Its delightfully simple! G3PCJ



SUBSCRIPTIONS!

I regret its that time again! Due to a rise in postal charges and my endeavours to have eight pages for each issue, I regret I need to raise the fee to £7 per year. (Its been £6 for 10 years!) As before, cheques payable to Walford Electronics please. Do it while you think of it now! Please do take the opportunity to tell me what you would like covered or if you have any questions or ideas for new projects. Even better still, write me an article! Many thanks for your support and encouragement over the last 10 years that I have been doing Hot Iron! Tim Walford G3PCJ.

Hot Iron

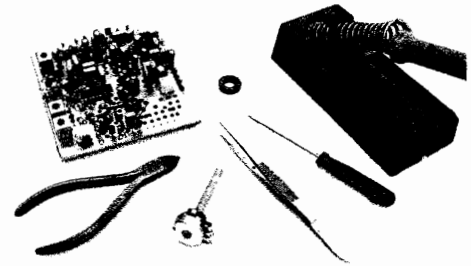
Autumn 2003
Issue 41

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Editorial

Firstly I must apologise for the delay in getting this issue of Hot Iron out to you. Many of you will know that I farm by day and August is a pretty busy time with harvesting etc. Apart from that, what has really taken my time, day and many nights, is the conversion of old Victorian barns into workshops for local businesses to rent. Back in mid-June we decided to have an open weekend at the end of August to give them a bit of publicity - but guess what - it took far longer to get them finished off than I anticipated - I still have to make the fire alarm work! (It is now!) My apologies.



The good news is that my good friend and regular contributor to Hot Iron, Eric G3GC, has now fully recovered from the illness that laid him low for a while in hospital with a longish spell recuperating at home afterwards. Unfortunately his wife then had a spot of trouble and also needed extra TLC but she too is now much better. Eric has decided to reduce his radio activities a little but I have a half promise that he will still do the odd article for us which is great; meanwhile any budding contributors, please speak up!

Kit Developments

I reported last time that Eric had evaluated the prototype Sidcot CW 80m TCVR; following two more being kindly built by Andy Howgate and Don Winterburn, I decided that a few changes were desirable - mainly to increase the RF gain. These have now been done, and a pre-set RF gain control added so that it is now ready properly for Construction Club members. An article on the RX aspects is due to appear in the Oct issue of PW, followed by the TX aspects in the following issue. It is a specialist CW 80m only DC RX having a number of features not usually found in cheaper rigs, including a strong switching mixer, double tuned RF filters, narrow band-pass filtering for CW, proper RIT etc; with semi break-in TR operation, sidetone, low pass filters for the 1.5 Watt TX. It costs £44 plus £1 for post and packing.

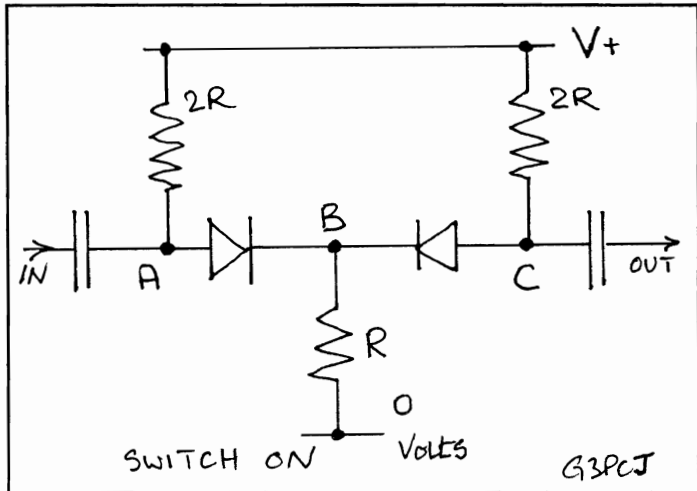
The next project will be a 'modern grid dip oscillator'; I have christened this the 'Dipsqueek' as I am trying to avoid using a meter or LED to indicate resonance, instead intending to use the change in pitch of an audio sound! I hope to make it pretty versatile with an RF output socket for feeding a counter or other test facilities. With a bit of luck it will thus double as a unsophisticated RF and AF signal generator! Tell me if you are interested. Tim Walford G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics—is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

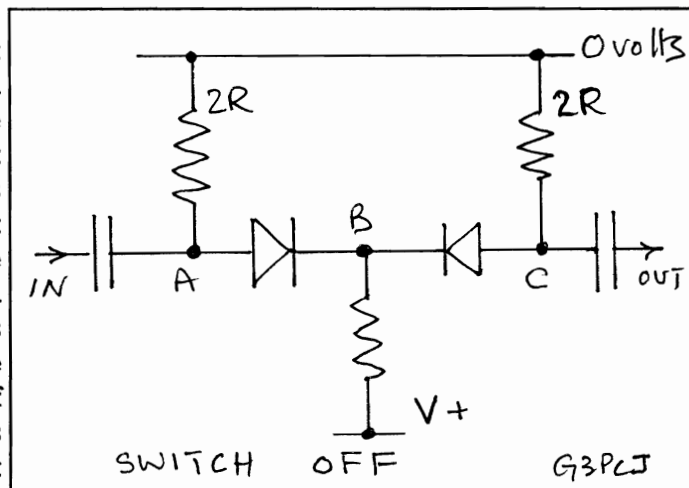
Diode Switching

This is a technique which we probably ought to be using more often! Diodes can be used to 'switch' AC signals quite effectively in many low or even moderate power applications - the main advantages being high speed operation, usually lower power consumption than a relay, and probably lower cost; the main disadvantage can be worse isolation between input and output compared to most mechanical contacts, and unfamiliarity! They can be configured for simple on-off or multi-way switching. Examples of their use are for transmit/receive signal isolation between antenna and receiver while transmitting, and for changing the direction of signal flow through IF filters in superhet rigs. The frequency range can be almost from DC to light depending on the associated circuits which tend to have their impedances in parallel with the signal path. Isolating the RX input from the transmitter output voltages is pretty challenging so lets look at that first!

Consider the simple circuit right which is a diode 'on - off' switch, with the applied DC voltages arranged to forward bias both diodes. Under no AC signal conditions the point B will sit at half supply voltage if the diodes were perfect, because the current through the single lower resistance R will divide equally between the diodes and develop the same half supply voltage across each $2R$ resistance. So if the AC input signal momentarily drags point A more positive, point B must follow and also go more positive. This will tend to reverse the voltage across D2 but since there is nothing to prevent the voltage on point C rising it will also go positive. If point A goes negative due to the signal input, then point B will also go negative as R draws point C negative; the negative signal limit will occur when all the current through R comes from the $2R$ connected to point C because D1 has become reverse biased. The positive signal limit comes when point B exceeds the supply voltage, this will be somewhat larger than the negative limit. Hence the negative excursion determines the maximum amplitude signal that the switch can handle. In a practical circuit the values of R would be arranged to be a few times the source and load impedances; they could be actual resistances or RF chokes with extra resistors to determine the DC currents. The choke impedances should be well above the circuit impedance.



Consider now the second diagram right where the DC supply voltages have been effectively reversed. We will see this has the effect of turning the 'switch' off so isolating input and output. Under DC conditions, both diodes are reverse biased and do not conduct so that points A and C are at 0 volts, and B is at the supply voltage. If now the AC signal takes A positive, D1 will not conduct until point A goes above the supply; however D2 will still be reverse biased so point C still does not alter. If the input takes A negative, then D1 becomes even more reverse biased and again the output is unchanged. Hence no signal gets through! In a practical circuit, the diodes will have some capacitance so there will be some leakage and the isolation will not be perfect but quite sufficient to protect the receiver's front end filters!

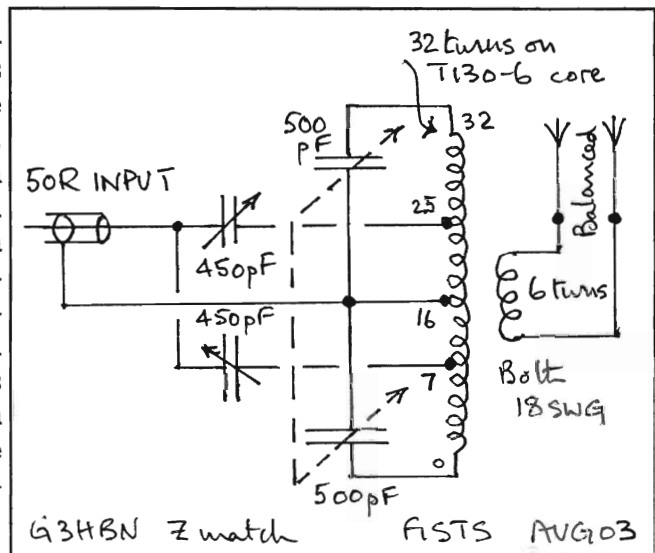


Normally the rig's TR circuits will change the supply polarity to the diodes. With a little extra cunning in the control circuits, half of such a switch can be used to route the desired RF signals to the receiver's input RF bandpass filters; this involves connecting the other RF BPFs through further diodes to the mid point B of the TR switch. Only the diodes of the wanted BPF are turned on. I hope to use this approach in the TR and band selection aspects of the forthcoming **Locking 20, 40 & 80m CW transceiver. G3PCJ**

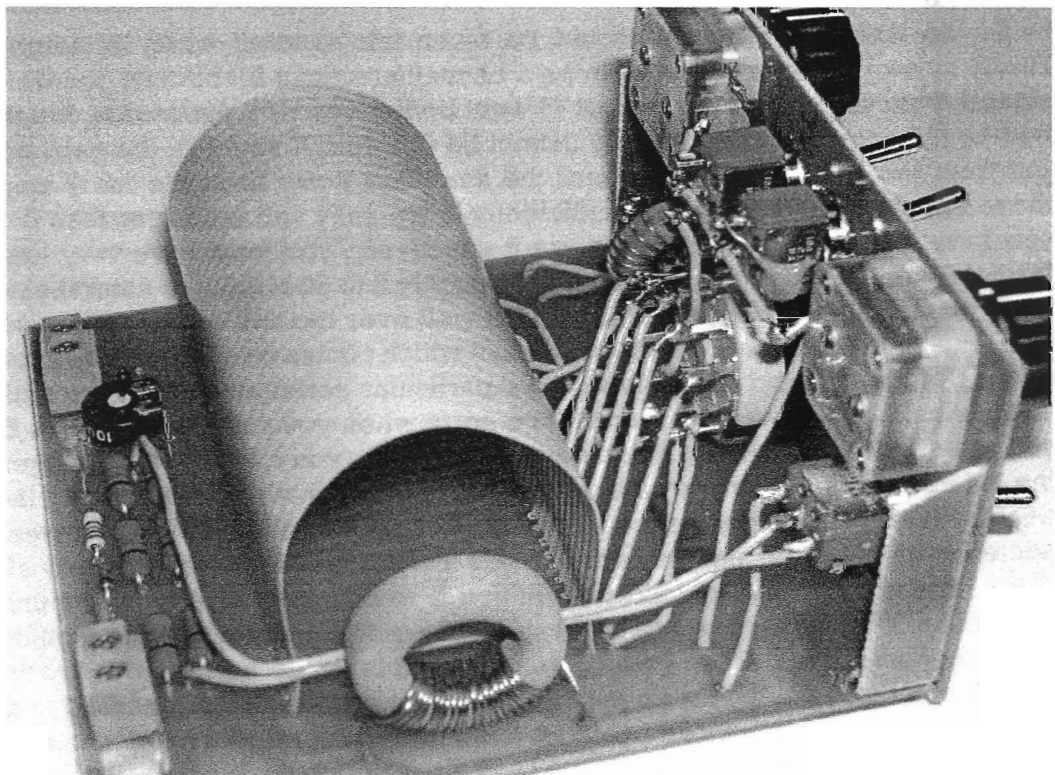
Antenna topics!

Monopoles! There have been several developments following my note last time about the G5IJ! My thanks to Radcom columnist Steve Hartley G0FUW who took up the story! Firstly I got the dates of the PW article wrong, it should have been August 2002 so perhaps it was not intended as an April fool joke as I feared! Steve asked for reader's comments; he tells me that he has had several and will be reporting them in due course. He also looked up the earlier note from G5IJ printed by Pat Hawker G3VA in TT of Radcom March 1996. The TT note had explanations by the originator of its method of working but G3VA had also been a bit sceptical about this scheme; however, he did try it out and did find that it worked well on 7 Mhz. This is supported by our members Dave Buddery and Andy Howgate who have both used it. My own impression (and without any practical experience of it) is that it is acting probably as a quarter wave roughly on 7 MHz, loaded against whatever the rigs earthing scheme happens to be. I still dont understand how it can work sensibly over such a wide frequency range effectively. As many have observed, under favourable conditions, even a bit of wet string can give good results so I think this is a case of good luck primarily! I shall be delighted to be proved wrong! I think the toriodal transformer contributes practically nothing and the raditing element would work just as well if connected direct to the rig with an AMU and counterpoise.

Balanced AMU Dave G3OEP also kindly sent a note from the August 2003 FISTS, the CW operators Club Newsletter, outlining a different z match style AMU from G3HBN. The brief details are shown right. It has three variable capacitors; a conventional main tuner (with split-stator) across the main inductor and two from the input to symmetrical taps on that main inductor. Unfortunately the whole article was not forwarded so I don't know the reason for this arrangement - I half expected two un-symmetrical feed taps - being used for low and high frequency bands etc.! Having a centre tapped main inductor with an output secondary wound over its middle this scheme does provide a true balanced output suitable for balanced feeders and radiating elements.



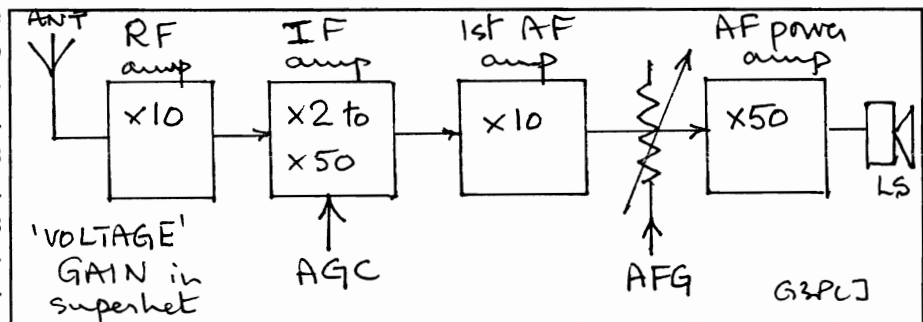
Here is another AMU but this time using the T match C-L-C approach. It incorporates a RF transformer at the input to the matching section so that the output is (almost) floating and can drive a balanced feed line and antenna. The kit also includes a resistive matching bridge and was reviewed in the July 2003 PW.



The Three S's - sensitivity, selectivity and stability!

These three aspects of a receiver almost totally determine its performance! People write books on each one but I will spare you that and most of the maths! A page on each over future issues should be enough. Firstly let's consider *sensitivity* and the order of overall typical gain required in a receiver. Suppose it is to produce 20 mV into a loud speaker for an input signal at the antenna of 2 μV . This would not be full LS output but is usually easily heard and might be sufficient for our weak input signal. This implies a voltage gain of 10,000. The same gain would (in principle) produce a useful audio output of 100 mV to the LS for a more typical input of 10 μV . Bear in mind that S9 is often taken to represent 50 μV signals. I know I am using these levels rather loosely but it is not uncommon for receivers to have a gain of more than 100,000 which allows for some losses or attenuation in mixers and filters. Of course, for really strong signals the gain is reduced, either manually with the AFG pot or by automatic means where AGC is applied to some of the amplifiers. In expensive receivers, the AGC control range will be large so that the signal level at the input to the AF gain pot will be held essentially constant over a very wide range of RF input signal levels.

Years ago, when high impedance phones were used, far less gain was needed because the phones had much higher sensitivity and they were placed right on your ears! This explains why it was possible to hear signals with a crystal set probably not having any gain - especially for the milli-volt RF signals from broadcast stations! (I once measured half a volt on my antenna lead from a 4 MHz BC station!) The above figures explain why the very simple 'single transistor does all' circuits are fun but never much good because they have only a tiny fraction of the gain needed for serious use. So how do you obtain a voltage gain of 10,000 or even 100,000? With great caution if it is all at audio frequency as in simple direct conversion receivers! It is highly likely to oscillate so the gain is nearly always spread over several different frequency bands - typically three in a superhet; at RF, IF and AF. Often there will be facilities to control the gain of each of these blocks either automatically or manually. These 'gain controllers' also help to divide each gain block physically so there is less likelihood of oscillation in each one. This leads to a 'gain' block diagram like that on the right - which is typical of a superhet. I have indicated some typical gain figures for each stage.



So what other factors should be taken into account when deciding the gain allocations? Firstly noise; this pesky aspect can be a bit mathematical! All circuits generate very small electrical signals even when there is no input - I won't bother you with the causes, but these noises get amplified by subsequent stages so they cannot be ignored. If you turn the gain right up, without any input from the antenna, you will hear the amplified noise from the early stages of the receiver. If these self-generated noises are sufficiently large, they will be larger than the wanted signals. So if you have lots of gain available, to use it effectively, you must have very low self-generated noise from the front end. For the HF spectrum (roughly 2 to 30 MHz), the natural electrical noise collected by a reasonably sized antenna should be well over the self-generated noise of the receiver front end. The antenna is receiving cosmic noise which comes from distant thunderstorms all around the globe. Hence the acid test of whether a particular aerial and receiver combination has sufficient sensitivity, is to see what happens to the noise when you plug in the aerial. If it does NOT change, you are only hearing the rig's self-generated noise - you either need a bigger aerial or to redesign the RX front end! If however, the noise level increases when you connect the aerial, then you are hearing the cosmic noise and all is well. (Strictly you should swap between a 50R resistor connected to the rig input and the aerial for this test but the difference is nearly always not detectable.)

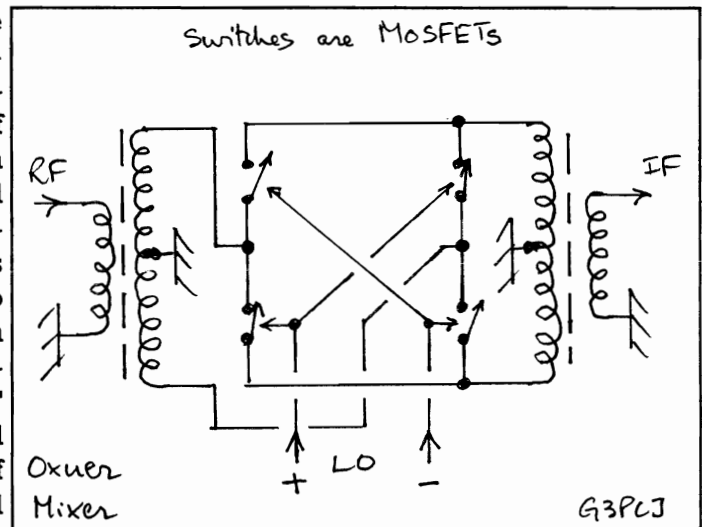
The other aspect of gain distribution is to consider what happens under large input signal conditions. If there is a fixed gain of say 1,000 before the gain-varying facilities, then a 1 mV signal would become 1 volt at the gain control stage; this would be near the overload limit of the output amplifier of these fixed gain stages (let alone subsequent stages!) leading to all sorts of trouble. It is essential to have only sufficient gain for the largest likely signal to just cause overloading of the output of the fixed gain stages. Next time I will write about the filtering circuits. G3PCJ

Switching Mixers

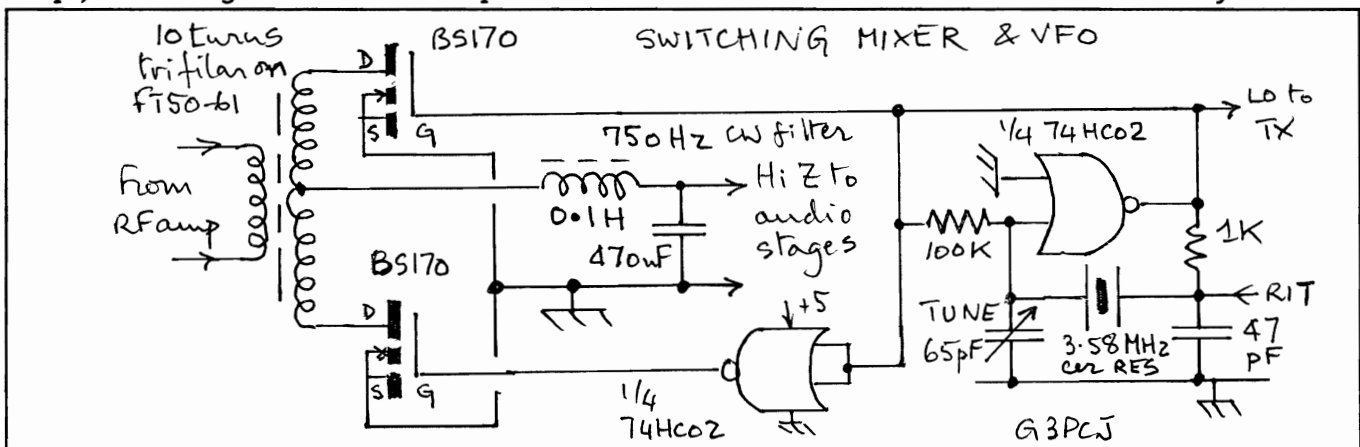
Over recent years there has been much emphasis by receiver designers on improving large signal handling ability. This is particularly important when very large unwanted signals are present close in frequency to very weak wanted ones - 40m is the classic example where the signals from broadcast stations above 7.01 MHz are huge compared to our wanted the weak DX! The classic symptom of an inadequate mixer frequently occurs in DC receivers, where the strong station comes through as mushy noises or BCI. Mathematically, signal handling ability is measured by the third order intercept point, often abbreviated to IP3. In recent designs, where there is limited gain at RF, it is the first mixer which often causes the problems. Hence the interest in what have become called strong mixers, or ones able to handle large signals.

The mixing process is a funny mix of both linear and non-linear processes! In the simple common situation, the wanted variable level RF signal is mixed with a large local oscillator (LO) signal to produce a variable level IF or AF output at either the sum or difference frequency. Without some non-linearity, caused indirectly by the large LO signal, no mixing can actually take place; and yet the IF output has also to be directly related in a linear manner to the RF input! It is this latter point where they fail as the input signals get larger. Often, the detail circuits are arranged to be balanced in order to minimise any undesired effects transferring from one 'port' to another. (The 'ports' are the three inputs/outputs.) The classic doubly balanced diode mixer is excellent but the maximum signal level is limited to roughly that which the diodes can handle from the high power LO input. Stronger versions of the common SBL-1 mixer can take up to +17 dBm but this is not really enough!

Recently, attention has turned to the use of FETs as the non-linear element instead of diodes. In a 'switching' mixer, the switch element - the FETs - are turned either fully on or off by the LO signals. Oxner's original suggestion is shown right & has been further developed into H mode mixers - but they are quite complex and beyond this note. (Radcom's TT has had several notes on mixers from about 2000 to 2003.) I offer a somewhat simpler scheme, with lower but adequate performance for most, using the cheap and plentiful BS170 MOSFET driven by digital signals. The turn on threshold of the BS170 is just over 2 volts so it lends it self very nicely to being driven by 5 volt digital logic.



I have incorporated a partially balanced version of this into the mixer in the SIDCOT CW receiver, which is shown below with the driving variable frequency local oscillator. The latter is actually a 'digital VFO' in that the output is a square wave running between 0 and 5 volts. (I appreciate the waveforms around the resonator are not digital, but this is not the digital VFO of commercial rig where a microprocessor input commands the output of a single wide range Direct Digital Synthesis chip!) This design has an audio output to the first CW filter but it could also be at IF. G3PCJ

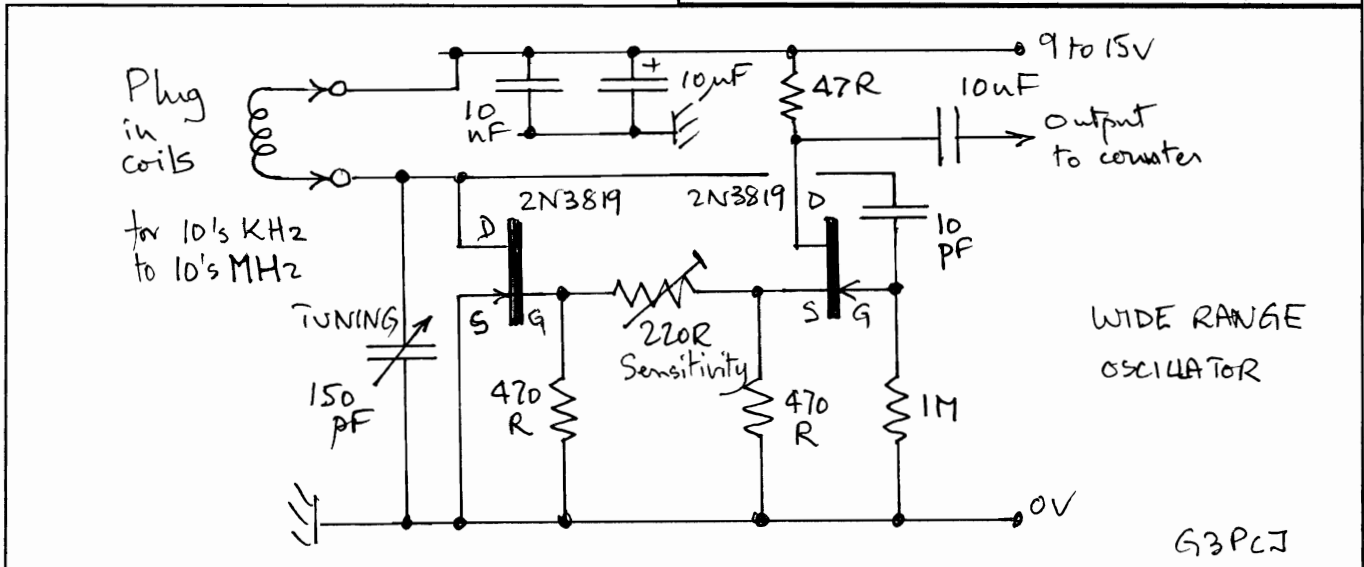
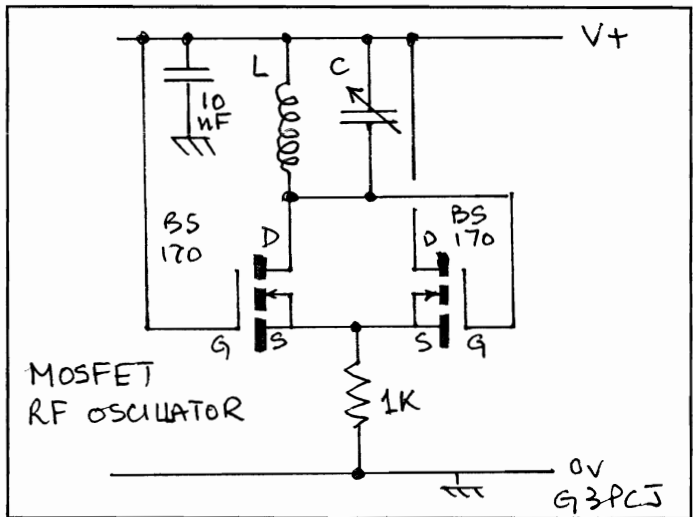


Oscillators for dip meters

After some quite severe prodding by several Construction Club members and Rob Man-nion, G3XFD Editor of PW, I have begun a Grid Dip Oscillator (GDO) project. The basic principle being that, when an unknown resonant circuit is brought near an oscillating LC tank circuit tuned to the same frequency, the unknown LC sucks out some energy from the oscillator causing a change in bias conditions which can be indicated on a meter. Of course the GDO name derives from earlier days when valves were used and the approach was to show grid bias resistor current on a sensitive meter. I still frequently use my 40 year old Heathkit GDO but it does have the drawback of being quite big and needing a mains lead. (I have not had cause to look inside since I built it all those years ago and hate to think what quality of solder work that I might find inside!)

The first item to consider was the type of oscillator that should be used. As ever simplicity and certainty of working are pretty important but for a GDO there is another very important point that was recently mentioned in PW by our occasional contributor Gerald Stancey G3MCK. Although one must be certain that the oscillator will start properly, the amount of feedback in its internal loop should not be excessive; this ensures that when the extra loading occurs due to the coupled circuit, the change in conditions will be quite large leading to a sensitive instrument. In other words, it should be possible to quite easily stop the oscillator!

I tried out several different oscillator configurations such as the familiar Hartley circuit which can easily work over the wide range of frequencies needed for the instrument. But this does have the drawback of needing a tapped coil and three connections for the several plug-in inductors that would be required for a range of at least 2 to 30 MHz. Other common 2 lead inductor circuits like the Colpitts can have limited tuning ranges due to their internal fixed capacitors. I eventually choose the one that I have used before in the signal generator kit. This has always worked well and with a very wide range of frequencies right down to tens of KHz! However the normal circuit did seem a bit unyielding when coupled to the unknown so I thought about how to reduce its internal gain. For amusement, I show right a very low parts count MOSFET version that I explored. I eventually decided against this because the tuning range was limited by the input capacitance of the BS170s but it does work well! The JFET version does not suffer this problem and gain can easily be controlled by using separate source resistors and a low value preset to link them as shown below. A further refinement is to have a RF output for a counter or other purposes. If the frequency can be measured accurately, it makes life much easier and also permits component values to be measured based on the difference in frequency when an unknown is added to the tuned circuit. G3PCJ



Snippets

'Mechanics' Charles Wilson reminds us of two important points. Firstly that VFO coils should have their turns cemented in position with a material, such as Balsa glue or Bostik. Even though they may seem tight and immovable on whatever type of former is used, in all probability they will be able to vibrate or even shift with temperature changes if not cemented in place. Such vibration can cause microphony in DC rigs. The best coil formers are made of ceramic but these are now very rare. Powdered iron toroidal cores are the next best, and will have less turns (hence less potential for change) than air cored inductors. Avoid PVC type plastic materials (such as overflow pipes), wood or worse for VFOs! These materials can be used as formers with caution in the HF range for general tuned circuits where the exact resonant frequency is not extremely critical as is the case for a VFO.

Charles' second point concerns heatsinks, especially big ones. His professional experience has shown that the inertia of even quite small heatsinks is sufficient to rip heatsinks and their devices from a PCB when not properly supported mechanically. This happens when packing the car in haste for field trips! More accurately its called chucking things in the boot! His suggestion is that any heatsink should be attached by nuts and bolts to the rig's case; this may involve repositioning the device and heatsink but provided the leads are kept as short as possible, it is feasible for devices working at up to 'middleish' HF!

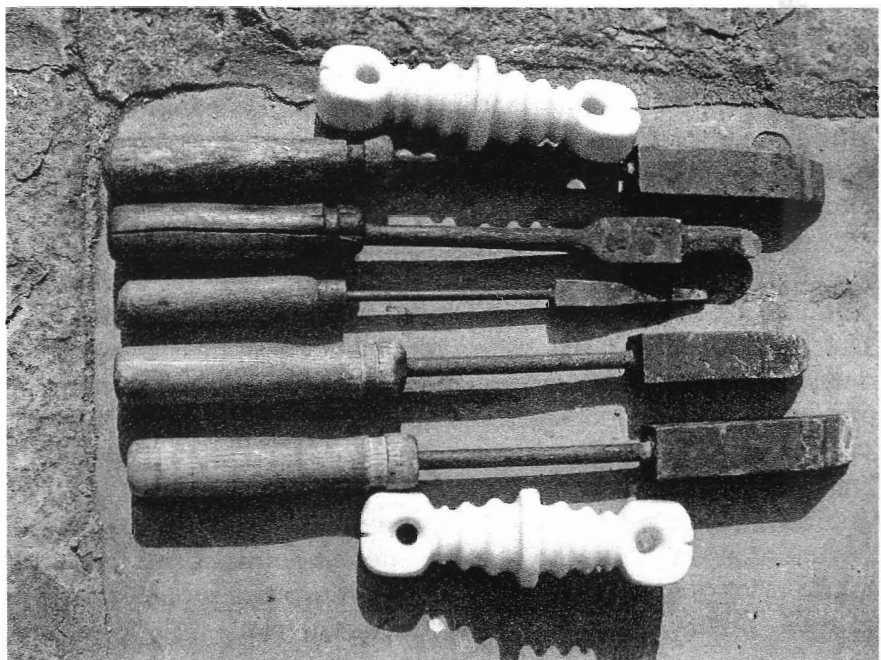
RF chokes Craig Douglas asks how to determine the value of choke that should be used when home-brewing a circuit. Generally the value should be high enough so that its reactance, at the frequencies in that part of the circuit, should be several times whatever other impedances are present at that point. This can be difficult to judge! For example, if an RF amplifier collector choke is driving a 50R load, then its reactance at the lowest frequency should be not less than around 200R. If its being used down to 2 MHz this leads to a choke value of about 22 or 47 micro-henries. If the load is lower, say 12.5R for a 5W RF amplifier one can get away with 10 micro-henries. Often the choke has also to carry considerable DC current as well so bear this in mind - the plastic encapsulated ones are not always adequate in such circumstances. In some situations such as TRF sets the choke may be blocking RF and AF signals so the value has to be very much bigger, or possibly an audio transformer instead! In the valve era, the RF choke in the final RF power amplifier was always a critical item especially if it had to work over a wide frequency range such as 2 to 30 MHz. The load on the valve had a high value (a few K) and the choke reactance had to be even higher; however if it was self resonant at some part of the range, there was a fair chance it would melt! Often it was its own inductance resonating with its self parallel capacitance - the cure was to divide it into sections each having different numbers of turns - in effect two or three different value chokes connected in series. This is rather like using 3 capacitors (10 μ F, 100 nF and 1 nF) in parallel for effective bypassing over a very wide frequency range. Another approach was untidy hand 'pile' winding!

A little amusement!

Here is some of my most recently acquired soldering equipment. I am tempted to offer a small prize to whoever can correctly identify their previous immediate owner but that might be a bit too easy! Perhaps it should be who was their 'original' owner?!

Any suggestions?

G3PCJ

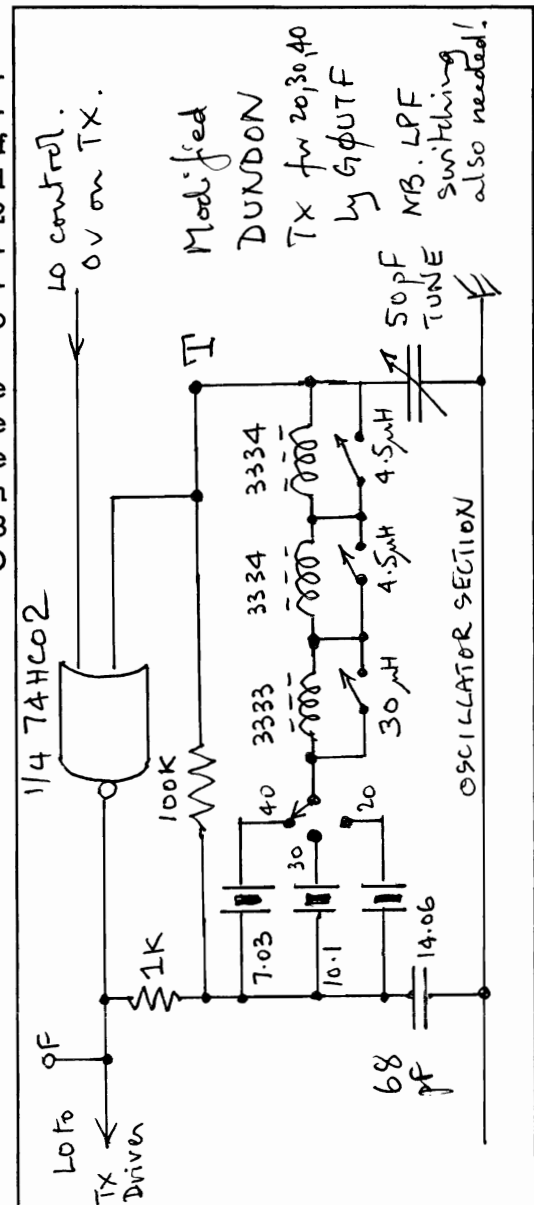


Pulling crystals

David Proctor G0UTF reports improving the frequency range for his Dundon CW transmitter. He has crystals for three bands 7, 10 and 14 MHz together with 3 sets of low pass filters on the TX output. He has worked all around Europe with just over the 1 Watt which it produces on a 12 volt supply. Bearing in mind the Dundon is stand alone separate CW TX with TR changeover etc, he uses it with a separate superhet receiver. He only sent me part of the circuit so I have guessed the rest and repeat it right!

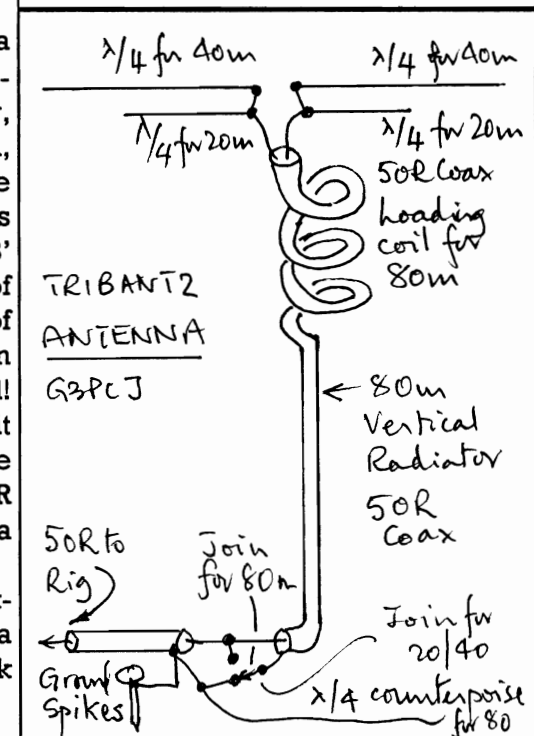
His alteration from the original is to add selectable inductance which now gives a very useful frequency range on all three bands when tuned with a proper 50 pF variable capacitor. David has arranged the choice of inductance with three tiny toggle switches. The 30 μ H coil is a TOKO 3333 with the core just out and the two 4.5 μ H ones are TOKO 3334s. They will pull further, but.....

Band	L = 0 μ H	L = 4.5 μ H	L = 9 μ H	L = 30 μ H
40m	7.029 to 7.031		7.028 to 7.030	7.021 to 7.028
30m	10.105 to 10.107	10.103 to 10.106	10.100 to 10.104	
20m	14.059 to 14.061	14.051 to 14.51		



The Tribant-2 Last time I floated a scheme for a 20/40/80m antenna that should not need an AMU when properly adjusted. As described it needed a 50R twin feeder, some of which was the vertical radiating element on 80m, with the rest acting as a loading coil or choke balun on the higher bands. The search for a source of such feeder has been fruitless. There are plenty of styles of twin 'figure of 8' cables but they all seem likely to have impedances of around 100R or higher which would defeat the objective of avoiding an AMU. I later realised that the vertical section could also be 50R coax which makes it rather more practical! The revised details are shown right but I emphasize that it has yet to be tried out - so coil details are lacking to resonate any particular vertical section. For QRP uses, the smaller 50R coax should be quite adequate and could be wound into a lightweight coil easily.

It would be great if one of our members cared to experiment and tell me the results. The cynic might say that a random long wire and AMU with counterpoise would work as well - but it would not be such fun as the trials! G3PCJ



Hot Iron

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Issue 42

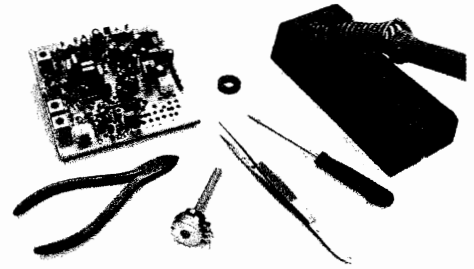
Contents

- Aerials for /P
- Selectivity
- Counters
- More on DC RX mixers
- Soldering irons and the Windom
- Theory - capacitors and impedance

The Walford Electronics website is at www.users.globalnet.co.uk/~walfor

Editorial

I have come to realise in the last few months that many of the UK's kit suppliers have ceased trading for a variety of reasons - mainly I think because they wished to retire and have a little peace! I wish them all contentment in their chosen leisure pursuits! One of the consequences is that I am increasingly being asked about mating my kits to earlier brand X kit projects! Sometimes this can be done without too much risk so I am always pleased to consider it and give an opinion on the likely outcome. It tends to be easier for accessories because their interface with the main rig is often less complex; it is much harder for transmitters and receivers since these are seldom conceived as independent designs nowadays.



I am pleased to hear of at least two new kit suppliers offering products for our hobby. It is always good to have competition because it keeps all of us on our toes commercially, and it also helps to stimulate new ideas. Their approach is certainly different to mine which can only be a good thing too! You, our customers, are the beneficiaries!

Kit Developments

The **Sidcot CW 80m TCVR** is now fully available having had a write up in the Nov and Dec 2003 issues of PW. It is a specialist CW rig with a strong mixer and many other features that take its performance way beyond that of the 'one transistor does all' CW rigs! £44 plus £1 for P and P.

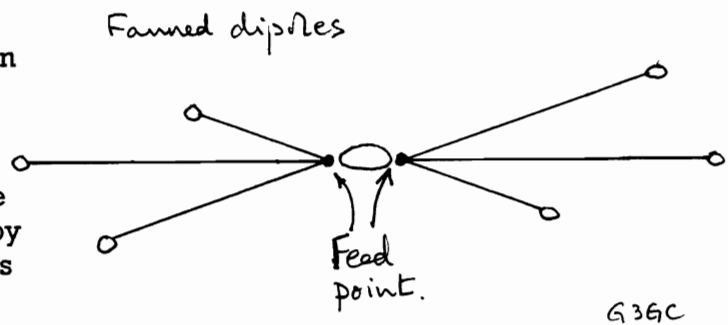
The dip oscillator project has become the **Dipper** which is now also available; it's a versatile instrument that performs traditional 'dipping' of unknown resonant circuits either by magnetic coupling, or with direct link coupling using its sensing head terminals; the latter can also be used to determine the resonant frequency of an antenna! It can also act as an absorption wavemeter. It covers 180 KHz to 35 MHz normally with ready made coils!! Sensitivity can be improved with your own optional home made coils! It has an output for a counter which works for dipping and absorption. Realising that frequency calibration can be a bit of a chore, I have designed a new **three digit counter** specifically to be mounted underneath the Dipper - see photo later. This gives a readout of XY.Z MHz. It uses a conventional meter as the 'Dipsqueek' notion got too complex! Both are battery powered with a timer. The Dipper costs £44, the 3 digit counter £35 or together they are discounted to £74, with P and P of £2. Tim Walford G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

Aerials for Portable Use

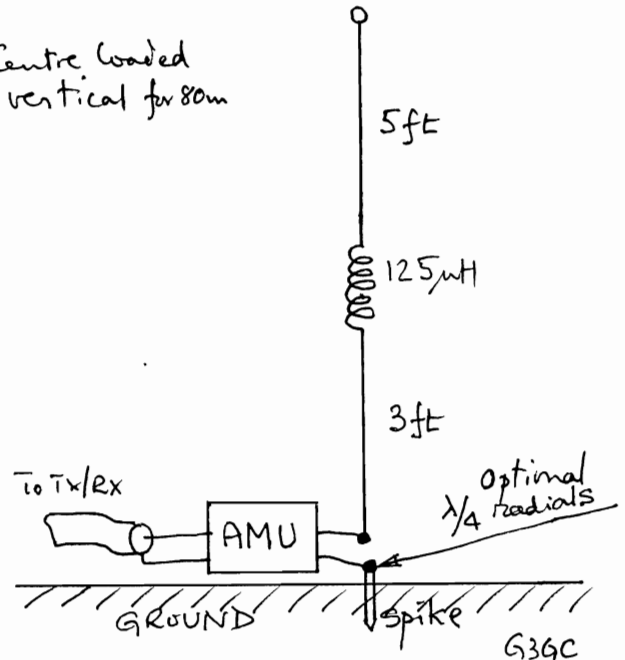
These need to be as light as possible to facilitate erection particularly if it is a one-man portable operation. For this reason the use of thin aerial wire commensurate with physical strength is desirable. This is against the usual doctrine of using thick wire to keep down losses and improve the bandwidth of an aerial but never the less is very important. Undoubtedly the best form of aerial is the centre fed half wave dipole with the centre as high as possible. This maybe achieved with a single portable mast and sloping wires to supports making the ends of the aerial some five feet or so off the ground. Remember the maximum radiation from a half wave dipole is from the centre and the low ends will only mean that it will have to be pruned to resonance if need be. Do not forget that these low ends are at the high RF voltage points and therefore should be clearly marked with a warning notice if open to the public. The 'mast' at the centre can often be a cord/rope hanging down from a branch of a large tree. The rope may be got over a tree by throwing a weight, attached to which is a thin line, over the branch or better still using a bow and arrow. The thin line is then used to pull up the cord/rope to hold the centre of the aerial. There are many multi-section light weight aerial pole/tubes available but a number of Yeovil Club members have been using the extending (up to 18 ft I believe) plastic fishing rods which have been advertised in RadCom recently.

Assuming that some form of half wave aerial to cover 20, 40 and 80m is required then this may be achieved by joining the inputs of three dipoles cut for each band together at a single feed point and fanned out away from each other to some extent as shown right. The antenna matching unit should be connected by balanced feeder to the central feed point. This can use home made open wire line or commercially made twin feed line.



One of the problems with portable working (as opposed to NFD) is that a half wave on 80m is rather large (132 ft) and consequently heavy making it difficult to erect. For this reason, it might be worth considering a centre loaded vertical for 80m. This could be attached to a non-metallic light weight mast or hung from the 'sky hook'. The value of the inductance required will be dependent upon where the coil is placed and the overall length of the aerial. Such aerials have been used in the past for HF mobile working where the overall length of the aerial was limited to about 8 ft. A typical aerial used a coil of 125 μH with 3 ft below and 5 ft above it. The coil consisted of 67 turns of 18 SWG wire on a 2.5 inch former with turns spaced one wire diameter apart. Connection to the aerial should be via coaxial cable, the outer of which should earthed by an earth stake at the aerial end. One or more quarter wave radials (66 ft) attached to the outer and the earth stake may well improve the radiation efficiency of the aerial. These maybe just laid on the ground. (See right.) The other end of the coax should be fed by the AMU. It is often desirable to join the rig earth/chassis to the aerial feeder coax screen/counterpoise(s). (This is not recommended for safety reasons, if the rig is mains powered - G3PCJ)

Centre loaded vertical for 80m

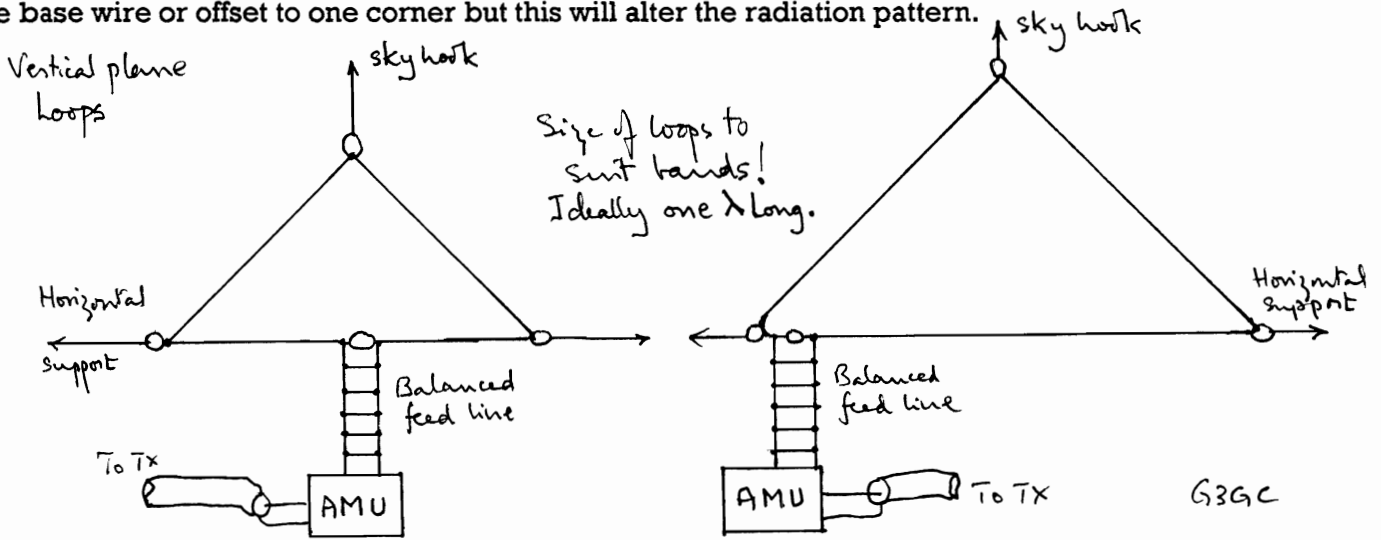


Horizontal loop aerials are always very useful and should preferably be made a wavelength long that maybe in the form of a square with 33 ft sides for 40m. However, provided the matching unit will cope, they do not have to a wavelength long or four sided but may take up a whole variety of shapes and sizes. They may be used in a vertical, horizontal or sloping configuration. The radiation pattern will be more or less unpredictable due the wide range of options.

Continued over...

Portable aerials continued

As before, the aerial should be connected by balanced feeder to the AMU. If the AMU cannot cope with the input impedance, then quite often increasing the length of the feeder will make it come within the scope of the AMU - this has to be done by trial and error. If the loop is in the form of a triangle or diamond in the vertical plane then the 'sky hook' may be used to hold up the vertex with the ends of the horizontal sides taken to low supports as shown below. The feed can be in the centre of the base wire or offset to one corner but this will alter the radiation pattern.



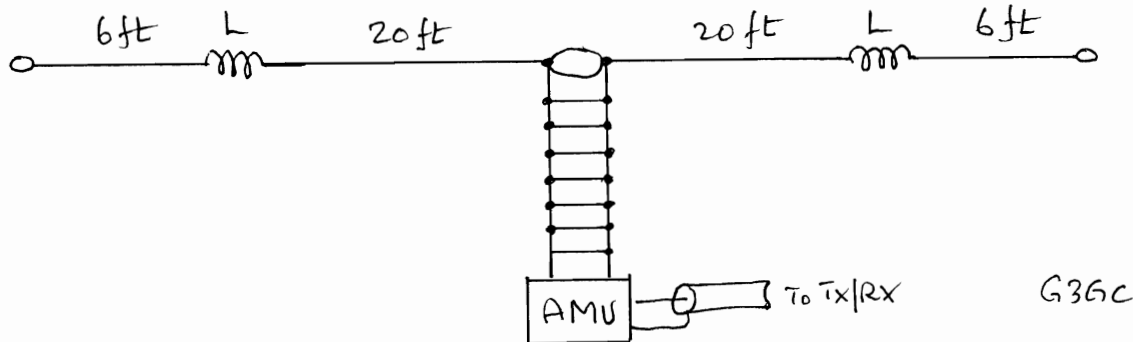
Another possibility is the use of a trap dipole but due to the weight of the traps reasonably thick wire is required which also adds to the overall weight. The aerial shown below was featured in SPRAT and is described as a loaded dipole for 10 to 80m. This aerial is 52 ft overall with loading coils 6 ft in from the ends. The coils are wound on 2.5 inch plastic formers using 55 turns of 18 SWG wire spaced one diameter apart. The weight of these coils will require a reasonable size of aerial wire.

I used to operate a lot portable whilst on holiday and used an end fed quarter wave supported by an ex-RAF sea rescue box kite. These kites fold up to go into a tin some three inches in diameter and about two feet long to which the kite string is attached. (I still have one somewhere! G3PCJ) The great thing about these kites was that there was never any problem in getting them airborne. If I couldn't get a stake into the ground I used a quarter wave radial. Modern kites maybe even better! As an aside, helium balloons were also popular in the fifties and sixties as sky hooks for 160m quarter wave vertical aerials.

A final general remark about portable working on the HF bands and particularly the lower frequencies. It is far better to choose a site with a good water table rather than a high site on poor ground. Typically, Caradon Hill, the site of the ITA/BBC TV station in Cornwall is a very good site for VHF/UHF but is useless for HF since it is on granite which is a good insulator.

Eric Godfrey G3GC

Loaded dipole for 10 to 80m - after SPRAT



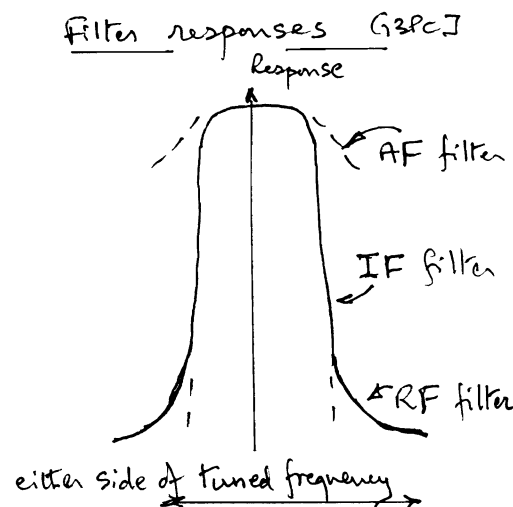
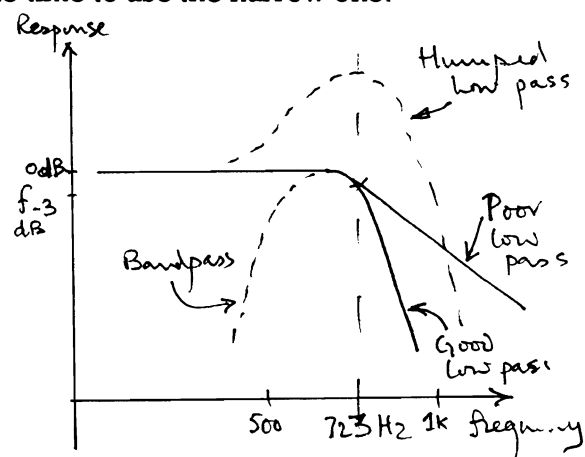
The Three S's - selectivity

This is the second aspect and concerns the ability of the receiver to hear the wanted signals while rejecting all the mass of unwanted ones! The main point is that the receiver's bandwidth should be wide enough to pass all of the 'information' in the wanted signal. This depends on the mode being used. For voice, the important range lies between roughly 300 Hz and 3 KHz. The ear's ability to understand a 'message' is not materially impaired by removing both the small amount of information below 300 Hz, and the considerable high frequency content over 3 KHz. A good *communications* transmitter will contain filters to restrict the audio range to roughly 300 Hz to 3 KHz, whereas a *broadcast* transmitter would be instantly taken off air if it wasn't passing the full range of the audio material (and probably more!). Restricting the range of the modulating audio directly reduces the RF bandwidth needed so allowing more 'channels' within a given RF band. (Complex coding, eg MPEG, can reduce the bandwidth even more!) In difficult conditions, where there is high adjacent channel interference, it is often advantageous to ignore even more of the high frequency content of the voice by limiting the bandwidth down to as low as 2 KHz; this can improve the 'understand-ability' but will detract from the natural vocal qualities of the person on the mike! (Note that 'speech processing' does NOT usually alter the signal's audio frequency range, but instead raises the *average level* of the signal compared to the *peak level* - but that's another subject!)

For morse or interrupted carrier signalling, the frequency content of the information is much lower because it is a simple manual on/off system. High speed morse implies an information bandwidth of roughly 100 Hz but to convey this information we actually listen to it anywhere in the audio range - often between 500 and 1000 Hz because our ear/brain work as a good filter thereabouts! Filters centred on 800 Hz are often used but many like it lower; I use 723 Hz because it comes directly from standard value capacitors and resistors! A good CW receiver will have audio filtering with a bandwidth down to 150 Hz; but if it is much lower than this, the implied filter Q will be too high causing the filter to 'ring' which is uncomfortable to listen too. Wider CW filters are desirable for searching the band, because it is very easy to miss a signal as you tune quickly across the band using a very narrow filter; having found something, then is the time to use the narrow one.

The above 'filtering' can be done at baseband (as audio), and or with filters before the demodulator at RF, and IF in a superhet. The narrowest *bandwidth* filter in the rig determine the characteristics, however a really narrow tuneable RF filter is impractical so that in a DC rig, the audio filters alone (almost always) determine the receiver's bandwidth - hence their importance. The sharper the *slope* of these filters (more poles and more complexity), the better it will be able to reject strong adjacent channel signals - see the curves right for a good and poor audio filter! The important filters will usually be low pass, humped low pass or bandpass because most of the unwanted signals are higher in frequency than the wanted one.

The main role of IF filtering (if fitted) is to increase the effective slope of the audio filters (so improving near signal rejection) without reducing the bandwidth. The slope of the response on the sides of an IF filter is directly related to the number of poles or resonators/crystals within it. The IF filter can also remove the unwanted sideband, both for reception and transmission since this cannot be done easily with an audio filter. The role of the rig's RF filter is to remove excessive signals outside the desired RF band, so preventing overload - notably of the important and tender first mixer - and also to reduce the image response at twice the IF from the wanted signals. Good selectivity comes from a combination of all these aspects! The lower diagram depicts the relative contribution from all the rig's filters. Next time I will write about keep^{ing} the rig on tune! G3PCJ

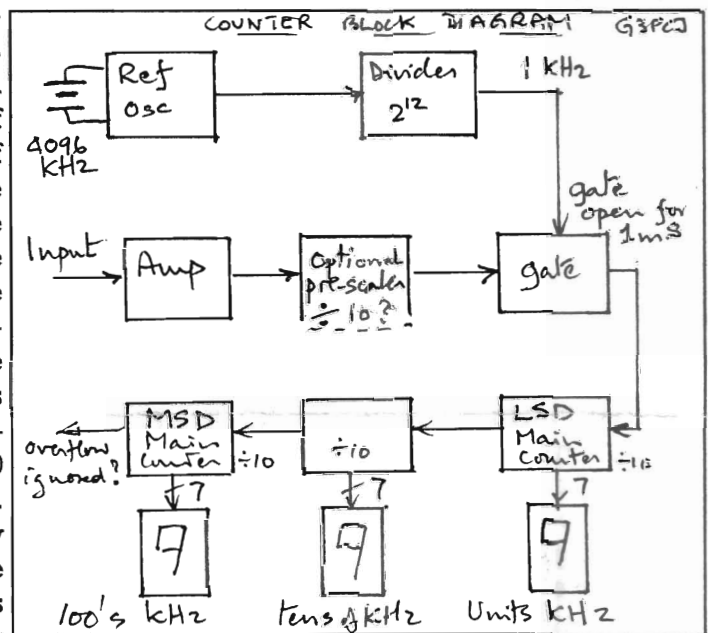


Counters

I rate having a counter pretty high up my test equipment list; for most people I suggest it should come not far after acquiring a good general purpose multi-meter. General purpose factory made new ones can be bought for a reasonable price now, and often bulkier older ones are available very cheaply at rallies. Coupling these permanently to a rig is wasteful (and often does not work well) so dedicated counters should also have a place in your shack or rigs!

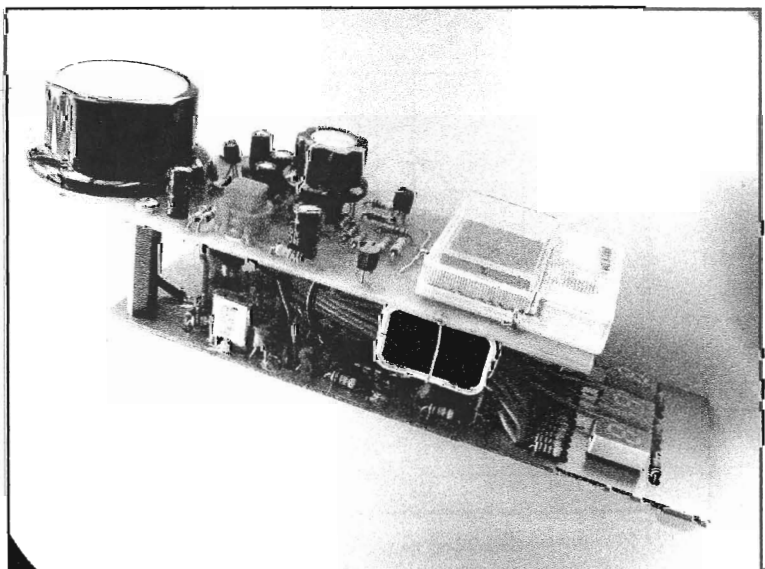
The first point to note is that all designs use digital techniques internally, and some of the cheaper ones will also have multiplexed drive to the LED displays. This approach involves moderately high currents being turned on and off rapidly in the low KHz region so is a prodigious source of RF interference! The reference clock and its harmonics can also be troublesome. A counter designed specifically for use in a receiver should be electrically quiet so that it does not mask wanted signals. This is possible by using CMOS digital circuits kept all close together on a good ground plane with plenty of supply decoupling. The quickly changing currents in such logic circuits (which cause the unwanted radiation) mainly charge/discharge the track capacitance, so small size helps appreciably. With direct drive to LED displays (not multiplexed), these connections carry DC and only change when the frequency is altered; so they do not radiate and don't have length or layout restrictions. Micro-processor based counters, all though versatile, are also often electrically noisy!

The diagram right shows the basic concept of a counter. A reference clock oscillator is divided down and opens a gate for a defined period. This directly determines the value of the least significant digit (LSD). For example, if the gate opens for 1 millisecond, the LSD will be units of KHz. When the main counter driving the LSD display overflows past 10, the next more significant digit increases by one etc.. The number of counter stages and displays determine the upper displayed frequency BUT note that the logic might not be able to work as fast as that! Often a pre-scaler counter is used to reduce the input frequency. If this divides by 10 say, then the LSB will become 10 times larger. The main counter stages and displays for any upper frequency capability, do not have to be present; if missing, the more significant digits just disappear out of sight leaving the only KHz part of the incoming frequency for our above example!



To cater for IF offsets in superhets, you can make a counter accept two inputs (from the LO and CIO) with the counter adding or subtracting to match the action of the rig's mixer - as in my 5 digit design. The new three digit unit is shown right mounted below the Dipper.

In this role it normally shows the XYZ MHz part with an upper counting limit of about 65 MHz. For use with DC rigs, by altering some wire links, it can alternatively show the important UVW KHz only part of the incoming LO frequency - the MHz bit having overflowed out of sight. The display section can be relocated to the rig's front panel with the logic PCB then occupying just 50 x 80 mm. It is also able to count up or down so will suit additive or subtractive superhet rigs having integer MHz IFs. (Because the erroneous MHz digits are out of sight!) G3PCJ



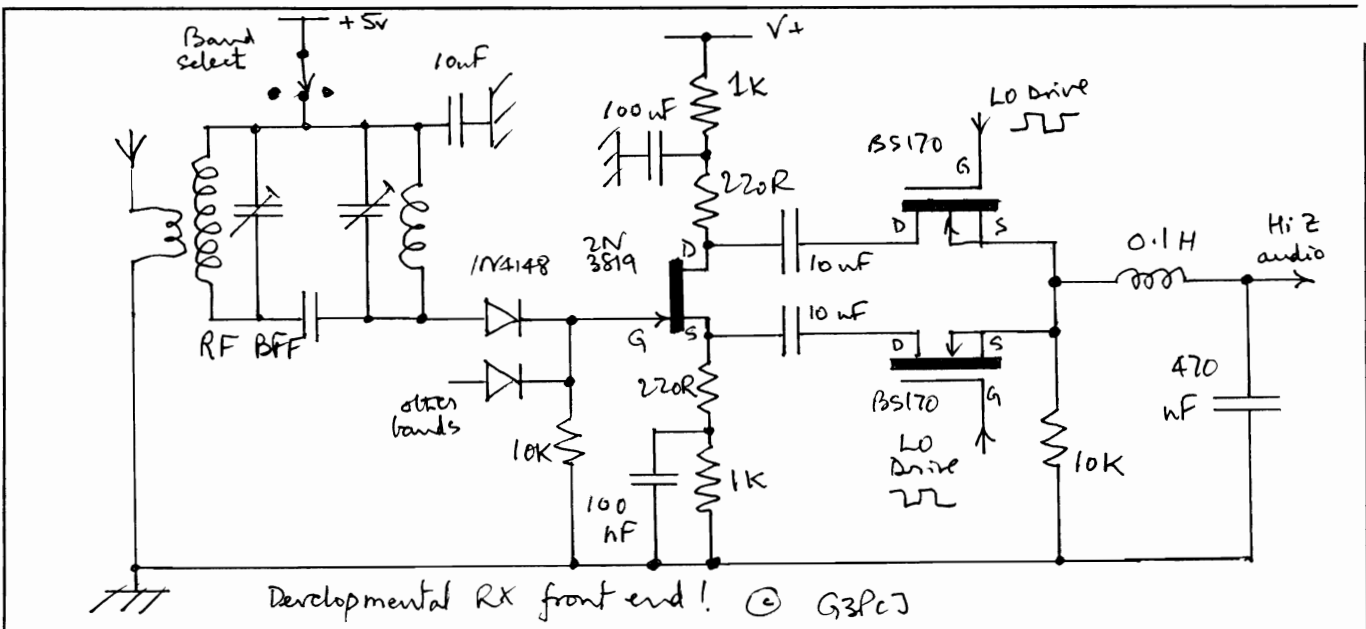
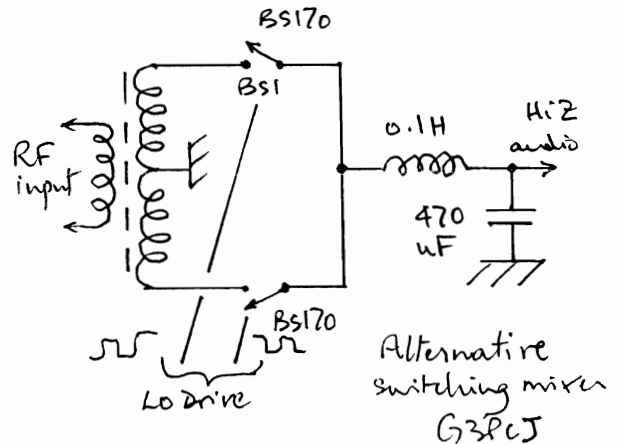
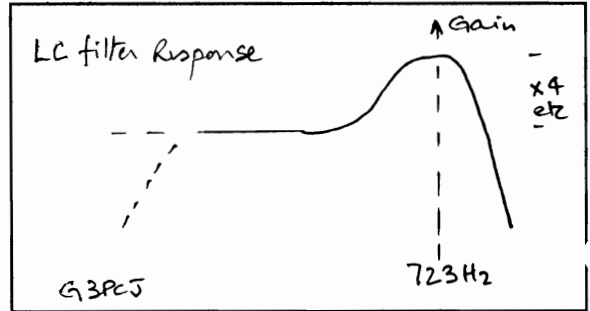
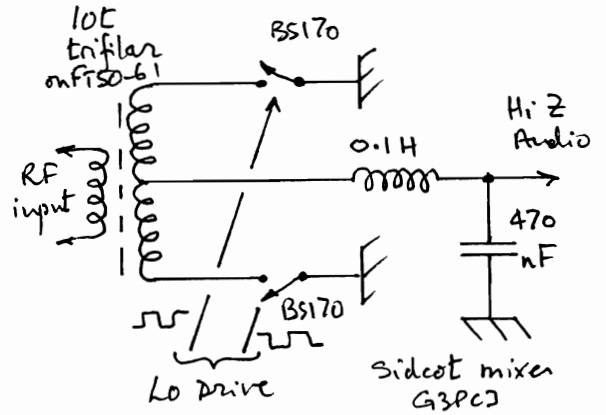
More on mixers for DC RXs!

Last time (page 5 of HI 41) I sketched the basic circuit of the detector in the Sidcot. This switching mixer has good signal handling ability but its drawback is the need for a tri-filar wound toroid; inexperienced builders don't care for winding such things but it is not really that difficult. It would be nice to find another way of providing the necessary anti-phase RF signals. Providing the other anti-phase LO signals is easy if they are digital since it only requires another gate in the LO chain. The Sidcot circuit (right) has a toroid to produce the RF signals feeding into 'grounding' switches so that the AF is developed at the toroid's centre tap, which then feeds a resonant step up circuit to the AF amplifier.

This scheme has the frequency response shown right so is ideal for a CW rig but is not much use for a phone receiver needing a flat response over a band from 300 to 3000 Hz. It does have the advantage of providing audio voltage gain without any potentially noisy active devices, so is inherently low noise and sensible for incorporation in the early stages of a high gain DC rig. (One does need to be a little careful about possible magnetic coupling into the inductor's core though!)

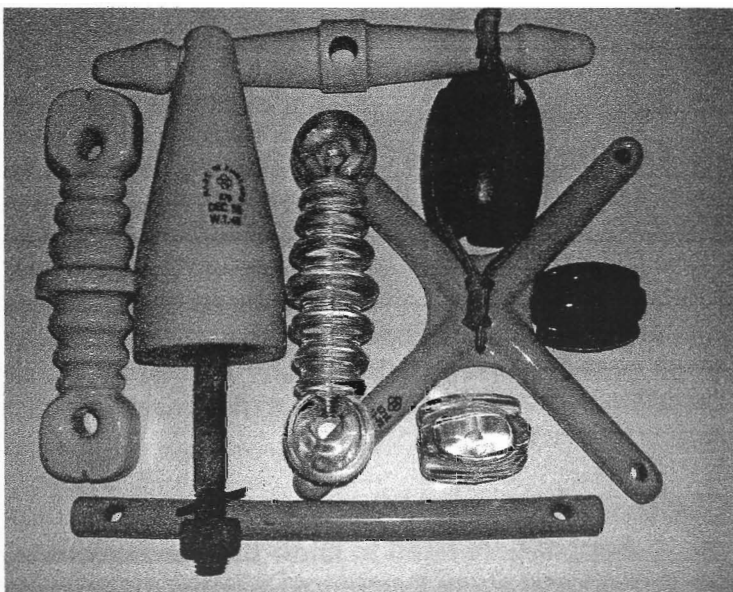
Another approach is to draw the AF directly from the switches rather than the RF transformer centre tap. This is shown in notional form right and has to be used if the two RF anti-phase signals are ground referenced, such as from an active phase splitter stage having equal value resistors in the source and drain of an RF buffer. (The DC biasing is a little more complex in reality.)

By using a JFET RF buffer connected directly after the RF bandpass filter, one can take advantage of the high impedances in the tuned circuits to realize some RF voltage gain at the same time as the phase splitting. This leads to a front end like that shown below. I emphasize I have yet to try this but it does look promising! Its my next practical job to try this for the Locking! Do let me know if any of you try it out yourselves! G3PCJ



Big soldering irons

Last time I showed you a picture of a collection of large irons and posed the question of who was the previous owner. Two readers responded; Stan Pilkington suggested that they had not come from Walters and Stanton at a recent rally (!) but might have a connection with the demise of Wooferton. Dave Buddery suggested the owner was VS1AA - see below. Both were original suggestions but neither was quite right - I was vaguely hoping that somebody might suggest Marconi knowing my interest in the Cable and Wireless beam radio station that used to operate nearby at Somerton. The station was originally built by Marconi for the Post Office and they were part of the aerial rigger's tool kit - I retrieved them from the scrap bin along with this range of aerial and feeder insulators when it was being dismantled by BT recently. Sorry - no prizes, just the glory of getting a mention!



The Windom and VS1AA

Dave Buddery G3OEP suggested that the tools belonged to the late Ken Mackintosh VS1AA because he had observed that I did not include, in the photo, any insulator for the centre of a dipole! The Windom is one of the few aerials that is a single length of wire, hence the tools were likely to be associated with the Windom and remote places. VS1AA was an expert on the Windom (maybe the only one?), who worked for many years as a rubber planter in Malaya - probably with limited electricity supply hence the large fire heated irons. During the thirties he described an improved 1-V-1 receiver with an extra 4th valve which he called the 'reactor valve', this was a tuneable oscillator covering the RX's bands, in effect he had constructed an early DC RX.

Dave calls the Windom, the 'Croquet antenna', because it resembles the game many consider outdated and played by effete Victorians on Vicarage lawns. The reverse is the case! (I play in a local fun tournament held close to Somerton RS - no further comment please! G3PCJ) Both are complicated and require skill for best effect. The length of the top must be correct, the tapping point is critical and the feeder must fall vertically from the top. Too many put up a crudely measured bit of wire, attach a feeder inaccurately and don't let it fall away vertically - they then wonder why it is disappointing. Ken said that if the feeder is made from wire about two gauges thinner than the top, the aerial will work better on the second harmonic.

Dave thinks the Windom is good for field days as it can be pre-measured and the operating caravan or tent can generally be placed vertically beneath the feed point, and if you are lucky enough to be situated on a damp Norfolk marsh you can easily find a good low resistance earth. Dave asks if this also applies to the Somerset Levels? Yes, but I have no experience of the Windom! As ever, with a single unbalanced feed, a good RF earth system is critical.

Long wire aerial material

You might care to consider livestock electric fencing 'string' - actually multi-strand plastic twine with embedded conductors. One has 6 strands of copper 0.25 mm wire. Under £10 per 200m!

20th Yeovil QRP Convention 2004

Make a note in your diary now! The date is April 18th 2004 and will be held at the Digby Hall, Sherborne, Dorset. This is the same venue as has been used for several years. Contact Derek MOWOB for details on 01935 414452 or via e mail to mowob@tiscali.co.uk There will be the usual range of talks and traders etc. etc.. A great day out with the minimum of distracting non radio electronics!

Theory!!

I can hear the groans already! Andy Howgate suggested I dissect a formula or two to make them more useable. What a task to give me! First lets try capacitors.

Its worth just reminding ourselves of the relationship between different units of capacitance. The basic unit of capacitance is the Farad but it's a huge amount of C - in practice only made as temporary standby energy storage devices for semiconductor memories; most capacitors are tiny fractions of a Farad. Often what we think of as 'large' caps are marked in micro-Farads, usually written as μF ; medium sized ones in nano-Farads, usually written as nF; and small sizes are in pico-Farads, usually written as pF. Their relationship is shown right.

Capacitive reactance

Suppose we need to know the reactance of a particular capacitor at some frequency. We use the following basic formula:-

$$X_c = \frac{1}{2\pi fC}$$

X_c in Ohms
 f in Hz
 C in Farads

The above formula also holds for frequency in MHz and capacitance in micro-Farads. It can be modified thus:-

$$X_c = \frac{1,000,000}{2\pi fC}$$

X_c in Ohms
 f in MHz
 C in pF

As an example, I have listed the steps right on my scientific calculator, to find out the reactance at 10 MHz of a 220 pico-Farad capacitor. Answer 72.38 Ohms

Sometimes we need to work out the capacitor size needed for a given reactance. The above formula is shuffled around to become:-

$$C = \frac{1,000,000}{2\pi f X_c}$$

C in pF
 f in MHz
 X_c in Ohms

Again the scientific calculator steps are listed right.

$$1 \mu\text{F} = 1,000 \text{ nF} = 1,000,000 \text{ pF} \\ = 10^6 \text{ pF} = 10^{-6} \text{ Farad}$$

$$1 \text{ nF} = 1,000 \text{ pF} = 10^{-9} \text{ Farad} \\ = 10^3 \text{ pF}$$

$$1 \text{ pF} = 10^{-12} \text{ Farad}$$

A capacitor marked 103 is
 $10 \times 10^3 \text{ pF} = 10 \text{ nF}$

G3KJ

Key strokes	Display
1	1
0	10
0	100
0	1000
0	10000
0	100000
0	Entered 1,000,000
÷	operator
2	2
÷	operator
500000	500 000
3.14	} decimal point 3. Value of π 3.14
÷	
159235.6688	159 235.6688
10	10 in MHz
÷	operator
15923.56688	159 23.56688
220	220 in pF
=	calculate 72.3798 Ohms

1000000	Entered 1000000
÷	operator
2	2
÷	operator
500000	500 000
3.14	Value of π
÷	operator
159235	159 235
10	frequency in MHz
÷	operator
72.38	Reactance in Ohms
=	calculate 219.99 pF

Please remember I am always looking for material for Hot Iron! I can use any questions as well as rough articles, or most things related to amateur radio with a mildly technical flavour! Its early, but HAPPY CHRISTMAS!

Hot Iron

Spring 2004
Issue 43

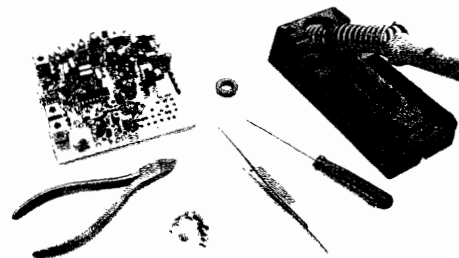
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The Walford Electronics website is also at www.walfordelectronics.co.uk

Editorial

I am pleased to be able to include an article from a new contributor, Richard Booth, who specialises in repairing elderly valved equipment - he tells me he has a link from the BBC history website! He has had a couple of (transistorised!) kits over the last few months which have led to the completed rigs shown on a later page. They look far better than anything I make! I also welcome back, with a fresh subject, a regulator contributor, Eric Godfrey G3GC, who has had a break after a personally rather difficult 2003. The article by Eric in the last Hot Iron was in my stock for future use! Keep up the good work please, and if you can make a contribution, then please do!



Most of you will know that I farm (by day!) on the low lying part of the Somerset Levels where water is pretty important. I have decided to go to Australia from Mar 8th for nearly 4 weeks to an International Conference on the Power of Water. Thus, the service from Walford Electronics will be a bit 'diluted'; so my apologies in advance when you don't get the quick answers you would like. I promise not to offer you a water powered kit on return!

Kit Developments

The article on the **Dipper** has now appeared in the March issue of Practical Wireless, and if you look carefully you can just see the associated new three digit counter in the photos. A second article on that counter kit is due a little later. Both are now available with details on the website. The Dipper costs £44, the 3 digit counter £35 or together £74, with P and P of £2.

Most of my development time has been spent getting the **Locking** prototype working. (It has been interesting and challenging!) This is the new three band specialist CW transceiver. It produces 5 Watts on 13.8 volts on 20/40/80m. It is direct conversion with full break in and narrow filtering, both at RF and at AF. There are RF and AF gain controls, with toroids and trimmers for easy adjustment of the various RF circuits. The VFO uses a ceramic resonator, with crystal mixing, to cover the whole CW section of each band. This arrangement causes 3.56, 7.03 and 14.06 MHz to share a single tuning position! Its not quite ready for release yet but three kind stalwarts will be building early models - hopefully completing them while I am away - to prove the circuits and text. Let me know if you are interested, price is likely to be £99.

Tim Walford G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics—is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

Filters for Reception

This article is not about designing and making filters but rather on how to use them to your best advantage. It is essential that changing filter bandwidths can be done quickly with a simple switch or push buttons. There are many modern black boxes that employ excellent digital filtering that can be set up to your own requirements but to change from one bandwidth to another often requires the use of two or more push buttons.

Filters, which are normally band pass filters, may be found in the IF amplifier, the AF amplifier or a combination of both. The IF filtering will help with removing strong nearby RF interference such as one gets on 40 Metres but will do nothing about any noise that is generated later in the AF stages of a receiver. Conversely the AF filter does nothing to help the 40 Metre problem but does reduce any AF noise that is generated preceding it. AF filters may also be of the notch variety, whose notch frequency may be adjusted to be the same as an interfering audio frequency and thus reduce the amplitude of a particular interfering signal or whistle/heterodyne in the normal AF pass band. Clearly this must also change the actual audio response to some degree.

It is generally accepted that for the reception of SSB a bandwidth of around 2.5 KHz is required for reasonable audio quality because the important part of the vocal spectrum is between 300 Hz and about 3 KHz, whereas a bandwidth of around 500 to 1000 Hz is not uncommon for most general CW purposes. The actual filtering maybe done at the receiver's IF, or at audio or both. Let us now consider the different requirements for SSB and CW.

For SSB reception the choice of the normal filter of around 2.5 KHz, and a narrower one with a bandwidth of around 1.5 KHz to 1.8 KHz, is useful as this may be used to reduce interference although at the expense of audio quality. If the filtering is done at the IF, then these figures are the desired bandwidth of the IF filter; however, if done at audio (or baseband to give it the technical term), then the filter should pass actual frequencies of 300 Hz upwards to whatever upper limit is desired. On SSB, the use of an AF notch filter as mentioned above, can be very useful so long as it can be easily switched in and out and the centre frequency is easily adjustable.

For CW reception a much narrower bandwidth may be used and it is not uncommon for this to be around 500 Hz. As before, this might be the bandwidth of the IF filter used for CW, or it might be the bandwidth of the baseband audio filter - however the centre of the audio filter can be anywhere in the audio range although it is commonly near 800 Hz. However under contest conditions a 250 Hz or less filter is often preferred but which filter to use is influenced by how one is operating in the contest. If one is "searching and calling" then the narrower filter is very satisfactory but if one is "calling CQ and listening" then if a station has quickly or badly netted on to you, he (or she) may be transmitting outside your pass band and will not be heard by you. By just pressing a button to get the 500 Hz or even the SSB 1.8 KHz or 2.3 KHz response, will immediately make this station audible. The RIT may now be used in conjunction with the narrow filter to tune in the station and you will of course still be transmitting on your original frequency and be heard by the other station. It is surprising just how easy and automatic this becomes with an "operator friendly transceiver" like my twenty five year old Drake TR7. It is possible of course to have even narrower bandwidths than 125 Hz but this usually means that the filter starts to ring, making listening unpleasant and reducing readability. A way round this is to have an external AF filter in the phone lead using three or four "op amps" in series which can be switched in as required. These filters will usually have three or four different bandwidths available, depending upon the number of "op amps", controlled by a switch covering the range 80 Hz to 250 Hz. Unfortunately, when using the narrow band widths these are prone to ringing but do provide some further cleaning up of audio hiss. This filter would only be used as a last resort to compliment the normal filters of a transceiver but they do make it possible to resolve some difficult copy in contests.

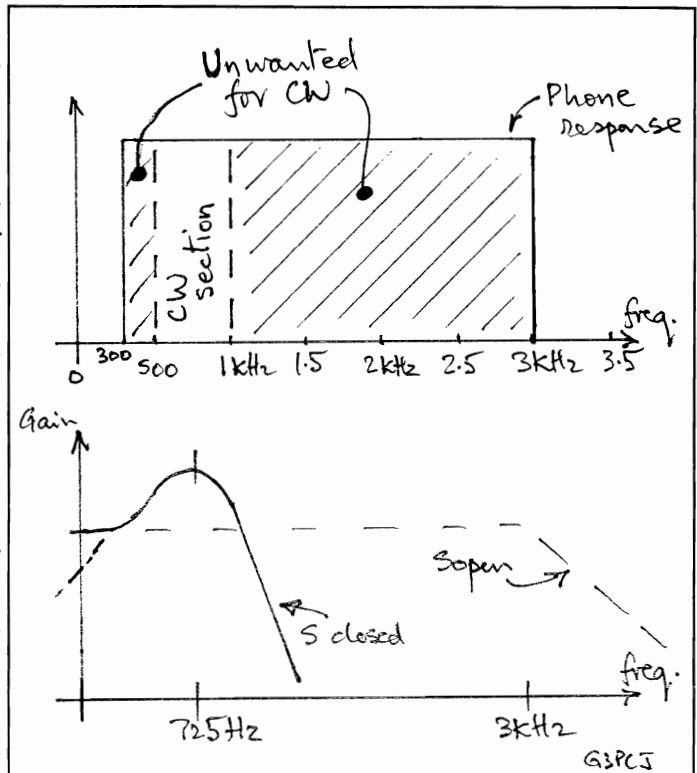
This is only a brief non-technical discussion on filters but I hope it may have been of use to some of you and perhaps some of you may like to have a go at making an "op amp" filter for your phone lead.

Eric Godfrey, G3GC

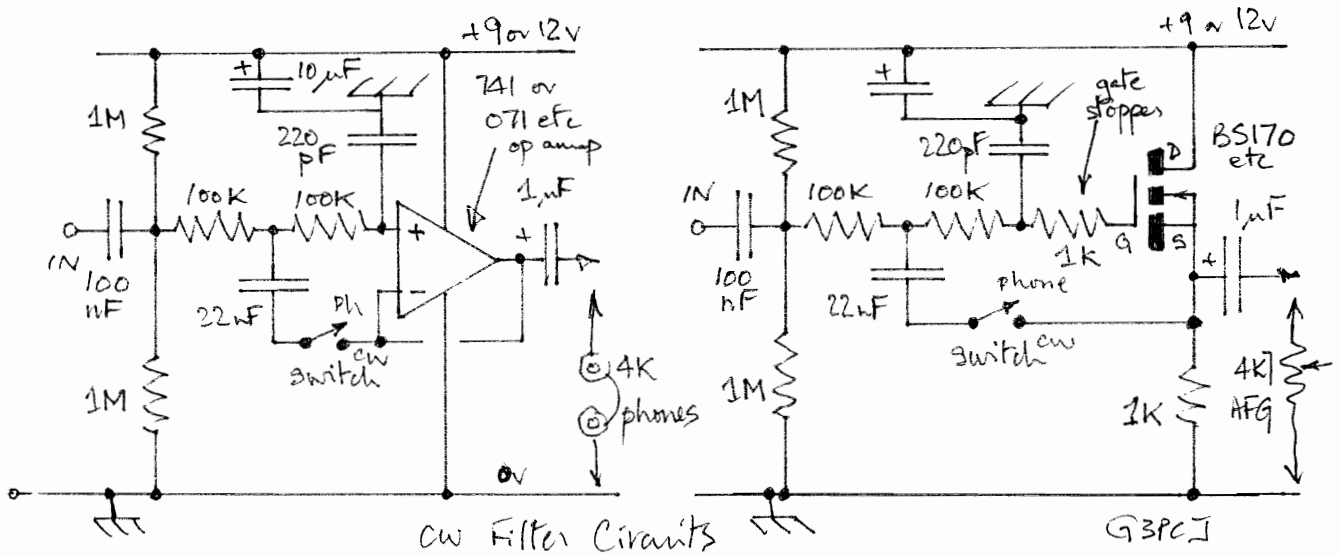
Audio Filter circuits!

Eric has told us on the previous page what the filter should do, so here are a couple of circuits. They provide the same response but use different devices so you can choose to suit your junk box! From Eric's note we see that it is the higher frequencies which are often not required but especially for difficult CW reception. If we set out to provide an audio filter primarily for CW, it would ideally have a bandpass characteristic with a centre frequency of roughly 750 Hz and a bandwidth of 500 Hz or less. Comparing this with the normal audio range used for phone of 300 Hz to around 3 KHz, for CW one would desire to reject signals between 300 Hz and say 500 Hz and also from 1 KHz to 3 KHz.

Diagrammatically this is shown right (with perfect 'brick wall' divisions!) where it is obvious that far more bandwidth, and hence potentially more numerous separate interfering signals, need to be rejected *above* the central CW passband than below; hence the common pragmatic provision of *low pass* filters to cut off the higher section while accepting the small possibility of unwanted CW signals below the desired central section. As a further refinement, the *low pass* filter can easily be made to have a slight hump in its response just before the high attenuation region; this gives the user the desirable impression that he is using the ideal bandpass filter because there is also some useful (but not complete) attenuation to the signals below the central passband. In fact a switch can be easily added to alter the response from the humped low pass to a much wider one suited for normal phone use. When the switch is open there is only one capacitor in circuit, instead of both capacitors when closed, so consequently the attenuation slope is also lower. Both circuits below provide this humped low pass response.



They need to be driven from a source impedance that is low compared to the 100K input resistors, and they can easily drive the older style high impedance phones. Neither circuit has a sufficiently low output impedance to drive a loud speaker or even 32 Ohm walkman type phones. Ideally the circuits would be placed after the receiver's main audio gain stages and prior to the rig's AF gain control which might typically have a value of 4K7. They can easily be powered by a 9 volt battery or the rig's normal nominal 12 volt supply. If you wish to make a more selective, or narrower filter, then two such stages can be connected in series. Tim G3PCJ



The Three S's - frequency Stability

This is the third aspect and concerns the ability of the rig to stay tuned to the frequency that you set an hour or so previously! It would be lovely if it stayed to within a single Hertz of where it was set but this hardly necessary or feasible! For AM and CW use, quite appreciable drift can be tolerated but for single sideband phone, the tuning needs to be correct within roughly plus or minus 20 to 30 Hz of the ideal frequency, which is where the carrier would be if it was not suppressed. This means that during a typical QSO lasting say 10 minutes, the tuning should not go off more than about 30 Hz. After the initial warm-up period, this is not too difficult. At the end of the QSO one often re-tunes, so any existing drift is effectively removed until you leave the tuning alone again for the next QSO! Staying on frequency for a long ragchew is more demanding! If you wish to work PSK31, which uses bandwidths of the order of a few Hz, then the requirements become very severe.

Modern commercial rigs will often have a frequency synthesizer; there are many types but their ultimate stability is usually dependent on a crystal oscillator, either directly or indirectly. This is also true of the latest rigs having a DDS chip (Direct Digital Synthesis). In grossly simplified form, this approach uses a very high frequency oscillator which is divided down digitally and then looks up the relevant amplitude value for the sequential output intervals of the wanted sinusoidal output frequency. Such an approach can set the frequency to within very small fractions of a Hz and stay set there for ever if the master crystal oscillator is good enough! (They can be a bit noisy though!) Homebuilt gear seldom employs such elaborate approaches and is often dependent on a ordinary tuneable LC oscillator tuning over a small section in the range of say 1 to 10 MHz. If the frequency is much higher than this, then it becomes increasingly difficult to correct the causes of drift. To obtain stable higher frequencies, it is common to mix a reasonably stable low frequency oscillator with a highly stable crystal oscillator and use either the sum or difference frequency for the rig's LO.

For a conventional LC oscillator, provided it is built in a mechanically solid manner, the usual causes of drift are an increase in inductance (taking the frequency down) and, ideally, a decrease in capacitance (taking frequency up so they cancel each other) as both items get warmer due to the RF currents flowing in them. From cold, these effects can often last for up to 15 minutes, depending on the 'bulk' of the components. One approach to reduce this, is to split the capacitor into several smaller value ones (but having roughly the same bulk) so the heating current is less significant for each. Often there will be a swift change in frequency over the first few minutes after switch on, and thereafter frequency changes are much slower; it is not unusual for the frequency to go first one way and then back beyond the starting value in the other direction! There is not a lot that can be done to alter the temperature characteristics of a given inductor but physical stability is the important thing. For air cored inductors, ceramic formers are excellent but are like hen's teeth nowadays! Powered iron toroids (like the red T68-2) are also very good but not all grades of ferrite are suitable. The ferrite used in TOKO 3334 coils has a much lower temperature coefficient (tempco) than that in 3335 coils! The latter has a much higher figure and also tends to be 'jumpy'. The usual approach to counter the inductor's increase in value is to use overtly negative tempco resonating capacitors. The black flashed/tipped small ceramic plate capacitors have a nominal zero tempco - meaning their value should not alter with temperature change - they are known as COG or NPO types. The orange flashed/tipped ceramic plate capacitors have a -150 ppm/°C characteristic and are the ones best suited to assist stability - often known as N150 types. For use with 3334 coils, generally at least half of the resonating capacitance should be N150, maybe more.

Air spaced variable capacitors can be assumed to be perfect and effectively COG unless you know otherwise. I have no data on the plastic variable PolyVaricon capacitors but experience suggests they also change very little with temperature. Where the frequency is determined primarily by a ceramic resonator, they are should be kept at an even temperature since their tempco is not good! However with good ventilation, when operating at up to a few MHz, they are quite adequate for normal use. Where the tuning is done by a varactor diode, temperature effects can be troublesome but often using N150 types for all the fixed capacitors will be adequate. Much more important for varactor diodes, is a stable tuning supply voltage. The ordinary fixed voltage regulators of the 78 series are just NOT good enough; the performance of the adjustable 317 series regulators is very much better!

All of this suggests a fair bit of 'suck it and see' but it does go to explain why VFO stability testing is so time consuming for a many-band rig, especially if soldering in between! Tim G3PCJ

PCB's another way

For years I've been dreaming of having my own UV light box, an endless supply of acetate sheets and a free supply of photo resist lacquered boards. It never happened. So like many others I used to photocopy the board layout from PW, stick it to an unsuspecting piece of copper clad, find the nearest sharp object to poke it with and bray the hell out of it with a toffee hammer. After thirty minutes of abuse you were left with a Braille dot to dot pattern that needed joining up with an etch resist pen. It worked, well after a fashion but took forever and if the paper slipped... disaster.

About six months ago I picked up that infectious radio building bug again. You know the one, it strikes for several months at a time then goes dormant again. It was time to make some more PCB's. After thumbing through the Maplin catalogue I discovered that a new product was available. Press 'n' Peel - it sounded like an excellent idea. All you do is print using a laser printer the layout you wish to etch on the special film. Then using a domestic iron (hot!) you transfer the printing to your plain PCB board and etch in the normal way. The results were mixed. The amount of heat required seemed quite critical and I wasted several sheets of film before I got any reasonable results. At nearly two pounds a go it was getting rather expensive, I was starting to think that maybe a UV box would be a good idea.

By chance I came across EI9GQ's website whilst browsing around looking for things to make, and I was drawn to an article on making reliable and more importantly, cheap circuit boards. No special film required, just a laser printer, some glossy photo printing paper and permission to use the iron! After several experiments I was so pleased with the results that I thought it should be brought to the attention of all like-minded constructors. Here's my method.

The first thing to do is to get your artwork printed onto the glossy photo paper. It has to be "proper" glossy paper as the coating on the paper traps the toner and allows it to be transferred later. You cannot use an ink jet printer - the ink has to be completely waterproof for etching. Thankfully toner is waterproof, and if you've ever tried to wash it from your hands you'll know exactly what I mean. If you don't have access to a laser printer then you can use a standard photocopier to print the layout on your paper. I've tried several different brands of photo paper for this method, all with good results. At a few pence per sheet it's certainly a lot cheaper than the specialist film. One thing to remember though is to reverse (mirror) your layout prior to printing. By doing this now your artwork will be the correct way around when transferred to the copper board.

Next you need to cut your plain copper clad board to the required size, and give it a thorough polish with some fine wire wool. Try not to get finger prints on the board after you have cleaned it, if so you can remove them with a little soap - make sure you rinse and dry it well. Cut your PCB layout to the same size as the board. You will need some masking tape to stick the paper in position, printed side down to the copper. I use two strips - one top and bottom to hold everything in place. Only use paper masking tape, as the heat used in the next stage will melt anything else.

You might need an assistant to show you how the iron works but if not then switch it on and set the temperature to high. Cotton or above should be fine. No steam required though! The yellow pages make an excellent ironing board; don't use a glossy catalogue such as CPC though as you'll end up with it's printing stuck to the underside of your new PCB. Once the iron is up to temperature you need to go back and forth over the board for about four minutes. Don't remove the iron from the board until you're finished. Apply plenty of pressure, and don't worry about the heat - it unlikely to damage anything, honest!

When finished remove the iron and turn it off. Allow the board to cool for several minutes. Do not be tempted to peel away the photo paper yet - whilst the board is warm the toner will still be soft and you risk pulling it off with the paper.

Run some water in the sink and put the complete PCB into the water. After about five minutes take it out and try to remove the top layer of the paper. It will start to peel away. Once the top layer is removed put it back into the water to soak for a few more minutes. At this point you should be able to remove the rest of the soggy paper by rubbing your thumb over it. Take care not to scratch your work. Congratulations. You should now have an exact copy of your original layout, transferred directly to your cheap board. If for some reason a track or pad has been damaged then you can touch it up with a suitable permanent marker pen. The beauty of this method is that if things should go horribly wrong all you need do is clean the piece of copper up again with wire wool and repeat the process. Nothing lost but a few pence. Continued over.....

PCB's another way continued

You can then etch the board as normal, if it's a double sided board with a continuous ground plane on one side then all I do is mask this side off with duct tape or good quality parcel tape prior to etching. It's a lot quicker than painting or spraying the board.

Caution! Ferric Chloride can seriously damage your marriage. I'll say no more on this matter.

Once it's etched, polish off the toner with wire wool, get the drill cracking and soon you'll have a professional looking PCB. For one off projects I doubt you will find an easier method.

Finally if you run out of Ferric Chloride and have plenty of time to waste try using Coca Cola to etch boards. At room temperature it takes about 2 days to do an average sized project. People drink this stuff you know.

Richard Booth G0TTL

20th Yeovil ORP Convention 2004

Make a note in your diary now! The date is April 18th 2004 and will be held at the Digby Hall, Sherborne, Dorset. This is the same venue as has been used for several years. Contact Derek MOWOB for details on 01935 414452 or via e mail to m0wob@tiscali.co.uk There will be the usual range of talks and traders etc. etc.. A great day out with the minimum of distracting non radio electronics! I shall be there - if any Members intend to collect kits at Sherborne, please let me know what you want beforehand to avoid disappointment!

Tuning by Variable Resistor!

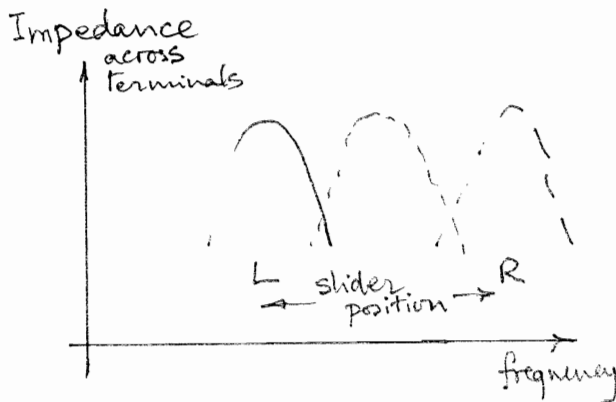
In the Jan 2004 edition of Electronics World (what used to be Wireless World) there is an interesting suggestion that you can make a variable frequency oscillator using a pot to change frequency. I haven't tried this out but hope to at some stage because of the problems of getting good variable capacitors. The essence of the resonant circuit is shown below, with its impedance curves, and would need to be added to an oscillator configuration that only requires two connections to the resonant circuit - for example that in the Dipper which is actually two 2N3819 JFETS in a grounded gate amplifier and a buffer pair. The response curves are based on theoretical calculation. The author goes on to explain that the frequency can be made to change from zero to infinity when:-

$$R = \sqrt{\frac{L}{C}}$$

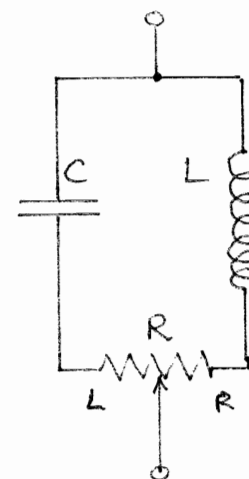
R in Ohms
L in Henries
C in Farads

It all seems too good to be true!

Tim G3PCJ



Novel tuned circuit after EW



G3PCJ

Testing Coax for losses

This approach is best for UHF work but I don't see why it should not also be relevant for HF. Attach dummy load to a suitable VSWR meter and connect to the TX; with a steady carrier, calibrate the meter for full reading, obviously the VSWR should show no reflection. The VSWR instrument should be for the same impedance as the coax to be tested – usually 50R. Without moving the settings then attach to the end of the coax you wish to test to the meter/dummy load and attach other end of coax to TX and turn on the carrier. If that cable is lossy at the frequency in use, you will obviously see the loss relatively on the calibrated VSWR meter, as the difference between full scale and the reading with the coax in circuit.

One could alternatively use a good power meter to compare the power at the far end with and without the coax. The difference will be that lost in the coax, which can then be expressed as a percentage loss or in dBs.

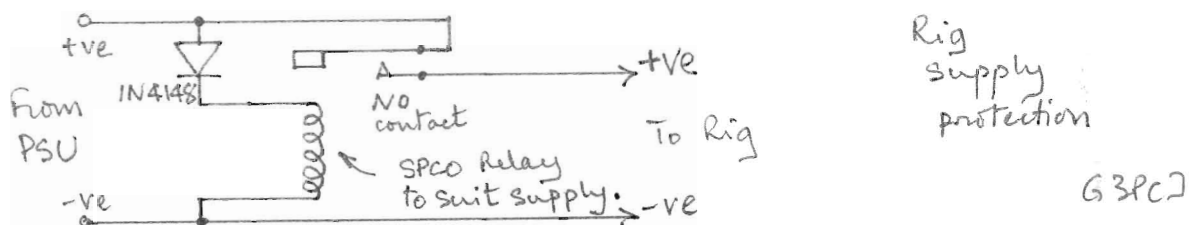
This test is of course a bit crude but maybe handy even at HF for testing cables that are old or possibly degraded through age but untried etc. Of course the test is done at the designed impedance of 50R and the dummy load at the end which is 50R so if coax is duff it will soon show up by the calibrated meter showing less of a full scale reading as set at the TX by comparison.

The technique when used at UHF soon had me changing my 213 or RG 8 to Westflex 103. I can tell you! There maybe a possibility of using this technique with other value dummy loads to indicate the power loss when coax is used to feed a mismatched load. Of course at QRP, losses are most relevant! As ever, it is very important to keep the weather out of any coax, so seal the ends well!

Andy Howgate

Reversed supply protection!

A couple of Construction Club Members have recently made the unfortunate mistake of powering up their Bristol rigs with reversed supplies. Having done it myself on a Yeovil years ago I know the feeling as things go pop before you can do anything! The good thing is, that if you have a fuse in series with the supply, it is quite likely to blow because the IRF510 in the output stage acts like a large power diode, with less damage than might otherwise be expected! Without that fuse, you may find the supply is damaged as well as the rig's devices - including the 510 which often disintegrates! The rig's electrolytic capacitors are often OK. The best thing is to add a relay. G3PCJ



This splendid pair of rigs have been built by Richard Booth G0TTL; on top is a recently built 20m Bruton and below is a 40m Fivehead with 10W Linear amplifier - he assures me that both displays do work! They are far better than anything I build! G3PCJ



Inductive Reactance

This time we will consider the reactance of inductors. They tend to also have more self capacitance which I shall ignore for this bit of theory. (In practice, these capacitive effects can be quite serious; for example, the classic case of destructive self resonance of anode supply feed RF chokes in valved class C RF amplifiers!)

The basic unit of inductance is the Henry. Its quite large but not an impractical unit. Chokes of a few Henries, with iron cores, were standard in the smoothing circuits of valved power supply units. More commonly, for RF circuits especially, values in the micro-Henry (one millionth of a Henry) are very common. The box on the right shows the relationships. Air cored inductors are often used but difficult to make well, so often, *powdered iron* toroids are used as a former and to increase the inductance for a given amount of wire. The values created are very stable and good for tuned circuits. Inductors can also be wound on *ferrite* toroids to very much increase the value but these are NOT good for tuned circuits; they are mostly used for untuned RF transformers.

Inductive Reactance

The reactance of a particular coil is easily worked out from this formula:-

$$X_L = 2\pi fL$$

X_L in Ohms
 f in Hz
 L in Henries

This formula also holds when the frequency is in MHz and the inductance is in micro-Henries. As an example, I have listed the steps on my scientific calculator on the right to determine the reactance of a 47 micro-Henry choke at 3.5 MHz, the answer is 1033 Ohms.

Sometimes we need to work out the required inductor size to achieve a given reactance; shuffling the formula around gives:-

$$L = \frac{X_c}{2\pi f}$$

L in μH
 f in MHz
 X_c in ohms

Again, the calculator steps are shown right (abbreviated).

There is a very useful article in the March 2004 issue of Practical Wireless about constructing toroidal inductors by Walter Farrar G3ESP - it has details of the inductance coefficients for a wide variety of different core materials etc.

Remember I am always looking out for subjects for Hot Iron, so if you have any suggestions, please tell me! Questions are also useful! G3PCJ

$1H = 1,000\text{ mH} = 1,000,000\mu H$
 $= 10^3\text{ mH} = 10^6\mu H$
 $1\text{ mH} = 10^{-3}H$
 $1\mu H = 10^{-6}H$

Plastic moulded inductors are usually marked in micro-henries, or μH , as two digits & a decimal multiplier. So 333 is 33mH & 100 is 10 μH .

Key strokes	Display
4	4
7	47 Entered in
X	operator μH
3	3
.	3.
5	3.5 entered in
X	164.5, operator MHz
2	2
X	329 operator
3	3
.	3.1
1	3.14 } value of π
4	3.14
=	calculate <u>1033.06 Ohms.</u>

1033	enter impedance
\div	operator
2	
\div	516.5, operator
3.14	value of π
\div	operator 164.9....
3.5	frequency in MHz
=	calculate <u>46.99</u>
	value in μH
	which is pretty close to 47 μH !

G3PCJ

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Subscriptions AND crystals!

The Walford Electronics
website is also at www.walfordelectronics.co.uk

Kit Developments

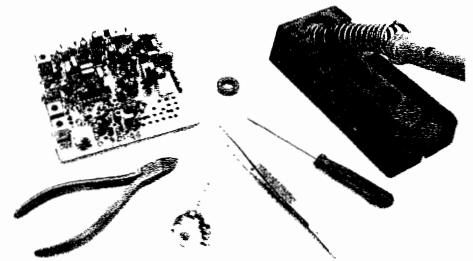
While I was away, three kind members built early models of the **Locking 20/40/80m CW TCVR**. All was not right with the design and it has required quite extensive alterations, mainly to the receiver. (I can hear the mumbles in the background!) My excuse is that development time had to be curtailed due to going to Oz! As ever, but particularly for a direct conversion rig, it is the mixer performance that is crucial - having a direct influence on the classic BCI problem. While making some changes it became apparent that others would be sensible so there are quite a few alterations and improvements. The work on the mixer has led to a much better design which I explain later in this Hot Iron. I am pleased to report that the 'VFO' arrangements, using a ceramic resonator on 80m, crystal mixing to 20m, and division by 2 for 40m that I outlined last time, do work well - and it is very handy to have the QRP frequencies of all three bands occupying the same spot on the tuning dial! While I am not yet ready to supply the Locking, because getting this Hot Iron out has taken precedence over up-dating the kit's instructions, it won't be long now! This is a full PCB with several toroids to be wound so it is an interesting and challenging project! Let me know if you are interested.

Tim Walford G3PCJ

Editorial

Thank you for your patience while I was away in VK land. We had a most excellent trip; it was most invigorating! It was partly work and partly holiday - the theme was water and agriculture. They were suffering from very serious droughts and it was fascinating to see they have the same legal and regulatory problems as we do here - despite our problem being exactly the opposite of theirs - too much water generally! The scale of things is awesome but we were made exceptionally welcome and had a great time.

Back here, we are now having our second Summer! The sun is streaming into the office and I expect to be called outside shortly! Perhaps I should have a solar powered computer; we have enough roof area but the convenient low ones all seem to point the wrong way! On the theme of independence from the 50 Hz mains, with oil at over \$40 per barrel and likely to stay that way, and possible power outages if generating capacity is not improved, I wondered if anybody would be interested in a static inverter kit? It ought to be fairly simple with a mains transformer used backwards.



Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics—is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

The Intermediate Course VFO

From time to time I get inquiries about parts for this VFO but to date I have not felt it worthwhile producing a kit for it. One instructor, with the approval of his local examiner, has instead used the Signal Source kit and got the students to calibrate that against WWV etc. I thought we ought to get the background from the horse's mouth:-

Tim has asked me to pen a few words about the VFO featured in the Intermediate Licence textbook. This is following a number of requests for kits, assistance in tracking down parts and suggestions for 'add-ons'.

First of all I must stress that it was never the intention that the VFO should be built by students as a stand-alone project. The idea was to give tutors a fall back in case students decided to build something that did not include a VFO. That said, it is an interesting project if you have never built a VFO before and it makes a good demonstration tool for drift, stray hand capacitance, the effect of mechanical shock on a 'poorly constructed' oscillator, etc. One tutor confessed that it was the first RF project he had ever undertaken, so much for the 'good old RAE'!

None of the parts are difficult to source, at least for the time being. Various FETs have been used (MPF102, J310, 2N3819, etc.) with excellent results. The only word of warning - if using something different, then check the pin outs. Another confessor claimed a record 40 minute construction time but excluded the time it took to work out that the lack of oscillation was due to 'crossed wires'! Perhaps the most difficult part is the variable capacitor. These are getting more rare but they are still stocked by the usual sources (e.g. JAB, Sycom, G-QRP Club) and good examples can be culled from old AM/FM portable radios.

What can you use the VFO for? I have run a Compton receiver from mine by replacing the ceramic resonator and coupling the output of the VFO through a small capacitor and I have added a buffer amp to help it drive the buffer/PA board from MOSFET 4 CW transmitter by VK3XU. My VFO, with buffer, has also done service in a simple 455 kHz IF superhet from the RSGB Radio & Electronics Cookbook. These would all be good projects for the IL students.

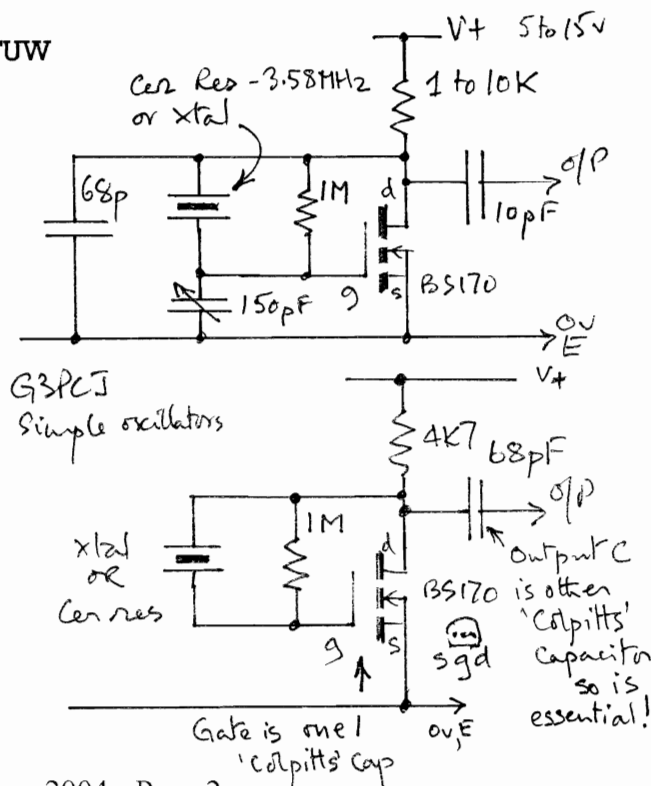
If you want something 'off the shelf' Tim has several oscillator-based kits that will meet the syllabus requirement and provide a useful piece of equipment for after the exam. Signal generators and dip meters are ideal if the student intends to carry on the practical route.

I hope this helps.

Steve Hartley, G0FUW

Simple fun 80m VFO

Here is a very simple little VFO which can be the subject of numerous experiments. It uses my favourite MOSFET, the BS170 because they are very easy to bias. If it oscillates, it will be near the bottom end of 80m so there is no need to worry about not being able to find it! The variable capacitor will pull it down to near the bottom band edge. The basic circuit can also be used with crystals on a wide range of frequencies but since they can't be pulled far there is not much use for the variable capacitor which simplifies it even further! See the lower circuit. The most original suggestion for either circuit gets a free crystal of their choice (see later) or a pair 3.58 and 3.69 MHz ceramic resonators! The rules are completely ill-defined! G3PCJ



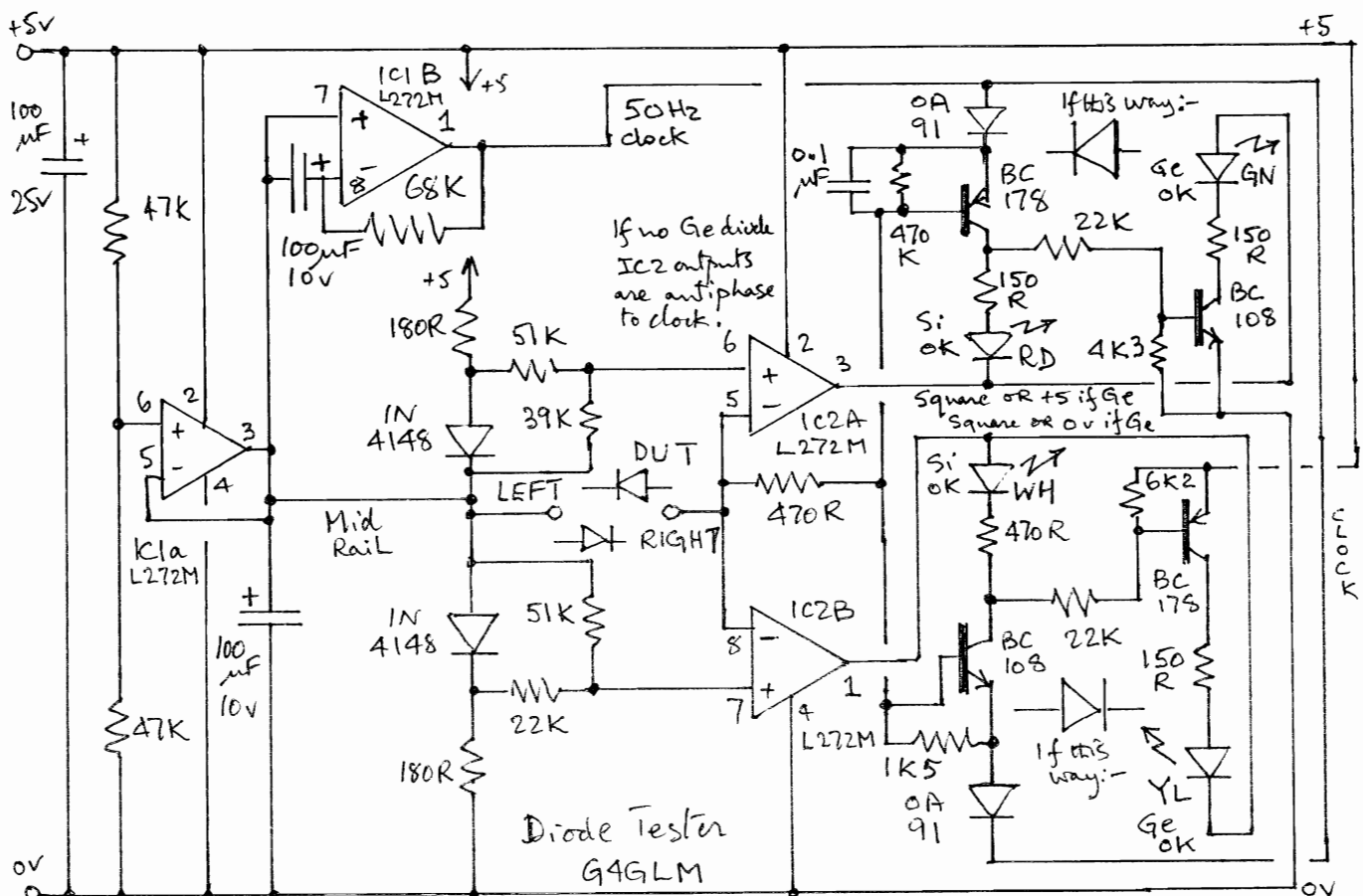
Versatile Diode Tester

Godfrey Manning G4GLM has kindly sent along a design for an instrument if you want to know what sort of diodes you have just acquired at a rally! The original article is a bit too long for this journal so I have taken the liberty of condensing it - I am pretty sure that if anybody wishes for more explanation, Godfrey would be happy to oblige. Members may build it for themselves.

Ordinary junction and point-contact diodes may be tested rapidly (e.g. while still on bulk bandoliers) by this circuit. The two test probes are placed across the diode, one of four LEDs illuminates to indicate that the diode is good, which way round it is (with respect to anode/cathode) and whether it is germanium or silicon. If the diode is open circuit, no LED lights or, if a short circuit, two LEDs (those indicating germanium) illuminate simultaneously. A single stabilised 5VDC power supply (about 30 mA) is required. The diode under test has one end held at a mid-rail level (close to 2.5V) whilst the other end is repeatedly offered the chance to conduct by alternate exposure to 0V and 5V. The alternation of the polarity of the other (right-hand) end of the diode is achieved by the clock circuit of IC1b. This runs at around 50 Hz, so that the LEDs appear to be on steadily when appropriate. When the unknown diode conducts, it supplies base current to turn 'on' either the top transistors (TR1, TR2) or, depending on polarity, the bottom transistors (TR3, TR4).

Dual power L272M op-amps are used in both linear and comparator (open loop) modes. To determine whether silicon or germanium, the voltage across the diode under test is compared with 0.5V references. The diode under test has 470R in series to define the current which is critical in ensuring good discrimination either side of the 0.5V threshold used to decide if the unknown is made of silicon or germanium. IC2a decides if it is Ge or Si when the unknown cathode is to the left, driving TR1/2 and associated LEDs; IC2b makes that decision if the cathode is to the right test terminal, driving TR3/4. The crucial 0.5 volt 'references' are derived from known silicon diodes. The display circuits driven by each pair of transistors, compare the phase of the op-amp outputs with the clock to decide which LED should be activated. IC2a output is a square wave or +5 volts if Ge, while IC2b is a square wave or 0 volts if Ge. The upper and lower LED transistor drivers are mirror images of each other.

(Godfrey. I do hope I have done justice to your intriguing circuit! Tim)

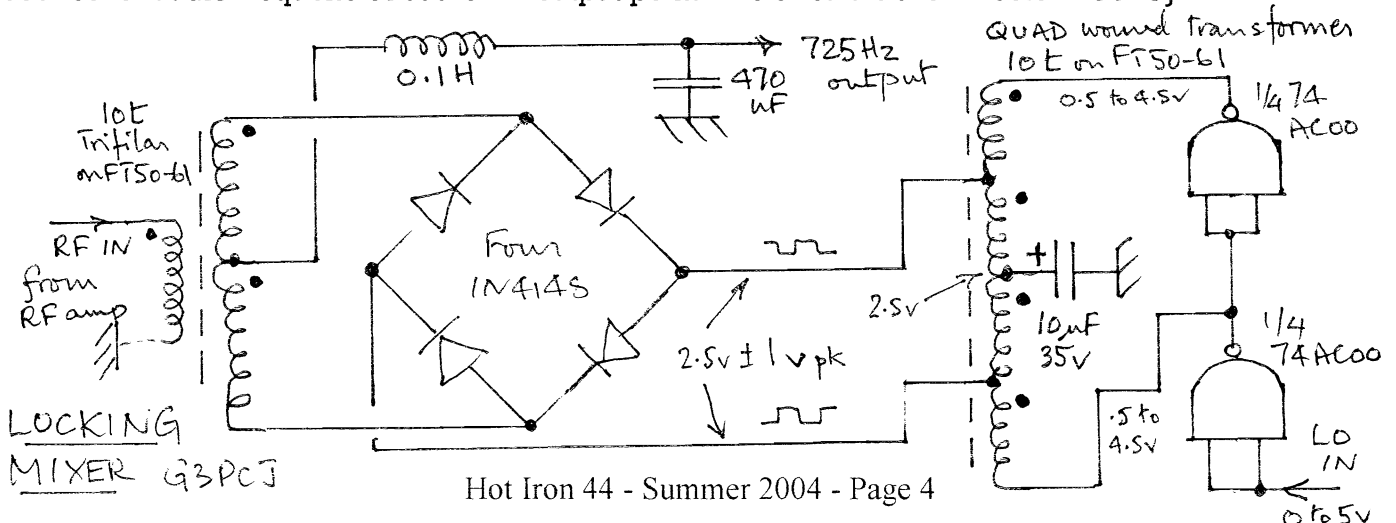
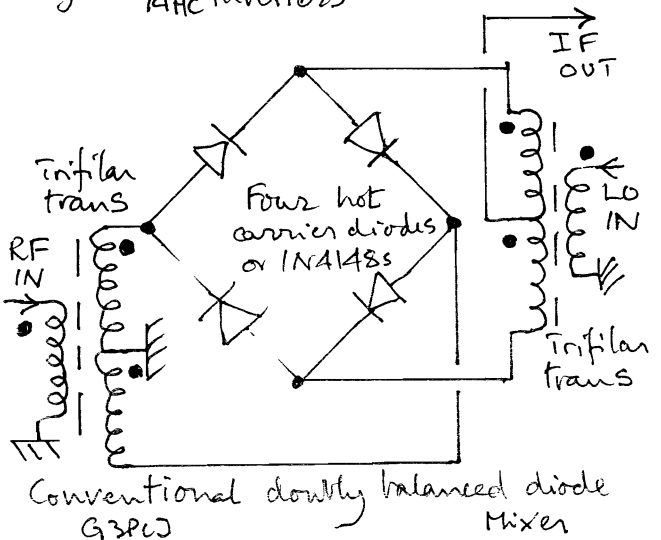
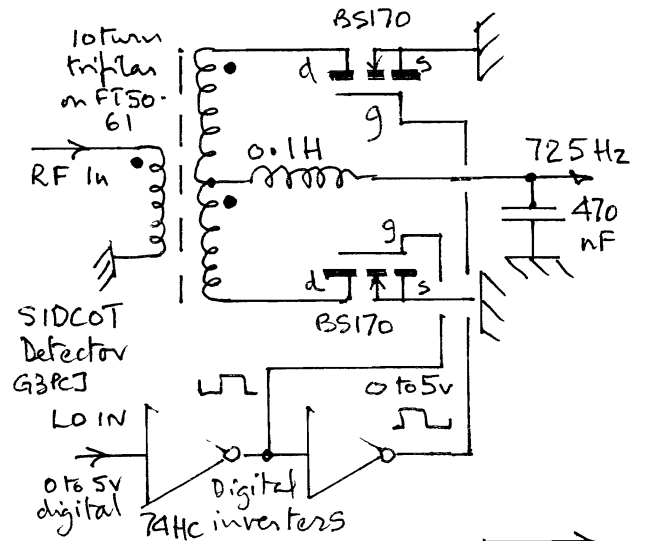


Another diode Mixer!

I had thought that the mixer which I used in the Sidcot might also be suitable for the Locking; it is a simple design which lends itself to a CW receiver with drive from a digital VFO - I don't mean a synthesized micro-processor controlled 'oscillator' but a simple oscillator that directly produces a digital square wave output. The mixer circuit is shown right. While in principle this should have a good ability to deal with BCI, the reality is that mismatching between the MOSFETs can lead to problems.

The Locking has a VFO with 5 volt digital outputs on all three bands so a broad band solution was required. The classic diode doubly balanced mixer is shown next down but suffers from the need for relatively high LO drive levels. Diode mixers, with a range of signal handling abilities, are available as commercially made functional blocks but are quite expensive and often need more than 10 dBm of LO power - quite a lot! (10 dBm means +10 dB relative to 0 dBm which is defined as 1 milli-watt into 50R, so 10 dBm is actually 10 milli-watts into 50R.) They can be home built using a couple of ferrite beads or toroids for the transformers and use either ordinary silicon diodes (1N4148s etc) or PIN diodes. Because the Locking is intended for fairly experienced builders, winding toroids can be considered; furthermore comparing the two circuits, it is obvious that only one more transformer is required for the LO drive to make a doubly balanced diode mixer. Note that it is quite permissible to interchange the IF output point to the centre tap of the other RF transformer! Having made that step, the only remaining problem is to drive the LO transformer!

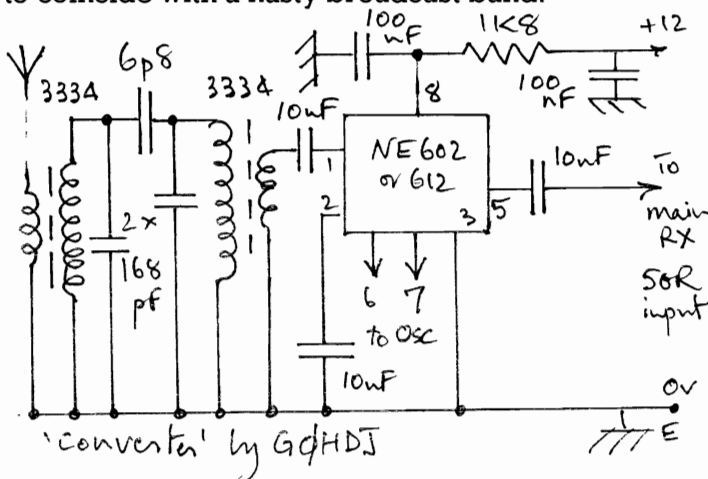
The desired input signal of +10 dBm minimum represents 1 volt peak, or 2 volts p-p across the nominal 50R impedance presented by the diodes/transformer; however, by manipulating the input turns ratio, one could use a higher LO voltage swing. The Locking VFO chips were originally ordinary high speed CMOS 74HCXX chips, but for convenience, I had already decided to change them to the same type as that driving the TX stage, which needed advanced CMOS 74AC00 chips - these still have nominal 0 or 5 volt outputs with lower impedance & more current. After a little head scratching and, realising that push pull drive was available from the LO, it dawned on me that an extra quad wound LO transformer could do the desired impedance transformation and provide a balanced output for the diode bridge. The bridge now operates at a DC voltage of half the digital supply (2.5 instead of 0 volts) so needs decoupling of the centre tap to reduce the bridge output impedance for audio frequencies at the 'IF' output point. The circuit is shown below. G3PCJ



Converter for 5 MHz

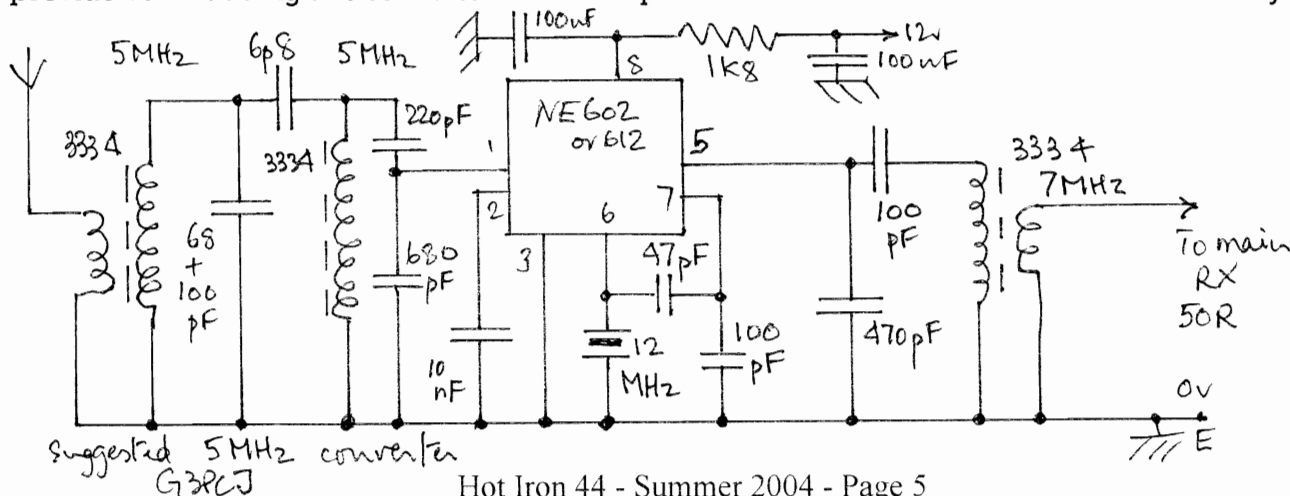
Craig Douglas G0HDJ writes that he tried listening on the new 5 MHz allocation by making a converter working into a 7 MHz receiver. It wasn't all that successful and wonders why. Craig's first question is whether it is better to convert up or down in frequency? In principle it doesn't matter but be mindful that it will switch the sideband if the frequency mixing scheme is subtractive. This won't matter for a receiver which can operate on either sideband, by operator selection or automatically as in a DC RX. The next question is whether to put the conversion local oscillator on the high or low frequency side of the converter's band. Generally this does not matter too much either; but an article in Elektor (kindly forwarded by member Charles Wilson), points out that the choice can seriously affect the attenuation given to signals at the unwanted mixer product (or image) frequency. This aspect applies for any superhet or for a converter. In this example, it would be possible to use a local oscillator for the converter on either 2 MHz or 12 MHz to cover the wanted 5 MHz ($7+$ or -5). For the 2 MHz LO, the image will be at 9 MHz ($7+ 2$) which is only 1.58 times the desired 5 MHz frequency, whereas for the 12 MHz LO, the image will be at 19 MHz ($7+ 12$) which is 3.8 times the wanted 5 MHz. Consequently the attenuation provided by the 5 MHz RF input filter will be much greater at 19 MHz than at 9 MHz, so, other things being equal, the 12 MHz LO would be better; this is especially important if the image were to coincide with a nasty broadcast band.

Craig's initial circuit is shown right but without the oscillator section considered later. It comprises a conventional double tuned filter for the wanted 5 MHz signals feeding into the 602/612 type mixer. Here is potential improvement number 1! The input and output impedances of the 612 are 1K5 so using the small coil winding of the 3334 TOKO to feed the mixer will be not optimum - a tap on the coil say one third or half way up would be better, or an impedance dividing tap of the second 168 pF resonating capacitance. Improvement number 2 is on the output where the 1K5 output impedance feeds directly into the nominal 50 R of the main receiver. This is a potential divider giving attenuation of about 30 times - this is the main reason why the converter was so deaf! A buffer or impedance converting transformer is needed.



Craig tried out several different local oscillators using either a crystal or variable LC tuned circuits. My own experience of using low frequency crystals has often been unsatisfactory but there is no real reason why Craig's crystal at 1.75 MHz should not have been fine; 1.834 MHz is also readily available. My own preference, for the reasons explained above, would be to use a 12 MHz crystal which is also readily available. With suitable 'Colpitts' capacitors to maintain oscillation and provide the desired crystal parallel load capacitance of 30 pF, it should work well. Hence my suggested overall circuit is that shown below - beware Craig - I have not tried it out!!

A multi-conversion RX can be disappointing if not properly designed for front end noise, birdies and non-linearity. Craig was using a Yeovil superhet which already has a converter added to provide 40m - adding this converter made it triple conversion! Fun but with drawbacks! G3PCJ



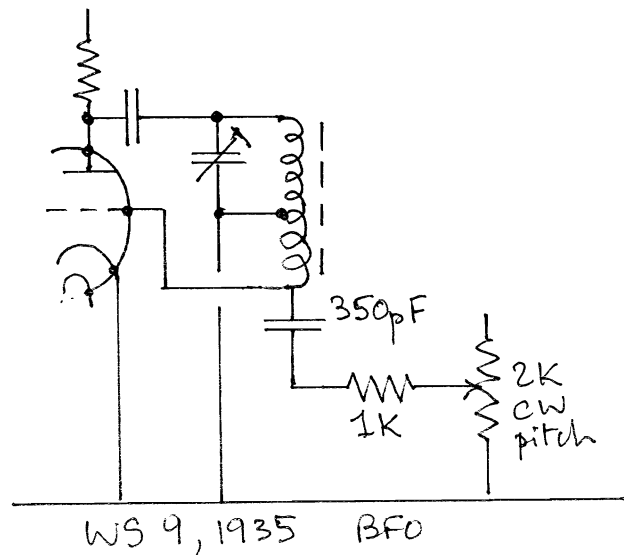
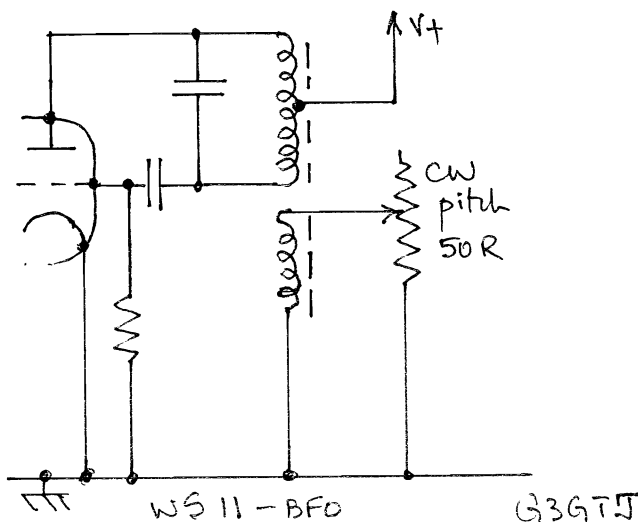
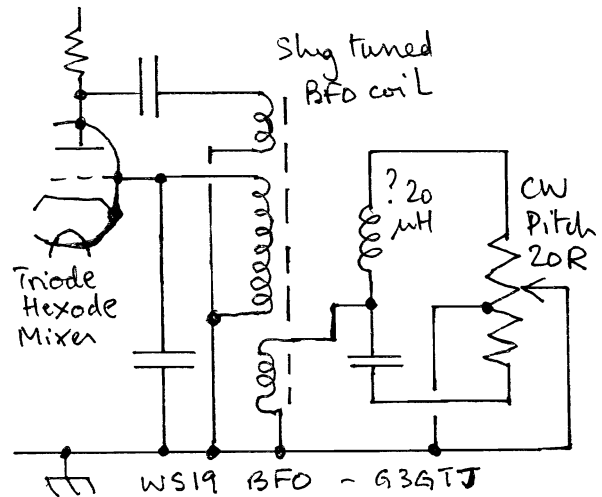
Tuning by Variable Resistors - Part 2!

The note last time prompted two responses! Great! John Teague G3GTJ asks 'what's new?' and writes 'This article rang a bell. Sure enough I was soon able to confirm that the British Army Wireless Set no 19 - possibly the best known military radio of WWII with over 150,000 produced in three factories in Britain and as many overseas countries - used the system for tuning its BFO. The WS 19 was the product of a Pye design group who were responsible for a range of HF radios through WWII and later; the resistance tuned BFO system was used by them in at least five designs. Initially the CW pitch control ("HET TONE") potentiometer provided tuning on only one side of the IF until a centre tapped one was introduced to give a full pitch control'.

'The circuit used is one in which an extra winding on the oscillator coil provides a low impedance connection to the resistance tuning arrangements. These are, typically, a low reactance inductance (actual value not known but probably around 20 microhenries) in series with a 50 nF capacitor and a 20 ohm centre tapped pot control to provide a total 6 kHz frequency swing about 465 kHz (see circuit right.)'

'The WS 19 was designed in 1938/39 winning a competitive play-off against the government sponsored design; it entered troop trials in 1940 and production soon afterwards. However this is not the beginning of the story. Digging further back with the aid of Louis Muelstee's seminal work "Wireless for the Warrior" the resistance tuned BFO was used in the 1937 Wireless Set No 11 (and in its Australian version) again with the link coupled system and "single sideband" - below left. The first military application I can trace is in WS 9, a 1935 design by the Signals Experimental Establishment. This operated at high impedance with a 2 K pot, a series 1K and a series 50 pF capacitor across a part of the oscillator tank circuit - below right.'

'To judge from the material I have all these systems seem to have been satisfactory in service. The WS 19 was primarily a tank radios but widely used in other roles. CW was the long distance, often skywave mode; bearing in mind the other limitations of the WS 19 it appears that a lot of trouble was taken to provide a full range CW pitch control - and in quite an expensive way but at low impedance providing some layout flexibility.'



Tony Green MONRB also writes 'had an idea to use such an oscillator in conjunction with an SA612 double balanced mixer with built-in oscillator. So I tried a number of variants of the circuit, but without any joy at all. So far I have come to the conclusion that whilst the tuning of the circuit does change as per the article in EW and Hot Iron, the Q of the circuit is so massively damped by the Variable resistor, that oscillation cannot be maintained. Of course I would be delighted to hear if any of your other readers have managed to get it to work!' I hope sometime to do a trial - Tim!

Resonant Circuits

The formulas that are mentioned below apply to both of the two classic forms of resonant circuit - the series resonant shown above top right and the parallel version shown below. These are ideal circuits because I have not included any lossy resistances. The most important aspect is their combined impedance at the resonant frequency. For the series circuit, the resulting impedance is very low at resonance; it is used either as a series filter allowing signals to pass through, or, in conjunction with some series resistance, it can short out a signal - this latter version is called a resonant trap. The parallel resonant circuit is exactly the opposite, having a very high impedance at resonance. It is widely used in receiver front end filters to reject unwanted signals.

Reactances

In both circuits, at the resonant frequency, the reactive impedances of each component are equal in magnitude but of the opposite type, so that they cancel each other out leaving only the 'unseen' loss resistance, this is (or should be with good components!) a very low value for the series circuit (below an Ohm) and a very high value for the parallel circuit (over 100K). Usually these losses can be ignored.

Resonant Frequency

By juggling with the formulas given for inductive and capacitive reactance given in the last two Hot Irons, it is possible to eliminate the impedance term to obtain a relationship purely between L, C and f. Sparing you this torture, it leads to the familiar formula:-

$$f = \frac{1}{2\pi\sqrt{LC}}$$

f in Hz
 L in Henries
 C in Farads

This formula also holds for inductance in micro-Henries and capacitance in microFarads & f in MHz. As an example, I have listed the steps on my scientific calculator right to determine the resonant frequency of a 5 micro-Henry coil and a 330 pF or 0.33 nF capacitor. Note that 1 μH is 1 x 10⁻⁶ Henries and 1 pF is 1 x 10⁻¹² Farads. The steps are shown right in the middle box.

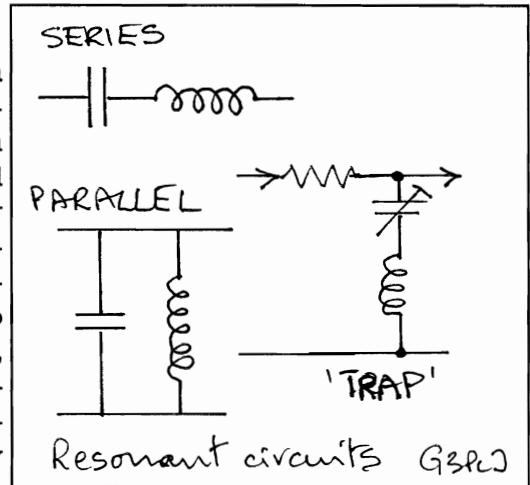
Calculating inductance

When using a Dipper, one measures the resonant frequency with a known capacitor so the equation is turned around to find the inductor's value:-

$$L = \frac{1}{(2\pi f)^2 \times C}$$

f in Hz, or MHz
 L in Henries, or μH
 C in Farads, or μF

Again, the calculator steps are shown right (abbreviated). The answer is in Hz. It can also be used to find the capacitor value for a known frequency and inductance - just use the known L instead of the C. G3PCJ



Key strokes Display

```

5                               5
EXP                             5.00
+/-                             5.-00
6 (value of L)                 5.-06
X Multiply                      0.000005
330                             330
EXP                             330.00
+/-                             330.-00
12 (value of C)                330.-12
= calculate                     1.65-15
√ sq root                      0.0000064
X multiply                      0.00000081
2                               (π)
X multiply                      0.000000255
3.14                            = CALC
=                               0.000000255
2nd F
1/x Reciprocal                 3920111 Hz
ANSWER = 3.92 MHz
  
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G3PCJ

```

2
X
3.14 π
X                               6.28
3920000 (value of f)
= calculate                     24617600
X square
= calculate                     60602622.14
X multiply
330
EXP
+/-
12 (value of C)                330.-12
= calculate                     199988.6558
2nd F
1/x Reciprocal                 0.000005 H
ANSWER = 5 μH
  
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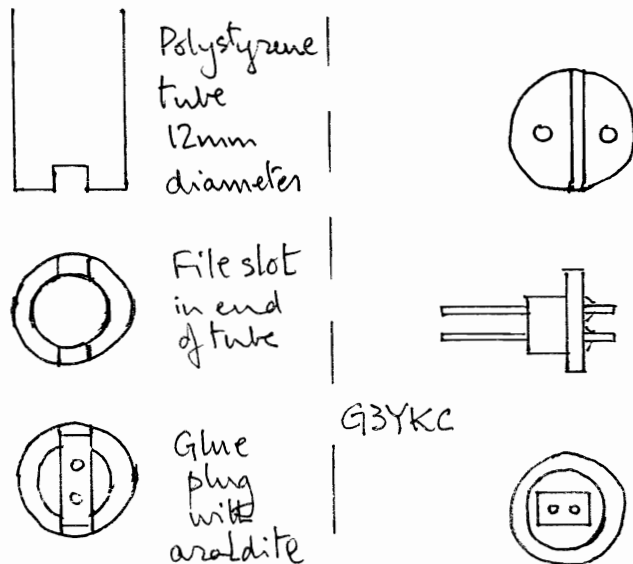
G3PCJ

Snippets!

Mixers By coincidence, the June 2004 issue of Radcom has an interesting article in Pat Hawkers TT column, on the evolution of simpler forms of balanced switching or commutating mixers.

PCBs Another Way Derek Alexander G4GVM tried Richard Booth's approach for making PCBs (Hot Iron 43) but without full success! Richard replies 'I think Derek's problem is the paper he is using - it's probably too "good" quality, it appears to have an extra more waterproof layer built in. I sent him 4 sheets of the cheapo (1.5p a sheet!) paper I've been using to make boards to try out. I'll let you know the results when he gets back to me.' No news is good news is presume - Tim!

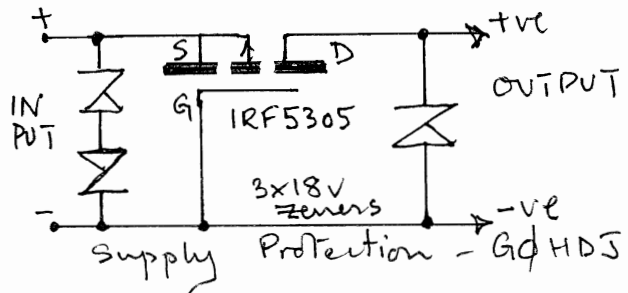
Dipper Formers Deryck Fayers G3YKC writes with details of the formers that he has made for his Dipper. He finds that having a dedicated 3 digit counter is a great deal better than having to calibrate each coil - especially as he has two sets! He has one set using the supplied moulded ferrite loaded inductors but also made a complete set covering 0.6 to 56 MHz of his own air cored ones to gain the better sensitivity that is possible without the ferrite. Some of his use 12 mm polystyrene tubing and others 20 mm electrical conduit pipe which is probably PVC. Fixing details below.



Cut piece of fibreglass pcb material and file to be a tight fit in end of pipe. Drill two holes 1.5mm diameter to suit plug contacts.
 Make saw cut using junior hack saw through copper to insulate the two copper contacts.
 Glue plug to fibreglass side of pcb and solder plug contacts to copper side.
 Glue complete assembly in end of pipe with araldite - roughen inside of pipe first.

Reversed supply protection!

Following last time's note on this subject Craig G0HDJ sends along his solid state 'protector' which is rather elegant! He uses a p channel MOSFET type IRF5305 which costs £1.37 from Farnell. He also added three optional 18 volt 1.3 W Zener diodes for over-voltage protection at a cost of 7 pence each! The IRF5305 has an 'on resistance' of just 60 milliOhms so the volt drop is negligible!



Subscriptions!

I am afraid its that time again! If you wish to continue receiving Hot Iron, let me have your cheque for £7 before Sept 1st for the next issue. As an inducement to renew, I have loads of crystals which I am unlikely to make any use of, so let me know if you would like any of the following frequencies - free apart from the packing & postage - as many as you like (within reason)! I will send these out on receipt of your sub so please add three first class stamps for the packing/postage of the crystals or increase the sub figure to £8. The following are available:-

Parallel Resonant - MHz - 5.0688, 5.6914, 5.752, 6.0177, 7.20, 9.30, 9.60, 10.2775, 10.44, 11.0258, 12.73819, 14.84830, 15.375, 16.5888, 16.623333, 17.9, 18.26, 20.105, 20.78

Series Resonant - MHz - 15.0, 18.0, 20.0, 21.0, 24.0

I have some TTL oscillators (sq wave output) £2 for P & P please - MHz 24.0, 30.0, 32.0

Send off your cheques now!

Hot Iron

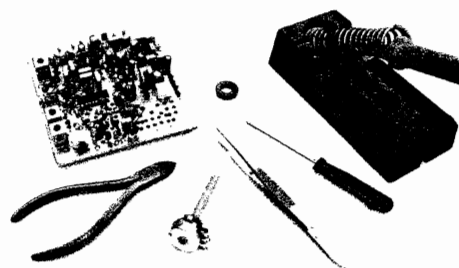
Autumn 2004
Issue 45

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Editorial

I see that I mentioned water in my last editorial! My word - I could dwell at length on that subject again! From a farming perspective, its proving very difficult for a great many farmers all over the Country. Since that excellent weather in May, we have had sunny periods and showers almost continuously - or so it seems! We are lucky, in that we have managed to do all our wheat harvest with just two fields left of barley and beans. It has nothing to do with electronics but I hope you don't object to the odd comment on rural matters!



I see I mentioned static inverters and the like - pondering if anybody was interested in a kit - evidently not! I have just lashed out on a photovoltaic 100W panel, deep cyclic duty 12 volt battery and a commercially made static inverter. I have yet to get it up on my roof properly because the best site is too high for comfort! I suspect an investment in heavy copper wire and sitting it on a nearby low barn will be better. Think of all that energy going into the cells for free! Totally uneconomic - more of that when its working!

The Walford Electronics website is also at www.walfordelectronics.co.uk

Kit Developments

Its been a busy time! After much evaluation, & change, the **Locking** 20/40/80m specialist CW TCVR is now available but I must emphasize that it is complex rig and is very full and quite a big project. Definitely not for those who have only built a crystal set previously. Many thanks to Craig, Jorgen and Andy for their help in sorting out early problems. I have just finished a new starter rig called the **Catcott**, this is a 20/40/80m regen RX for first time constructors. See the photo later. £24. I have also just finished building the prototype of a new 1.5W CW DC TCVR called the **Brent**, full break in and good performance etc. Supplied normally for 80m (100 KHz range), but will do any band to 20m with a crystal & so a limited tuning range. Hence the new Mini-Mixer kit to regain the 100 KHz by mixing the 80m VFO with a crystal for the chosen band. It seems quite promising, supplied in flat format, 80 x 100 mm PCB for 80m. £34 or +£14 with the mixer for full CW section coverage of other bands. See later - an early builder would be handy!

I am preparing another multi-band RX project called the **Sutton**, and associated CW TX called the **Mallet**; both are well developed but still in my mind! I had best not tell you too much or I wont finish the Brent! More on that next time since I hope it will be working by then. Tim

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

Mixing up a Fivehead

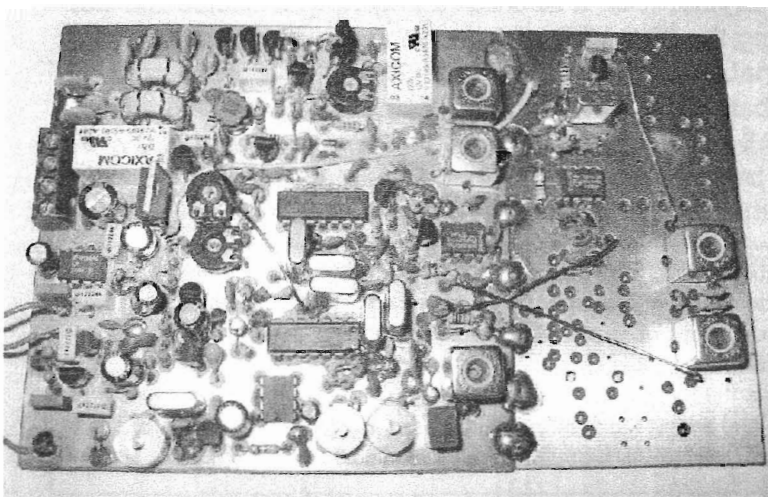
28 MHz or 10 meters as most folk call it, is an excellent QRP band, when conditions and sunspots allow. You can work the world with a few watts and a very simple, compact antenna. That wasn't the main reason why I wanted to build a single band 10m rig though. The plan is to use it as a tuneable IF and SSB exciter in order to drive a 70 MHz transverter. By doing this, it releases my Bristol to do things more HF, and I'll also have a nice little 10m rig for portable work.

Having already successfully built a Fivehead for 40m, I was happy with the design and performance. In order to get the rig working on 28 MHz you need to add an extra mixer and filter stage to the VFO. Enter the mixer kit. By making the Fivehead on board VFO run at 4 MHz and then mixing this variable frequency signal with an 18 MHz crystal, you generate a VFO or local oscillator signal at 22 MHz, the clever part is the original stability of the 4 MHz VFO is retained. The band pass filter after the extra mixer stage is necessary to pick out the wanted 22 MHz signal as with all mixing processes you generate a sum and difference frequency. The new 22 MHz VFO is then fed back into the main Fivehead board.

Having built one already, construction of the second Fivehead and extra mixer was straight forward, although as Tim always reminds you, you do need to take care with the BS170's ! I used an old Jackson air spaced variable capacitor with a value of about 200 pf for tuning the VFO, rather than the supplied polyvaricon component. At this frequency I decided that any extra stability was worth a bit of mechanical complexity. New air spaced capacitors like this cost a fortune, but if you are lucky like me to have access to lots of junk 1960's transistor radios - you'll find one in just about every set.

To get the mixer VFO working and on frequency, first of all set up the 4 MHz variable oscillator - easiest with a frequency counter but you could also use a communication receiver to get it roughly on frequency. Next thing was to check that the 18 MHz oscillator is running on the mixer board - no problems there. Setting the bandpass filter for 22 MHz is easiest using a receiver with an S meter. Assuming the 4 MHz VFO is set to 4 MHz, the output sum should be 22 MHz. So tune in 22 MHz on your receiver and you should be able to pick up the generated carrier. Adjust the cores of the two Toko coils on the mixer board for maximum S meter deflection.

That's it, the rest of the construction is the same as any other Fivehead transceiver. Guess what... it works! I must confess though to a few mistakes which needed sorting out. With my 200 pf or so tuning capacitor I've managed to achieve a swing of about 450 KHz, it seems stable too even with the PCB on the bench with flying leads running to the capacitor. The receiver is adequate, but could possibly be more sensitive. My feeling is that the 4066 signal switching at this frequency is pushing it a bit and is this is likely where the signal loss is. On transmit with all specified components in the PA it develops about 700 mW of clean RF using a 13.8V supply - more than enough to drive my transverter or possibly in the future a two stage linear amplifier to give a few more watts on 10 when the higher bands are quiet.



In conclusion I think this has been a worthwhile experiment, and I am pleased with the results. As a mono-band rig for 17,15 or 10m the extra work involved is minimal. 17m is a cracking QRP band, very low noise and not crowded. I'm happy to hear from anyone else who attempts a mixing Fivehead. Maybe this one should be called the Tenhead!

Richard Booth GOTTL

See elsewhere in this issue about the **new, smaller, simpler and cheaper mixer kit** that will also go with the Fivehead! G3PCJ

Would you like a squeeze? by Eric Godfrey G3GC

I have been asked about different types of keyer. The following is an extract from an Edge-ware Club Newsletter that I wrote years ago considering if 'squeezing' is worthwhile.

"To refresh our memories, a squeeze keyer has two paddles, each with a single contact, mounted side by side. The left paddle is capable of being moved to the right causing the contact to close and the keyer to generate a series of dots; and the right hand paddle can move to the left, generating a series of dashes. If both paddles are operated so that both contacts are closed, then a series of alternating dots and dashes are generated (the first and last character are determined by which paddle contact is closed first and opened last). This is the condition which gives the keyer its name since the two paddles are squeezed together between thumb and forefinger. On the other hand an ordinary electronic keyer has a single paddle, with two contacts - one on each side of the paddle, which may be moved from its neutral position to either left or right which generates a series of dots or dashes respectively.

I believe the argument for using a squeeze keyer is that it reduces the number of movements required to send morse. In the Table below are listed the number of movements (closing and opening a contact is considered one movement) for both types of electronic keyer and also for a hand straight key (not bug). From the Table it can be seen that there is quite a reduction from the hand key to the ordinary electronic keyer (34.5%) but only a reduction of six movements (11%) between the ordinary and squeeze keyer and these are confined to the letters C, F, K, Q & R. The number of movements for numerals is exactly the same for either electronic keyer which effectively reduces the 11% down to 8%.

Returning now to my opening paragraph where I asked the question is a squeeze keyer really worth while, I doubt it very much since, for a small saving in operator movement/fatigue, there has been a further complication introduced into the sending technique - when to squeeze and when not! In any event, whether one has an ordinary or squeeze keyer, a lot of practice is required before going on the air or one may join the ranks of those who send at character speeds of 25 wpm or more with an average speed of 10 wpm or less due to continuously having to correct errors.'

(There were some further comments from the EN's Editor but space has run out! Next time if wanted.)

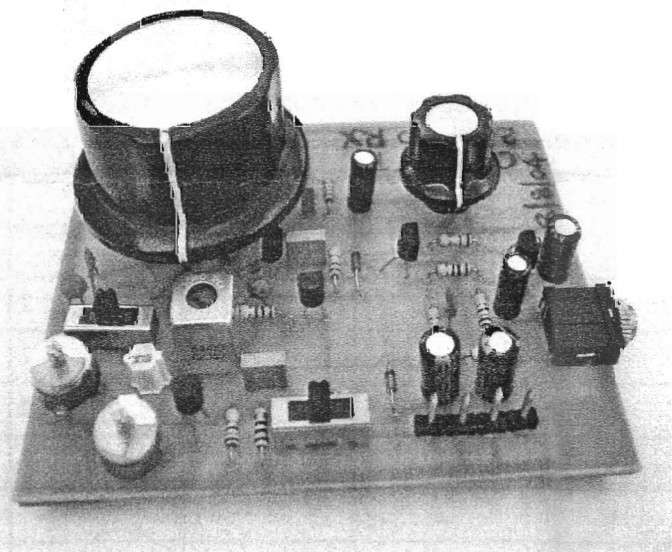
Letter	Hand key	Electronic Keyer		Letter	Hand Key	Electronic Keyer	
		Ordinary	Squeeze			Ordinary	Squeeze
A	2	2	2	N	2	2	2
B	4	2	2	O	3	1	1
C	4	4	2	P	4	3	3
D	4	2	2	Q	4	3	2
E	1	11	1	R	3	3	2
F	4	3	2	S	3	1	1
G	4	2	2	T	1	1	1
H	4	1	1	U	3	2	2
I	2	1	1	V	4	2	2
J	4	2	2	W	3	2	2
K	3	3	2	X	4	3	3
L	4	3	3	Y	4	3	3
M	2	1	1	Z	4	2	2
Totals	42	27	23		42	28	26
Key movements Squeeze action required				Brght fwd	42	27	23
				Grand Tot	84	55	49

Computers in rigs

Adding a computing type device to most consumer gadgets brings masses of benefits at little extra production cost! Such devices, in almost single chip form as micro-processors, are increasingly being used in even small radio projects - both commercially made and home produced. In extreme cases much of the filtering and lower frequency (IF and AF) signal processing will be done digitally within the micro. One of the simplest and most obvious uses is to drive a digital read-out of the tuning frequency. Modern micros are well able to count the LO input frequency. They can then directly drive the display without having to worry about dedicated decoding chips for seven segment displays and the like! Often, an LCD display is more expensive than the micro! Adding a microprocessor to the local oscillator control arrangements, will bring many benefits too! Band changing becomes much easier with the dividers of the LO phase locked loop being under control of the micro! The micro also switches the associated RF filters either using relays or semiconductor switches. When such a rig is provided with 'two VFOs' it does not actually have two VFOs - merely a memory location in which the second VFO frequency is stored when not being used, so that it can be instantly recalled to control the VFO PPL when the correct button is pressed!

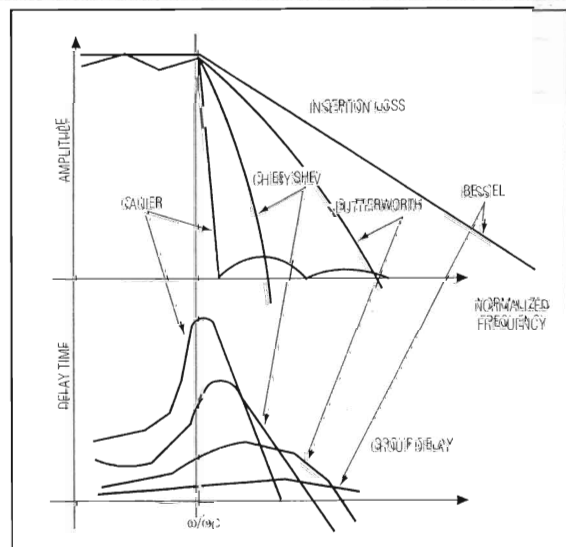
But there is the first hint of trouble! Too many buttons. The range of options just becomes so great that the required controlling keyboard is bigger than the signal handling part of the device and a degree in 'buttonology' is required! (Yes - my age is showing!) Is this device easily understood? Does the operator understand the processes going on to achieve the desired filtering etc - if not, they will not get the best out of the rig and there is little hope of making sensible adjustments for alternative conditions. Do you know how to alter the coefficients in the Kalman filters to change the bandwidth or damping? What happens when it goes wrong? Can you stick your common test instruments into it to fault find or do you always pay somebody else £40 an hour for the pleasure? When it becomes slightly older, will they still be able to get the specialist parts? What of the electrical noise from all these wide bandwidth digital circuits which have to run in an unsynchronised noisy manner the whole time? Especially if they control high current things like LED displays!

In short, for keen home constructors there is much to be said for using micros rather sparingly! They do nothing for understandability, adaptability and repairability! They can improve performance but the technology needs applying judiciously. All of which is long winded way of saying KISS - keep it simple, stupid! This is a convenient entry for showing you a picture of the new **Catcott 20/40/80m** regen TRF receiver! You cannot get much simpler than this! G3PCJ



Active Filters

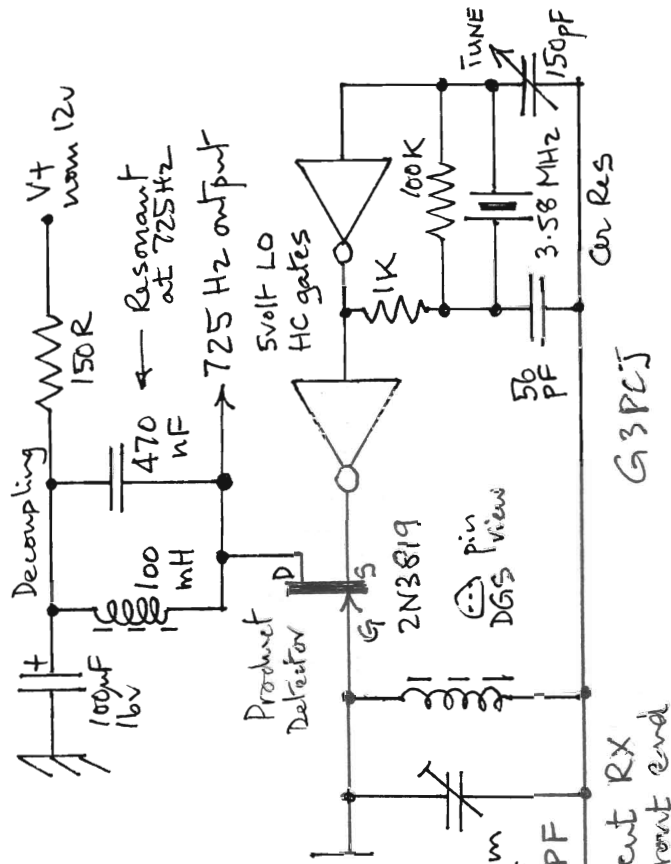
The diagram on the right was in a recent Maxim application note. It shows the amplitude and phase response of several different types of filter. Any of them can be built (in principle) for any frequency range - audio or RF etc.. In many situations, one would imagine that a sharp filter roll-off (high attenuation outside the pass band) would be the obvious choice; this is not always so because the associated phase or time response can distort the wanted information. This is why Butterworth filters are often used as a good compromise in RX audio filtering. These responses can be produced with normal continuous time filters or using switched capacitors. G3PCJ



Brent Product detector

When scheming ideas for the **Brent** CW TCVR, I wanted to get away from the complexity of quad diode mixers. (A product detector is a specific case of the general mixer, so arranged to mix the two input frequencies down to audio.) Space was likely to be tight and low cost was pretty important as ever! The simpler diode detectors using just two diodes were ruled out due to high LO drive requirements and signal attenuation requiring more gain elsewhere in the RX. This led to consideration of the simpler active mixers using either bipolar or field effect transistors. The FET approach has the advantage of a high input impedance allowing the RF input to come directly from the inductors of the receiver's RF bandpass filter utilising the input step up from the aerial.

Normally, the advice when using a junction FET mixer, is that the weak RF signal be applied to the device gate and the strong LO signal be applied to the source; with output at the drain being filtered for the desired mixer sum - subtraction to audio in our case. The LO input should just switch the device on and off completely so that it chops up the wanted weak input signal.



Resistors and Capacitors in series/parallel

First the easy cases!

Resistors in series The values just add together! Obviously a large one will dominate the combined value if the other is much smaller. eg. 100K in series with 1K is 101K.

Capacitors in parallel Again they just add together! The range of standard value capacitors is a limited so Cs in parallel are often needed. eg. 100 pF par 22 pF gives 122 pF.

Now for the harder cases!

Resistors in parallel Stated simply, the resulting value is the reciprocal of the sum of the reciprocals! Mumbo jumbo I hear! If the resistors are R1 and R2, the resulting value R_{par} is:-

$$R_{par} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

R_{par} is always lower than R1 or R2!

Quite often one actually needs to find what values to 'add' together in parallel to achieve some specific value R_{des} . In this case, the formula is turned around, in terms of the desired and one 'guess' R_g value, so R_{sel} is:-

$$R_{sel} = \frac{1}{\frac{1}{R_{des}} - \frac{1}{R_g}} \quad R_g > R_{des}$$

The steps on my scientific calculator are listed right for both. Its worth noting that many resistors will have a 5%, or greater, tolerance so that using two components of widely different values will be unsatisfactory. This applies whether they are in series or in parallel. Keep the larger no more than 4 times the smaller. This applies to capacitors too.

Capacitors in series This is just like the resistors! The combined value C_{ser} of C1 and C2 is:-

$$C_{ser} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$$

When you need to achieve an odd value C_{odd} , the formula can be turned around in terms of what you have C_{have} and what you need to select C_{sel} from the junk box:-

$$C_{sel} = \frac{1}{\frac{1}{C_{odd}} - \frac{1}{C_{have}}} \quad C_{have} > C_{odd}$$

Note that for all these sums, provided all the components are using the same basic measurement values, then you don't have to enter the component multiplier. So you can add pF to pF so obtaining a result in pF; but you must not add pF to nF or KOhms to MOhms! Clear as mud now? G3PCJ

R's in parallel		
key	display	notes
1	1	
0	10	R1 value 1K
shift		
1/x	0.1	1/R1
+		operator
2	2	
2	22	R2 value 22K
shift		
1/x	0.04545	1/R2
=	0.14545	
shift		
1/x	6.875	R_{par} value
10K in parallel with 22K = 6.88K		

R to achieve a value!		
key	display	notes
8	8	R_{des} value
shift		
1/x	0.125	1/ R_{des}
-		operator
1	1	
0	10	R_g value - 10K
shift		
1/x	0.1	1/ R_g
=	0.025	1/ R_{sel}
shift		
1/x	40	R_{sel} value
Find a 40K resistor to go with 10K to achieve 8K.		

C to achieve a value!		
key	display	notes
3	3	
8	38	C_{odd} value in pF
shift		
1/x	0.0263	1/ C_{odd}
-		operator
1	1	
0	10	
0	100	$C_{have} = 100pF$
shift		
1/x	0.01	1/ C_{have}
=	0.0163	1/ C_{sel}
shift		
1/x	61.29	C_{sel} value
Find a 61pF cap to go with 100 to get 38!		

Snippets!

Digital Radio Mondiale DRM, as this is known, is a means of obtaining broadcast FM quality while staying within the 9 or 10 KHz allocated for each channel on LF, MF or the HF broadcast bands. It depends on a clever modulation scheme using many sub-carriers to compress and convey the audio information. The BBC are radiating DRM material on the old 405 line TV frequencies.

Resonant Circuits Dave Buddery G3OEP kindly suggests an alternative more friendly but very slightly less accurate formula, for relating L, C and F in resonant circuits:-

$$f \text{ in MHz} = \frac{159}{\sqrt{LC}} \quad \begin{array}{l} L \text{ in microHenries} \\ C \text{ in picroFarads} \end{array}$$

He also has an interesting tip for sizing the components for a given frequency. First change the frequency to wavelength (by dividing the MHz into 300), then the capacitor in picroFarads should be half the wavelength in metres, and the inductor in microHenries should also be half the wavelength in metres. They can also be scaled up and down provided the product is unchanged.

Auto electrics! I recently received a PR note for a new chip which is intended for the higher battery voltages which are coming into use on newer vehicles. 42 volt systems are being increasingly used, based on nominal 36 volt lead acid battery technology. At this higher level, currents are appreciably reduced for a given load and copper losses are also much reduced. This new chip is used to drive 6 power FETs (each rated at 100 volts and 600 Amps!) in a complex half bridge arrangement across the battery supply, coupled to a standard 3 phase rotary machine, so that it can either act as starter motor or as alternator to charge the battery. Hence less weight! The chip includes soft start technology to limit inrush currents, which the bump helpfully explains are a potent source of EMI - as if we didn't already know that!

Mini Mixer kit

This is a simpler, smaller, and hence cheaper version of an earlier kit, shown in Richard Booth's photo in this issue. It comprises a NE612 mixer, plus crystal to suit the mixing task, and a buffer which drives a pair of toroids and trimmers for the RF bandpass filter - instead of TOKOs. The original task was to obtain reasonable coverage of the CW section of each band when used with the **Brent** on bands above 80m. The scheme is to feed the normal 80m VFO from the Brent to the mixer, where it is mixed with the band dependent crystal, through the band pass filter to select the wanted sum or difference frequency, and then back to the Brent LO stages for the rest of the rig. For example, to obtain 20m, the 3.5 to 3.6 MHz coverage of the standard Brent VFO is mixed with a 10.5 MHz crystal, and the RF BPF is tuned to 20m with output over 14.0 to 14.1 MHz.

An alternative use of this kit is as a receiving converter for higher bands, ^{with} your existing base RX. In this role the mixer RF BPF is tuned to the wanted higher band, say 20m. The BPF is connected this time ahead of the mixer, where the signals might then be mixed with a 10.5 MHz crystal, and fed from the mixer output direct to your existing 80m RX. The RF filters of the 80m rig will automatically selected the wanted difference frequency and reject the unwanted 24.5 MHz output! It is a double sided 50 x 80 mm PCB but even some of this can be cut off if space is tight! It costs £14.

Crystals!

Some members took up my offer of supplying crystals from the range below but I still have masses of all these values. The offer is still open! Send a stamped address envelope, and they wont cost you anything more! Just tell me what and how many you want.

Parallel Resonant - MHz - 5.0688, 5.6914, 5.752, 6.0177, 7.20, 9.30, 9.60, 10.2775, 10.44, 11.0258, 12.73819, 14.84830, 15.375, 16.5888, 16.623333, 17.9, 18.26, 20.105, 20.78

Series Resonant - MHz - 15.0, 18.0, 20.0, 21.0, 24.0

I have some TTL oscillators (sq wave output) which need padded bags so £2 in stamps please for P & P for these - MHz 24.0, 30.0, 32.0

I also keep a largish range of integer value MHz crystals and an increasing number of X.5 MHz ones. These are all fundamental 30 pF parallel load types. Let me know what you want. G3PCJ

Hot Iron

Winter 2004
Issue 46

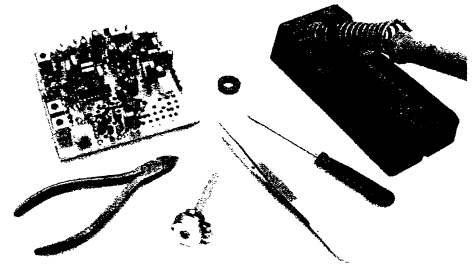
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Variable bandwidth
filter
Torrid Toroids!
Correspondence
Power on rails
Crystal giveaways!

The Walford Electronics
website is also at www.walfordelectronics.co.uk

Editorial

Its still raining 3 months later after the last Hot Iron! The good news is that it prevents one from going outside unless essential! (Nasty penetrating drizzle this morning but a hard frost was actually forecast! Rain always comes when doing roof repairs - which we are!) Being stuck inside makes the mind turn to future projects that might be of interest to members. Over the years, valve based projects often get mentioned but I hesitate owing to the safety aspects of mains and relatively high HT supplies. I understand there are ranges of low voltage valves which might circumvent these problems - I don't have any knowledge or experience so if any enthusiast cares to direct me in the right direction we (he/she/me) might be able to get a project off the ground. This might turn into an enthusiast's project where you use your own mechanical parts - air spaced capacitors and transformers, audio or mains. Should one go for a RX or TX - AM or CW?? A crystal controlled TX would be easier but do you really want to be rockbound? If not, it probably means crystal mixing and that's as complicated as a superhet RX! Tell me!!



Kit Developments

Early reports on the **Catcott** are very favourable and there will soon be a suitable crystal controlled TX - see Mallet below. The **Brent** is also working very well on 80m and I now have mine working on 20m with the Mini mixer kit. I have also added the new Variable bandwidth Filter (see later) which makes a tremendous improvement in signal to noise ratio.

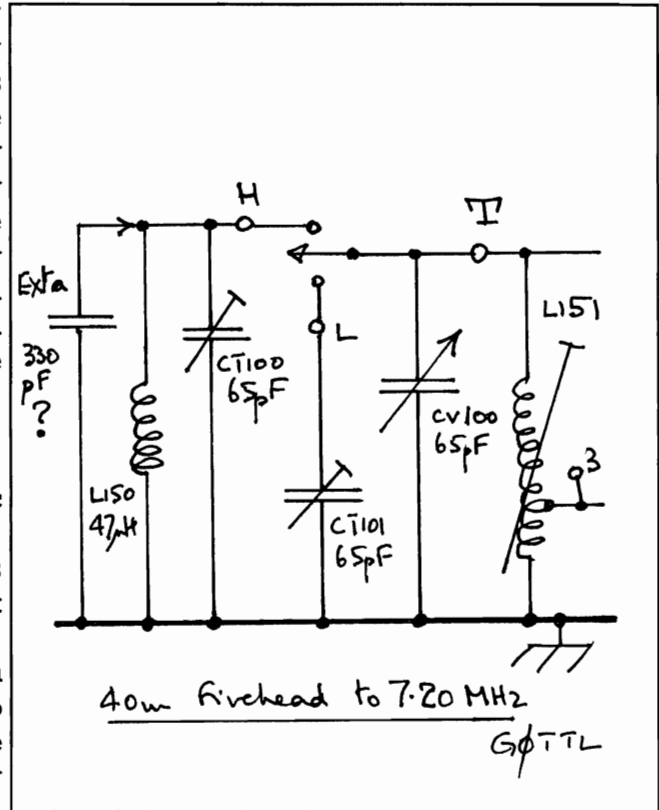
The major task has been the detail design and lay out the PCBs for the **Sutton** RX and associated transmitters. The Sutton is a DC rig using 3.58 and 3.69 MHz ceramic resonators to give coverage of the bottom 200 KHz of 80m. Both ceramic resonators do nominally 100 KHz but these are sub-divided into two sections by a switch/trimmer for a better tuning rate. There is also a fine tuning control which doubles for RIT with the CW TX. It includes LS drive with wide and narrow filters suited to CW and phone. The RX PCB also has space for a LO crystal mixer and a set of pins for a plug in band card so that the rig can then do 80 and any of the traditional harmonically related bands by plug-in cards. (It could do any band but the demand for WARC bands is too low.) The **Mallet** is the matching 1.5W CW TX (includes TR, LPFs, muting, ST etc) and the **Pedwell** will be the matching phone DSB 1.5W TX. Volunteers for early builders please! Tim G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

Expanding coverage the 40M Fivehead

As you probably know a few weeks ago our 40M allocation effectively doubled in size. During daylight hours the new 7.1 to 7.2 MHz band is pretty much free from the continental interference and general racket that is to be heard on the lower 40M frequencies. Which means QRP is infinitely more possible. Hence it was time to stretch out the frequency coverage of my Fivehead rig. It's pretty simple to achieve and only needs a couple of extra components to give full coverage in 3 switched ranges. Here are the steps needed (refer to the original construction notes)

- 1 Fit L150 at grid IO (47 uH inductor)
- 2 At grid H1 point H solder a 330 pF ceramic cap between the pin H and ground.
- 3 Make sure the VFO switch wiring is connected up as shown in the PCB layout diagram.
- 4 You will now need to set up the VFO high and low bands by adjusting the two trimmers (see construction notes for more details). On my rig I have about 80 KHz per "band" with some overlap.



That's it, you should now be able to tune right up and down all of 40M. You might need to adjust the value of the 330 pF capacitor, if on the high switch setting the VFO frequency is too high, increase the capacitance or vice versa if it's too low. You shouldn't need to adjust the PA or band pass filters. Tuning wise it seems to be quite linear and has not affected stability in any way.

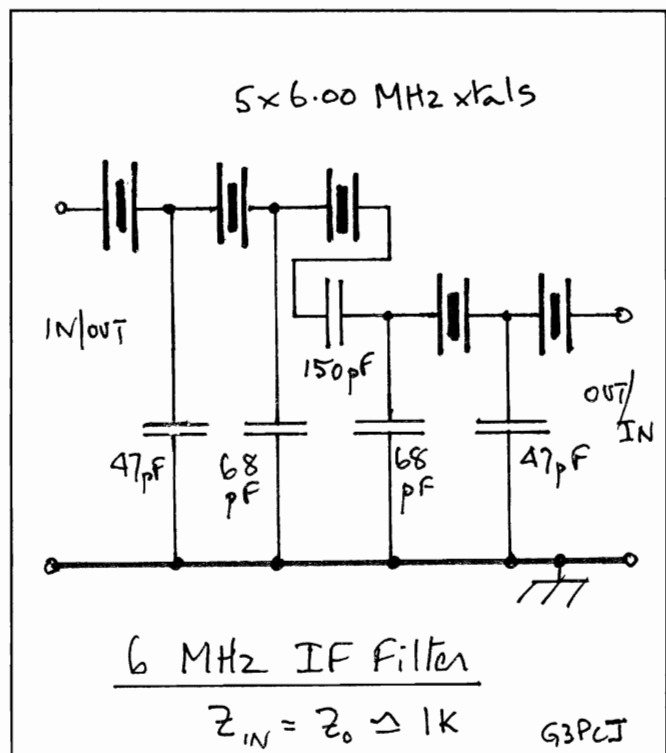
Good luck, you can reach me via QRZ.com if you fancy a Fivehead net on 40M.

Richard Booth G0TTL

6.00 MHz crystals

John Teague has kindly sent along details of a trader who he thinks will have many 6.00 MHz low profile HC49 crystals at giveaway prices - probably just pence each! John saw them at a recent auto jumble event at Blenheim. His name is Andrew Marks and phone number is 01752 208301. (See also the last page of this issue!)

Such crystals can form the basis of a very adequate IF filter for a superhet receiver (or transmitter). The circuit shown right suits direct connection to NE602 style mixers as the desired nominal input and output impedances are about 1K. This gives a bandwidth of near 3 KHz with good 'off the nose' rejection. (Its not as good as a proprietary IF filter - say for 9 MHz - but then it does not cost £40!) Another advantage of using 6 MHz for an IF is that a single CIO frequency (60015 KHz) can give all the usually used phone sidebands for all bands (except 30m) with a suitable choice of LO frequency. High side LO for 40m and down, low side LO for 20m and up! G3PCJ



The Joys of Engineering by Eric Godfrey G3GC

Despite the fact that I was not enthusiastic about becoming a pen pusher I was entered by my father to sit for the 1936 Civil Service Examination. In those days the Civil Service was a good and secure job and also sons did not argue with their fathers. However as luck would have it, shortly before the Examination I managed to get measles which at the age of sixteen was a serious complaint and usually subject to complications. In fact I got abscesses in both ears also and very nearly contracted pneumonia which the doctor had told my parents could well be the beginning of the end. However I managed to survive and after six weeks was slowly on the mend. By that time the Civil Service Examination had come and gone and as it could only be taken at the age of sixteen I had missed it forever. This allowed my interests in all things scientific to come to the front and together with my amateur radio interests (I was a member of the RSGB and a keen listener on the broadcast and amateur short wave bands) I persuaded my father to let me try to get a job in radio and television. As a consequence in the spring of 1937 I wrote to three companies, namely GEC, Cossor and EMI to see if I could get a job in their research departments. I got a reply from GEC saying that they had not any vacancies at that time but they would keep my name on their files. About a week later I had a reply from EMI inviting me to an interview at their research laboratories at Hayes and I am still waiting for a reply from Cossor!

I was interviewed by Alan Blumlein who was the Chief Engineer at the EMI Research Laboratories and was the brains behind the development of the new EMI 405 line all electronic television system that had begun transmitting from Alexander Palace towards the end of 1936. At the interview he was interested in my amateur radio activities and ultimately said he would like someone else to talk to me. This turned out to be a Dr. White and while waiting for him to arrive Blumlein said how his neighbours annoyed him by having Radio Luxembourg on so loud on a Sunday morning. He then went on to say he had made himself an oscillator that he used to swamp out Luxembourg if it got too bad. Dr. White was in charge of the Television Circuit Section of the Laboratories and he also showed interest in my amateur radio involvement but he mainly quizzed me on mathematics since at school I had taken what was known as Advanced Mathematics instead of a second language for the General Schools/Matriculation Examinations held in June each year. These Examinations have long since been replaced with the current modern examinations but a fundamental difference was that they were examinations in six subjects all of which had to be taken and passed at the same time. I must have made a reasonable impression at the interview as I was offered a job as a laboratory assistant in Dr. White's Section of the EMI Research Laboratories starting on 16th August 1937 with a salary of twenty four shillings and sixpence per week. (A week was five and a half days in 1937).

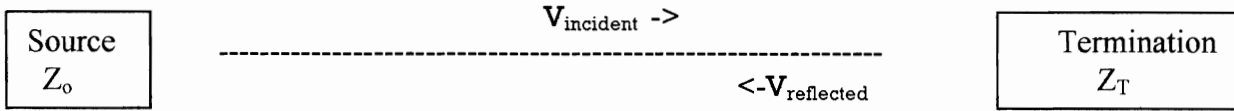
This preamble seems to have taken some five hundred odd words without really saying anything about the Joys of Engineering but I thought that this general background to life in the thirties might be unknown to the younger members of the Constructors Club. However as you can see one of the Joys of Engineering was already apparent at my interview when Blumlein told me about his jamming operations on Radio Luxembourg. This was only a prelude to the very satisfying life at the EMI, a company with whom I stayed for the whole of my working life of forty-five years. If the Editor is agreeable in the next issue of Hot Iron I will tell you about the fun and games that both lab assistants and engineers got up to and also about some of the peculiar and eccentric people employed in the labs that contributed to the Joys of Engineering.

The photo right is one of only four known to survive of Blumlein. I will ask Eric to tell us more of those experiences but Blumlein had a phenomenally inventive mind, including what we now call stereo. G3PCJ

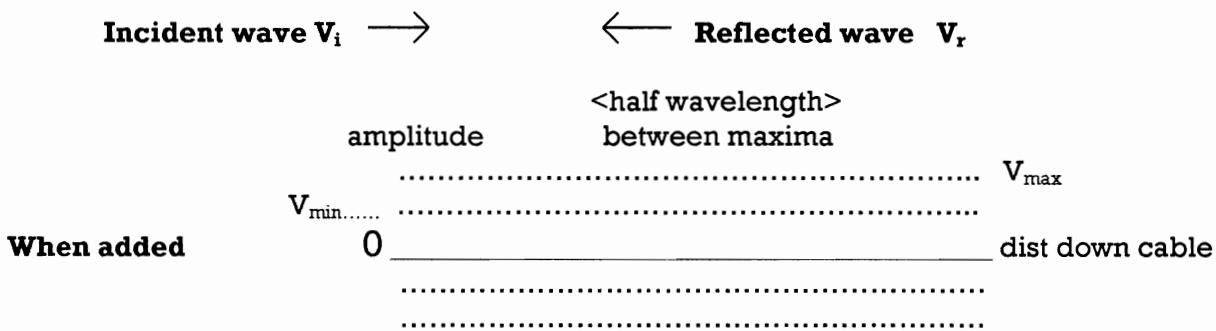


Voltage Standing Wave Ratio by David Proctor GOUTF

We all know that the VSWR should be near to unity and its something to do with feeder cables. Well let's look at it again with a bit of maths (numbers are better than words!). When an RF signal travels down a transmission line of characteristic impedance Z_o (at just less than speed of light) it eventually meets a termination Z_T . If $Z_o = Z_T$ and is resistive, all the energy is absorbed by Z_T and none reflected. If $Z_T > Z_o$ there is a part reflection back as a wave *in phase*. If $Z_T < Z_o$ there is a part reflection back as a wave *out of phase*



When **two** waves of **same speed** and **wavelength** are moving in **opposite** directions along the same cable, they set up a **stationary** or **standing** wave. The stationary wave is due to the addition of the two waves, and has maximum and minimum values. By plucking a guitar string, violin string or even a taught washing line, you get a stationary wave which does not move down the string, the string simply moves up and down.



VSWR = V_{max}/V_{min} ← **This is the definition** $V_{max} = V_i + V_r$ and $V_{min} = V_i - V_r$

At the termination, we say there is a **voltage reflection coefficient** (p) which is the ratio of reflected voltage to incident voltage = V_r/V_i which can be positive or negative.

So, $VSWR = V_{max}/V_{min} = (V_i + IV_r I)/(V_i - IV_r I) = (1 + IV_r/V_i I)/(1 - IV_r/V_i I) = (1 + |p|)/(1 - |p|)$

VSWR = $(1 + |p|)/(1 - |p|)$ ($|p|$ = magnitude of p e.g. magnitude of $-0.5 = +0.5$)

This equation shows us that if reflection is zero, $p = 0$ so $VSWR = 1$

If you know Z_o , your characteristic impedance, and your termination Z_T you can find

voltage reflection coefficient, p **$p = (Z_T - Z_o)/(Z_T + Z_o)$**

EXAMPLE:- $Z_o = 50R$ $Z_T = 100R$, $p = (100-50)/(100+50) = +1/3$ so $|p| = 1/3$

$VSWR = (1 + 1/3)/(1 - 1/3) = 2$

REFLECTED POWER

We do not want power reflected back to the PA of a transmitter, so keep VSWR close to 1, that means p close to 0. The fraction of the outgoing power which is reflected back = $(p)^2$, so in the example, fraction reflected back = $(1/3)^2$ = about 11%

In practice the values of Z_T are nearly always reactive (not just resistance) so the maths can get complex, literally. However, this gives us the idea about reflected waves adding to incident waves to get a standing wave. With resistive loads this maths is quite correct, and shows us why matching is so important.

(Apologies for the mix of Greek and English letter p for the letter rho! Computers - Ug! G3PCJ)

A Basic Linear PSU by Mark Bywater MODFF

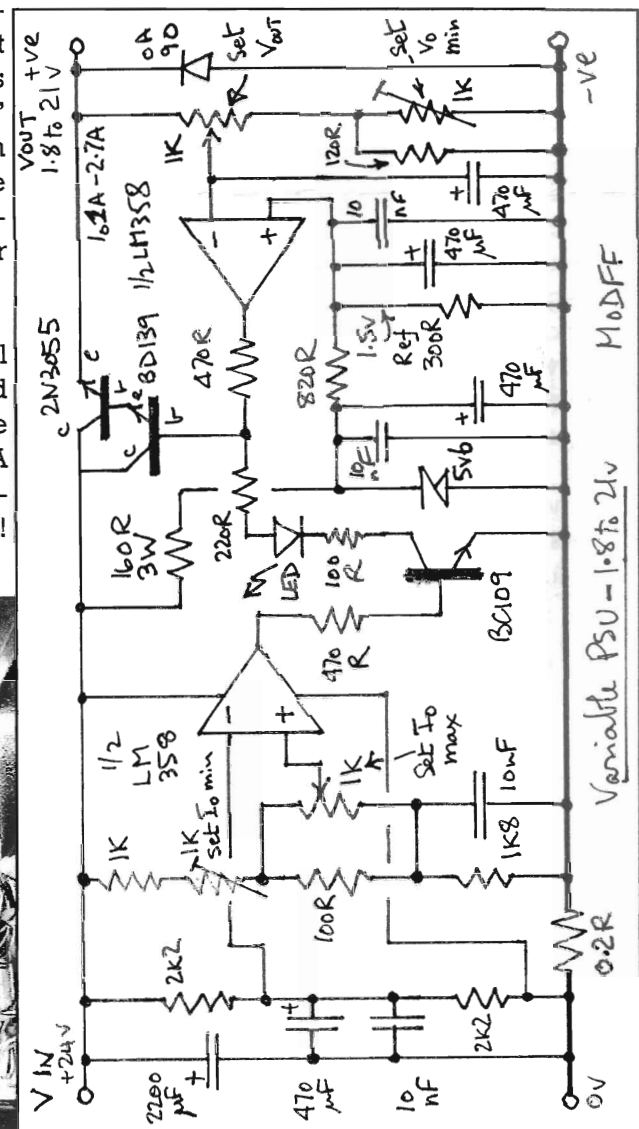
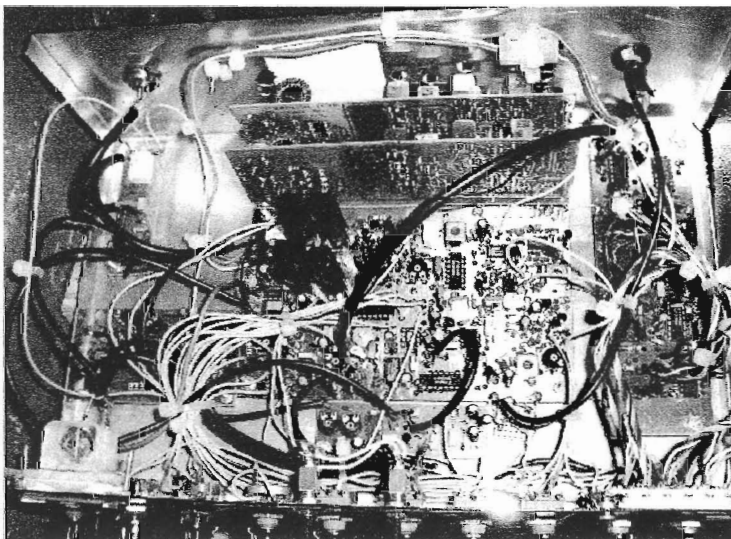
The need for this power supply came about when experimenting with many of the Walford kits - it being useful to have a variable output voltage and variable overload current. There are commercial units on the market with a commercial price tag as well. I decided to use my existing 24 volt 3A unit to provide a variable output from 1V7 to 21V with a trip current that could be set from 1A to 2A7. Another option would be to use two 12 volt batteries for the incoming 24 volts.

Circuit description There are two sections, the voltage regulator part nearest the output and the excess current override part on the input end. The voltage regulator part uses a 5v6 zener for best temp stability of the reference voltage; this is tapped down to about 1.5 volts and applied to the positive input of the controlling LM358 op-amp. A portion of the output voltage, dependent on the setting of the voltage control pot, is fed back to the negative input of the op-amp. Heavy smoothing is applied to eliminate unwanted electrical noise. A OA90 diode is fitted across the output to give protection against reverse polarity voltages on the output. The main 'pass' transistor is a 2N3055 with a BD139 in a Darlington configuration to provide sufficient base drive from the op-amp. The 2N3055 is fitted on a large heatsink because it might have to dissipate up to roughly 50 Watts!

The over-current part of the circuit relies on the load current flowing through a 0.2 Ohm resistor in the negative supply line. Two resistive potential dividers feed the over current op-amp inputs, so that as the load current increases, the difference between the inputs increase to the point where the BC109 transistor is turned on to remove the base drive from the voltage control op-amp so reducing the output voltage. The output side voltage divider pick off point is adjustable to set the over-current trip point. The 'shunted' away output drive current, of the voltage loop, is passed through the LED to indicate the over-current condition. Why the combination of 1K pots in parallel with 100R and 120R fixed resistors? Because I didn't have 100R pots in my component stock!

Construction and setting up. The overload was calibrated with a few low value power resistors, a volt meter and ammeter. Construction of the circuit was on plain matrix board mounted onto a PCB "chassis" via plastic stand offs. It has been tested with a high current/inductive load which was over voltage. The load failed but the PSU lives on! There are many improvements that could be made, but it works well for what it is - a basic PSU of standard components.

Mark has also sent along this photo of his Bristol complete with most of the optional extras - two band card switch kit, five digit counter on the right, the meter kit and speech processor are all in there! A big project which I hope did not cause the over-current trip to operate too often during building! Well done! G3PCJ

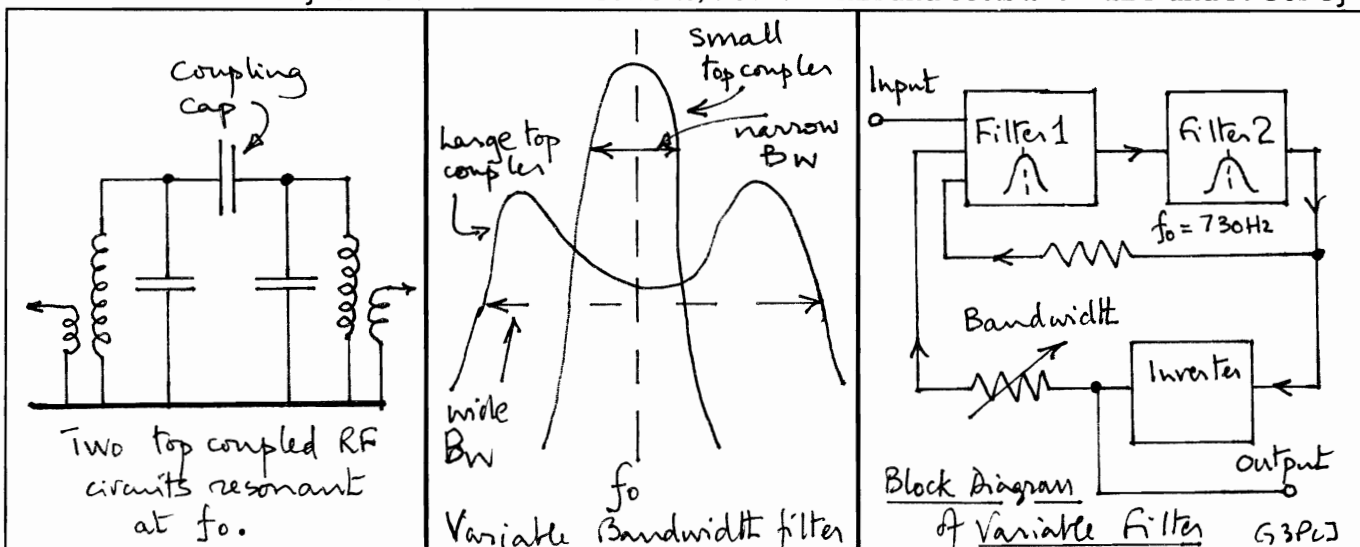


Variable Bandwidth Filter

This project has taken 41 years to mature!! But its darn good now!! It is actually an audio filter for adding to a CW receiver but it is based on work that I did for my university thesis! I have been searching for a better CW filter for some months now but there always seemed to be a drawback - complexity to get the performance and often not easy to use! Using a low pass filter to remove the high frequency signals above say 800 Hz is good and simple but not versatile - what is really wanted is a variable bandwidth bandpass filter. It can be used 'wide' for general listening around but then narrowed down for digging the weak signal out of the wideband noise/interference from other stations close in frequency. Although a variable centre frequency would be nice it is less important than variable bandwidth/good HF attenuation.

Often the 'state variable' filter is advocated because frequency and bandwidth can be independently adjusted with a choice of outputs - low, high or bandpass. But the simple forms do have drawbacks - it needs three op-amps and gain usually varies with bandwidth or Q. Due to the single CR on high and low sides of the peak, the response slope only falls off at a poor 10 dB per decade away from the central bandpass frequency. Improving the 'off nose' rejection by increasing the Q dramatically, will make it ring and be tiring on the ears. Hence a second state variable section is suggested with 3 more op-amps to give 20 dB per decade attenuation - all too complex! This was the basis of my thesis years ago but it did also have variable bandwidth by adjustment of an overall feedback loop - this made the two filters behave just like two top coupled resonant LC circuits where the coupling capacitor is used to adjust bandwidth. See the left diagram below and the nominal effect on the response shown in the middle diagram.

Since a fixed central frequency is acceptable, the normal single op-amp bandpass filter is quite adequate. The kit uses standard value parts for a nominal 'nose' central frequency of 730 Hz with a Q of 5. Two of these are connected in series which gives a slope of 20 dB per decade away from the nose with the two op-amps in a single IC. The output of the second is in phase with the input signal so a little of this fed back will increase the Q and narrow the bandwidth. A value is chosen which just makes it ring so that, when an inverted version of the output is also fed back, it will partly cancel out the in phase feedback. With careful choice of the feedback factors, variation of the out of phase part will alter the response between the shapes shown in the middle diagram! A final objective was to make the gain essentially fixed to avoid having to reduce gain as Q is increased. A recent note in Electronics World suggested a suitable method. In fact I have arranged it so that the voltage gain increase from unity to times two on the nose - this helps to lift the wanted signal out of the noise. After trials with signal generators, I connected it up to my Brent and was very surprised at how well it works. The noises disappear and the wanted signal stands out nicely. The actual block diagram is shown right. The kit also contains two extra pairs of CRs to reduce the height of the peaks when set for wide bandwidth - hence the slope approaches 30 dB per decade on both sides off the nose. As the best place to connect such a filter is just before the rig's main gain control, it is not designed to be able to drive a loud speaker directly although it will drive Walkman type series connected 64R phones. It is a 50 x 80 mm single sided PCB with PCB mounted shafted present for bandwidth adjustment. It needs 9 - 16 volts, about 20 mA and costs £15 + £2 P and P. G3PCJ



Torrid Toroids!

They are definitely NOT that bad! There are two main types. Firstly those made from **powdered iron**; these are always painted - red and yellow types being mostly used for HF work but there are green, white, black and other colours also. Powdered iron ones are generally used for resonant circuits and are known as Txy-z where xy is the outside diameter in hundreds of an inch and z denotes the mix/colour. Hence these are easily identified. The red ones are suitable for 2 to 30 MHz and the yellow ones for about 10 MHz to 50 MHz. The other main type of toroids are made of *ferrite* material - I will deal with them next time. Ferrite ones are usually unpainted black or a dark greyish colour and often slightly dusty looking.

In both cases the inductance of a given number of turns is dependent on toroid size and material. The table top right gives this A_L value for each of the common **powdered iron** types. The inductance is given by:-

$$\text{Inductance } L (\mu\text{H}) = (n/100)^2 \times A_L$$

where n is the number of turns
and A_L is dependent on the toroid core

The steps for this calculation are shown in the next box down using my scientific calculator for a winding of 15 turns on a yellow T50-6 core. The answer is 0.9 μH . Note that these figures assume the winding is *spread evenly* around the whole core; if the winding is bunched up with the turns close together the inductance can be much higher - maybe by 25%!

More frequently, one needs to work out how many turns are required for a desired inductance. The above formula turns around to:-

$$\text{Number of turns } n = 100 \times \sqrt{L/A_L}$$

where L is the desired value in μH
and A_L is dependent on the chosen core

The steps for this calculation are shown in the bottom box. This shows that to achieve a winding of 5 μH (that would resonate with 380 pF for 80m) you need to put on 29 turns for a T68-2. Round down the actual number of turns to the nearest whole number or even one less if the lead lengths are likely to be a bit long. Remember that the actual inductance can be increased a little by bunching the turns together. Each time the wire goes through the central hole of the core, it counts as one turn even if it does not wrap around the outside all that much! The easiest way to do the winding is to slip the core onto the middle of a suitable length of enamelled wire, put on half the winding with one end (pulling each turn tight), and then the other half with the other end. Its easy!! G3PCJ

Powdered Iron Toroid Type		Designation & A_L value	
Colour	Mix	0.50 inch diameter	0.68 inch diameter
Red	2	T50-2 49	T68-2 57
Yellow	6	T50-6 40	T68-6 47

Key Action	Display
15	enter no of turns
\div	Divide
100	constant
=	calculate
x	square
=	calculate
x	multiply
40	A_L value
=	calculate
	<u>0.9 μH</u>
	Answer

Calculating Inductance
G3PCJ

Key Action	Display
5	Desired Inductance in μH
\div	Divide
57	A_L value for T68-2 toroid
=	calculate
$\sqrt{\quad}$	Square Root
x	Multiply
100	constant
=	calculate
	<u>29.617</u>
	Answer Use <u>29 turns</u>

Calculating no. of turns

G3PCJ

Correspondence!

Following Eric's G3GC interesting article on squeeze keying, may I present my case for having nothing to do with it?

I find it hard to accept that for the average amateur squeeze keying has any positive benefit. In fact I would go so far as saying that the benefit is negative in that it is an excellent way of making lots of errors! Amateur radio is a hobby and we are all free to do it as we like (within the law) and learning new skills is part of the fun of the hobby. If learning to squeeze key gives you pleasure then all well and good, however don't learn it because you think that this is a prime requirement for being a good CW operator because it isn't. I have done a mini survey of people I rate as being top class CW men and very few of them squeeze key. In fact quite a few of them use single lever paddles. Whilst it can be invidious to name calls may I suggest that you listen to the immaculate fast CW coming from G3FBN who uses a single lever paddle.

A few years ago W9KNI, Mr Bencher, wrote an excellent article extolling the virtues of squeeze keying and suggesting that time spent in mastering the technique was time well spent. However in the last paragraph he said 'it really comes into its own at speeds greater than 40 wpm, and is probably not worth doing at speeds less than 25 wpm.' I rest my case.

I would go so far as to ask why use an electronic keyer? Again it is fun to learn a new skill and for some people who suffer from arthritis etc a keyer is a boon. However if you don't send much faster than say the mid teens then do you really need to use a keyer? The good old straight key can make superb morse and even scruffy morse is more readable than perfectly formed errors that so often come from those using keyers. With the straight key you can show that you are a true master of the art of sending by slightly accentuating the last dash of characters such as Y and J. This greatly reduces the possibility of them being read as C or P. With the fully adaptive manual manipulator you can more easily change speed on a letter by letter basis if conditions so dictate. If you want to listen to excellent hand sent morse you know as well as I do who to listen to in the Yeovil Club.

Gerald Stancey G3MCK

More Power for the rails!

This story came from Power Systems Design Europe June 2004. It refers to regenerative braking on electric trains such as used by London Underground. When accelerating the train, the motors draw power from the DC supply (often in the range 500 to 1000 volts) in the conventional manner. However under braking conditions, the control circuits make the motors behave as generators putting the power back into the supply network. This is fine but does need another train wanting power at that moment! In practice much of the surplus kinetic energy of trains has to be dissipated as heat, either in conventional brakes or in special resistive loads. A means of temporarily storing the surplus energy is needed. Could this be a capacitor? Studies have shown that, with suitable capacitors, London Underground could reduce total demand by about 30% and so save 300 tonnes annually of CO2 emission! Very large low voltage capacitors are now available with several thousand Farads in the size of a beer can! They feature a power density of about 25 kW/Kg with an energy density of 5 Wh/Kg. One such system has 1300 units of special capacitors each having 2600 Farads operating at up to just 2.5 volts! Clearly clever devices are also needed to convert the excess power on the main supply into such low storage voltages! Tim G3PCJ

Crystals!

I still have loads of crystals. One savvy member had a load of 6.0177 MHz ones - he didn't tell me the use but I bet it was for an IF filter!! The offer is still open! Send a stamped address envelope, and they wont cost you anything more! Just tell me what and how many you want.

Parallel Resonant - MHz - 5.0688, 5.6914, 5.752, 6.0177, 7.20, 9.30, 9.60, 10.2775, 10.44, 11.0258, 12.73819, 14.84830, 15.375, 16.5888, 16.623333, 17.9, 18.26, 20.105, 20.78

Series Resonant - MHz - 15.0, 18.0, 20.0, 21.0, 24.0

I have some TTL oscillators (sq wave output) which need padded bags so £2 in stamps please for P & P for these - MHz 24.0, 30.0, 32.0

I also keep a largish range of integer value MHz crystals and an increasing number of X.5 MHz ones. These are all fundamental 30 pF parallel load types. Let me know what you want. G3PCJ

Happy Christmas to you all!

Hot Iron

Spring 2005
Issue 47

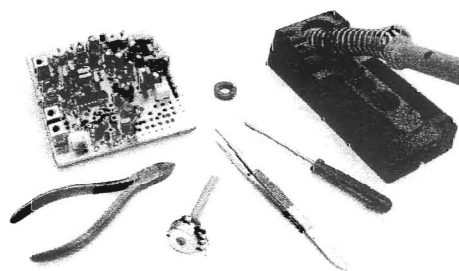
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QRP Convention
Somerset Supper

The Walford Electronics
website is also at www.walfordelectronics.co.uk

Editorial

The sun is out and streaming into my office so Spring is not far away! I even smelt it in the middle of our local town the other day! It turned out to be the flower market!! At my local Club last week (Yeovil), there was the familiar discussion about a lack of equipment building and a poor entry for the Construction Competition. It was strange because I knew that about 40% of those present either had or continued to build pieces of their own gear - some from kits but many as completely home conceived projects. There is a hesitancy by builders to even display their efforts but others love to see these things - it gives much encouragement to those not quite so adventurous, especially when the build standard is not very high but the 'thing' does actually work! One of our members recently reported that he had just had the best QSO in 40 years - why - because he had just nearly finished building his own rig!! It was a very significant achievement for him. If a construction leader can be found, then Clubs should have no difficulty devising a project that can be built in small stages so it is easy to fund, get going and also keep up the interest. The **Sutton** (see below) suits the bill!



Kit Developments

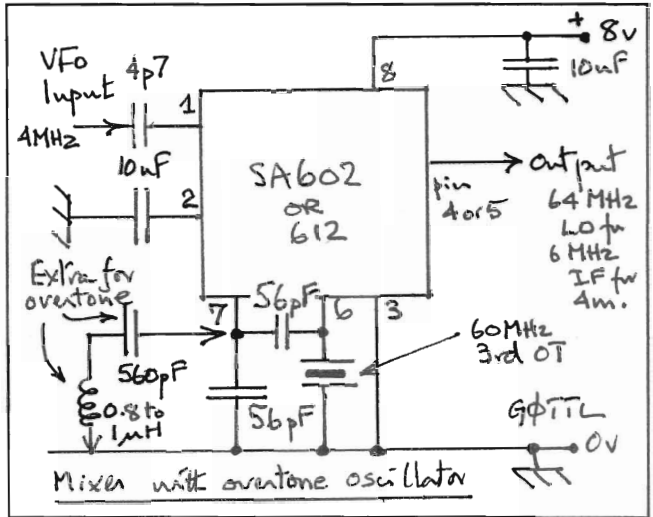
Many of you will have seen the publicity for the **Brent** in Sprat and Radcom which has kept me busy etching PCBs! Most have been for 80m but several have chosen higher bands with the Mini mix kit. (It can also be used as a receiving converter.) The LO frequency mixing scheme for higher bands is the same as that used in the **Sutton DC RX** - photo later. Reports from my ever helpful band of early builders are encouraging - not too many errors and it does seem to work! It starts life as an 80m rig but with parts for a LO crystal mixing scheme to work (in principle) on any other band but I have limited it to the traditional harmonically related bands (to 10m) for commercial reasons only. The crystal and new RF filters are on a small band card which plugs into the back of the RX so it becomes a switch selectable 80/any band plugged in RX. The band card also contains the 50R low pass filters for an associated transmitter; there being two choices of TX! The **Mallet** is the 1.5W CW transmitter which can also take amplitude modulation with the standard Audio amp kit and a small transformer. The phone alternative is the **Montis** double sideband suppressed carrier 1.5W TX. Both TX's can drive the 10W Linear. Plenty of stages for a Club project! These will appear in PW shortly so I must not fully publicise them yet! Tim G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

The SA602, it's internal oscillator and overtone crystals.

My current project, in between building Tim's rigs - see below, is the development of a VHF SSB transceiver for 6 and 4 meters, of which space permitting, I hope to describe to you in future editions of Hot Iron. According to Philips, the internal oscillator of the SA602 chip can operate up to a frequency of 200 MHz, which makes it a good choice for simple mixer VFO circuits. Fundamental mode crystals are only readily available up to about 45 MHz. So for a 50 MHz radio you could use a 40 MHz fundamental crystal mixed with a 4 MHz local oscillator. Add this to a 6 MHz IF stage and you are on 6 meters. In order to get on 70 MHz or 4 meters though with the same IF and local oscillator you would need a crystal frequency of 60 MHz. Which means using an overtone type crystal.

Overtone crystals are cut in such a way that they oscillate at an odd harmonic of the actual crystal frequency. So a 60 MHz 3rd overtone crystal is really a 20 MHz component which generates a strong 3rd harmonic at 60 MHz. Normally in a discrete component oscillator you would use a tuned LC circuit to select the required overtone oscillating frequency. With the 602 internal oscillator though it works the other way around. What you have to do is suppress the fundamental oscillation with a tuned circuit, which forces the internal oscillator to run at the overtone frequency. You achieve this by adding a single series capacitor and inductor from pin 7 of the IC down to ground.



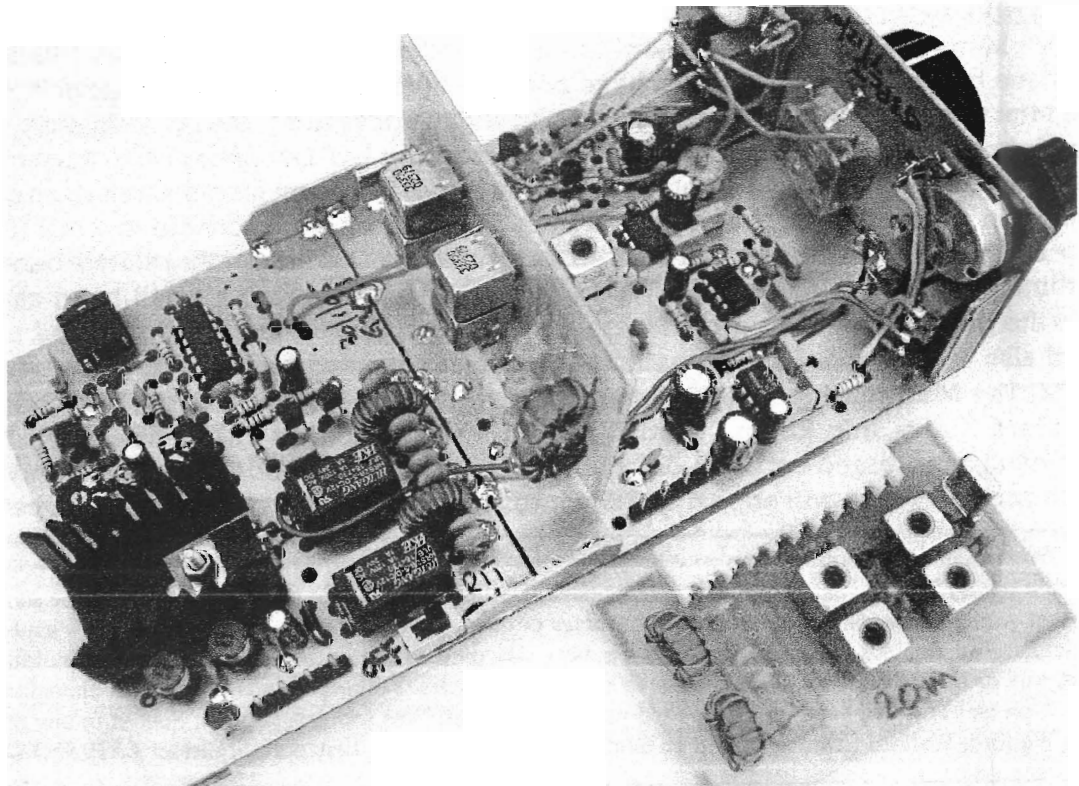
I've done a few tests with overtone crystals I had to hand and it does work well, the highest frequency I've tried so far was 120 MHz using a 5th overtone. I'm waiting now for the 60 MHz components to arrive and then I'll make a proper start on the VHF project. Watch this space!

Vintage components and tuning capacitors.

If I can help with air spaced capacitors for projects, valves or other vintage radio parts do get in touch. Also transistor radio spares or bits to build things with. I need the space! You can email me at richard@pasttimesradio.co.uk or telephone 01302 858468 73 Richard Booth G0TTL

Sutton RX etc

Richard Booth is kindly helping to evaluate the Sutton RX. This is what mine looks like with a band card plugged in etc. This version has the Mallet CW transmitter attached at the rear. The Montis phone DSB TX is the same size as the CW TX. I am testing the prototype Montis right now! G3PCJ



The Joys of Engineering Part 2 - by Eric Godfrey G3GC

When I arrived on the first day at EMI as a lab assistant I was shown up to Room 501, Dr. White's Office, on the top floor adjacent to the lift. Adjoining his office was Room 502 accessible both from his office and from the corridor. Dr White was the leader ("Managers" had not been invented in those days!) of the "Circuits Section" and Room 502 was his main laboratory of about 1000 sq. feet. The offices and labs were constructed from metal/glass partitioning some ten feet high, the lower four feet being metal and the upper six feet were glass, partly frosted for privacy. From the lift, a long corridor led to the end of the building with more labs and a workshop. The "Circuits Section" continued along the left hand side of the corridor and included a special laboratory (looked after by one of Dr. White's senior engineers) that was constructed as a windowless screened room with the door having metal tongues to complete the screening when closed. There was also a small workshop about twelve by twenty-four feet with two 'resident' mechanics, with drilling machines, lathes, vices, a hand press and a forge, all of which could be used by any of the 5th floor engineers and lab assistants. On the right hand side of the corridor was the "Receiver Section" (Tom Cocking, G2CV was one of the engineers) and the small "Filter Section" led by a mathematician. Going back in the other direction from the lift there were more small laboratories and a large "Dark Room" for viewing television pictures. Beyond this was a large but virtually empty area where the transmitters, by then installed at Alexander Palace, had been situated for the experimental television transmissions from Hayes prior to the opening of Alexander Palace in 1936. The modulated sound and vision carriers, vision 45 Mc/s and sound 41.5 Mc/s, were fed via separate 5" diameter rigid copper feeders, to the aerials on the tower behind the labs. This had vertically polarised omni-directional aerials for both sound and vision with the latter mounted above the former. The tower erected on top of Alexander Palace for the public service was identical with this one at Hayes. I have taken a bit of time to describe this area since it was often the battle ground for "Solder Wars" or shooting with "High Pressure Hose Guns" and many practical jokes.

In 1937, solder was not as thin as it is today but was about an eighth of an inch in diameter usually with three cores of resin embedded in it (the smallest soldering iron was 60 Watts with a bit about 5/16" in diameter). A piece of this solder about an inch and a half long folded into a "U" shape formed a good missile for a catapult made from strong elastic bands, available from the stationery stores, held between one's thumb and finger. Many a lunch hour was spent avoiding these lead bullets and the layout of the corridors and dark rooms made good hiding places for snipers. Sometimes things went wrong and on one occasion I managed to hit one of four large audio valves (DA100s) in a mobile rack of equipment used to provide a high power signal anywhere in the audio range. (I believe this had been used as the audio test source for modulating the experimental TV transmitter but was now used as a general audio source). The solder penetrated the glass envelope but inexplicably the glass did not shatter. With some difficulty I managed to get the solder out of the valve and so the appearance of the hole in the glass was a mystery, although I suspect that some senior staff had a good idea how it happened but not, I hope, by whom.

A second type of missile launcher was made from brass tube some two feet long (the internal diameter of which was just a little larger than a flat headed 2 BA screw) connected to a rubber hose fed from the high pressure (80 lbs / sq in) air line. A trigger mechanism was made for the hose end of the tube and the 2 BA screw was dropped down the tube to rest against it. On turning on the air and releasing the trigger the screw shot out at high speed and with great force. Wisely only one of these were made as the missiles were highly dangerous being able to penetrate three ply wood at a distance of twenty yards. With only one available it was used for shooting at home brew targets and we became very skilful in its use. So much so, one could come back during the lunch hour only to find one's teacup being used for target practice, usually with terminal results.

Going back to when I first arrived at EMI, I was introduced to all members of Dr. White's section except for a junior engineer who was away in hospital having his "cross eyes" sorted out. They must have been very bad because when he returned he was still a bit cross-eyed. I was also introduced to the two mechanics in the workshop and to the section leaders of the Receiver and Filter Section. Everyone seemed very likeable to me except for the crossed-eyed one with whom I felt ill at ease. In due course I found that he was very self centred, thought a lot of himself and was in fact not like by any of the staff. This made him the target for many practical jokes from anybody on the 5th floor. Next time, I will recall some of these and other jokes that were perpetrated by staff at all levels.

Gear for Home Constructors

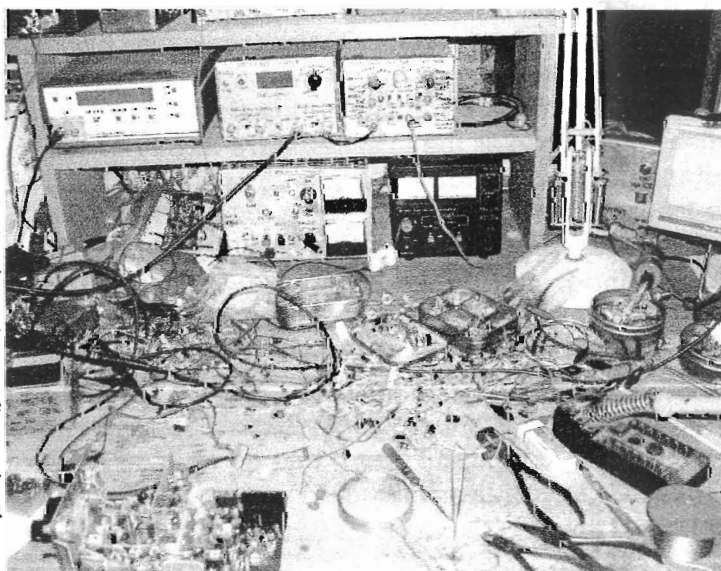
Years ago, the first bit of gear that a budding radio enthusiast was encouraged to build was a multi-meter! No one would ever do that nowadays since the yellow commercially made digital multi-meters are so cheap! The old approach did at least have the benefit of teaching you about Ohms Law even if the meter's calibration wasn't too good. Starting with the things to buy:-

1. Tools. Buy a new one whenever you find you haven't got the right one! 18W iron and multi-core solder, long nosed & ordinary pliers, tweezers, selection of screwdrivers (various sizes and types of head), small round and flat files, hand drills, wire side cutters. Highly desirable - solder sucker, junior hacksaw, selection of small nuts and bolts and self-tapping screws, wire strippers, selection of leads with small insulated croc clips, etc.
2. Digital Multi-meter, four and a half digits minimum covering AC and DC volts to say 1000, Ohms to 10M, DC current mA to 10A and maybe AC current. Nice to have frequency and capacitance but not essential! Alternatively buy an AVO or lesser equivalent if found cheap!
3. Variable Bench DC power supply. Suggest adjustable from 0 to about 20 volts at up to 4 Amps. One can fairly easily make one of these but commercial ones with twin meters are now almost as cheap as buying the parts and they are risk free (almost)!! As cash allows, acquire a fixed 13.8 volt 5A supply for equipment in regular use. Ditto sealed 12 v ex-alarm batteries.
4. Counter. These can be made without too much difficulty but the commercially made ones are now within financial range, especially 10 year old ones seen at rallies. Aim for at least 6 digits, preferably 8, so that MHz frequencies can be measured directly down to Hz. Go for as wide as bandwidth as possible. Often the input impedance is 1M for scope type probes up to 20 MHz and 50R for higher frequencies.
5. Scope! I know they are expensive but you will never regret buying one. For years it was the only piece of commercially made gear that I had. Single trace old 10 MHz scopes can often be picked up at rallies for £10 - 30. A new 30 MHz dual trace one is now about £300 with probes and represents excellent value for money. If you win the lottery, add a spectrum analyser!

Before you have acquired all the above, you should have contemplated building some of the following:-

1. RF power meter. Easy to build - 50R with ranges of say 5W, 0.5W and 50 mW. Calibrate in dB.
2. 50R step attenuators. Very useful with above and again easy to build. Suggest at least two, first unit with switches giving any combination of 1,2, 3, 4, 10 dB (power) and second unit having two switches for 20 and 30 dB power attenuation.
3. Harmonic marker generator. Wide band output with selectable fundamentals of say 50 KHz, 100, 500 KHz and maybe 1 MHz. Easy to make. For cheap receiver frequency calibration.
4. General purpose Audio power amplifier and LS. Say 3 W max output with gain control and maybe a switch controlled pre-amp with overall max voltage gains of x10, x100 and x1000.
5. Two tone audio signal source for setting up SSB TX. Two frequencies within audio range, equal level outputs, adjustable between say 10 mV to 1 volt. Desirable to also have a variable frequency one covering say 50 Hz to 5 KHz.
6. QRP 50R RF resistive matching bridge. Forward and reflected indications.
7. Wide range RF signal generator. Variable output level up to about 10 mW. Frequency range - 100 KHz to 30 MHz.
8. Several 50R in/out fixed gain wideband RF amps, say with power gain of 10 dB and others of 20 dB. At least one with max output of 1 Watt.
9. Selection of 50R twin low pass filters for each of main bands to clean up signals.
10. Diode mixer. 50R in/out at all three ports.

Making that lot should keep you occupied for a while! Don't let it get like my bench right! Tim G3PCJ



Radio Frequency Chokes

Steve Hartley G0FUW asks about winding RF chokes. That's not something most people do nowadays so it tells you he is a keen constructor! I shall not take it literally though!

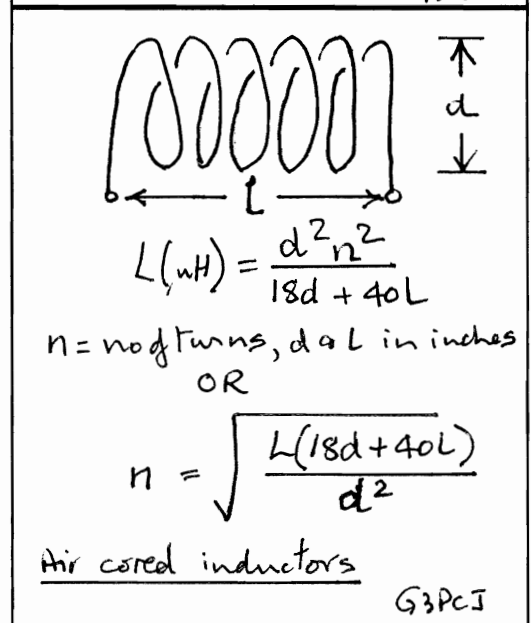
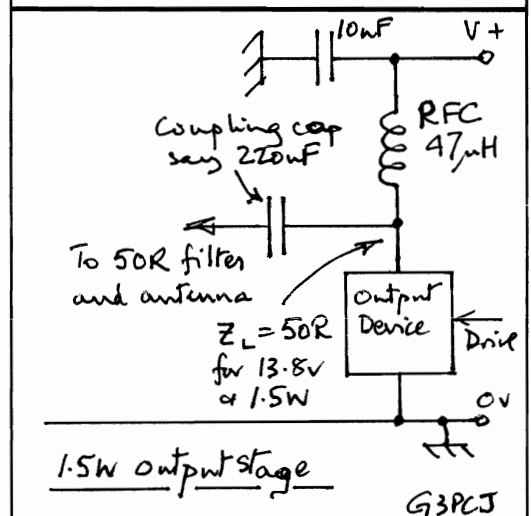
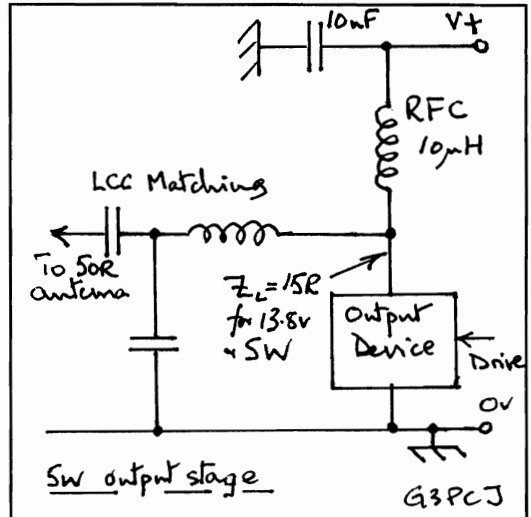
The first thing is to calculate the inductance that ought to be provided! This is not as hard as you might imagine since rules of thumb are often used. The first point is that the impedance of the choke at the lowest operating frequency should be several times the other 'controlled' circuit impedances. The second rule is that if there is any doubt, increase the inductance several times!! Let me try to explain the first point by using an example where I went wrong!

For many years I have used the circuit on the right for 5 Watt RF output stages. The three unlabelled LCC parts are a resonant impedance transformation network between the impedance at the device drain/collector and the 50R antenna - they are not relevant to this discussion. The choke (labeled RFC) is there to provide the DC supply and its impedance in parallel should not materially reduce the other circuit impedances at that point - in this case the drain or collector load impedance to get the wanted output. Lets consider the 80m case when wanting 5 Watts from a rig using a 13.8 volt supply. The peak (SSB) or maximum power on CW (the desired 5W) will be the peak voltage squared divided by twice the load impedance. (Standard power in a resistor theory. Note *NOT* RMS voltage hence the $2R_L$!) Allowing for the transistor, the peak RF voltage will actually be a bit under the supply voltage, say 12.25 v. Turn this formula around and the drain load works out to be 15 Ohms, so the choke impedance should be several times this - say $\times 4 = 60R$ on 80m. Using the inductive impedance formula, this needs a choke of a 2.7 micro-henries. For that reason I used a 10 μH choke for many years, which also allows for use on 160m.

Imagine my dismay when a new design of 1.5 W rig would not give full output on 160m using the somewhat simpler output circuit in the middle box. I eventually went back to the theory and realised my mistake! As before, the drain load impedance is roughly supply volts squared divided by twice the desired output = 12.5^2 over $2 \times 1.5 = 52$ Ohms. (This why simple rigs, directly connected to the antenna, are often rated at 1.5W!) 10 μH is only 113R on 160m - not enough! When changed to 47 μH all was well!

Steve, wishing to wind his own, will have to use more theory! They can be air wound like the traditional valve output choke and split into several sections to avoid unwanted resonances. Note that a valve output stage operates at much higher load impedances anyway due to the higher supply voltage, so that the value of the choke becomes very much greater. The total number of turns for the desired inductance would be calculated from the formula right and perhaps increased by 10 - 20% to allow for a 'sectionalised' format.

It is equally permissible to use a ferrite loaded inductor - on a known type of toroid or bead. The dusty dull black ferrite FT50-61 toroids with say 10 turns is a good starting point for low voltage QRP rigs, because it has a much higher inductance per turn than the coloured T50-2 (red) powdered iron toroids. Unknown black/grey toroids, which often come from mains filters or switch mode PSUs should not be used because their characteristics are unknown and they are intended for use on much lower frequencies. Tim G3PCJ

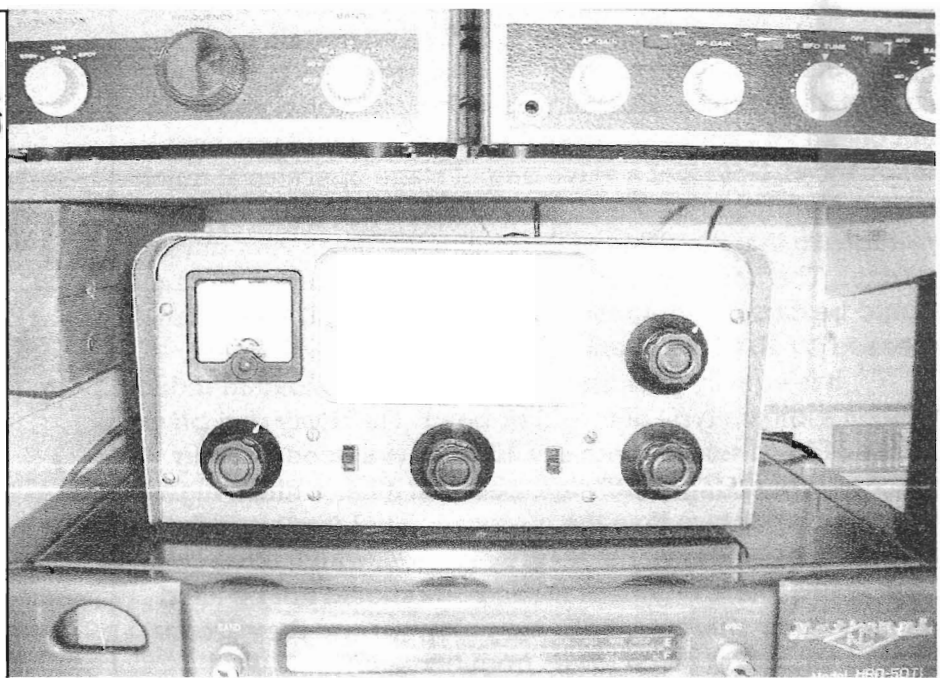
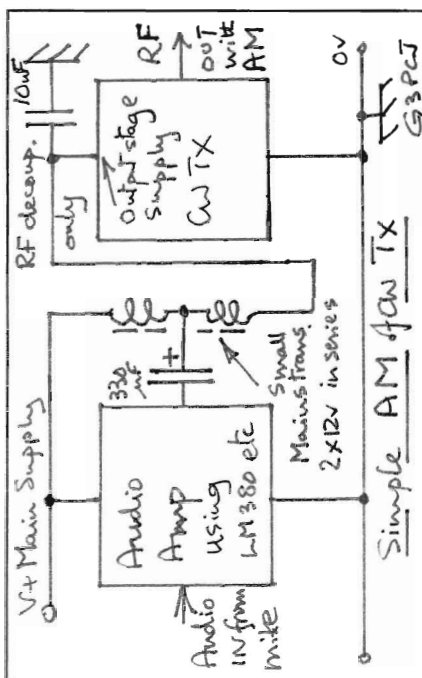


Amplitude Modulation

Recently there has been a revival in interest in amplitude modulation (AM) for a variety of reasons - I guess improved speech quality compared to 'Donald Duck' SSB, doing something 'different' and, perhaps more importantly for readers of Hot Iron, it enables phone communication without too many complications! The two main disadvantages are a strong steady carrier, which is potentially annoying to other band users, and spectrum inefficiency because both sidebands are transmitted simultaneously. The transmitter has also to dissipate a higher level of wasted power for a given RF output. These reasons have caused AM to be almost unused now for high power amateur use. (Interestingly, AM is still used for commercial broadcasting but not for all that much longer if you believe commercial broadcast receiver designers!) Its historic attraction was easy 'detection', so that a receiver could be made with not much more than a diode and high gain audio amplifier; but the serious drawback was lack of selectivity! The pioneers used multiple RF amplifier stages to improve selectivity and sensitivity but these were complicated and often unstable! This was not properly overcome until the superhet was devised. (An interesting sideline was the regenerative TRF RX but this was too temperamental for unskilled operators!)

I have recently been trying to add a phone capability to the Sutton range of DC rigs so considered AM. The main alternative of phasing SSB is just too complicated for most kit builders. There is also now fresh AM activity on the extended 40m band and more action by enthusiasts on 160m using historic gear. Adding AM to a CW transmitter is fairly easy (see later) but reception was a worry! Not wishing to depart too far from the conventional direct conversion receiver with its good selectivity, I reckoned that a stable DC rig should be able to read AM. If the RX's stability is good enough to read phone single sideband (either sideband without the carrier), it should be equally good when both sidebands are there! What of the carrier? As this has a constant level and is on the same frequency as the RX's LO, it will not demodulate (in the DC rig's product detector) into an audible signal. AM is often thought to be tricky to copy but I suspect this has more to do with a poor transmitter - perhaps one that has some unwanted frequency modulation as well as the desired amplitude modulation. So Andy Howgate, using a Sutton RX, and his friend Roger G3VKM with a KW One Sixty TX (6W carrier with plate and screen modulation) very kindly set up a test. They operated on 1.952 MHz and Andy was able to easily copy Roger even when the rigs drifted slightly apart in frequency. Roger's KW160 is shown below.

AM is most easily applied to a CW transmitter by modulating the output stage supply voltage with the audio signal. Full modulation requires a swing between 0 volts and twice normal volts. The audio power required is half the RF carrier power. When a semiconductor audio power amp is used, whose output DC level is half the supply voltage, then a 2:1 step up is required. A conventional modulation transformer is terribly expensive but a small mains transformer will suffice! The circuit below shows how AM is applied to the Mallet CW TX using the Audio Amp kit. G3PCJ



Transformers!

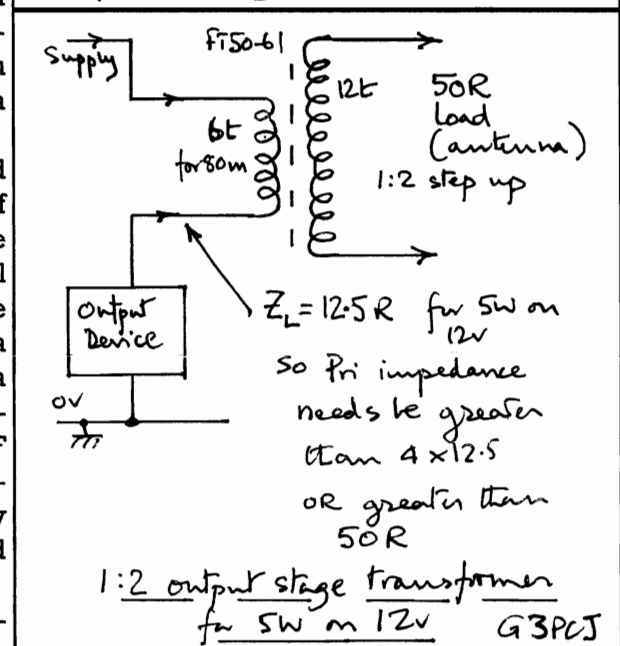
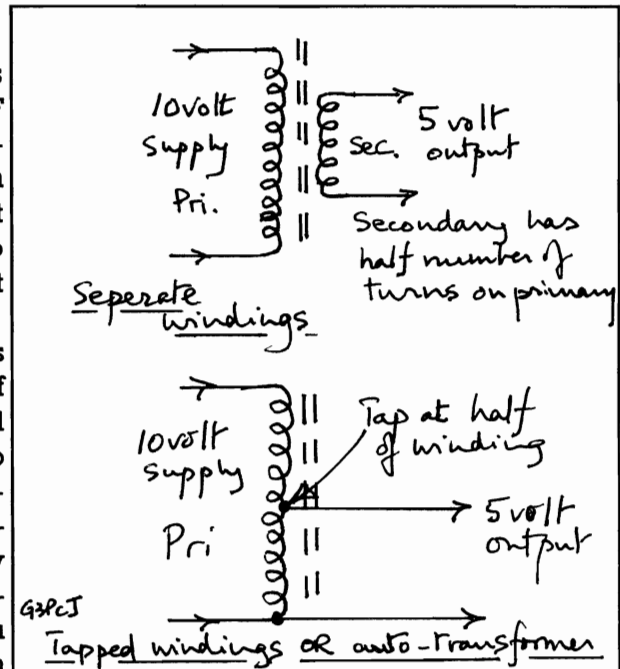
For this type of discussion, the theory applies equally well to power transformers as it does to RF transformers. They are really quite easy things to understand and are a most valuable circuit element! In the general case, there are separate input and output windings as shown right. Tapped windings are also often used for economy and may transform the input voltage either up or down.

The key parameter of a transformer is the turns ratio between the windings. This is the number of turns on the secondary divided by the number used for the primary. So a transformer with a 1:2 turns ratio would have twice as many secondary turns as primary. This means that its output voltage will be double that of the input because the increase is directly related to the turns ratio. So if your transformer is using say a 10 volt supply and you need 40 out, then you need four times as many turns on the secondary as on the primary. If you want only 5 out for the 10 volt supply then you need only half the primary turns put on for the secondary. Very easy! You don't even need a calculator.

In principle they can be used either way round (swapping input and output) but do this with caution if it is operating near its maximum power level. (See later.) The next point to consider is how many actual turns should be put on the primary, and hence on the secondary when multiplied by the turns ratio. As a guide, the impedance of the primary winding as a plain inductor should be several times the circuit impedance. A figure of four times is often used for RF work. (For 50 Hz mains transformers it is more complicated. For low voltages it is much easier to accurately measure the voltage output of a few turns and add turns as required by threading around the core.)

Another consideration is the change in impedance levels through the transformer. This aspect varies with the square of the turns ratio. Thus a 1:2 step up transformer actually quadruples the impedance at the output. Consider a 5W output stage running on 12 volts with a load impedance of 12.5R which needs transforming to the 50R antenna line. The primary winding impedance should be at least $4 \times 12.5R = 50R$ (by coincidence!) which needs 2.3 μH on 80m and hence min 6 turns on an FT50-61 (see right). The secondary has to have double this. In this case the transformer primary can also act as the supply choke.

Maximum power handling calculations are much harder to do and are related to the saturation characteristics of the core material. Half inch diameter rings like the FT50-61 are fine for 5 Watts of RF. Use more side by side for higher levels. At 50 Hz, the core will be gapped iron laminations where max power will be related to the central limb's size. Figures of around 25W per square inch are a guide! Tim G3PCJ



For 50R on 80m

$$L_{pri} = \frac{Z_p}{2\pi f}$$

$$= \frac{50}{2 \cdot \pi \cdot 3.5 \times 10^6} = 2.3 \mu H$$

for a toroid

$$N = 1000 \sqrt{\frac{L (mH)}{A_L \text{ Value}}}$$

For a FT50-61, $A_L = 68$ (ARRL data)

$$N = 1000 \sqrt{\frac{2.3 \times 10^{-3}}{68}}$$

$$= 5.7$$

So use 6 turns on Pri
or 12 turns on Sec G3PCJ

Snippets and Correspondence!

David Buddery G3OEP questions how the Lancaster bomber in which Blumlein died while doing early radar experiments, could have crashed due a single engine failure. According the detailed crash report recently declassified & recounted in his biography, the sequence of events was that a loose tappet adjusting lock-nut on one inlet valve of the Merlin, allowed the tappet clearance to become excessive leading to higher than normal temperatures and eventually valve stem failure; this led to a very severe inlet manifold fire which the engine bay extinguisher could not control, and which eventually melted the main spars of the wing causing it to snap & aircraft to fall out of the sky. *Godfrey Manning G4GLM* has kindly offered to help out with requests for elderly (mostly) germanium semiconductors. He has quite a supply but is always keen for re-supplies if old gear is no longer required. Contact him first at cgmm@thersgb.net

Chris Rees G3TUX comments that there IS a case for using a twin lever paddle key even if you do not 'squeeze' or use it Iambically! He argues that the arm of a single lever has to travel much further than is the case for a twin one (theoretically x2) which can lead to poor sending such as 3 becoming SM. This is even more apparent when operators use semi-automatic ('bug') keys where the gap on the dash contact has to be quite wide to ensure sufficient vibration of the pendulum arm! (There speaks the man who sold keys - including a twin lever one to Gerald Stancey G3MCK! Tim)

Spinach powers battery! A recent research note reports on a new solar powered battery developed using spinach laced with special salts and silver electrodes! No output figures per tonne of plant material are given but it does report 12% solar efficiency which is quite high compared to solar PV panels. Its not quite the time yet to plant your garden with nothing else in case the 50 Hz fails!

The 21st Yeovil QRP Convention

This will take place on April 10th 2005 at the Digby Hall, Sherborne, Dorset as in recent years. Doors open at 1000/1030 and there will be talks, radio traders, bring and buy stalls, eats and drinks etc etc. The talks will be on HF DX Propagation (G3MYM), HF Telcoms - Poldhu to Telstar (G4KHU), and What's my frequency (G4JBH). Full details and help with accommodation if required can be obtained from George Davis G3ICO george@mudford.fsnet.co.uk Do make yourself known to me if coming down. If you contemplate purchasing a kit, advance warning is sensible in case I am overwhelmed by unexpected orders! See below for distant travellers.

The Somerset Supper!

To have a little bit of fun, that well know firm of kit suppliers will be holding a **Supper** the night before the QRP Convention, ie the evening of April 9th. It will be held in a Sherborne hostelry yet to established, for locals and those staying overnight. To make it slightly more interesting I plan a small display of an item from each diner's home built radio equipment! (Please also bring a QSL card or label.) This will qualify you for a *free* place at the supper table! You buy your own drinks. I do plan to take a photo or two for publicity purposes but this will not intrude into this **social** event where all (including XYLs) will be very welcome. A minimum of formality! Places by advance booking **only** by Mar 28th so please get in touch soonest via walfor@globalnet.co.uk letting me know numbers or special dietary needs. Hope to see it and you! Tim G3PCJ

Finally I must apologise for getting this Issue out a little late - my excuse is that we went to Spain to get a little Spring sunshine. Not a bit of it! We left after the aircraft has been de-iced and arrived in steady cold rain. It got worse - with more snow, rain and serious wind! We did have two good days though and found a few Spring flowers in the mountains. Returned to ice again and a power cut that had put the heating out of sync with real time!

Another reason for publication delay is having to think too hard about suitable topics to include! I do need your suggestions, comments, questions and articles *please - just anything will help!* I reckon I can tidy up most rough material (although you might not think so)! Tim G3PCJ

Hot Iron

Summer 2005
Issue 48

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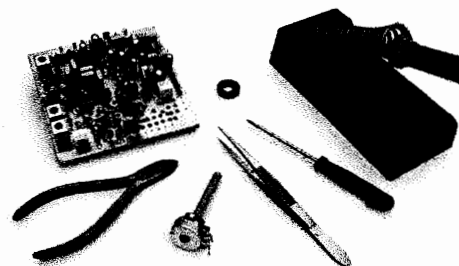
Fivehead in the Hills!
Joys of Engineering
Dual Gate MOSFETs
More on JFETs!
50 Ohm test gear
Superhet freq plans
Bandwidth and Q
New rig options
Sale items
Somerset Supper
SUBSCRIPTIONS!

The Walford Electronics
website is also at www.walfordelectronics.co.uk

Editorial

This time its raining hard outside and I am delighted!! Our clay soil is rock hard after a long dry period and needs this moisture badly - it is essential just now to ensure plenty of grains in each ear of corn! Nothing to do with radio except that it keeps me inside preparing this!

Having introduced several new DC rigs recently I realise that its about time I thought about superhets again! If one wants the rig to work on the higher bands then stability is the dominant problem. This is quite a challenge while keeping the concepts simple and low cost! Increasingly there is a good case for having a micro-processor in the rig - especially if there is a frequency read-out to be driven, however I am endeavouring to avoid it! I do remain concerned about digital clock hash that can emanate from such designs, especially if unshielded so, for the present anyway, I am going to do without micro-processors. Some might say 'He's stuck in the mud' but there is no point in replicating what others can do better. We all need to be different! I shall endeavour to maintain the 'character' that I am told my designs have! Tim



Kit Developments

Those of you who read Practical Wireless will have seen two, maybe three articles, on the new **Sutton** family of DC rigs. After one small gremlin that affected the 160m band cards, I think all is now fine! To date, the **Montis** double sideband phone transmitter is proving more popular than the **Mallet** CW transmitter - which does surprise me given the article on the Montis is not yet out!!

The next task is to complete development of the **Kilve** and the **Kilton**. The **Kilve** is a very simple DC single band RX aimed at supporting those taking their exams. The intention is that one set of parts will enable it to do 20, 40 or 80m by combinations of inductors and capacitors. It has a conventional PolyVaricon tuned VFO rather than a ceramic resonator and hence can be set for any part of the band. There is just one control for tuning and output is for Walkman type phones. The **Kilton** is the matching simple stand alone 'crystal' controlled 1.5W CW transmitter - again for any one of 20, 40 or 80m. Both are 50 x 80 mm double sided PCBs. Target prices are low for impecunious students!! But I do have to get them working yet!! Tim Walford G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

The Hills are Alive with the Sound of Fivehead by Richard Booth G0TTL

To look at me you wouldn't immediately think of winter sports man. Still the perseverance on that first trip in March 2000 paid off. At first my skis had a mind of their own and my knees refused to bend. "Lean to the valley" my instructor would say, it took me a while to realise he didn't mean "fall to the valley taking half my classmates with me". By this time my wife had disowned me as a hopeless cause and I was sent to practice on my own away from other innocent victims, trees and ditches. Five years on I've never looked back and now will happily tackle any run. Where's this leading to? Well a little matter of my holiday to Austria this year when my luggage included amongst other things a little radio I call the Fivehead Compact.

I wanted to build a small self-contained 20M SSB transceiver that needed nothing else than an antenna, power source and microphone to get on the air with a respectable signal. In other words a holiday radio. With it's 100 mm sq PCB the choice had to be the Fivehead transceiver. However I also wanted to squeeze in a 10W linear amplifier, S meter/AGC kit and a 3 digit counter. All in a cabinet not much bigger than the main board!

The most awkward bit to fit in was going to be the linear amplifier. After some head scratching I decided the best way to proceed was to mount it vertically, at the rear of the main PCB, with the heatsinks overhanging. To make the amplifier clear components though I did need to shorten what would be the lower heatsink by about 15 mm. In practice I doubt it would make much difference but I also cut down the upper heatsink to match, my thoughts being that this would help to keep any thermal properties closely matched between the two output transistors. The 3 digit counter also mounted vertically, running front to back along the side of the case. Connections to the front panel displays via ribbon cable. The easy bit was the S meter kit, which I mounted between the back of the meter and a long stand off fastened to the case. Another first for me was to use an ultra bright white led for meter lighting.

So after construction and a bit of testing on air it was time to get the skis out of the roof, pack up the car and head off down to Austria. This time around we rented a traditional Austrian chalet house near Kufstein, which was hidden up a lane surrounded by snow clad forests and farmland. We were in the heart of the Tyrolean Alps. The scenery is breath taking, just think of the best Christmas card picture you have seen and multiply this by ten.

Time to get OE7/G0TTL on the air. The first spot of operating was après ski in the afternoons. Whilst my other half was soaking in the tub I got to call CQ on 20M. My 13 watts and a dipole antenna strung up to the tree next to the house (one end fastened to the tree, the other to the upstairs balcony) loaded up fine and I had plenty of contacts. It's true, if you have a slightly more exotic callsign everyone wants to talk to you. The "Compact" worked a treat, it was stable enough once up to operating temperature and I had no complaints of the audio quality on transmit. From the house my best contact was a station in Canada. During the second week the weather turned considerably warmer which meant the tracks used to climb some of the lower peaks thawed, opening them to normal traffic. We had a day off from skiing so my plan was to escape for a couple of hours in the car and play radio up an Alp. Somewhere not far from Kitzbuhel I turned off the main road and followed a narrow winding track past a frozen lake and up to the mountains. Expecting the local police to arrive at any time I set up the antenna on the top of the car (a centre loaded whip), plugged the compact into the cigarette lighter and checked the SWR against the bridge part of the S meter. After a spot of length adjustment at the antenna everything was fine. Conditions seemed not to be so good but I still made plenty of contacts around Europe and Russia. What was good though was the absolute lack of any interference. Not even the click of an electric animal wire fence - in the Alps animals seldom come out to pasture before May. No power lines, switch mode power supplies or broadband internet connections to generate square waves and their infinite harmonics. It was radio, how it used to be in the UK 25 years ago.

As usual the holiday was over too soon after it began, it was time to say our goodbyes and head back to Calais. The Fivehead Compact performed well, better than I expected it to, considering how much is squeezed in. One improvement I will make will be to fit a miniature slow motion drive to the tuning capacitor. If I was to build another one with hindsight I'd mount the amplifier board the other way around and have the heatsinks protruding from the back of the case through cut-outs. This would give a little more space inside and help to reduce heating of the VFO capacitors. G0TTL

(I am indebted to Richard for writing this while away from home in St. Ives! Thank you, Tim.)

The Joys of Engineering Part 3- by Eric Godfrey G3GC

Since the publication of part 2 in the last issue of Hot Iron I have had a number of comments from people saying that they hoped that I would continue to recall the Joys of Engineering. This was also highlighted at the very enjoyable Somerset Supper held the evening before the Yeovil QRP Convention when I had the opportunity to put a number of faces to the names and call signs of Construction Club Members. I gathered that there was not only interest in the "Solder Wars" side of life, but also in the general state of engineering in those days. I will therefore describe some the various aspects of the Research Laboratories and its controlling company, The Gramophone Company Ltd. located at Hayes, Middlesex within a stone's throw of what is now Heathrow Airport.

The Gramophone Co., locally know as "The Gram", was the controlling company for the various factories manufacturing gramophone records, portable gramophones, radios, televisions together with the Research Department and Works Designs Department. At its peak the Company employed between 15,000 and 20,000 people. The Head Office included the recording studio where Dame Nellie Melba made her first recording. Head Office still remains today although it is now unused and boarded up. The whole of this area occupied by the Company, bordered on the East by the Grand Union Canal was divide by two public roads running through it. East of the canal the Company also owned farmland that was let out to a local farmer. During WW2 one of the dividing roads was closed to the public for reasons of national security. The complex was generally self sufficient and one could get virtually anything from the General Stores; rolls of brown linoleum, toilet paper marked TGC and liquids like "Carbon Tet", Benzine, Metholated Spirits. Even the arrival and departure of the local GWR trains were timed to normal factory hours.

Returning to the labs, my "Circuits Section", was on the top floor and immediately below was the valve and tube section. Here all the development and manufacture of camera tubes (Iconoscopes) took place and it was most interesting to see these large tubes being constructed and finally evacuated and sealed off. It was always very hot in this section due to the use of molten the glass. Many of the operators in order to keep cool drank a lot of water, lemonade etc. which that kept in sundry bottles near them. Unfortunately one operator took a swig from what he thought was lemonade but was actually a caustic solution which resulted in a very painful death. This was definitely not one of the joys of engineering. No doubt "Health & Safety at Work" would probably have prevented it today. This section was useful for having the broken stem of a wineglass repaired.

In the last paragraph of part two I mentioned a junior engineer with whom I felt ill at ease and I later found that he was generally disliked and in future I will refer to him as "JEX" (Junior Engineer X). His attitude to people was such that he bore the brunt of many practical jokes. One that immediately comes to mind was when in 1938 he was going to Switzerland for a holiday, and the Friday before the holiday, he arrived in the labs with an alpine walking stick plastered with mementoes of various places he had previously visited. This was too much for the senior engineer with whom I worked and I was given the job of making a brass memento with "EMI HAYES" punched on it and filled in black. It was beaten into shape to fit the diameter of the stick and the senior engineer duly screwed it to the stick with two wood screws, the screw driver slots of which he filed off for good measure. Needless to say that when JEX returned after his holiday he was not in a very good mood and was to be avoided if at all possible.



It was not long after this that JEX suffered another incident. In the small workshop mentioned in part two there was a drilling machine with the drilling table at sitting height and the electric motor behind it. The two were connected with a belt system allowing for different drilling speeds. One day JEX was using the machine for trepanning a hole some two inches in diameter in a piece of eighteen gauge sheet steel. Trepanning was always a difficult job and JEX was having problems resulting in frequent visits to the grind wheel to sharpen the cutting tool. He was called away to the circuits lab for a bogus phone call and whilst he was out the drive belt on the machine was crossed over resulting in the trepanning tool running backwards and thus failing to cut. He struggled with this for some time with more and more visits to the grind wheel to sharpen the tool and the use of more and more cutting oil on the work. Finally he realised what the problem was and stormed out of the workshop in a very bad mood.

It should be remembered that despite all these things going on there was a great sense of loyalty in the labs with the staff willingly doing a lot of unpaid overtime.

Eric Godfrey, G3GC

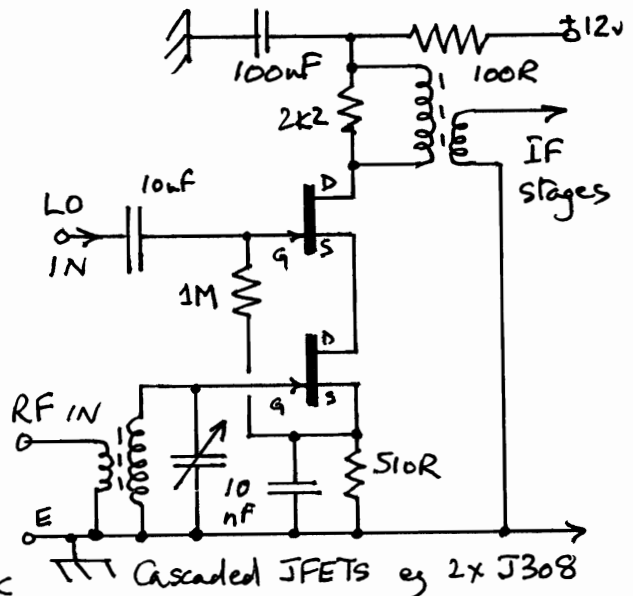
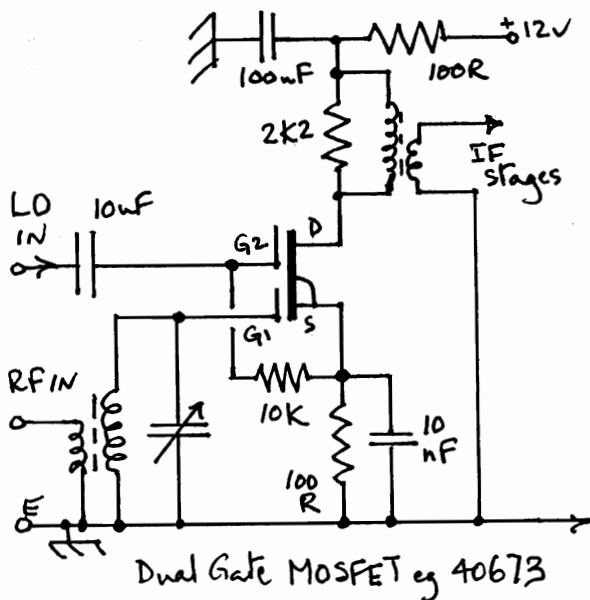
Dual Gate MOSFETs by Gerald Stancey G3MCK

There can be few home constructors who have not used the dual gate MOSFET; equally there can be very few who have not viewed with concern the fact the common types like the 40673, 3N201 and MFE201 are no longer made. They are still available from suppliers such as Sycom but for how much longer? Therefore it was with relief I found that there is a solution to this problem.

The excellent ARRL book Experimental Methods in RF Design, by Wes Hayward W7ZOI and others, shows how two normal JFETs can be cascaded to produce a 'dual gate MOSFET'. One example that he gives is a mixer - the diagrams below show the familiar arrangement for an actual dual gate MOSFET and that for a pair of cascaded J308's. The only comment that Wes makes is that some experimentation maybe needed to set the bias to the correct level.

The March 2005 Issue of Practical Wireless contains an excellent article by G4FYC on the dual gate MOSFET where he shows that it is derived from cascading two JFETs. The article also gives some useful design information.

As they say, when one door closes another opens. Life is full of challenges and fun for the home builders. G3MCK




More on FETs!

Although the previously common dual gate types mentioned above are now becoming like hen's teeth, the VHF type BF981 is still available. This is sold as a sort of 'surface mount' device, actually as a bead with four flat legs protruding sideways - as opposed to ordinary leads out of its underside. I have not used them myself but there is no reason why they should not be used at lower frequencies provided precautions are taken to ensure they do nothing un-intended - like oscillate at VHF! This might require gate stopper resistors.

I have always found that the 2N3819 JFET is rather easier to use than the J3XX series, because they have a lower zero bias drain current which means they can often be used with zero gate bias if it simplifies the circuit. The tolerance on the zero bias drain current is quite large for all JFETs (about 5 to 15 mA for the 2N3819) so it is necessary to make sure that the drain supply, and any voltage drop in drain resistors, can accommodate this current without the drain voltage becoming too low for the desired signal excursion. The use of a source resistor, which in effect applies negative feedback, can stabilise the operating current to lower values. Depending on application, the source resistor can be bypassed for signal purposes.

Another point to watch out for is that the 2N3819 is confusingly available with two different pin-outs!! The more common pin out shown top right from Siliconex is unfortunately the more expensive! This is the one that I supply in my kits.

Yet another interesting point about the JFET is that the source and drain are interchangeable because the device is symmetrical! G3PCJ

Siliconex 
2N3819 DGS
Pin Views

Other 2N3819's 
Beware!

Simple 50 Ohm Test Gear

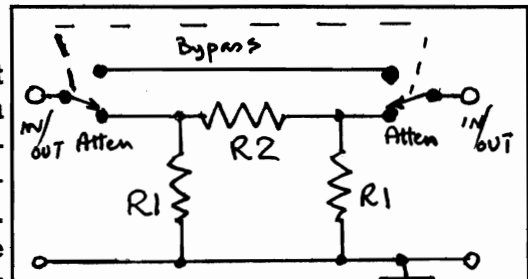
Over the years, these three items have been the most used items of my test equipment - after a scope which is in an altogether different price league! If you contemplate doing any experimental work at HF, where 50 Ohms is the common interface impedance, then these will be invaluable. Items which have 50 Ohm in and out impedances can be plugged together without further complication. That applies especially to these three units.

The first is a set of 50 Ohm attenuators. For RF work it is common to consider the gains/losses in decibels (dB) of power. Either T or Pi circuit form attenuators can be used provided they have an impedance of 50 Ohms looking in from both directions. It does not matter which is used as input or output! Its handy to have switches which give increments of 1 dB up to about 30 dB max in any one unit. (Leakage around the switches makes much more than this unwise.) 30 dB corresponds to a reduction in output power to one thousandth of the input power, or output voltage equal to about one thirtieth of the input voltage. See the top box. They can be used to attenuate the RF signals into a RX prone to BCI, or when measuring minimum detectable signals, etc.

The second device is a broadband RF amplifier. By using negative feedback it is easy to make a bipolar transistor amplifier have nominal 50 Ohm in and out impedances with a power gain of 10 dB (10 times). Restricting the gain to 10 dB will keep the bandwidth high (well over 2 to 30 MHz) and avoid winding RF transformers! Two such stages in cascade will provide 20 dB power gain (times 100) or a voltage gain of 10. They can be used to increase the signal of a low power oscillator to drive a diode mixer, or to increase the sensitivity of a deaf receiver, etc! Again its sensible to not have too many stages in one unit for fear of unwanted feedback - two is fine. The circuit right (for a each stage) is very dependable! For linear operation, the maximum output power is related to the standing current in the transistor, which is governed by maximum dissipation. These designs should allow up to about $\frac{1}{10}$ Watt output, ie 20 dBm.

The third device is an indicating dummy load power meter. It is based on a peak reading RF voltmeter which can be calibrated in volts or more commonly in power, usually expressed in dBm. For low power RF work, power is usually expressed relative to the power of one milli-watt into 50 Ohms, which is commonly known as 0 dBm - 223 mV RMS. Hence 10 dBm is 10 milli-Watts (10 dB above or 10 times 0 dBm) and 30 dBm is 1 Watt (30 dB or 1000 times 0 dBm). dBs are used because they can be added and subtracted more easily than multiplying or dividing if gain or attenuation figures were used! The circuit right has a RF voltmeter which actually responds right down to DC allowing it to be calibrated from a DC source that can be accurately measured with a digital voltmeter. It has three ranges providing useful indications from about 1 milli-Watt up to 5 Watts.

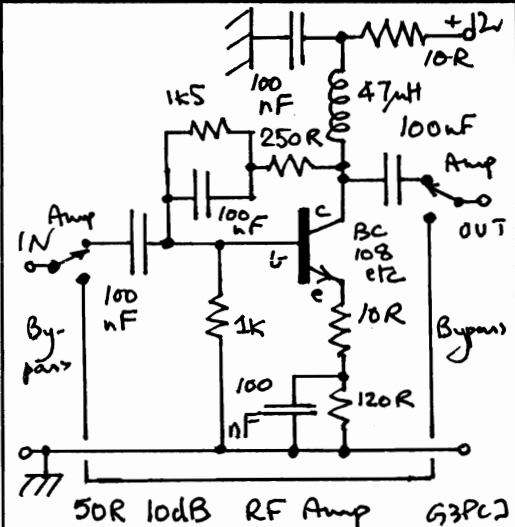
I hope to provide three kits based on these designs at around the £15 mark for each - details to follow! G3PCJ



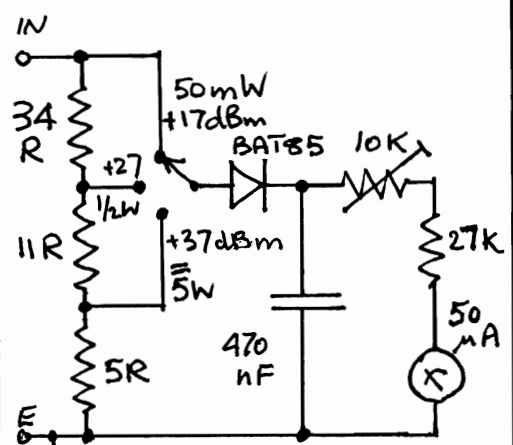
50R Π Attenuators

Attenuation dB	R1 Ohms	R2 Ohms
1	870	5.76
2	436	11.6
3	292	17.6
4	220	23.8
10	96	71

Theoretical Values G3PCJ



50R 10dB RF Amp G3PCJ

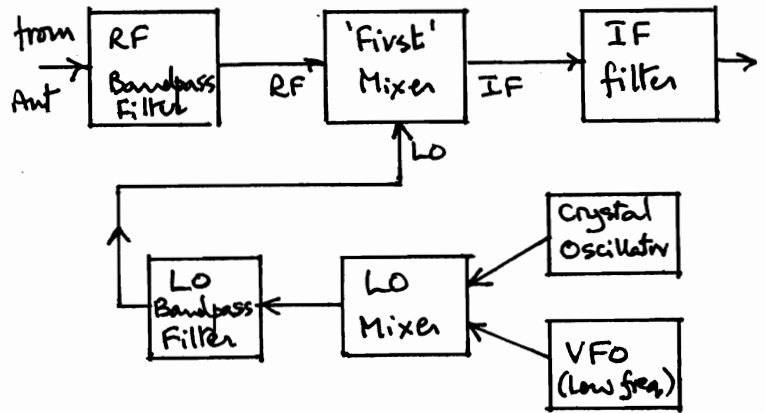


Indicating dummy
50R Load / power meter

G3PCJ

Frequency Planning for Superhets

When designing a new rig, there are many aspects of its frequency 'plan' that have to be considered. The plan can be quite simple if it has only to work on a single low frequency band, because the VFO is likely to have a low frequency that will ensure its stability. If the operating band is much above 15 MHz, then a local oscillator (LO) mixing scheme is usually needed to preserve the stability of a lower frequency VFO. Often the LO mixing is done with a crystal and the unwanted mixer sum filtered out before injection into the rig's first mixer. This arrangement is shown right for the front end part of a superhet RX.



front end of LO mixing superhet G3PCJ

If the rig is to be multi-band, then life gets a lot more complicated! The first consideration is what Intermediate Frequency (IF) to use. I have now standardised on 6 MHz because a phone bandwidth ladder filter can be made with 5 low cost crystals, and which has a reasonable impedance match to the 1K5 in and out impedance of 602 mixers that might be at both ends of the filter. (Another reason for choosing 6 MHz is that it allows direct LO injection for all bands up to 14 MHz while keeping below 8.5 MHz for the VFO, which is adequate for stability aspects.) The next consideration is sideband switching! If the LO is above the RF for 30m to 160m and below for 20m up, then a single Carrier Oscillator frequency of 5998.5 KHz will provide the conventional sideband for amateur phone work on all bands with the exception of 30m - but it does not matter which sideband is used for 30m because it's a CW only band! This means that the digital frequency counter must be able to count the LO frequency and add, or subtract, the CIO frequency as bands are changed. (Another advantage is that this form of counter operation is much easier than other plans which might need LO-CIO and CIO-LO!)

Next comes the tricky bit - finding a crystal/VFO mixing scheme that avoids unwanted products/harmonics from the VFO, crystal or LO at the IF, the RF image frequency or reception band! The table below I think meets this bill - its based on a 6 MHz IF, 500 KHz wide operating bands, with all bands tuning the same way, and a 2.5 to 3 MHz VFO with crystals to suit! All frequencies in MHz.

There are some potential nasty birdies but they are outside actual amateur bands, except for 160m. Luckily many of the crystal frequencies are either standard values or used in other rigs, so it needs only four 'specials'. I expect to adopt this scheme in the replacement for the Bristol. Tim

<u>Band</u>	<u>Local Oscillator</u>	<u>RF image</u>	<u>Crystal for 2.5 - 3 VFO</u>	<u>LO Unwanted Mix</u>
1.5 - 2.0	7.5 - 8.0	13.5 - 14	5.0	2.5 - 2.0
3.5 - 4.0	9.5 - 10.0	15.5 - 16.9	7.0	4.5 - 4.0
7.0 - 7.5	13.0 - 13.5	19.0 - 19.5	10.5	8.0 - 7.5
10.0 - 10.5	16.0 - 16.5	22.0 - 22.5	13.5	11.0 - 10.5
14.0 - 14.5	8.0 - 8.5	2.0 - 2.5	5.5	3.0 - 2.5
18.0 - 18.5	12.0 - 12.5	6.0 - 6.5	9.5	7.0 - 6.5
21.0 - 21.5	15.0 - 15.5	9.0 - 9.5	12.5	10.0 - 9.5
24.5 - 25.0	18.5 - 19	12.5 - 13.0	16.0	13.5 - 13.0
28.0 - 28.5	22.0 - 22.5	16.0 - 16.5	19.5	17.0 - 16.5

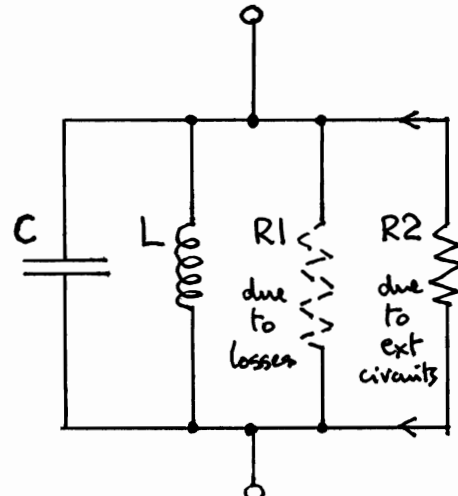
Bandwidth and Q

In this note I will only consider LC resonant circuits, although the considerations for other forms of filter circuits are very similar. Either series or parallel resonant circuits can be considered, but to keep things simple, I will stick with the parallel form because that is what one is most likely to encounter. The behaviour of this circuit as frequency is changed is very dependent on the effective 'resistance' across the ideal L and C components. This effective resistance has two components, firstly R1 due to losses (because the L and C are not ideal parts - L is usually far more lossy than C), and secondly R2 which is applied by the external circuits to which the resonant circuit is connected. These are shown right as R1 and R2 but a combined value R can be used instead, whose value can be worked out using the resistors in parallel theory.

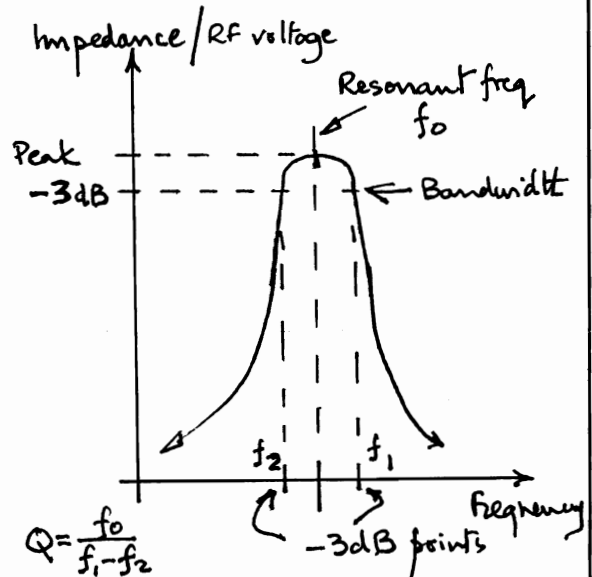
The familiar impedance curve for the parallel form is the 'hump' response shown right with its high maximum impedance at the resonant frequency. The width and height of this hump is related to the value of R. The high impedance is usually desirable to give the best response to a wanted signal while rejecting the unwanted - for example in RF bandpass filter circuits at a receiver's front end. (If the circuit is a series resonant circuit, then the impedance is a minimum at the centre frequency - which is why it is used as a trap to attenuate unwanted signals.) The bandwidth of this circuit is the numerical difference in frequency between the points where the response is 3 dB below the peak. For example, a filter for the front end of an 80m CW receiver, would need a minimum bandwidth of 3.60 less 3.50 MHz which is 100 KHz.

The 'goodness' or Q (quality factor) of this circuit is related to the resonant frequency by dividing the resonant frequency by the bandwidth - in this example, 3.55 MHz divided by 100 KHz (0.1 MHz) which means the circuit has a Q of 35.5. It is a dimensionless number and generally the higher the better! If needed, it can be lowered by adding real resistors across the circuit but cannot be raised above the values implied by the losses in the L and C, without any contribution from the external circuits.

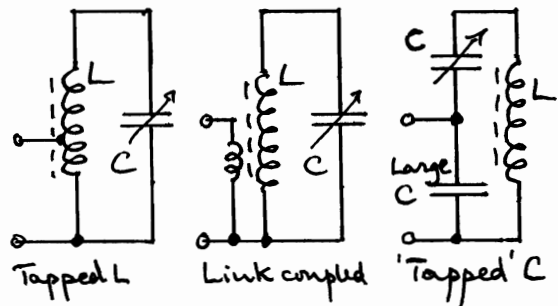
The theory gets a bit heavy if you really need to work it out fully - there are excellent notes in the ARRL and RSGB handbooks. However for casual experiments, a rough approach is to ensure that the external circuits imply a load R2 on the resonant circuit greater than very roughly 5 KOhms. This can be done by tapping down the L, or using a small link winding, both acting as a transformer (see earlier theory about impedance transformation), or less commonly, by a capacitive tap using a large C value (at ground end) in series with the smaller resonating C value. G3PCJ



Parallel Resonant circuit with 'losses' G3PCJ



Parallel Resonant circuit response



Alternative methods to couple low Z circuits to maintain high Q .

G3PCJ

Physical Layout Question?!

My next major superhet is likely to be a CW and phone 5W TCVR for any band up to 20m with everything on a single 100 x 160 mm PCB, but capable of working to 10m - with an external card containing the LO crystal mixing extras. To make it work on a single higher band this might be a version of the existing Min - mix kit; but it would be more interesting to have the additional PCB also provide extra 'fitted' bands, most likely two, with the band parts soldered into the PCB. Another option might be to make the extra unit cater for any band in the main rig and one, maybe two, 'pluggable' bands using small band cards like the Sutton. Either approach would make it into a two, or three, band rig - perhaps changeable. The main single band rig would cost roughly £90, the additional unit for two extra bands about £25, or in the region of £15 plus £15 per band if 'pluggable'.

I would be delighted to have any comments on these ideas, especially from those who might be interested in such a rig. No promises on those prices though! Tim G3PCJ

FOR SALE!

My existing oscilloscope is surplus to my needs. It is a two channel 40 MHz Goldstar OS9040 with dual timebase etc. and is working excellently. I have had it since new in Dec 1993 when it cost £340 + VAT. If wanted, I can include two suitable probes. If you are interested, please give me a call and make an offer!

I also bought the following by mistake in quantity! Can anyone use them?

0.3 inch wide 7 segment high intensity common anode LED displays - fine for hard wiring top digits
24 volt standard sized 2 pole changeover PCB mounting relays

Construction Club member Jim Geary has passed me his mostly completed Bristol which he offers to a good home; it includes a single band card for 160m, twin band 10/17m & 15/40m, with card switch kit. The PCBs have been built very carefully and has all the controls etc. Needs a box!

Tim Walford G3PCJ on 01458 24122 before 6:30 pm.

The Somerset Supper!

This was duly held the evening before the Yeovil QRP Convention, and a good time was had by all! Rob Mannion G3XFD, Editor of PW, kindly presented the prizes to Nicky Marriot M5YLO and Ray Lawrence G8AWB, he also presented me with a loaf of bread as his entry ticket since he didn't bring an electronic device! The entry ticket devices brought by diners can just be seen on the right! In the foreground is Brian Purkiss who deserves a medal for doing all my PCB drilling. Date for next year is April Sat 8 and Sun 9th 2006. G3PCJ



Subscriptions!

I am afraid its that time of year again! If you wish to continue receiving Hot Iron, let me have your cheque for £7 before Sept 1st for the next issue.

I still have loads of crystals if wanted. Free apart from postage at two first class stamps!

Parallel Resonant 30 pF load - MHz - 5.0688, 5.6914, 5.752, 6.0177, 7.20, 9.30, 9.60, 10.2775, 10.44, 11.0258, 12.73819, 14.84830, 15.375, 16.5888, 16.623333, 17.9, 18.26, 20.105, 20.78

Series Resonant - MHz - 15.0, 18.0, 20.0, 21.0, 24.0

TTL oscillators (sq wave output) - MHz 24.0, 30.0, 32.0 for four first class stamps.

Send off your cheques now!

Hot Iron

Autumn 2005
Issue 49

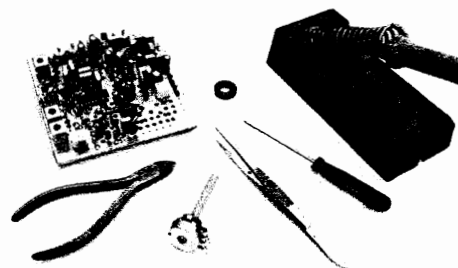
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The EP antenna
TX controller
The Porcupine!
HF Linear amp
More kit news!
RF Crystal filters
Theory - decibels
Snippets
Request for help
Photos of Kilve

The Walford Electronics
website is also at www.walfordelectronics.co.uk

Editorial

Mid August and the sun is out. The corn is ripening and my mind is in neutral owing to the heat! I take my notebook out into the garden to try and have a (any!) new idea for something interesting but end up asleep! The snag is really that once one has developed a few direct conversion rigs and then done mutli-band superhets; its quite difficult to improve their performance without causing the cost to increase significantly. I am acutely aware that cost is pretty important for most people but there is a small sector, who having built cheaper rigs which prove to be a bit lacking in some department, realise that good performance does cost appreciably more. My aim therefore is to give good value for whatever builders decide to spend - apart from a few dodges in the circuitry, it often comes down to being mean on the mechanical things! I think cases are poor value for money because they are seldom essential. If you wish to take it up a mountain, then yes - go for a case and many other aspects that would be found in a military radio, but you will end up paying! All of this is a way of saying I need some ideas for what would interest you next! What about ancillaries - which ones? Tim



Kit Developments

Last time I mentioned the new 'K' family! They are for novice builders and those taking their exams! The parent is the **Kilve** DC receiver! It is for any single band 20 to 80m - it can even do 5 MHz if needed! It has three JFETs for the RF stages and three BS170 MOSFETs for the audio part. Its intended to drive walkman type phones and has just one control - the PolyVaricon tuning! As cost is strongly influenced by size, it is a single sided small PCB of just 50 x 80 mm. The single set of parts is suitable for any of the bands 20 to 80m. The price is £19 with £2 for P&P.

There are two 'matching' 1.5 W transmitters, both on 50 x 80 mm double sided PCBs and both designed for stand alone use. Both have their own oscillator which is supplied with an 80m ceramic resonator and trimmer which will give roughly 75 KHz of tuning range on 80m; for the higher bands (up to 20m) you need a crystal or an external VFO scheme to avoid the problems of chirp or 'FMing'. The **Kilton** is the CW transmitter and the **Kilmot** is the double sideband phone transmitter. Their prices are £19 and £24 respectively. Ordered with the RX you save on the postage and get a TR relay too! Later some of these will be featured in Practical Wireless, hence only brief details now. I hope Rob M wont mind me including a photo! Tim Walford G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

The EP Antenna

David Buddery G3OEP has sent in this note but I am not sure if he designed it or what EP stands for! No matter - it's a very interesting approach! He says it was designed by an elderly Ham as an inexpensive yet efficient all band antenna suitable for portable use or a small garden. Tim

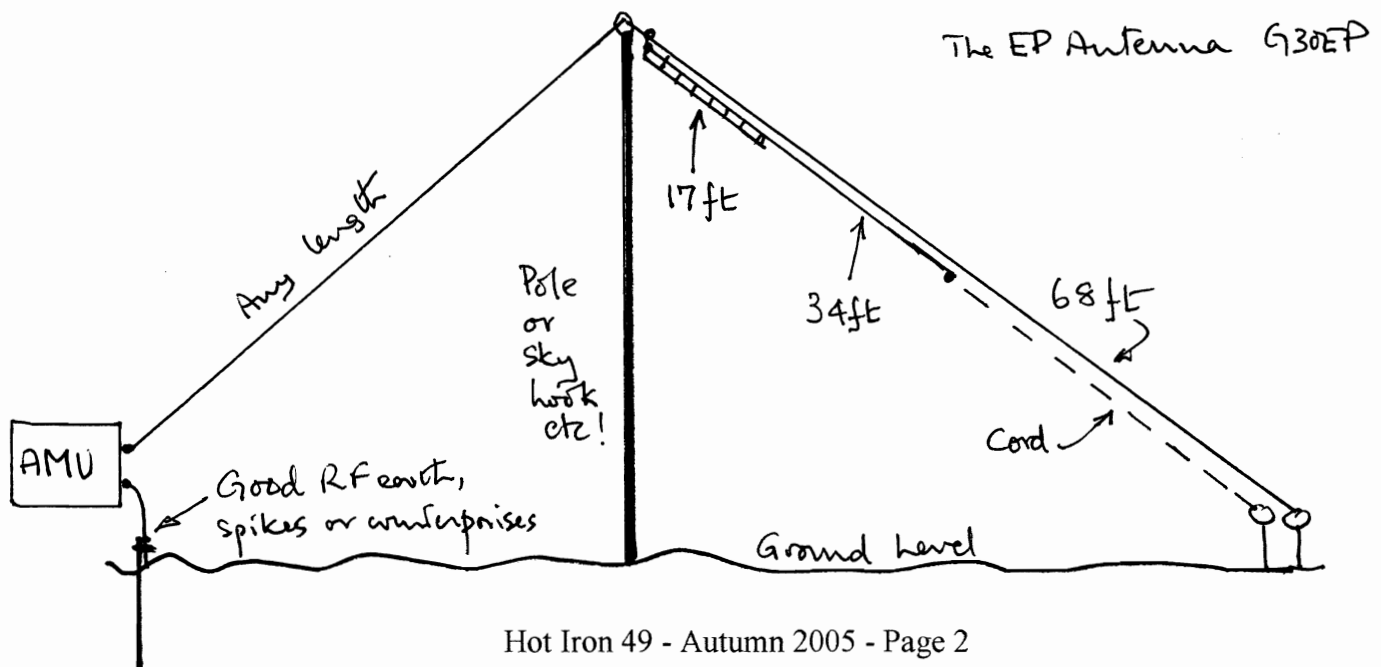
Design Principles

The EP antenna is an attempt to load any wire without using coils or traps such that its highest point corresponds to a current node. The basic design of the antenna depends upon the fact that in any end fed wire antenna, a current maximum (a node) is found at every ODD quarter wave. Hence for a wire one quarter wave long, there will be a node at the feed point; however if it is three quarter waves long, there will be two current nodes - one at the feed point and another a further half wave along the wire. Most antenna experts agree that the majority of the radiation comes from the current nodes so an objective should be to get these high. (If you don't agree with these suggestions, then this antenna is not for you!) The only disadvantage of the EP antenna is that it MUST be tuned against a GOOD RF earth.

So how was the device developed? Consider a quarter wave length of wire supported at one end, the lower end being at an angle to the ground. The upper end will present a current node to any wire connected to it, ie there will be a current node at the top of any feeder wire connected to the quarter wave wire irrespective of the feeder length. The impedance at the AMU end will be very different though - varying with band and feeder length!

Physically, I took a 17 ft length of slotted 300 Ohm feeder cable and at one end (the top end), soldered both conductors together; to the far end of one conductor, I joined a further 17 ft of wire, while carefully insulating the unconnected other conductor of the 300 Ohm feeder. Now I had one conductor 34 ft long which is a quarter wave on 7 MHz and three quarter waves on 21 MHz. The other conductor of 17 ft is a quarter wave on 14 MHz. I now took a 68 ft length of wire and soldered it to the top end of the 300 Ohm feeder, thus presenting a quarter wavelength and a current node at the conjoined top of the set up for 3.5 MHz. Hence I had current nodes on 21, 14, 7 & 3.5 MHz at the top of the device and ANY feeder wire connected at the top will be presented a low impedance current node on all these bands. The other wires, which are not quarter waves for the band in use, will have a much higher impedance in parallel so will not materially alter the low impedance presented by the active quarter wave wire. The mode of construction means that there will be but two lengths of wire suspended from the support; indeed, if the 7 MHz wire is secured by a good insulator to the 3.5 MHz wire, then only one wire will need to be attached to the distant support - see below.

I have said that the feeder, which is part of the radiating system, can be any length, though for best results on the lower frequencies length under 45 ft do not secure ideal conditions. A good versatile Aerial Matching Unit is essential together with an effective RF earth system, possibly several ground stakes, or a set of counterpoises (each a quarter wave long) for the bands in use.



Transmitter Controller - by Eric Godfrey G3GC

Whether one uses high power, low power, professional or home brew transmitters it is always wise to soak test them for quite long periods such as might be required in contests. To help test transmitters under these rigorous conditions I made a transmitter controller to simulate these conditions. The controller is assembled on the lid of a die cast aluminium box measuring 12 x 6 x 4.5 cms, operates from its own internal 9 Volt battery and provides two transmitter test facilities when plugged into the key socket of a transmitter:-

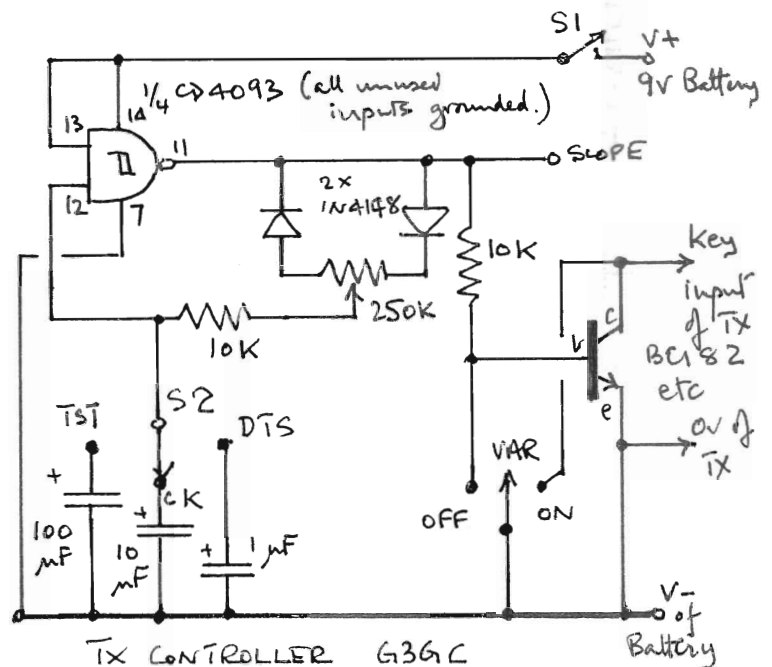
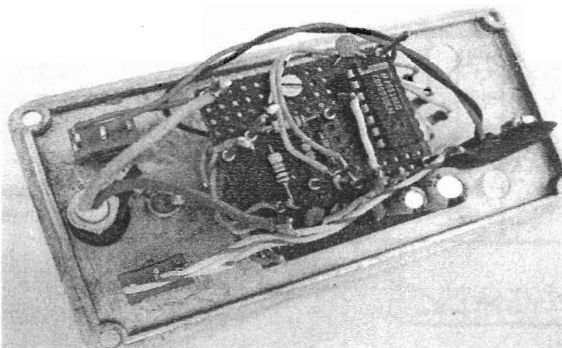
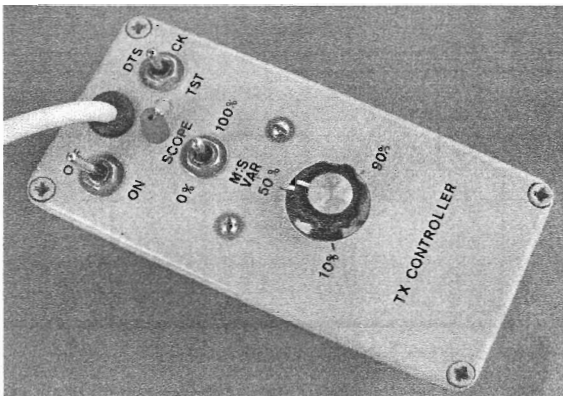
(1) To automatically key the transmitter with variable duty cycles from around 5% to 95%, together with two fixed duty cycles of 0% (transmitter off) and 100% (transmitter on).

It is quite often unknown how a transmitter will stand up to continuous use over a long period of time such as field days, contests etc and I expect that you have all heard some of the poor quality signals at the end of field days. These conditions can be simulated by connecting the transmitter to a dummy load, turning the power up to maximum and then use this controller to continuously key the transmitter with various duty cycles over hours or even days. This will provide a good indication as to whether there is likely to be any problems with overheating, drifting, etc and also, by listening on a separate receiver, if there is any deterioration in signal quality. Although this device is in effect testing in CW it is quite satisfactory to go over to SSB during the test period to check the quality in the SSB mode as well as CW.

(2) To provide a continuous series of dots at around 17 wpm.

This is useful for identifying the transmitter's harmonics and/or any other unwanted birdies when listening on a general coverage receiver.

The basic circuit is simply an A-stable Nand Schmitt Trigger connected to a switching transistor to key the transmitter. The jack plug, which is connected between the transistor's open collector and ground, simply plugs into the key socket of any transmitter that has a positive control line. This positive control line may be anything up to about 15 Volts which is universal in professional equipment these days. In the circuit diagram, where S1 is the battery on/off switch, the repetition frequency of the A-stable is dependent upon the position of S2 selecting one of three different capacitors, giving three 'speed' ranges covering 4 cycles per minute to about 17 words per minute of dots. The proportion of each cycle in which the 'key' is up or down are also adjustable owing to the different rise/fall time constants, as selected by the two diodes and their section of the potentiometer. In mid position the key down and up times will be equal. The output for a scope is useful for triggering the display to show the RF envelope. S3 allows the controller to run, or be stopped or the 'key' kept down continuously. Eric Godfrey, G3GC



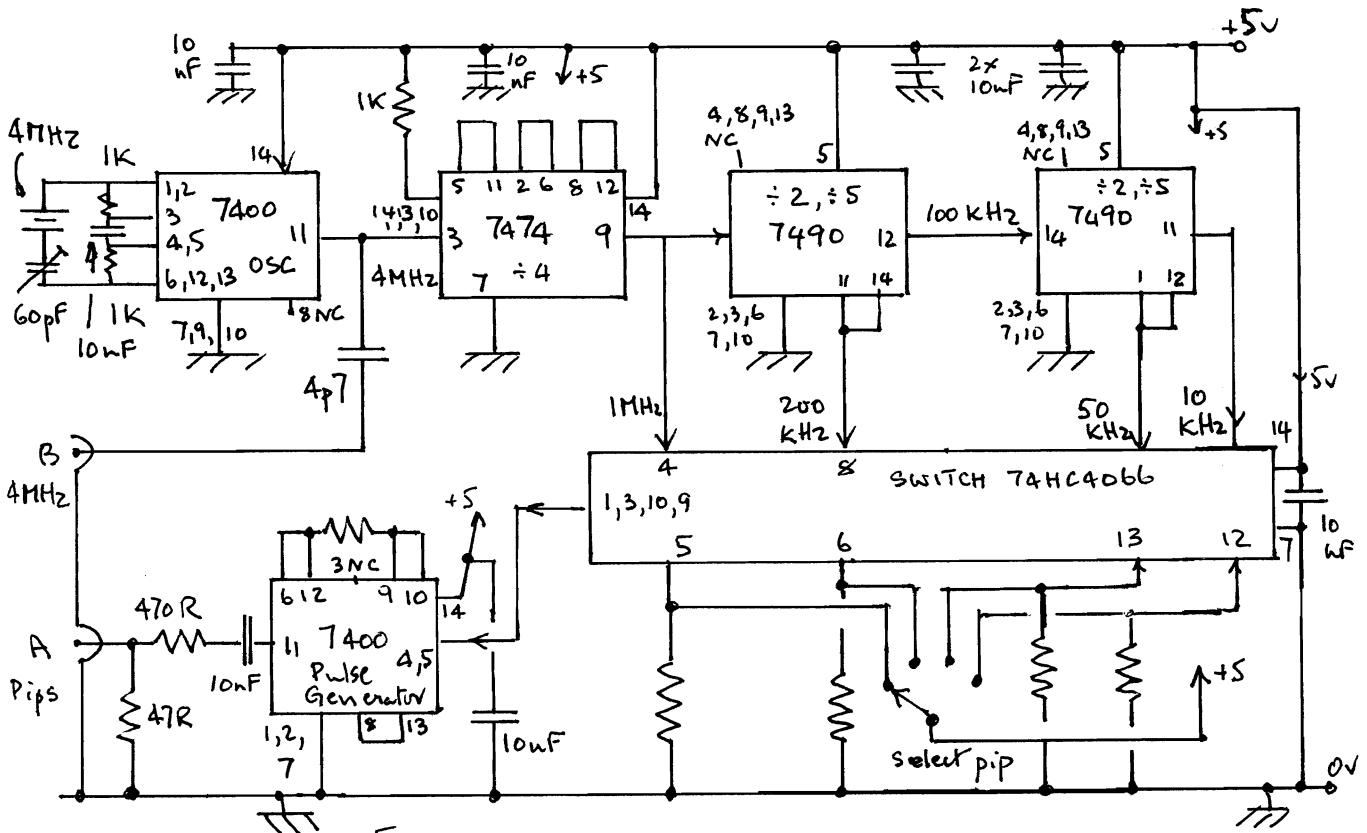
The Porcupine - so called because it has so many spikes! By Gerald Stancey G3MCK

(The original was written for the Vintage Military & ARS Newsletter, to whom I am most grateful for permission to publish. Due to lack of space I have had to edit it down heavily - my apologies. Tim)

Those of us who enjoy using classic receivers know the value of having a crystal calibrator for establishing band edges and for accurately calibrating the logging scale. Many handbooks give circuits using 74 series chips and this note explains how the utility of such circuits can be extended.

I have often found that 10:1 frequency ratio between pips is too large and that counting 10 KHz ones is not easy either! At times I have even not been too sure of the 1 MHz pips! The '7490' decade divider chip has separate divide by 2 and 5 stages making it possible to obtain 1 MHz, 500, 200, 100, 50, 20 or 10 KHz pips easily depending on your chosen crystal frequency. I choose 1 MHz, 200, 50 and 10 KHz pips derived from a 4 MHz oscillator. It is sometimes useful to have other discrete frequencies such as 3560 or 3500 KHz which will give pips at their harmonics on all bands upwards. For receiver alignment purposes, having the output impedance at 50 Ohms is desirable and is easily achieved by adding a 50R output impedance attenuator. It is also handy if the amplitude of each pip (for a given fundamental frequency) is the same; this is easily done by using a pulse generator of the type given by Ian Braithwaite in his excellent Radcom article in June 1998. If the output depends on just the harmonic content of the selected fundamental, which may not even be a square wave, then odd and even harmonics will not have the same amplitude. Another bonus of this circuit is that the difference in amplitude between pips of different fundamentals is easily calculated - it is 20 times the log of the ratio of their frequencies. For example, in this calibrator, the difference in amplitude of the 50 KHz pips compared to the 10 KHz pips will be 14 dB.

All of the above features are present in my calibrator which uses a 74HC4066 chip to select the fundamental that is fed to the pulse generator. If you try a rotary switch, you may have too much leakage affecting the pip amplitudes. I know because I tried it! Because the 4066 has only four 'switches' I provided a separate 4 MHz output whose amplitude cannot be directly related to those from the spike generator. A spectrum analyser showed that all pips of each fundamental were within +/- 1 dB across the HF spectrum and I see no reason why similar results would not be obtained by anyone who makes this unit. The measured levels were: 1 MHz fundamental pips @ -37 dBm, 200 KHz pips @ -51 dBm, 50 KHz pips @ -63 dBm and 10 KHz pips @ -75 dBm.



THE PORCUPINE - G3MCK

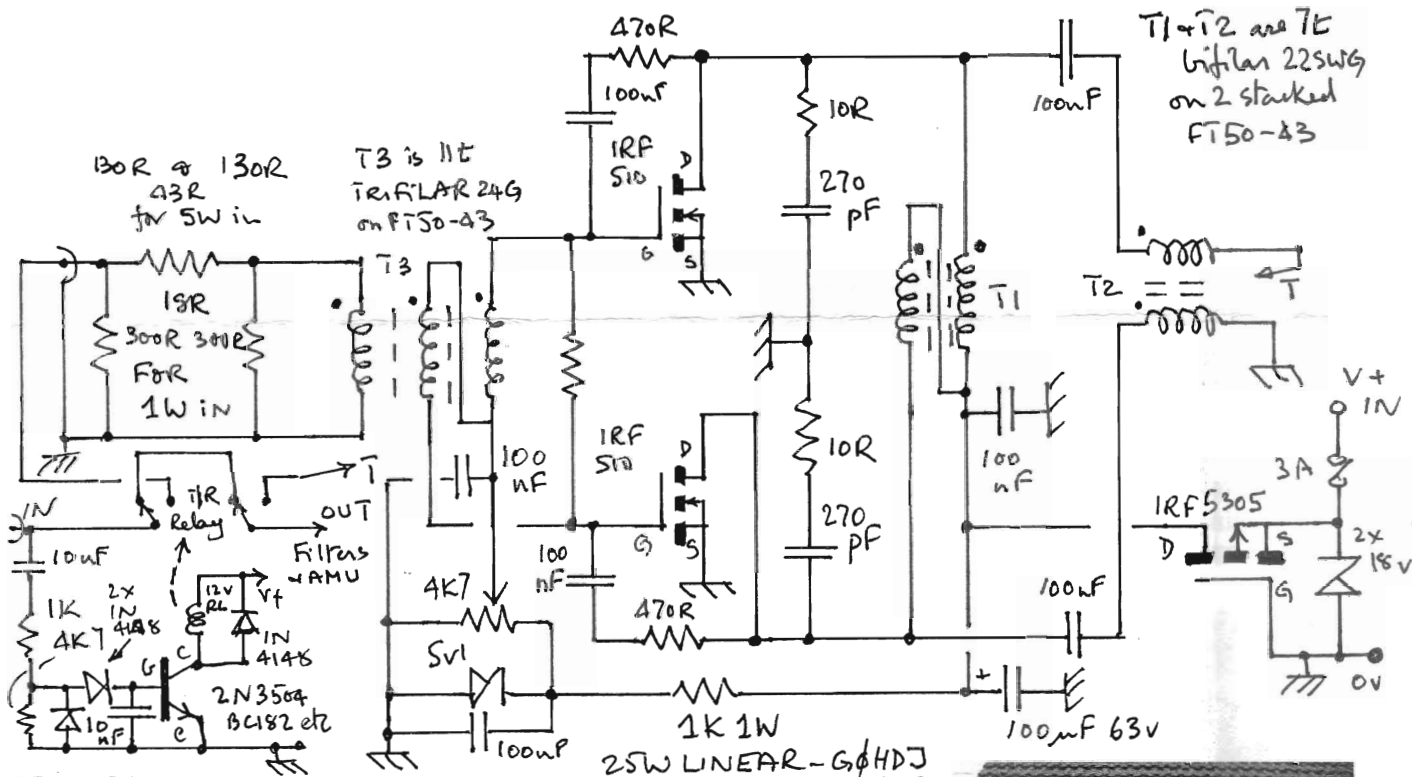
HF Linear amplifier by Craig Douglas G0HDJ

This circuit is certainly not original and the main part comes from 'Radio projects for the Amateur' by Drew Diamond VK3XU, a 25W MOSFET Linear, which he states is for 1.8 to 7 MHz but useable to 14 MHz. The input power is nominally 1W and the output 25-30W with a 25 volt supply.

The antenna switching circuit came from an article by Mike Kossar WA2EBY, 'A broadband HF amplifier using low cost MOSFETs (QST Mar 1999). His amplifier looked good but required a few more parts so I opted for the easier one on the KISS principle. The output is fed into 7 element Chebyshev filters based on designs by Stefan Niewiadomski published in PW in Feb 2005 which I have put into a separate box for greater flexibility.

The input attenuators are also switched between two designs for either 1 or 5 Watt input so that I can use it with a variety of TCVRs. Into a dummy load, my scope shows an ether disturbing 9W from a 4W input on 13.8 volts - well its serious QRO for me anyway! Drew gives a few construction requirements and a layout diagram in the above book which I can copy if required. The circuit also has reverse supply protection because the MOSFETs look like diodes across the supply if it is connected the wrong way round and they will conduct many Amps!

(This Linear is very similar in concept to my HF Linear kit but it does not have some of the extras that Craig has incorporated. Increasing the supply voltage on Craig's to the design 24 volt level should lead a big increase in maximum output level - theoretically x4 - not quite so much practically due to the 'on resistance' of the MOSFETs. Tim.)



More kit news!

I shall shortly be retiring the Bristol and Locking - mainly because some of the parts required are no longer made/available!

I have just, or will soon have, laid out the PCBs for several new accessory kits. They are a new relay selected dual low pass filter kit for TXs, a relay selected dual RF bandpass filter kit (50R in with 50R or 1K5 out) - both any bands 20 to 80m. I am doing a new versions of the RF signal generator, the two tone audio oscillator (or sig gen) and harmonic marker generator which will provide pips based on fundamentals of 5, 2.5, 1 MHz, 500, 250, 100, 50, 25 or 10 KHz.

Question - who owns the car pictured right with number plate AY599? Answer on the back page! More on that maybe next time.



Crystal Filters and the Sutton - by Andy Howgate G7WHM

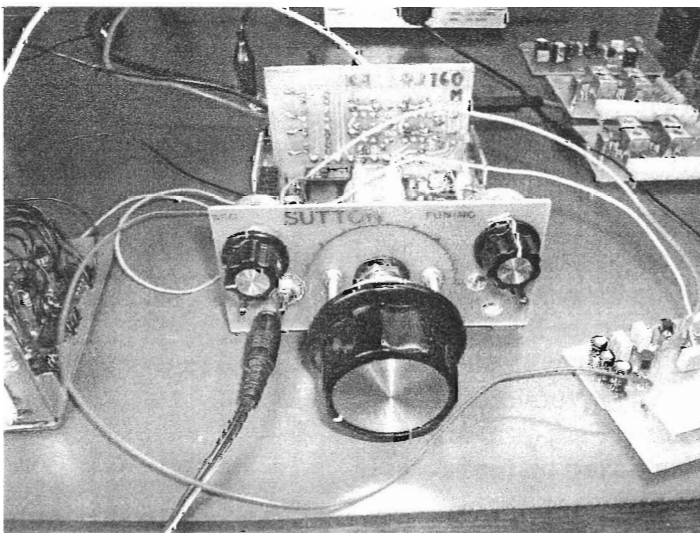
First off this is not an in depth technical article but more a simple experimenter's observations to assist the removal of BCI in the humble direct conversion receiver. Having built the Sutton RX and trying this receiver using several band cards as ever BCI can be a problem particularly so with 40m and 20m this is of course a common problem with this type of receiver at certain times of the day.

It became in my case, a quest to minimise the affects and since I wished to use this RX with the Mallet transmitter for the CW mode of operation in and around the QRP calling frequency. Having done some reading and web searching I came across an application where a crystal can be used ahead of the BPF to add some selectivity at the expense of sensitivity so having got into experimenting mode I applied a 7.030 MHz crystal to the front end during a period of heavy BCI and noted a dramatic improvement. I was so impressed I actually added the crystal to the band card but also included a switch so that the crystal could be shorted out so giving the benefits of reduced sensitivity but high attenuation to BCI when the switch was open and at other times the switch being closed restored the rig to using the BPF only. I would like to point out that this rig did have the Meter kit installed which provides some extra gain and AGC action.

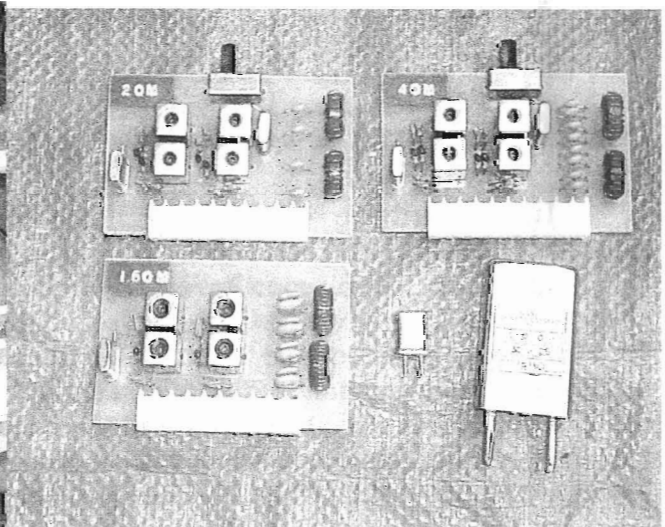
Applying the same thought to the 20m band card I added a crystal for 14.000 MHz and duly noted the same attributes but obviously on both bands the further you move the tuning away from the marked crystal frequency the more attenuation occurs but the rig had become far more useable and more gentle on the ears with the AGC of the meter kit helping to compensate for the loss in sensitivity. Thinking further I thought I would try another crystal in parallel but in this case the only crystal frequency available was on 7.070 MHz – the affects were most interesting and over all it was possible to gain 1 S point in signal strength across a tuning range of 100 KHz or so but noted a peak signal strength at each marked frequency. Applying two crystals of the same frequency value will also raise an extra S point.

I think it fair to say that a receiver would need to be fairly sensitive if applying this technique and it may not suit all types of receiver, however if a receiver was to be designed using a crystal as part of its front end then the possibilities could be of major benefit. Included here are some photographs some of which for amusement and some to display the crystals as fitted to the band cards with the switch. I should also be most interested if anyone else may have knowledge of this application and improvements. During my enquiries, a friend of mine had knowledge of crystals being used as front end filters mostly on fixed frequency military equipment and I have also found one kit maker in the USA using a crystal as a filter element in a simple minimalist CW transceiver. The final transceiver here, when completed, will have 4 band capability via the band cards 160m to 20m and I plan using 160m on Am as well as using CW whilst the other bands will be used mostly at or close to the QRP frequencies.

Andy Howgate G7WHM



Sutton with air variable tuning
Andy Howgate G7WHM



Sutton band cards with extra crystals

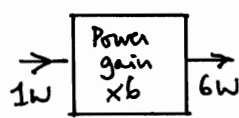
Theory - decibels

Many people feel very nervous of these strange 'units' but they were invented to make life much easier; especially when considering the progress of signals through some form of processing chain such as a receiver. THE most important thing to remember is that they are relative measurements - that it to say something is x dB greater than another, or if it is less than the other it is minus y dB written as - y dB.

For RF work, it is common for the two quantities to be measured as power since one is often concerned about extracting, or not wasting, power. You need a scientific calculator to work out the Power gain in decibels, because the answer is 10 times the log of the ratio of the two power figures. This is explained in the box right where an input signal is one watt and after processing of some sort it emerges as 6 watts, giving a power gain of 7.8 dB. If instead it had emerged with a power of only half a watt, then the power gain would be minus 3 dB or - 3 dB.

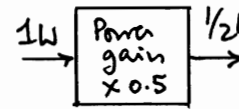
If now the signal is processed through several boxes that might have gain or attenuation, the advantage of using decibels will become apparent. For example if there were three boxes with power gains of 6, 0.5 and 20, one would calculate the overall power gain as $6 \times 0.5 \times 20 = 60$. However it is much easier to ADD up the gain expressed as decibels which becomes $7.8 + (-3) + 13 = 17.8$ dB. As a check that this is correct, the log of 60 is 1.78 which multiplied by 10 gives the same answer of 17.8 dB. These examples are really rather trivial but if the signal processing is much more complex with several processes, doing the sums by direct multiplication is cumbersome - it is much easier to add up the stage gains in decibels taking account of any minus signs which imply that the process is reducing the power level through that box. This is especially true of switched attenuators that often form part of some test set up - the dBs of the many switches that are set to attenuate are just added together to give Z dBs of attenuation. If now the input power is known to be say 1 milliwatt, then the output of the attenuators will be Z dB below 1 milliwatt.

For convenience, certain power levels are commonly used as references, the receiver RF work the level of 1 milliwatt is often used and is known as 0 dBm, where the m designates the milliwatt aspect, thus the output of the attenuators above would be said to be - Z dBm. Consider another example - your licence states that certain bands have output power limits of 26 dBW, in this case meaning 26 dB above 0 dBW or one Watt; if you work the formula backwards, 26 divided by 10 = 2.6 which when 'anti-logged' on your calculator comes out at 398 - near enough to the commonly known level of 400 Watts! It is important to know whether you are dealing with dBs of power 'gain' because they can also be used for voltage gain - see next time. G3PCJ



$$\begin{aligned} \text{dB} &= 10 \log \frac{P_{out}}{P_{in}} \\ &= 10 \log \frac{6}{1} \\ &= 10 \log 6 \\ &= 10 \times 0.778 \end{aligned}$$

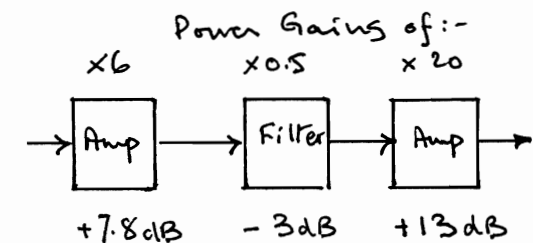
$$\text{Power gain in dB} = 7.78 = 7.8 \text{ dB}$$



$$\begin{aligned} \text{dB} &= 10 \log \frac{P_{out}}{P_{in}} \\ &= 10 \log \frac{0.5}{1} \\ &= 10 \times (-0.3) \end{aligned}$$

$$\text{Power gain is} = -3 \text{ dB}$$

G3PCJ



$$\begin{aligned} \text{Total Power gain in dB} &= 7.8 - 3 + 13 \\ &= 17.8 \text{ dB} \end{aligned}$$

As a check power gain is $6 \times \frac{1}{2} \times 20 = 60$
in dB = $10 \log 60 = 10 \times 1.78 = 17.8 \text{ dB}$

G3PCJ

Reference Levels

$$0 \text{ dBm} = 1 \text{ milliwatt}$$

$$P = V^2/R \text{ so } V = \sqrt{P \times R}$$

$$\begin{aligned} \text{For dBm} &= \sqrt{.001 \times 50} \text{ for } 50R \text{ Load} \\ &= \sqrt{0.05} \\ &= 0.224 \text{ V RMS} \end{aligned}$$

$$\text{For 0 dBW} = 1 \text{ W}$$

$$\begin{aligned} \text{so } 0 \text{ dBW} &= \sqrt{1 \times 50} \text{ for } 50R \text{ Load} \\ &= 7.07 \text{ V RMS} \end{aligned}$$

$$\text{For 400 W}$$

$$\begin{aligned} P \text{ in dBW} &= 10 \log \frac{400}{1 \text{ W}} = 10 \times 2.6 \\ &= 26 \text{ dBW} \end{aligned}$$

G3PCJ

Snippets!

Godfrey Manning offers a couple of comments:-

Low voltage valves He suggests these are often ordinary valves selected for better low voltage performance and not specifically designed for this use - hence their performance tends to be rather dismal, especially in a power handling sense. He has acquired 1960 Ford car radio which has valves (using 12 volt HT) for the RF stages but with an OC26 for the audio output stage!

Godfrey has also sent me an article on an *antenna rotator controller* that he has designed using stepper motors. I regret it's a bit long and complex to include in Hot Iron but I should be very happy to put any member in touch if they are interested. It involves 6 integrated circuits which are mostly CMOS 4000 series devices. It features continuous automatic stepping at speeds ranging from one step per 2 seconds to way beyond the abilities of most motors! He strongly advises a thorough soak testing of any second hand stepper before committing it to a major project!

Static Inverters Having been messing about with a photovoltaic solar panel, which is used to charge 12 volt lead acid batteries, I hope to be able to use this power source for more everyday loads that would normally be using the mains. Hence I have been contemplating a static inverter design. To be any real use, it has to have a waveform that is closer to a sine wave than the very simple square wave types! With a little digital logic and watty MOSFETs that is not too hard. Any interest? About £20, with your mains transformer (secondary 9-0-9v) and some heatsink metalwork. Tim

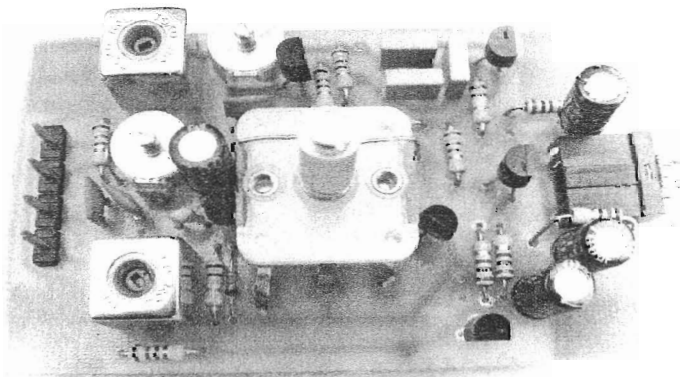
(The very next day after writing this, I had to use mine in anger! Clashing overhead lines in trees took us out! My commercial one would not start the fridge but it did keep the gas AGA alight!)

Request for help

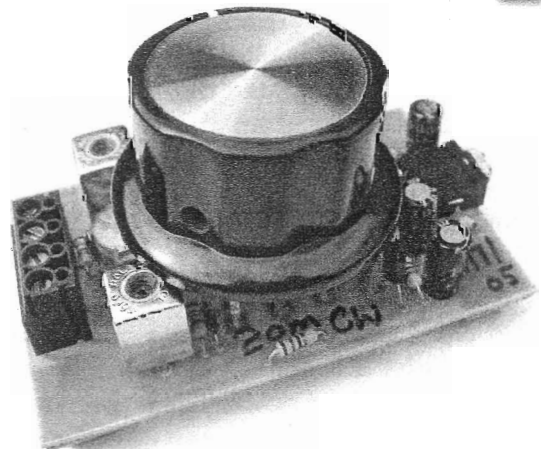
My name is John Windybank, I am a novice at kit building. With help from Tim I managed to put together the Catcott RX, ATU, and Dundon TX. I had 2 QSOs on 40m and decided I needed greater selectivity in the RX. I eventually bought the Brent TCVR kit. I have commenced the very first connections and know it will not be a quick job for me. Although Tim is ready to advise constructors I thought it would be good to discover fellow Brent constructors who are able to give advice when and if required on:- Frequency counters, Scope divide by 10 probes, Dummy loads, Power meters and the alignment of Brent RX RF filters when those stages are reached. If any constructor could advise on these matters my telephone No is 01462 681796 or e mail johnwindebank@amservice.com

Supercaps!

Members may recall that I mentioned that it was now possible to obtain capacitors with values of several Farads. The recent crash of an A300 series aircraft in Canada drew my attention to a press release about such capacitors. They are used to provide emergency power for the door locking actuators in these aircraft! Apparently each door has its own set of capacitors and they store sufficient power for up to 8 hours in standby and then be able to release the catches. Ultra capacitors are said to be more reliable and lighter than conventional batteries. I was delighted to note how well the escape arrangements worked in that particular incident - a very quick evacuation without loss of life.



Kilve RX - with & without knob!



Hot Iron

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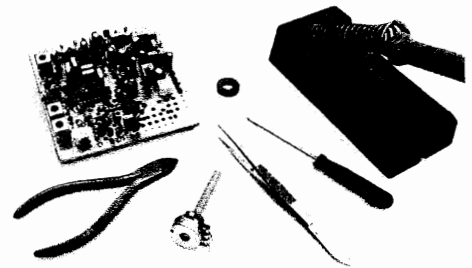
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Somerset Supper
New kit photos

The Walford Electronics
website is also at www.walfordelectronics.co.uk

Editorial

Re-reading the last Hot Iron, I see that my mind was in neutral due to the heat; this time is the opposite extreme! Its been below freezing for several days at night and often not thawed out fully out of the sun by day. Blizzards were forecast for last night but it only started snowing just as I left the house this morning to feed the cattle and sheep! Two hours later and the sun is out with a lovely bright day.

Over the years, we have been plagued by 50 Hz mains failures for all sorts of reasons ranging from lightning strikes to collisions by swans on the overhead 11 kV supply lines, so with the warnings about supply shortages, I have invested in standby alternatives. Two days ago, the local 11 kV transformer burnt out a winding so I felt rather pleased when I was able to change to the back up to keep the gas powered/electrically controlled AGA cooker going! Being an old farmhouse and difficult to lag properly, it loses heat pretty quickly so an alternative is rather important. See later for details - but I have to warn that this was not cheap and was partly an interesting experiment! Tim Walford



Kit Developments

Last time I mentioned the new 'K' family! The Kilve RX is available now and will be featured in the Jan 2006 PW, with articles on the DSB phone TX, and how to link them up for transceiver operation later in the year. I have begun thinking about the replacement for the Bristol, which I had to withdraw due to the relay manufacturer ceasing production of the right model. The current idea is for a base CW and SSB phone 5W rig; which would do any single band to 20m with a direct injecting VFO. Then an 'extras' unit could be added to provide two more bands and a crystal mixing scheme for the LO so that it would become an any three band rig up to 10m, with AGC and other accessories like a variable bandwidth CW filter.

In the meanwhile, I have replaced the signal source kit with a new and more capable harmonic marker kit, re-introduced the two tone audio oscillator (both £15 + £2 P and P), laid out a relay selected twin RF bandpass filter unit, laid out a new RF signal generator/twin band VFO, and started on a small static inverter unit. That lot all needs writing up, testing etc., as well as an update to the website!! Looks like a busy run up to Christmas. **Merry Christmas** to you all and may Santa do everything that he is rumoured to do! Tim G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics—is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

The Top Loop by Richard Booth GOTTL

For some time now I've been using "magnetic" loop antennas with excellent results on the HF bands. Considering the size of the driven element and the fact that they work well at only a few meters above the ground I've found them to be very useful. Until recently though I've not tried anything on 160M and having an urge to try something different I decided to have a go at building this loop. Conventional magnetic loops use a single turn as the radiator, however at this frequency you would need to make the loop at least 3 meters in diameter, and use a large 1000pF plus tuning capacitor to make it efficient. As you can imagine mechanically things start to get complicated with something of this size and keeping the whole structure upright and in shape would be a challenge. This loop differs in that it is made from 4 complete turns in a coil wound at diameter of just 170cm. It covers the whole 160M band with a very high Q factor which means you need to adjust the variable capacitor to resonance every time you change operating frequency - the bonus here though is that the antenna acts as a band pass filter and gives a tremendous reduction in out of band noise. It is also somewhat directional which gives a useful null that's handy for cutting out local interference sources - a common problem on 160M.

Construction is fairly straightforward. Good quality solder joints are required as the goal is to keep the resistance of the loop as low as possible. You'll need a decent quality tuning capacitor which will go up to 125pF. A standard air spaced broadcast type is OK for power levels up to 10W - above this you need to use a higher voltage component, for instance at 50W the RF voltage across the plates is about 2000V. A cheap solution is to dismantle a 500pF capacitor from an old valve radio and reassemble it with the plates well spaced out. This will bring the total capacitance down, and put the working voltage up. I can help with this!

The main loop is made from "thick" type coaxial cable. If you can get the semi rigid kind that's even better as it will be easier to keep the loop uniform. You need a single length 21.5 meters long to wind it. First of all strip an inch off either end and solder the inner and outer conductors together to make one single conductor. You'll need to make some kind of cross shaped timber or fibre glass frame to support the loop. Each arm of the frame should have a right angled front facing piece at the outer edge to support the separate turns of the coil. You can use a metallic pole for the vertical support but it is essential that this is truly vertical and passes through the centre point of the loop. Wind four turns onto your frame, starting at the bottom end next to one side of the tuning capacitor. Remember to leave enough to make the connection to the capacitor! Fix the cable at each leg, leave a space between each turn equal to the thickness of coax used. Try to keep the loop as circular as possible, but don't worry if it droops a little between the supports. Solder each free end to either side of the tuning capacitor.

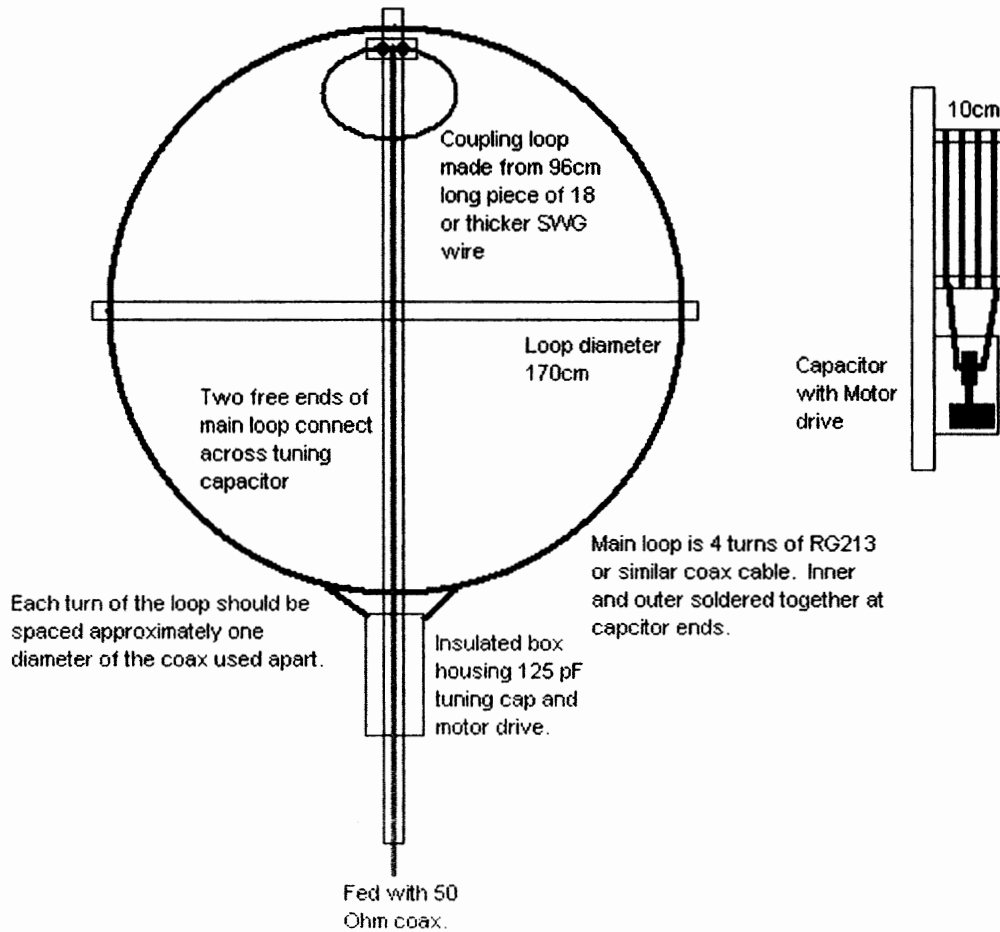
The tuning capacitor really needs to be motorised. I used one of the gearbox reduction types available from Maplin for my prototype and connected through a further 6:1 Jackson type reduction drive to the capacitor. This works reasonably well but does generate a fair bit of interference when making adjustments. Some people might find that useful - when the noise is loudest you should in theory be tuned to resonance! Mount everything in a weatherproof box. A cheapo lunchbox from Tesco and a few blobs of silicone sealant does the trick.

The coupling loop is made from 16 or thicker SWG wire. I used stripped down 30A twin and earth ring main cable. Leave the insulation on. For this you need a piece 96cm long. Bend this into a loop. Each free end connects to either side of the feeder coax. I suggest mounting the two ends of the loop into a plastic box, fit a SO239 socket in the base and then solder the two free ends to the socket. If you drill some holes for a U bolt in the back of the box you can clamp it in place at the top of the main loop (see diagram). The feeder should run vertically down the centre support and away from the antenna. When testing the antenna you may need to slightly alter the shape or location of the coupling loop to achieve the best SWR. I've found that a squashed almost oval shaped coupling often gives the best results. My prototype loop has an SWR of 1:1.4 and a useable bandwidth of about 4KHz before retuning is required. Just enough for a QSO!

(Richard has done such an excellent diagram that I have to repeat it on the next page untouched by my pen! Tim)

The Top Loop continued

If you do have a go at building the Top Loop I'd be happy to hear from you. I'm QTHR or you can email me at richard@pasttimesradio.co.uk Richard Booth, G0TTL



Antenna Snippets

As a comment, Richard's design above is very similar to my 'heating radiator' loop! That uses 15 mm malleable copper pipe instead of heavy gauge coax, formed into a multi-turn square of side about 0.5 metre. I have always felt that input coupling through a small loop would be a bit less efficient than direct connection of the driving rig so I used a gamma match approach – in effect a tap a small part round the loop from an 'earthy' point. This can have the disadvantage of unbalancing the loop and might also degrade the Q, which in Richards case is very high indeed to achieve such a small bandwidth! I also found out the hard way that using one turn of rubber covered multi-core mains cable (with the cores connected into a multi-turn loop) is no good whatever! It has far too much self capacity between cores so that hardly any external tuning capacity is needed! It was also very lossy! Forget that approach!!

Last time I was unsure who had designed the E P Antenna that Dave Buddery had sent in. I now know that it was Dave himself! Well done.

I also see a correspondence item in Radcom about Windom antennas; there had been an article about what was supposed to be a Windom but the authors opinion was otherwise. Its is really surprising how often new ideas for antennas turn out to have been invented in about 1920!

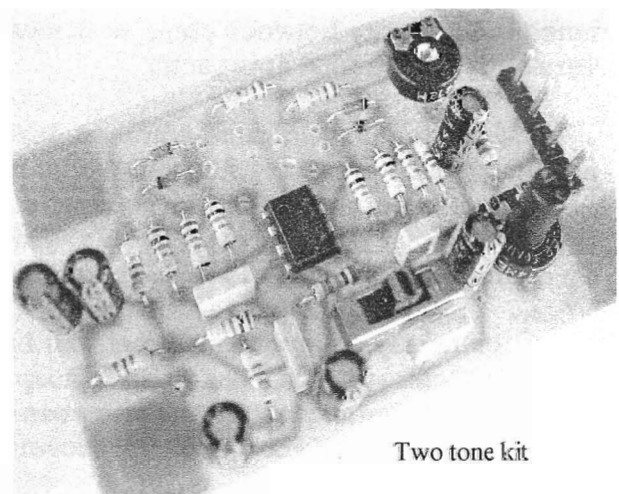
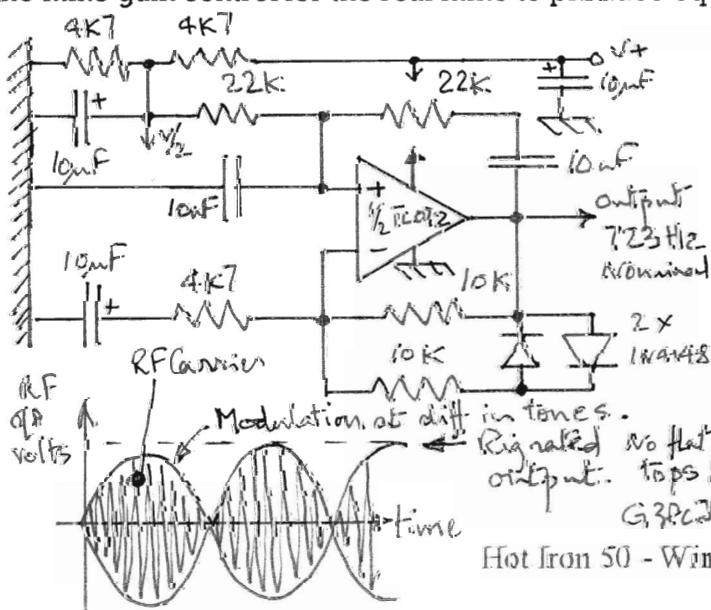
Its hardly an antenna snippet, but I must also report that my good friend and antenna advisor, Eric Godfrey G3GC, has been in hospital for some weeks following a fall. I am pleased to report that he is getting better and was even talking recently about laptops for writing articles in Hot Iron etc!! We all wish you a speedy recovery Eric. Tim G3PCJ

Two Tone Oscillators and setting up a phone rig

Setting up a phone SSB (or DSB) transmitter should ideally be done with an audio signal source that is based on two equal amplitude audio tones. This sort of transmitter has to have linear RF stages so that the amplitude modulation inherent in the modulation process is maintained all through the transmitter. This is not required when ordinary amplitude modulation is applied to the final stage of a CW transmitter. The SSB (or DSB) transmitter stages should be adjusted so that none of them are limiting on speech peaks. If a stage does 'limit' in either direction, unwanted extra harmonics of the audio are produced which appear as rubbish modulation for a few KHz on both sides of the nominal carrier frequency. Limiting of a particular stage can be due to insufficient signal handling ability in either direction; in a negative sense the output voltage can get too close to 0 volts or to the 'hard on' device output voltage - an effect sometimes known as 'bottoming'. In a positive sense, there maybe insufficient voltage excursion range between the normal device output and the supply rail. When the load or DC feed path is inductive, the signal excursion can exceed the supply voltage so the causes are not always obvious! However the appearance on a scope of this sort of poor signal, is always a flat top and or bottom of the signal at its maximum excursions. Using a modulating signal consisting of two individual tones makes it much easier to observe these defects.

Each of the tones in a Two Tone source should be within the normal audio passband and not harmonically related. The signal from each tone should be sinusoidal and they are added together before input at low level to the rig under test. Generating sinusoidal tones is not as easy as it might seem - especially if a wide adjustable frequency range is needed - thankfully not needed in this application! Standard value capacitors and resistors can be used for nominal frequencies of 723 Hz and near 1590 Hz, with a circuit using a frequency selective feedback network based on the Wien Bridge. The easiest way to control the amplitude of each audio tone is with silicon diodes in the op-amp negative input feedback network. The sketch below shows the circuit for the 723 Hz oscillator. The Two Tone kit (photo - £15 + £2) has two oscillators with a control switch so that each maybe used on its own as a signal source. They are added and output at low level for the rig's mike input.

The transmitter is connected to a dummy load with RF output being monitored on a scope. When correctly adjusted, the picture should look like that below, where the RF envelope is amplitude modulated by a sinewave whose frequency is actually the difference in frequency of the two tones. Note this is NOT the ordinary appearance for amplitude modulation - with no audio input the SSB RF output is also zero and there is a sharp cross-over at 0 volts of the modulating envelope. The procedure is to first make certain that the later stages are not causing a flat top or bottom of the output envelope, due to problems in any stage after the one being adjusted. This is generally done by reducing the RF output to a fraction of its rated figure. The gain or drive level in the earlier stages is increased until a flat top/bottom appears and then eased back a little. This is repeated for the next gain adjustment control(s) until flat topping is just avoided in the output stage. This sounds complicated but is actually quite easy when you have tried it once! The peaks the envelope now should correspond to the rig's rated output. If either tone is now turned off, the plain carrier level due to the remaining steady tone should be half the rig's rated output. It is possible to get near the optimum settings with a single tone, but using two makes it much easier. It will be necessary to adjust the mike gain control for the real mike to produce equivalent levels to the 2 Tone source. Tim



Two tone kit

Retirement to Alderney by Chris Rees GU3TUX

Since packing up business last year and our subsequent move to this diminutive island in May, I've had a whole new series of problems to overcome in pursuing my interest in amateur radio. Not least amongst these problems has been a lack of interest! I guess that having had radio as a business has, for me, rather taken the shine off it as a hobby and the progress of technology has taken much of the excitement away as global communication is now cheaply available to the masses. I'm still interested in communication but, like the youngsters, using today's technology in the form of the Internet and its mobile interfaces.

I've redefined amateur radio as a 'heritage activity' – a means of keeping old skills alive. Indeed, I'm convinced that this is the only way to ensure that the hobby survives in the long term, rather like the groups in Oz and the USA who keep the land line telegraph accessible. This new definition means that I shall really only obtain any mileage from the hobby by using homebrew equipment (and QRP CW to boot!). I've brought down here crates of components, kits, aerial materials and just about everything I shall ever need but, for the time being, my shack is limited to a small bureau-like piece of furniture in the corner of the bedroom. We've moved to a small bungalow which has space and potential for expansion, so I'm hoping for a custom built shack later.

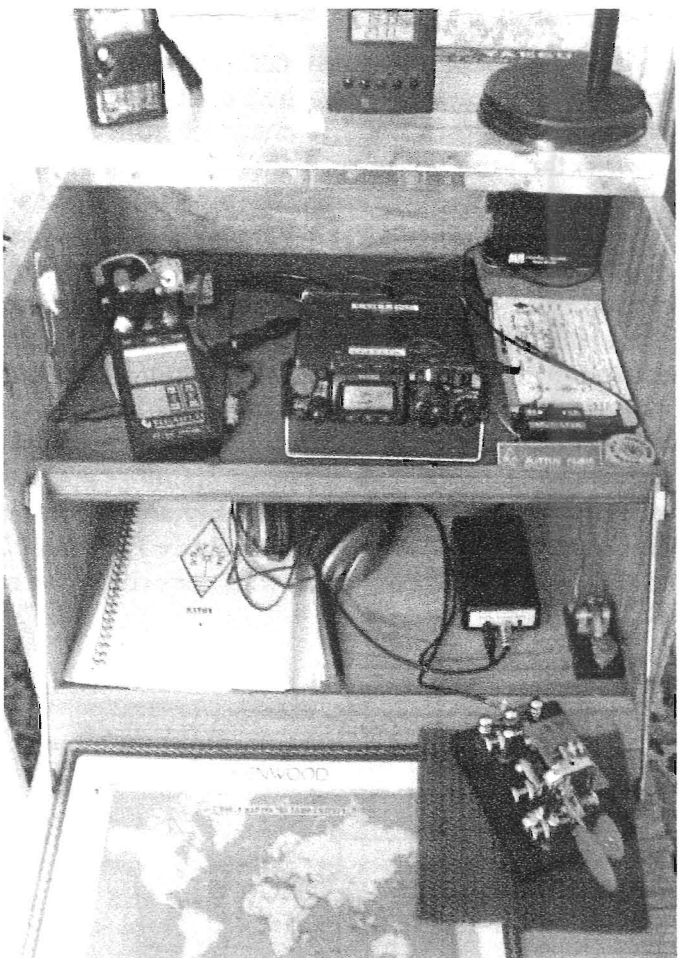
Due to the strength of the winds, Alderney is not well endowed with tall trees and I'm deprived of any natural aerial supports. Our corner plot is exposed to the public gaze so the strict planning regulations mean it is unlikely I'd obtain permission for masts, although I might get away with a flagpole and an inverted V disguised as guy wires. At the moment I have dipoles for 20 and 40m in the loft on a single coaxial feeder which I strap at the base end to load on the other bands.

The rig pictured is an FT817 supported by an Elecraft T1 auto ATU which I built within the confines of the bureau flap. My keyer is also a kit – the TiCK4 which offers a couple of memories and my preferred mode A keying. The other accessory is a simple RX audio filter, adapted from a design by G4BJM in 'Radcom'. This has a LPF to cut down the hiss from the 817's AF stage and a gentle peak for CW operation. I must mention the loudspeaker – it is a MFJ281. Not only is it incredibly sensitive but it also has a noticeable response peak at around 700 Hz. It must represent very good value for money, especially for the CW operator.

I don't have any VHF/UHF aerials in the loft – yet. Past experience suggests that quads are relatively unaffected by adjacent objects and a likely candidate for another home-brewing exercise. Indoor aerials have a number of advantages; they're discreet, they don't have to be wind and rain proofed and - usually - they're easy to install and adjust. Radio lore says that the roof tiles account for a loss of 6 dB versus an outdoor slung equivalent, but this can be a fair price to pay. If you're thinking of trying a nest of dipoles on common feeder, start by pruning the highest frequency aerial first and the LF one last.

I do monitor the VHF/UHF channels on a QRP handheld, the little Yaesu VX1R. The local airport and harbour frequencies provide no little entertainment, especially in dirty weather. The island has relatively sophisticated communications for its size. We talk to the outside world via microwave link to Guernsey. This includes 1 Mb broadband access for private subscribers. A communication profile of Alderney could be the subject for a future article.

Finally, with our locally generated electricity currently costing 17p per kWh unit, QRP is a definite advantage and I'm planning to use solar power for the station in the New Year.

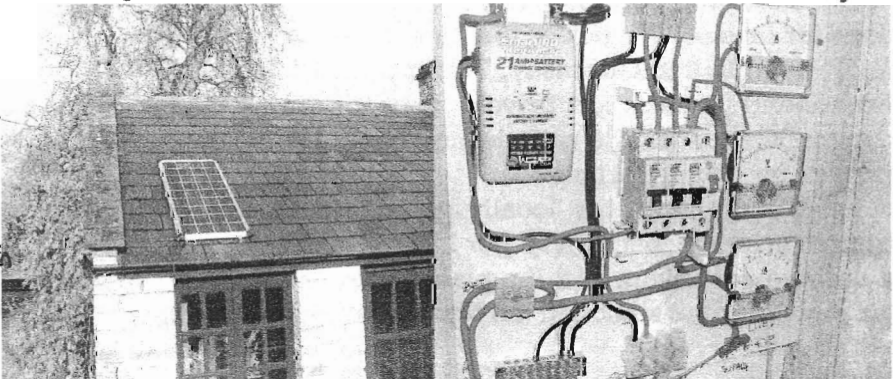
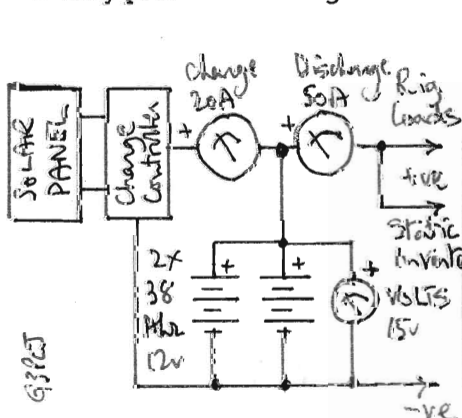


Standby Supplies

There are several important questions that have to be answered before one can design an alternative to the normal 50 Hz mains. Perhaps the first is to decide what loads one needs to cater for, measured in Watts; bearing in mind that not all need be supplied at the same time. Its also important to distinguish between running consumption and start up consumption. (In the case of many electric motor powered items such as fridges and freezers, the starting load maybe many times the running load and also highly inductive so these are best avoided if possible. Interestingly, central heating pumps do not seem to be a problem - perhaps because they are not genuine induction motors.) My primary concern was to keep a gas powered cooker supplied for its fan and electrically controlled gas valve, with a secondary objective of running the central heating - again gas powered but with electric controls and three pumps. The load of the cooker is about 25W, the central heating controls and boiler about the same and each of the three pumps about 75W. So I was considering a normal load of around 100W rising to perhaps 300W if all were on at the same time.

There is no need for these to have un-interruptible 50 Hz provided by a continuously running inverter. (Computers are very different as they should be turned off in an orderly manner.) The cooling time constant of all these heating loads are of the order of an hour so, giving plenty of time to reconnect to the standby source using ordinary 13A plugs and sockets! I reckoned that having to power all for more than a few hours was unlikely but I might conceivably need 24 hours at the lower 100W level. I wanted 12v lead acid batteries for storage so that I could also run the electronics bench from them. The inverter load of 100W would imply a 12v DC of around 10A allowing for small inverter losses. This suggest that batteries with 240 Amp-hr capability should be provided. That's a lot of battery, especially as the deep cyclic discharge type are advised for this application (not car or tractor types); they are comparatively expensive so I opted for two 38 Ahr ones connected in parallel. I chose a 600 W 12v DC to 240v 50 Hz inverter as there might be uses for it around the farm to power hand tools etc. (As an aside, most commercial static inverters now produce a modified sinewave output that is neither truly sinusoidal nor a square wave - these have a lower harmonic output and are suitable for most domestic loads. They work by producing high frequency AC (to reduce the transformer size) which is then rectified to produce plus/minus 350v DC, which is then chopped for 240v 50 Hz output.) When put to the test recently due to a burnt out local 11 kV substation transformer, the inverter input current was 5A when powering only the cooking stove - fine for at least 16 hours. Beyond that, I can use a 5 kW diesel engine powered generator!

The battery bank is charged from a barn mounted solar panel. This was more convenient (lower) than the house roof and also pointed in the optimum direction but was distant so relatively heavy cables were prudent to minimise IR losses. Again cost dictated the panel size! A nominal 100W panel is about 2 ft by 6 ft and it attempts to charge even in the weak morning frosty sunlight. At midday in bright winter sun it is producing 4 Amps - half its nominal rated output. Depending on cloud cover etc, it will take some days to recharge the batteries when totally discharged but for powering the electronics bench, it is more than enough. A charge controller is used to prevent overcharging. Because this installation was 'experimental' I over egged the panel meters and added MCB trips to protect against the lengthy cables being damaged. The outline circuit is shown below - plus pic! Don't ask what it all cost! The trickiest practical bit is installing the solar panel on a slated or tiled roof. The supplied stainless steel brackets were an unsuitable shape, so flattened 22 mm copper tube was used, suitably solder tinned to avoid corrosion where it touches the aluminium panel frame - as advised by Andy Howgate. The brackets need securing to the roofing battens so they protrude through the roof covering. The metal work was then covered in Waxoyl. G3PCJ



Theory - CR Coupling circuits

These sums are probably the most often used ones that an analogue circuit designer will require. They relate the size of input and output coupling components to the bandwidth of signals that they will pass.

The top circuit is said to be a high pass coupling network because it will not pass DC and yet, the higher the frequency, the less the attenuation there will be. In between those extremes, the response changes markedly when the reactance of the capacitor is near the value of the resistance. The capacitor might be the input coupling capacitor of an amplifier (to prevent the external circuits altering the device bias conditions), and the resistor might be an actual resistor or, more likely, the parallel combination of the bias resistors and device input impedance. Consider the response for sinusoidal input signals. The C and R form an attenuator, and making the simplifying assumption that the driving device has a negligibly low output impedance and also that the following circuit (amplifier or whatever) has a very high impedance, it is easy to work out the output voltage in terms of the impedance Z of the capacitor:-

$$V_{OUT} = V_{IN} \times \frac{R}{R+Z}$$

From an earlier note on capacitive reactance, you will recall that:-

$$Z = X_C = \frac{1}{2\pi fC}$$

Substituting this into first formula gives the output level in terms of frequency:-

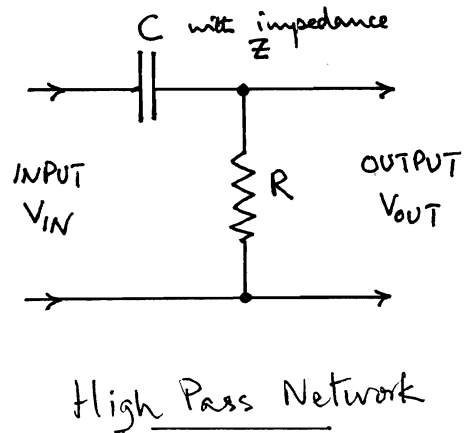
$$V_{OUT} = V_{IN} \times \frac{2\pi fCR}{1 + 2\pi fCR}$$

From this it is easy to show the output level is down to 0.707 of the input when the capacitor's reactance is equal numerically to the resistance. This corresponds to the output being 3 dB down (voltage - not power) compared to the input and is the point which is commonly taken as 'the bandwidth' - in this case being the lower limit since it is a high pass network. One can easily turn this around to determine the capacitor size needed to ensure that all signals above a given frequency are passed with less than 3 dB of attenuation:-

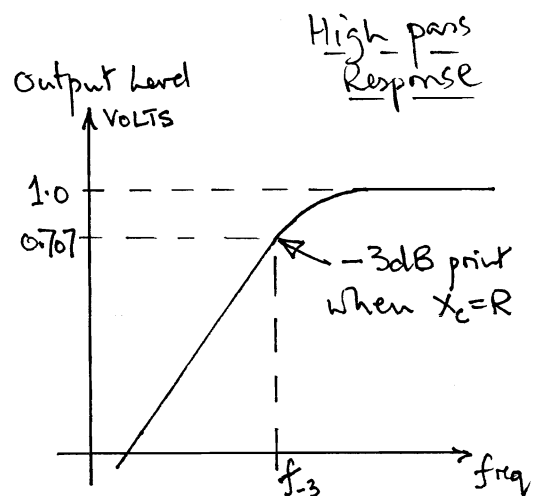
$$C > \frac{1}{2\pi fR}$$

C in Farads
f in Hz
R in Ohms

The same formula(s) can be used to determine the size of the required an output coupling capacitor in terms of the lowest frequency to be passed and load of the next stage. Very useful stuff! Tim G3PCJ



G3PCJ



G3PCJ

$$C > \frac{1}{2\pi fR}$$

with C in Farads
f in Hz
R in Ohms

can be changed to:-

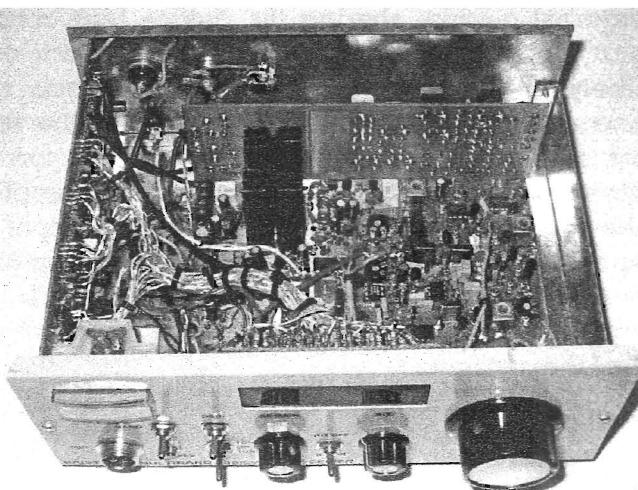
$$C > \frac{1}{2\pi F\Omega}$$

with C in uF
F in MHz
Ω in Ohms

G3PCJ

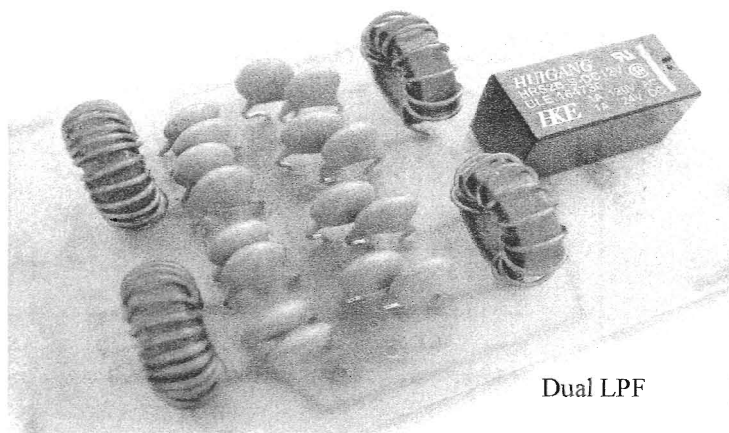
Boxed Bristol

Following my tradition of building things just as they go out of fashion I recently completed my take on the Bristol project. I think the main board layout is a work of art. (What about that cable-form then?! Tim) The completed rig has now become my main HF transceiver and I'm very happy with the end result. Just a few modifications were made to the original specification; I replaced the tuning pots with a single 10 turn type and changed the switched filter wires with screened leads. The 5 digit counter uses larger 0.56" displays. I found that add/subtract connection between the counter board and main PCB also needed to be screened due to interference from it on 10 meters. This most likely though is due to my choice of vertical position for the counter PCB. The case used is supplied by CPC. They sell a range of nice looking dark grey/blue powder coated steel cases with plain aluminium front panels and ventilation slots for between £5 and £11 depending on the size of the case. This is the largest version which is 225 x 175 x 89 mm. CPC code EN81242. The front panel after drilling and several hours of filing to make the slots clean was then sprayed with white primer, and a few hours later with the top coat of car aerosol beige. The labels are laser printed onto acetate and stuck in place with a pritstick type of adhesive. This dries transparent and allows you to move the label around a bit before the glue sets. Any excess can be wiped off with a damp rag without spoiling the paint work. The display filter is made from red lighting acetate sheet, to stiffen this up I glue the acetate to a piece cut from the front of a CD jewel case. Hope to hear you sometime on HF! Richard Booth, G0TTL

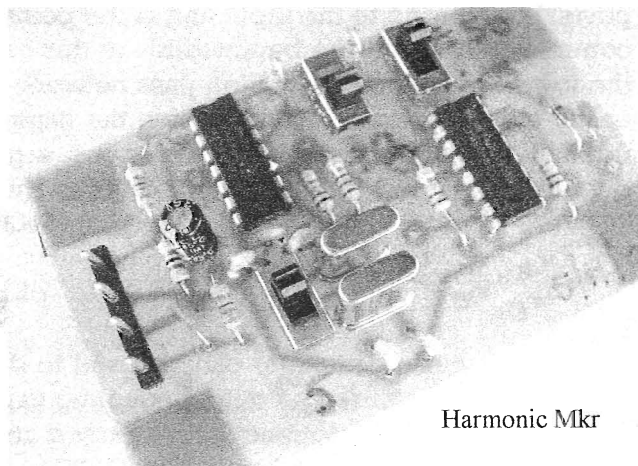


The Somerset Supper and Yeovil QRP Convention

I am planning the second supper to be held on April 8th 2006 in Sherborne for locals and those staying overnight. This is the evening before the Yeovil QRP Convention scheduled for April 9th in the Digby Hall. The convention will have the usual array of interesting talks, trade stands, bring and buy stalls etc., so is well worth while coming - why not make it a weekend! As before there will be a small display of items from each diner's home built radio equipment! Your entry must be different from last years ticket! (Please also bring a QSL card or label.) This will qualify you for a *free* place at the supper table! The competition will this year be judged by Steve Hartley, the well known author of many amateur radio books who writes the Newcomers column for Radcom. He will decide how to judge it and his decision is final! You buy your own drinks. I do plan to a take a photo or two for publicity purposes but this will not intrude into this *social* event where all (including XYLs) will be very welcome. A minimum of formality! Places by advance booking **only** by Mar 28th so please get in touch soonest via walfor@globalnet.co.uk letting me know names. Places are limited - first booked secures their place! Hope to see it and you! Tim G3PCJ



Dual LPF



Harmonic Mkr

Hot Iron

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Issue 51

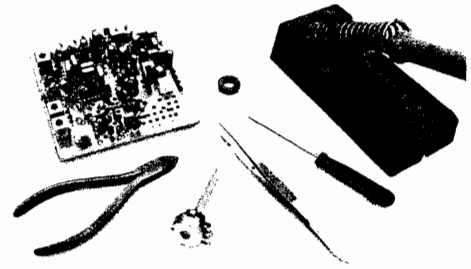
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Universal Supplies
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Snippets
Somerset Supper

The Walford Electronics
website is also at www.walfordelectronics.co.uk

Editorial

My mind is still in neutral due to the cold (again) and colds! I am longing for some warm Spring sunshine to lift our spirits and get out to those outdoor tasks. I am glad to say we have not burnt out any more 11 kV local mains transformers! However the recent energy price rises does make me wonder if I should expand the solar plant and have a 50 Hz inverter running continuously for lighting loads. I just wish the cost of solar voltaic panels would drop significantly, particularly the sort that can be made into the roof's waterproof covering. It cannot be long before most new south facing houses have them a standard. The greatest physical challenge (for existing roofs) is to mount and properly anchor the panels on top of the tiles, slates or whatever without breaking the water barrier. Corrosion and cleaning are further important matters for such long term investments. Fortunately, for most self build radio design projects, total energy consumption is not a major design criteria but it is vital for modern commercially made electronics. Hence the keen interest in improving power supply efficiencies and the resulting desire to move away from 'linear' regulated supplies. See later, Tim



Kit Developments

I seem to have been typing instructions or articles for publication non stop on this machine since the last Hot Iron! The revised website is active and will have a few more extras added shortly. Meanwhile the new relay selected twin BAND pass filter is available - the standard kit does any pair of amateur bands, 20 to 80m, but with other part selections, it can do any 'band' in the HF spectrum. In due course this and other modules can be used to make up a two band RX. I have also built the prototype Mk 2 Signal Generator, its fine but I need to also try out the two band VFO aspects of it.

I have also completed the new Supplies kit; a single set of parts does the timing for two uses - firstly as a Static Inverter, or alternatively a Supply Booster. The Static Inverter will produce 50 or 60 Hz mains from a nominal 12 volt DC supply and the devices are suitable for driving a transformer rated at up to 200 VA. There are many possibilities to use whatever you have to hand so the transformer is not included - apart from its cost & postage! When used as a Supply Booster, it can nominally double a 12 volt supply to 24v (off load), or around 20v delivering 2 Amps. It can alternatively generate a negative 12 volt line giving up to 2 Amps. It has a simple form of maximum voltage regulator and does not need a transformer since it uses a charge pump technique. Tim G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics— is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

High Attenuation Attenuators by Gerald Stancey G3MCK

The function of an attenuator is to provide a controlled amount of loss in a matched impedance system. The usual configuration is either a pi or T network, see right. The choice of configuration usually depends on the components that are to hand. These attenuators only introduce loss into the circuit; they do not change any impedances. Consider a signal generator whose output impedance is 50 Ohms and is connected to a 50 Ohm load. Adding an attenuator between the generator and the load will only introduce a loss into the circuit. The generator will still be looking into a 50 Ohm load and the load will still be being fed from a 50 Ohm source.

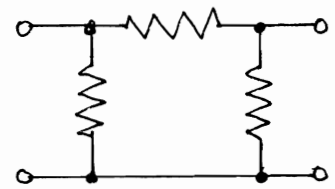
Attenuators are designed for use in systems of a given impedance. This means that an attenuator that has been designed for use in a 50 Ohm system cannot be used (sensibly/accurately) in a 75 Ohm system. The usual handbooks give values for the resistors that are needed for the most commonly used attenuations and 5% tolerance preferred values are usually satisfactory for amateur use. Attenuations can be simply added, irrespective of the form of the actual circuit - pi or T. If you need a 9 dB attenuator, all you need to do is put a 3 dB attenuator in series with a 6 dB attenuator. It is usual to build them in screened boxes and toggle switches are satisfactory for switching them out at HF and low VHF. Again, good examples of construction are shown in many of the handbooks. (I intend shortly to be offering low cost 50 Ohm attenuators that will do 0 to 20 dB in 1 db steps - Tim.)

It is customary to limit the attenuation of any one section to no more than 20 dB. This is done to make sure leakage around the attenuator is much less than the intended loss. However there are times when you just want to put more than 20 dB of attenuation into the circuit but are not too bothered about either the exact amount or impedance. In this case a short cut can be used to calculate the main series resistor value - R of the pi form. R is assumed to be appreciably higher than either the load or source impedance and they are matched by the 'fixed' 50 Ohm resistors at each end. The formula right gives the attenuation in terms of R; this can then be turned around to find out what value of R is required for a given attenuation. For example, in this 50 Ohm system, when R is 1K, then the attenuation will be 32 dB. Normally the value of both resistors labelled r, would ideally be just greater than the system impedance; in practice they can be whatever is to hand in the range 47 to 56 Ohms. Such an attenuator can be lashed together on a piece of PCB material as it is not meant to be used in a precision manner.

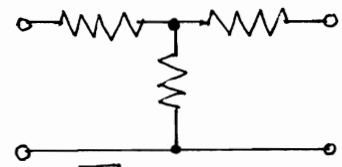
Connectors for RF coaxial cables

I have been trying to decide what type of connectors to use on the new bits of test gear (attenuators, power meter, amplifiers etc) that I have in mind. As you might guess, these will have an 'open' style of construction to reduce their cost, so PCB mounted connector versions are needed! PL259 types are far too clumsy, relatively expensive when new, and I have yet to see PCB mount females. For preference/quality, I would use 50 Ohm BNC types but they are pricey and not too easy to assemble without special tools. I have long used the standard Belling Lee style UK TV 75 Ohm types, although made for 75 Ohms, they are acceptable for 50 Ohm HF work; but being made of aluminium, they eventually corrode.

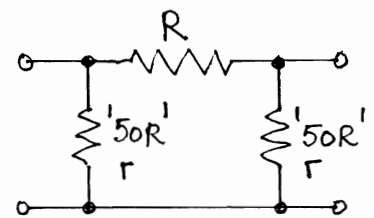
The only other possibility that I have found so far, are the RCA phono type. They are cheap, have PCB mount females, and appear to use plated steel rather than aluminium. They are partially screened but without a fully symmetrical coaxial form. Originally intended for audio work, no impedance figure is quoted. They should be quite adequate for most HF amateur use and are my current favourites. I shall be glad to have any other suggestions - but quickly please!! Tim G3PCJ



Π attenuator



T attenuator



High Value attenuator
where:-

$$\text{Attenuation (dB)} \\ A = 20 \log \left(\frac{R}{25} \right) \\ \text{eg. if } R = 1\text{K}, A = 32\text{dB}$$

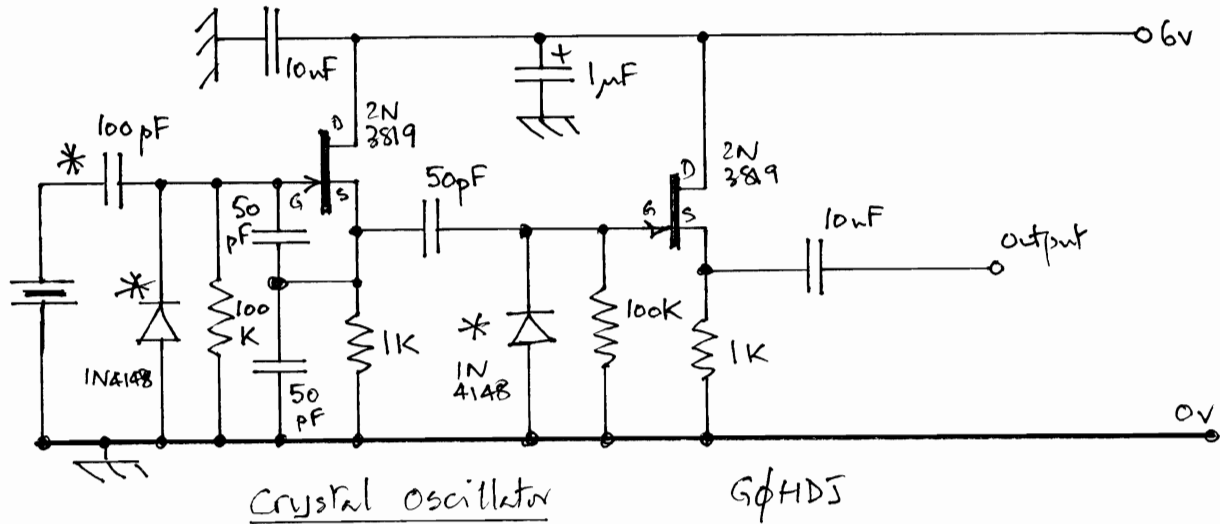
$$\Delta R \\ R = 25 \times 10^{A/20}$$

$$\text{eg if } A \text{ desired} = 30\text{dB} \\ R = 25 \times 10^{30/20} \\ = 25 \times 10^{1.5} \\ = 25 \times 31.6 \\ R = 790R$$

G3MCK

A reluctant oscillator! Prompted by Craig Douglas G0HDJ

Craig explains that he wished to use the crystal oscillator circuit below to set up a receiver on different bands but was puzzled because it 'didn't want to oscillate at the correct frequency on 10m. Perhaps you could comment on this?' Talk about difficult questions!!



From Craig's words I infer that it works as expected on other frequencies but that when he changes to his 10m crystal, something is wrong. I have no information on the crystal but it might be an overtone type since 28 MHz is relatively high for a fundamental type. Fundamental crystals are certainly possible to 40 MHz but are a relatively recent development over about 25 MHz. If it is an overtone type, which means that its fundamental will be near an odd sub-multiple, mostly likely 3 in this case, implying a fundamental of 9.33 MHz or thereabouts. The circuit has no parts to suppress its fundamental oscillation mode so, if it is a third overtone type, it would run at near 9.33 even if marked as 28 MHz. What is its actual fundamental output frequency? Even if the third harmonic is audible at near 28 MHz, it would not be exactly correct since the fundamental of any overtone crystal is always slightly off the exact sub-multiple. (Crystals marked for even higher frequencies might be third, fifth or even seventh overtone occasionally.) Adding a series trap resonant at the fundamental across the crystal should stop it, but would make the circuit useless for a wide range of crystal frequencies!

The next, but much lower probability, is that something in the circuit does not like running at 28 MHz. There are three slightly suspect items. Firstly, if it is supposed to be a parallel resonant sort at 28 MHz, the commonly used load capacitance should be 30 pF in parallel. (It might be a series resonant sort but this should still work but at a slightly off frequency.) The absence of the normal load capacitance does not mean that it will not work, but that it will not run at the plated frequency. In this circuit the load capacitance is 100 pF in series with two 50 pF in series, which if you do the maths, is 20 pF so it would tend to run at a higher frequency than expected. I would suggested omitting the 100 pF in series with the crystal and up the two Collpits capacitors to 56 or 68 pF. The next oddity is the diode across the crystal - it is there to help stabilise the oscillation amplitude but I think it's the wrong way round! Its presence, when the right way, should be fine. (You could try omitting it to see if it then runs.) The other suspect item is the second diode on the gate of the buffer stage. I cannot see any reason for including it! I doubt that its presence will prevent the oscillator from running! All it does is alter the buffer stage bias when the oscillator is running.

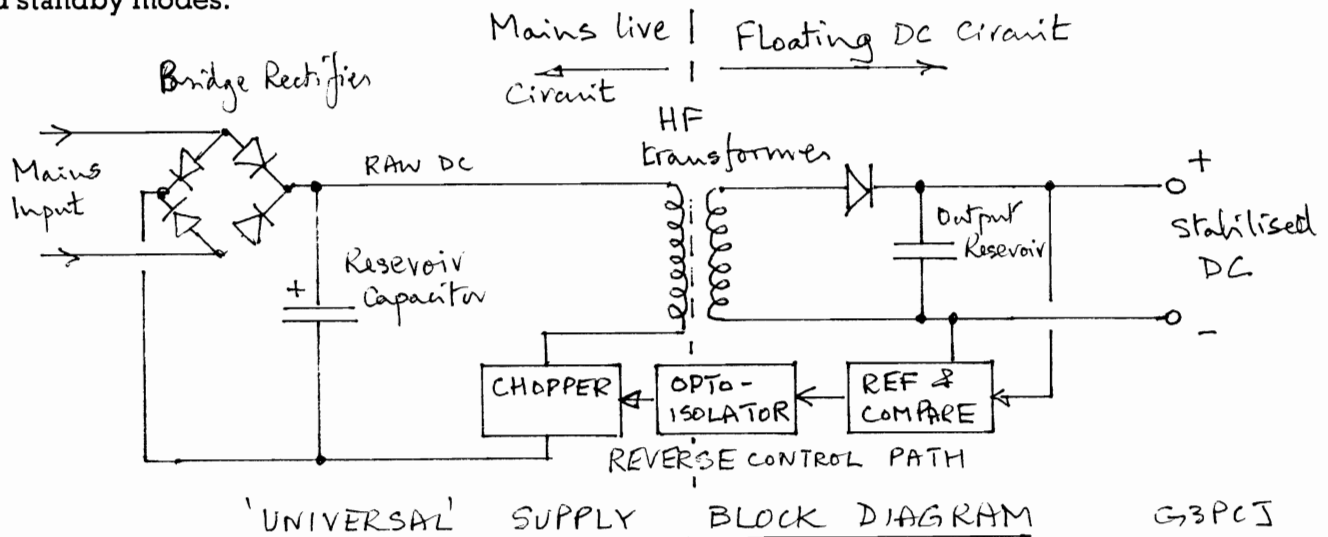
Just to fill the page, I recall that somebody has suggested using low voltage valves as the way to make very stable oscillators - on the basis that there is very little change in inter-electrode capacitance with temperature. The electrode capacitance is of course part of the tuned circuit and would influence frequency. This is a valid comment but usually the amplifying device is loosely coupled to the tuned circuit in any oscillator so the effect of its capacity changing will be diminished. In my opinion it is far more important to make certain that the main tuned circuit L and C are really high quality low temperature coefficient items. That means ceramic formers and air variables! Both are becoming increasingly rare and or expensive! Tim G3PCJ

Universal Mains Supplies

Many modern mains powered electrical gadgets can be used on 'any' type of mains supply! No longer do you have to adjust the tapings on a transformer to cater for American or European voltages, or even frequencies. These items are designed to run on anything between 110 and 250 volts with either 50 or 60 Hz! I suspect they are also quite able to use 400 Hz which is sometimes used on aircraft or ships! They might even be able to use the old 16.67 Hz standard that was used in much of Europe in the 1930's but that is less likely! How do they cater for such a wide input range!

The key is that they generate a high voltage DC supply direct off the incoming mains, without any mains transformer, consequently this voltage might be anywhere between about 150 to 350 VDC. They have a reservoir capacitor large enough to cater for the lowest input frequency without excessive ripple. This DC supply is then chopped at a much higher frequency, often in the tens to hundreds of KHz range, and applied to a small high frequency transformer. The output of the secondary winding(s) are then rectified and smoothed for the desired output supply rails. Clearly without further clever circuits it would have very poor regulation! So the output voltage is compared to a reference and a control signal fed back to modify the chopping process feeding the high frequency transformer. If the output voltage is too high, the chopper is stopped until it gets too low, when it is restarted etc.

Unlike the old valve radios that did not have a mains transformer, with the supply neutral connected directly to the radio's chassis (with potential safety issues), the modern unit depends on the small high frequency transformer for mains safety isolation of the forward power path. The reverse control low power path has its mains safety isolation provided by an optically coupled isolator. In consequence, be very careful when investigating faults in modern PSUs because most of the circuitry is at mains voltages, and with high DC values on top! Furthermore their control loops make it very difficult to decide what stage is faulty - so often the most sensible approach is to buy a new one! The block diagram below shows the principle elements; in reality they are often somewhat more complicated to provide extra facilities such as input power factor correction, shutdown and standby modes.



Interestingly, the approach of high frequency chopping an incoming DC supply to generate a much higher DC voltage is widely used in static inverters. The internal high voltage lines are + and - 350v (for a nominal 250v RMS output), which is then chopped at 50 Hz into a pseudo sine wave output - actually positive and negative rectangular pulses with gaps between them so that the RMS voltage is similar to a genuine sine wave but without excessive harmonic content.

In pondering how to better utilise my free solar power (at 12v DC), I contemplate stepping this up to 250v RMS at some much higher frequency than 50 Hz to minimise the transformer size. Ordinary incandescent light bulbs could use this direct but conventional fluorescent lights would not like the higher frequency. I am not sure what the modern long life miniature bulbs would do with a MF input! If they have chokes to limit their current, there is an obvious problem; but they would be alright if the incoming supply is rectified first to generate a high voltage.

Anybody know what is inside a modern long life bulb?

Tim G3PCJ

Stable VFO for 20/30/40m By David Proctor G0UTF

For years, I built and used VFOs usually for one band at a time. They worked fine, but going above 7 MHz was rather dicey as they were not too stable. After many years I went to crystals and was amazed at their stability. More recently, frustrated by their lack of range, I set my mind back on building a VFO that didn't drift "too much". This effort consists of a 2.0 - 2.2 MHz VFO mixed with 5, 8 & 12 MHz crystals via a Walford mixer to give 7, 10 & 14 MHz. Of course you can do other bands with more crystals & filters. The VFO result is quite pleasing, drifting less than 10 Hz in 1/2 an hour. The VFO circuit is shown below - I haven't got round to the rest yet! Some will say it is too complex but I had all the bits in the junk box, and I don't intend building lots of them. Using a small die cast box there should be few hot spots, and even the KANK coil is strapped to the metal. The total power dissipated is 130 mW and this could be reduced by a remote regulator. The whole transmitter is as yet incomplete but it may sow a few ideas in readers minds. With better components, it could be more stable.

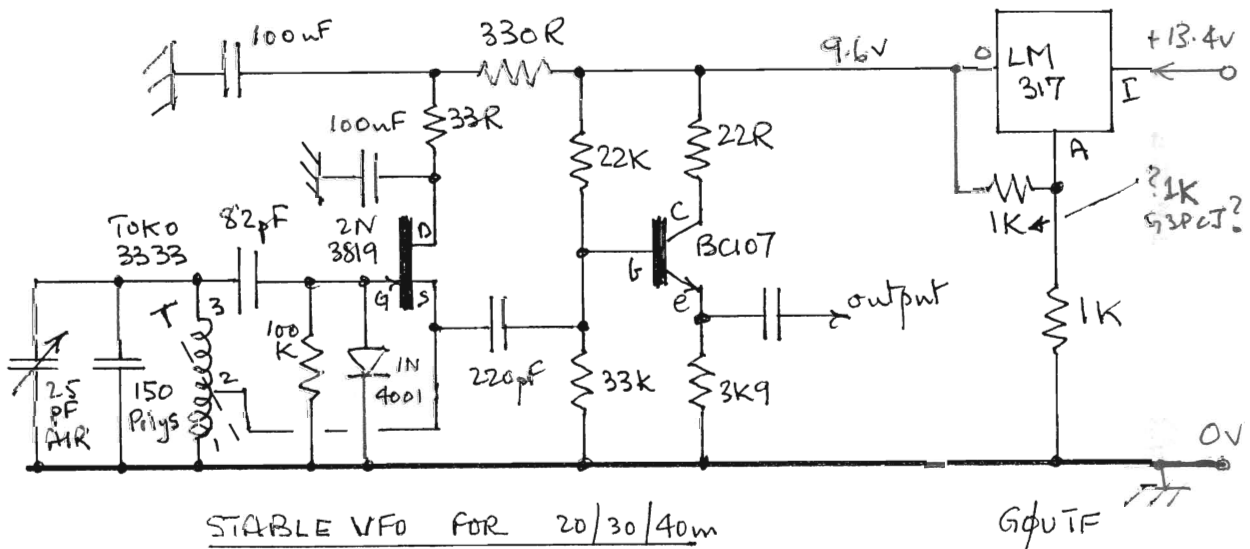
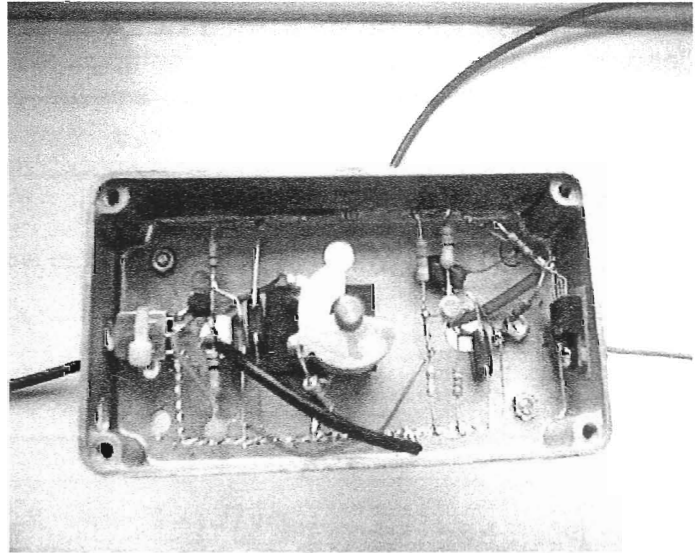
Run 1

Mins after on	5	10	15	20	25	30	45	60
Drift (Hz)	0	-5	-2	-6	-1	-9	-9	-4

Run 2

Mins after on	5	10	15	20	25	30	35	40	60
Drift (Hz)	0	10	17	23	28	33	36	39	43

(David explained that both these sets of figures were taken with an initial 5 min warm up period during which drift was ignored. Run 1 was done in a stable temperature condition. Run 2 was done as his central heating was coming on and has convinced him that he should have a water cooled VFO to keep it at constant temperature! Even so, these are good figures! Tim)



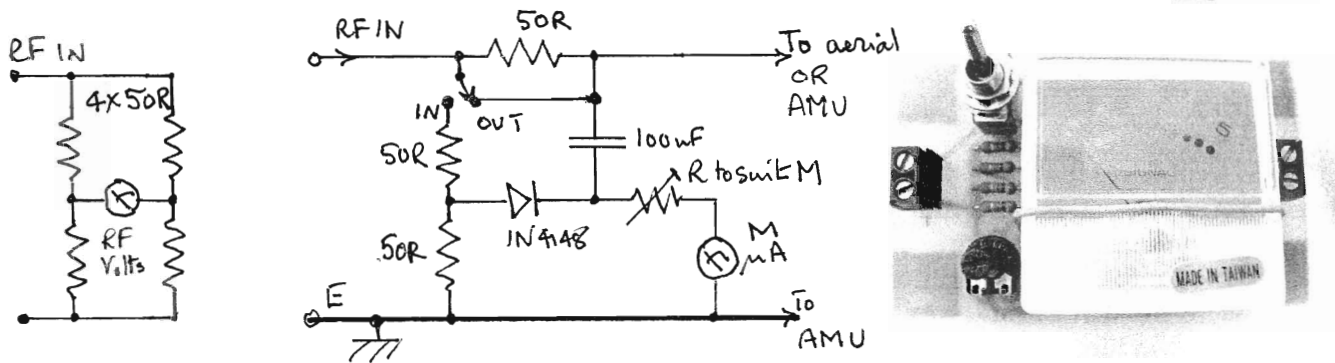
CW and VFOs

For direct conversion CW rigs, the receive and transmit frequencies of the VFO need to be different in order to generate a received audio beat note. Hence there is usually some form of automatic tuning offset for reception only (RIT). Arranging this tends to degrade the intrinsic stability of the VFO and is seldom compatible with a simple Huff and Puff stabiliser - if one is contemplated. Using a single sideband 'phone' type TX superhet with an injected CW tone overcomes the Huff & Puff incompatibility because the VFO frequency does not change. Its no longer essential to have RIT but it's a useful feature in any rig! You can Huff & Puff stability, or RIT, but seldom both! G3PCJ

Mini Bridge

The kit designs below are derivatives of the standard AMU. I have split it into two units (matching indicator and antenna matching circuit) so that each fits onto a 50 x 80 mm PCB, to match the **Kilve/Kilmot/Kilton** single band rigs. Each is £19 + £2 P & P, or both £38 inc P & P.

The Mini Bridge is a 50 Ohm resistive bridge where the antenna is connected instead of one of 'four' bridge resistors. If all four were exactly 50R, the bridge is said to be balanced and the voltage across the mid points (as shown left below) would be zero - hence we need a circuit that detects when there is least voltage between these mid points. This can be done with a simple RF voltmeter. After the bridge has been used to indicate the best match obtained by adjusting the AMU controls, the bridge circuit is switched out, but the detector remains connected to the antenna thus showing output RF voltage, or power with a square law scale. The preset is adjusted for full scale deflection with the bridge out of circuit while feeding rated TX power into a 50R dummy load; then with the bridge in circuit, the maximum reading will be half scale for an extreme open or short circuit antenna load. The load on the driving TX has to be between 33R and 100R, so will always be a safe load, irrespective of the actual AMU settings. With the bridge in circuit, you adjust the AMU controls for the lowest indication, (all four 'resistors' equal 50R), and then switch the bridge out. G3PCJ

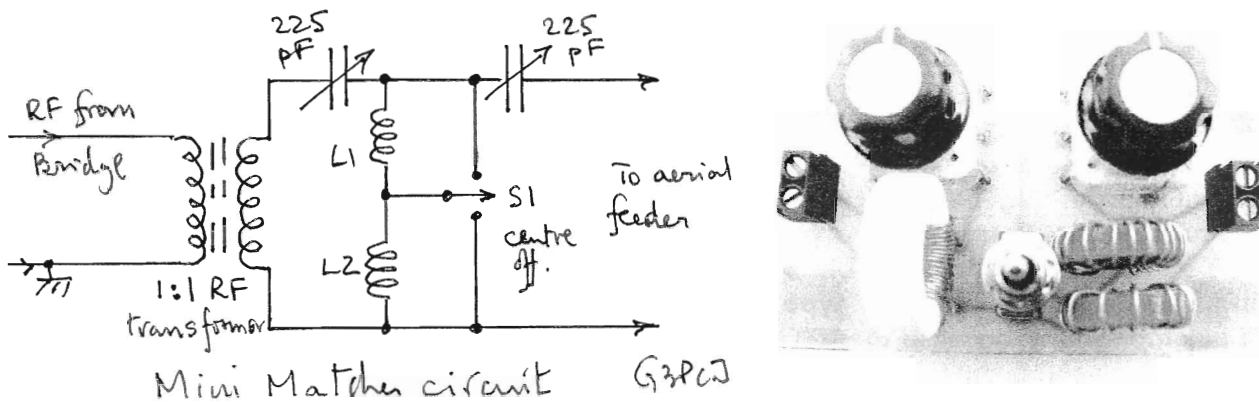


OUTLINE OF BRIDGE CIRCUIT

G3PCJ

Mini Matcher

This is a simplified version of the T match part of the AMU, with a restricted inductance range to cater for a single band. The two inductors are wound to suit the chosen band and probable feeder impedance. The standard capacitors should suit all bands 10 to 80m; 160m might need extra fixed C. The T circuit can cope with a wide range of loads, and although not fully balanced, it can drive a balanced feeder/aerial system because the input RF transformer 'isolates' it from the usual unbalanced output of a transmitter. If the aerial is genuinely unbalanced, e.g. quarter wave vertical against RF ground, then the input 1:1 transformer can be omitted. (Beware mains/RF earth isolation aspects.) Because the complete circuit is bi-directional, you can reverse the signal flow through the unit, with the RF transformer on the output driving a genuinely balanced feeder. However, this is not really recommended because the transformer will work better if it has a resistive load - this is less likely with a reversed signal flow unless the antenna is actually matched to the feeder impedance properly (which is seldom the case!), to prevent there being any reactive component being passed through the RF transformer. The normal, and preferred, signal flow from transmitter through RF transformer to matching circuit, does have the transformer working with a resistive load. The radiation pattern is likely to be disturbed by other metalwork in the near field anyway!



Mini Matcher circuit G3PCJ

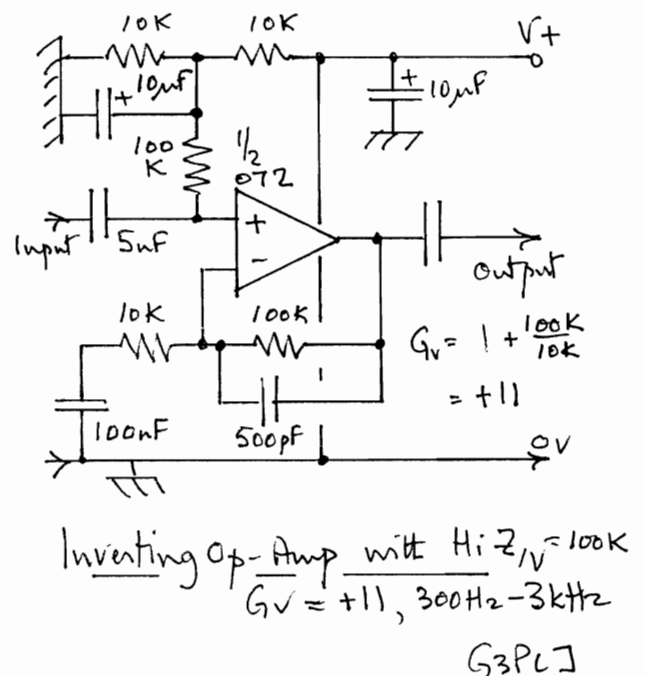
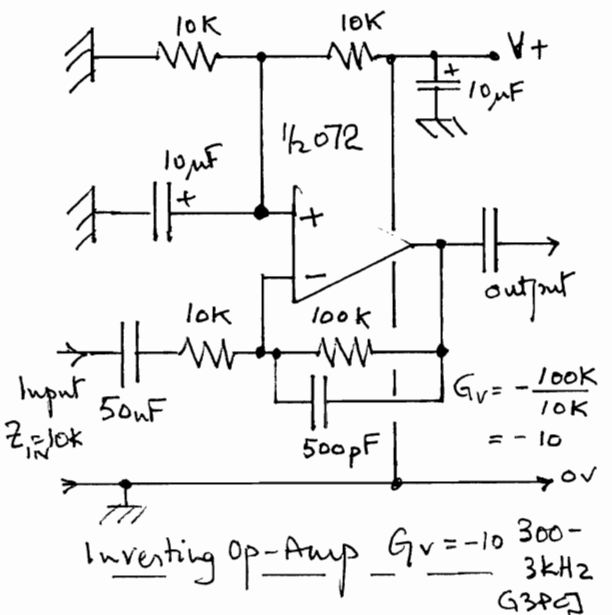
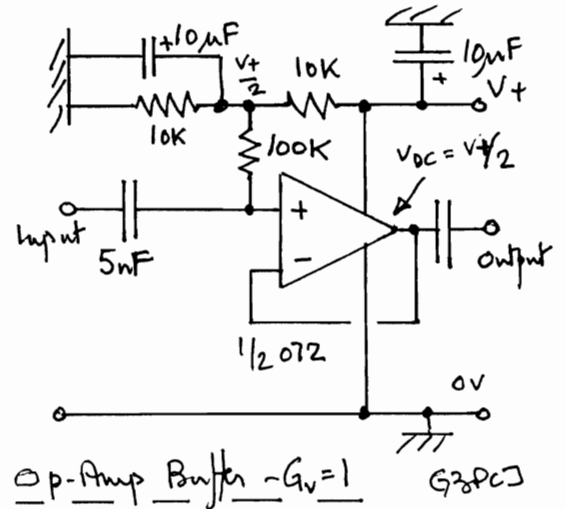
Theory - Using Op amps

The first thing is to select one that is designed for the anticipated supply voltage. The common TL072 type that I use liberally, is a dual low noise type suited to audio applications and comes in a plastic package with a supply range of about 5 volts to 30 volts. The next point to consider is the biasing, to make the output settle at the desired DC output voltage - often half way between the supply rails. The device will usually have both positive and a negative signal input terminals. A positive going signal on the positive input will make the output go positive; a positive going signal on the negative input will make the output go negative. The actual input bias currents are often so small that they can be ignored. A convenient approach to biasing is to feed the negative input in a DC sense (but not necessarily AC) direct from the output without any form of attenuation; the DC output voltage will then directly follow that applied to the positive input. Where 0 volts is the negative supply rail, then a 'pseudo' mid rail supply is often used to set the output voltage by applying this mid rail value to the positive input. This leads directly to the very useful *buffer* circuit shown top right. This has a high input impedance and a low output impedance with unity voltage gain. The upper bandwidth limit is hundreds of KHz. The low frequency limit is determined by the input coupling capacitor and the bias resistor - about 300 Hz for the example values shown.

The middle diagram shows a typical AC coupled audio inverting amplifier. It actually has a voltage gain of 10 and a bandwidth of 300 Hz to 3 KHz. The gain is defined by the ratio of the two resistors, literally the feedback one divided by the input one! The output impedance is low (often less than 100 Ohms) and the input impedance is the value of the input resistor! This is because the junction of the resistors at the negative input is a virtual earth, having negligibly small audio signals owing to the very high gain of the internal amplifier. The low end response is determined by the input CR and the upper response by the feedback CR. The negative sign means in and out are out of phase.

The final circuit is a variant of the middle one above, where a higher input impedance is required and it is acceptable for the input and output to be in phase. The gain is now still highly dependent on the resistors at the negative input but to their ratio you must add one! The lower end bandwidth is now dependent on both the negative 'input' decoupling cap and the positive input coupling. (Think about the very first circuit above without negative input resistors, so their ratio was zero but adding 1 for the use of the positive input gave the correct gain of +1. The plus meaning that in and out signals are in phase.)

Not really much need for fancy maths or the calculator to work out the gains! Bandwidths are all the usual CR sums! Tim G3PCJ



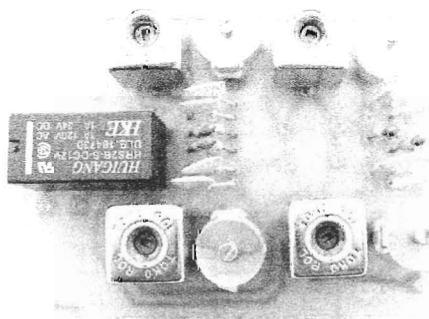
Snippets

Lithium batteries Dave Buddery passes on a tip from his son who is in the oil industry, and hence rather conscious of safety matters, that these batteries are prone to self igniting if allowed to discharge too quickly. I hazard a guess that discharging should be limited to their 1 hour rate max. This would imply a current numerically no greater than their storage capacity in Amp-hrs.

Huff and Puff stabilisers David Proctor asks if I ever contemplate a stabiliser kit that could be added to a builder's VFO to improve its frequency stability. This is a project that I have often considered but never tried. An early customer, who is not any longer a member of the Construction Club - otherwise I would get him to write something on it, spent many hours trying to stabilise a varactor tuned VFO and eventually gave up. I think this was because his particular VFO design was prone to small jumps or changes in frequency (but not sufficiently large to hear), due to temp, supply or other variations affecting the tuning diode, which were comparable to the finite size of the control steps of that particular stabiliser design. Since large capacity varactor diodes have become like hen's teeth, leading to the use of PolyVaricon tuning capacitors, I will re-examine this topic.

40m phone crystals Several of the new simpler transmitters require an actual crystal for the oscillator on bands above 80m, this is because ceramic resonators are not stable enough as frequency rises. Luckily I have found a low cost source of 'standard' value 7159 KHz crystals so that you can now use them in the extended phone part of the 40m band. £2 +£1 P and P.

Lead free solder A messy situation! Many components are going extinct as manufacturers change their processes to cater for the desired abolition of lead products in electronic goods from about now. Solder is the main concern. There are plenty of substitutes but they nearly all require higher temperature soldering irons for the making of satisfactory joints. Interestingly, the military and certain other organisations have obtained exemptions where extreme reliability is demanded. It is also permissible to use normal 60:40 tin-lead solder to repair equipment which was made with that material. It seems likely that 60:40 solder should be available for some time to come.



The photo is a relay selected dual bandpass filter, this one has a 20m filter on the right and an 80m one on the left. The inclusion of trimmers makes adjustment slightly easier and will also allow for toroidal cores when eventually TOKO 333X series are extinct! The relay has two alternative positions, for nominal 50R in & out, OR nominal 1K5 in & 50R out for the in/out impedance of 612 mixers. The filters are actually bi-directional so it can be 50R in and 1K5 out OR 1K5 in and 50R out. Both bands have to use the same impedance setting of the relay. A single set of parts is supplied for the normal amateur bands 20 to 80m but it can do others with alternative parts. G3PCJ

The Somerset Supper and Yeovil QRP Convention **REMINDER for those who have not yet booked!**

I am planning the second supper to be held on April 8th 2006 in Sherborne for locals and those staying overnight. This is the evening before the Yeovil QRP Convention scheduled for April 9th in the Digby Hall. The convention will have the usual array of interesting talks, trade stands, bring and buy stalls etc., so is well worth while coming - why not make it a weekend! As before there will be a small display of items from each diner's home built radio equipment! Your entry must be different from last years ticket! (Please also bring a QSL card or label.) This will qualify you for a free place at the supper table! The competition will this year be judged by Steve Hartley, the well known author of many amateur radio books who writes the Newcomers column for Radcom. He will decide how to judge it and his decision is final! You buy your own drinks. I do plan to take a photo or two for publicity purposes but this will not intrude into this social event where all (including XYLs) will be very welcome. A minimum of formality! Places by advance booking **only** by Mar 28th so please get in touch soonest via walfor@globalnet.co.uk letting me know names. Places are limited - first booked secures their place! Hope to see it and you! Tim G3PCJ

Hot Iron

Summer 2006
Issue 52

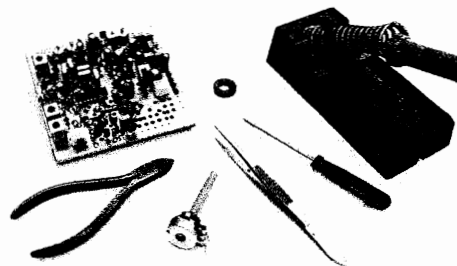
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Subscriptions!

The Walford Electronics
website is also at www.walfordelectronics.co.uk

Editorial

Last night Tony Blair signalled a push on nuclear power stations supported by extra work on renewable generation and other items designed to save energy. All very sensible! It makes me feel slightly smug that my solar panel is now charging - even on this dark rainy day! Since writing last about it, when I contemplated driving much of the house lighting circuits from a static inverter, I realised that the modern 12 volt AC 'low voltage' lighting and associated fittings is entirely suitable for DC use also. I have now installed a DC supply from my main storage batteries around the central parts of the house, complete with small tungsten halogen light fittings. This works well and will reduce the 50 Hz consumption appreciably from those lights which were often left on for long periods. I have used large section cables from the batteries to the middle of the house, so that I can easily connect a static inverter there to power the TV and heating etc, in the event that the 50 Hz does fail. Maplin Electronics have been selling a 12 volt 600W (1500W surge) inverter for near £50 which makes doing your own uneconomic. The whole 'investment' has a very long payback period but is all good fun!! Tim



Kit Developments

Quite a few things going on! The revised signal generator turned out to be too complex and finicky so I have started afresh with a simpler design, without the VFO frills. If all goes according to plan it will have nominal output of about 10 dBm (analogue or digital) over at least 1 to 30 MHz. In a similar vein, and with a fair bit of prompting from a good supporter in Norfolk(!), I have designed a new All Band VFO kit. This does all the traditional bands by crystal mixing with digital dividers but also avoids having an excessive tuning rate or span on any band! See later for the concept. It might even drive an All Band CW TCVR but that is another story!

I am also working on a 1.5W DSB phone TCVR called the Brean. This will be essentially 'crystal' controlled and suitable for any band up to 20m. Either a pullable ceramic resonator for 80m, or for the higher bands, an actual crystal or a wider tuning range with the Mini Mixer kit.

The other major project is the Minster. This is progressing steadily but it is not something to be rushed given the complexity of multi-band operation etc.

None of this helped by my **being away on farming business for most of July!** Sorry about that but I will deal with any queries immediately on my return. Regards, Tim G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics—is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

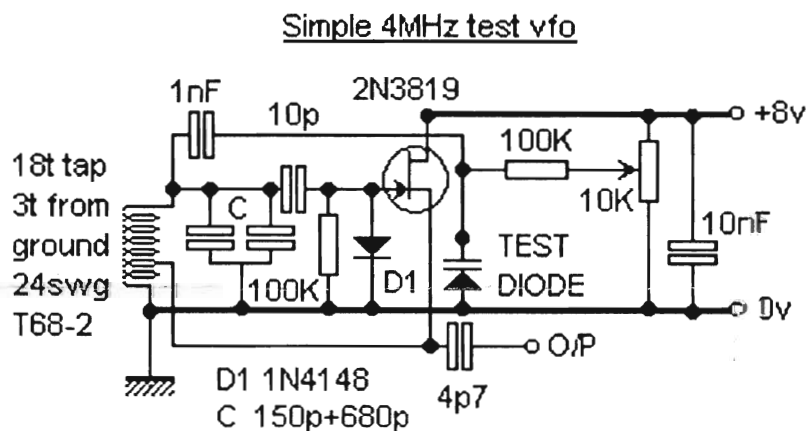
Diode Abuse!! by Richard Booth GOTT

Purpose built high capacity varactors or as I know them varicap diodes are now a thing of the past. Philips stopped making the useful BB212 several years ago with supplies quickly running out, and like everything else in short supply prices for the remaining few are increasing at a rapid rate. The reason for this in much the same way as 10K TOKO coils are now becoming extinct is that very few if any new commercial designs have traditional L/C tuned circuits. Cheap direct digital synthesis IC's and PLL circuits nailed the coffin closed on this chapter of analogue electronics.

However if your thoughts, like mine are about building and maybe designing useful and relatively easy to construct amateur radio projects then you needn't worry too much about that problem. Not all components do just what they say on the packet - take for instance the old trick of scratching the paint from a germanium OC71 and hey presto you have a photo transistor. Or maybe Tim's favourite of using digital logic gates as linear amplifiers or oscillators. It's all about lateral thinking which to my mind makes building your own equipment all the more interesting.

For some time now I've been pondering over a few rig ideas which one day all being well will come to fruition. The VFO has been one of the sticking points, simple mechanical arrangements and only using a variable capacitor as a last resort were my thoughts. So a varicap alternative would need to be found. It's well known that all diodes exhibit some level of variable capacitance when a reversed bias voltage is applied across it. So the plan was to test a selection of readily available diodes and get some meaningful results.

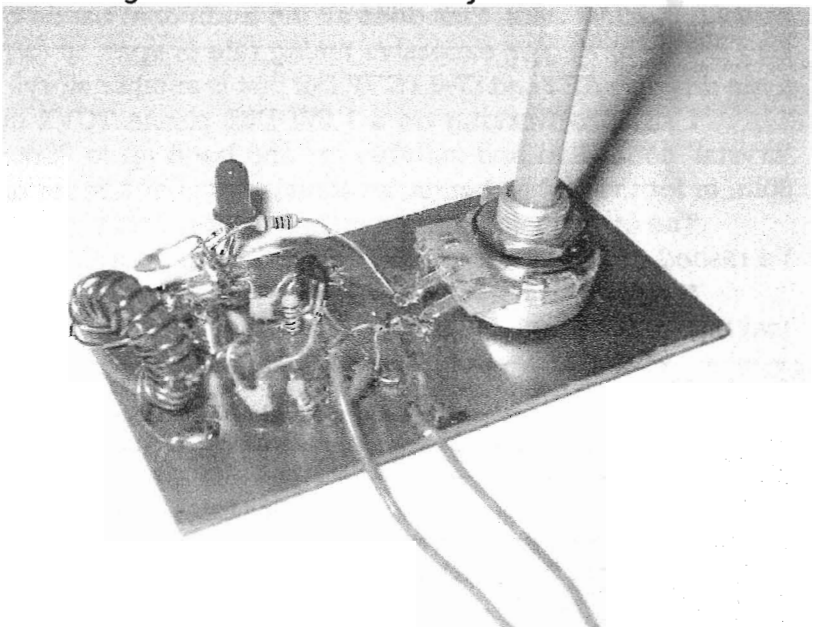
First of all I threw together a simplified version of the Midney VFO circuit, originally designed for the BB212 diode and changed a few things around, to make it run at 4 MHz, substituting the 10K TOKO coil for a tapped toroid and did away with the voltage stabilising components. Running direct from the bench power supply at 8V was good enough for this test.



The circuit was constructed dead bug style on a small piece of PCB material. 1M Ω resistors were used as standoffs. No frills and definitely not to be repeated in an actual transmitter! As a first test just to make sure that the circuit was working I soldered in a BB212. Just less than 500 KHz of swing was available with the selected component values, with the oscillator running between 4 and 4.480 MHz. I then proceeded to test various diodes including LED's which yielded some odd results!

How not to build your next VFO!

This picture shows my quick lash up VFO board. A red LED is being tested.



Diode Abuse Continued

After reading about success using Zener diodes in this application I was surprised to find the actual results obtained to be so poor - see the Table right. Strangely the LED's however worked quite well as a varicap, although it does seem to be colour dependant! The green types (and I tried several different makes to check this) all seem to have an odd hysteresis effect in that their tuning range is different depending on the direction of the reverse voltage, i.e. going low to high and vice versa.. I expected the larger sized LED's to have a higher total capacitance due to their internal dimensions but again strangely this is not the case. The big surprise though was the 1N54 series of diodes. Rated at up to 1 Kv the 1N5408 turns out to be the winner of best substitute varactor of 2006. Although it's quite a chunky power diode it's not much bigger in PCB space terms than the BB212, especially if mounted up on one end. Tuning across the range seems to be reasonably linear.

So it would appear that several suitable alternatives are available, all of them costing 15p or less. The zener types are probably best suited for RIT or fine tuning control.

A practical example

Just to prove to myself that this would actually work in practice I removed the BB212 from my 160M Midney superhet receiver and replaced it with a single 1N5408 diode. This is my test bed receiver built on a lump of old timber to make it a bit sturdier with numerous sockets for checking IC's and transistors which I have a habit of killing. Without changing any of the frequency dependent capacitors or inductors I'm pleased to say the results were good. Just a quick tweak of the VFO TOKO coil and an adjustment of the 10K tuning range preset had the receiver tuning 1.8 to 2 MHz with no real difference from its original performance worth noting. For novelty, having never had a receiver tuned with an LED before I also tried fitting a single red 5 mm led. At this frequency 100 KHz of the band was covered - this of course could be increased by altering the capacitors in the oscillator circuit.

Do let me know how you get on if you use any of the diodes I tested, or if you know of any other types worth trying out. 73 Richard Booth, G0TTL

Caution!!

Richard's excellent piece of work reminds me of the point that the ordinary 78 series fixed voltage regulators are just NOT good enough to provide the supply for main tuning by a varactor diode. This applies to any device of the 78 series, irrespective of their size! The variation of output voltage with changes in output load current, and with changes in input voltage, is too great for a decent rig. Its frequency will jump about as the volume alters!! The LM317 range of adjustable voltage regulators are almost an order of magnitude better in both key respects! Thus if you do contemplate using a varactor for a wide tuning range (say more than 25 KHz), then use a 317 regulator (L or T type) for the supply feeding the tuning pot. If you only need a small tuning range, such as for Fine tuning or RIT, then the 78 series or other fixed ones maybe adequate.

I am hoping Richard will report soon on the temperature stability of the 1N5408. Tim G3PCJ

Diode Type	Oscillator Swing at 4 MHz
BB212 dual Varicap	480 KHz
BZY88 5V6 Zener	10
BZY88 12V2 Zener	11
BZY88 36V Zener	13
1N4007	70
1N645	70
1N4148	20
Red HE 5 mm led	125
Red HE 3 mm led	135
Green HE 5 mm led	40 with hysteresis!
White 5 mm led	120
Red 10 mm led	45
BA148	40
BY127	25
1N5401	150
1N5404	200
1N5406	245
1N5408	305 KHz

Shack Standards by Gerald Stancey G3MCK

When using a voltmeter I wonder how many of us stop and think 'I wonder if the meter is correctly calibrated?' In a professional laboratory this problem is, or should be, taken care of by having a procedure where the calibration of all test equipment is regularly checked and recorded to give a certifiable audit trail. The professionals use specialist test-houses for this function and it costs money.

So what can the amateur do? Ignore it and hope that no problem ever occurs or spend big bucks. There is a third way which while not being high precision is better than nothing. You simply measure the voltage of a new Duracell PP3 battery and assume that it is 9.5 volts. Hey I hear you say, this is real simpleton optimism but just think, if the battery is really 9.4 volts your error is only 1% and this is not at all bad. Hence this method while not being of test-house accuracy, will at least show if your meter is really up the pole. Another possibility is to use Zener diodes or voltage regulators but I have not investigated these. Precision voltage standards are also available but these do not seem to offer very much better accuracy.

Readily available frequency standards is an area where we seem to have regressed. In the old days it was simply a matter of checking your 100 KHz standard against MSF on 5 MHz or the BBC on 200 Kc/s, note the use of c/s rather than Hz to keep in sympathy with the times. However all is not lost as the People's Republic of China make standard frequency transmissions on 2.5, 5, 10 and 15 MHz to an accuracy of better than 10 in 10^{10} . They identify as BPM in CW at H+29 and H+59. I have used the 5 and 10 MHz transmissions.

Another possibility is to use standard BC stations. In the medium wave they are all channelled at 9 KHz spacing and their frequencies evenly divide by 9 so 900 KHz, 909 KHz etc are all BC channels. The shortwave BC stations are even better as they operate with 5 KHz channel spacing. I do not know how accurately they control their frequencies but the BBC control to 1 in 10^8 . Checking a number of BC stations in the 40m band suggest that their accuracy is adequate for normal amateur use.

This raises the question 'how accurate do you need a standard to be?' The answer depends on what you want to measure but a rule of thumb is that the standard should be ten times better than the accuracy to which you need to measure. The post war amateur licence required an accuracy of 1 in 10^3 , ie 1 KHz per MHz. If we assume that BC stations control their frequency to better than 1 in 10^5 , ie 10 Hz per MHz then it appears that they will make adequate standards for amateur use.

Frequency checking technique

Its not too easy to check an oscillator against a BC station but this is what I do! Tune in the BC station, preferably on a very stable direct conversion receiver. Adjust the tuning for zero beat of its carrier. Wait and see if either drifts away and no longer remains at zero beat - hopefully not! Then introduce the output of your test oscillator also to the receiver, ideally this would be at about the same signal level as the broadcast station. So it is likely to need quite a lot of attenuation. It might be adequate just to bring the oscillator near the RX input. (The oscillator should have been switched on well in advance so that its temperature has stabilised before the comparison.) When the oscillator signal is introduced to the RX there might be a low audible whistle, or the AGC might pump at a few tens of Hz if it has AGC. Twiddling the oscillator's frequency trimmer might swing it far enough to make the frequency difference audible; but in any case you actually desire that the beat frequency between BC station and test oscillator be zero! You often have to listen exceedingly carefully to detect any 'signal' once the difference in frequency goes sub-audible at roughly 20 Hz. If the RX does have AGC, one can sometimes hear a change in the background noise level as the gain alters at the beat frequency. Failing this, you will have to set the trimmer mid way between the two points at which you can just hear the note with the same frequency. Do this and you wont be far out bearing in mind that the error is in tens of Hz for a carrier of several hundred KHz! Tim G3PCJ

Ideas for an All Band VFO!

Prompted by David Proctor's article last time and Andy Howgate, I have often contemplated how to make an 'all band VFO'. At first sight it is easy! It needs good stability so a crystal mixing scheme is almost obligatory - and it would of course prevent chirp when used to drive a transmitter. So all you have to do is mix a low frequency VFO with a crystal to get 28 MHz, and then divide the output down for all the lower bands. There are two big snags; firstly it needs a tuning range of 28 to 32 MHz to divide by 16 for 1.75 to 2.0 MHz, this is a bit wide for easy tuning/stability and there is a 2:1 change in tuning rate for all bands compared to the next above or below! The other problem is that it cannot do 21 MHz as this is not a binary multiple of any band.

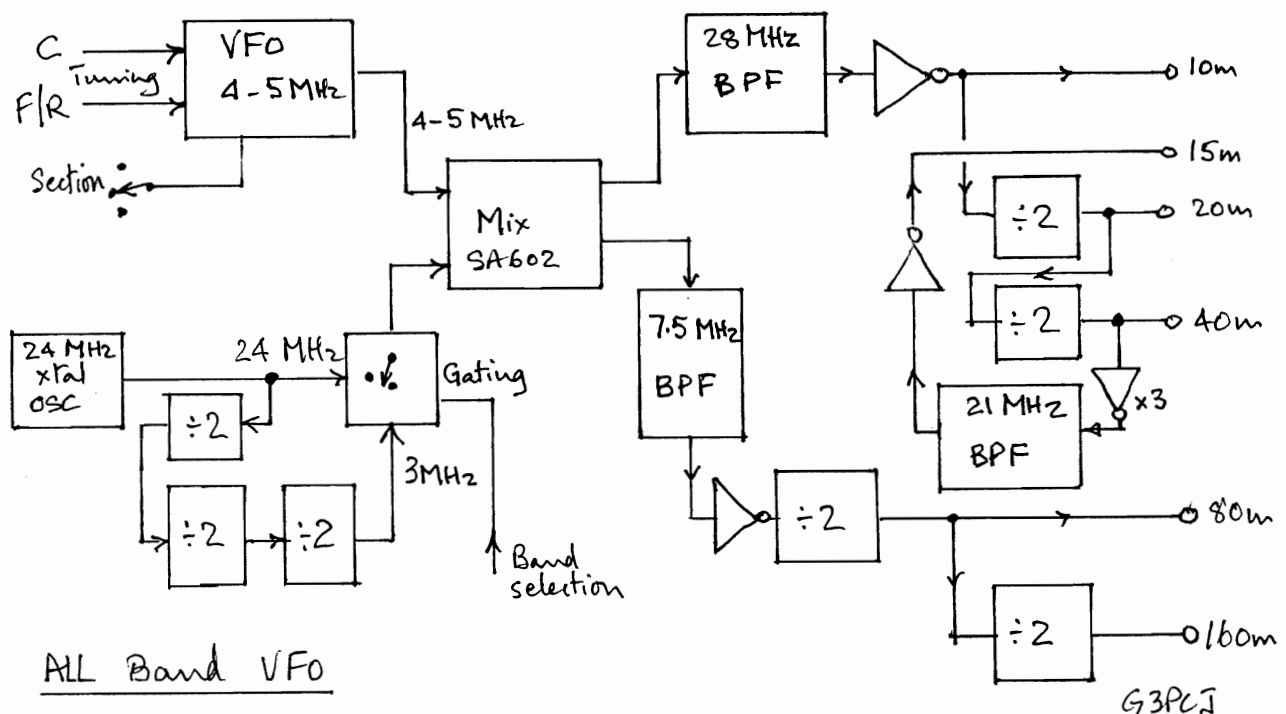
After many doodles and much head scratching, I realised that the two outputs of a SA602 might offer a solution. One could drive a BPF for 28 MHz and then be squared up in a digital gate, followed by two stages of digital division to get down to 7 MHz. The change in tuning rate would be limited to 4:1 overall and a 1 MHz swing at 28 MHz would give coverage of all of 20 and 40m. The other output could drive a second BPF covering 7 to 8 MHz, which with squaring, could again divide down for 3.5 to 4 and 1.75 to 2 MHz. Clearly the inputs to the mixer would have to suit each active BPF. One input could be an actual VFO covering 4 to 5 MHz, the other mixer input being the 602's internal oscillator using crystals of 24 and 3 MHz! A 2 pole 6 way range switch could select the BPF/divider output and crystal.

How to get to 21 MHz though? This is the third harmonic of 7 MHz and what are square waves rich in? Odd harmonics. We already have 7 MHz square waves divided down from 28 MHz, so feeding this 7 MHz into a 21 MHz BPF should select the desired third harmonic content, which can be squared up afterwards. Easy!

The above scheme would need crystals of 24 and 3 MHz, but 3 MHz is not a standard readily available value. By luck 3 is a binary sub-multiple of 24! So a further divide by 8 stage would get us 3 MHz from a single 24 MHz crystal and then only need gating to select the right output. This would be rather more reliable than actually switching over the crystal directly by the band switch. The resulting block diagram is shown below.

Clearly stability will be important if it is to be used for a rig's VFO, so suitable toroids and capacitors would be best. The 1 MHz tuning range needs dividing into sections with the provision of a further Fine tuning control being desirable. If this Fine control used varactor tuning, then it is easy to make this also double as a RIT control making the VFO directly suitable for a DC CW rig.

I have laid this out as a main PCB with a small upright front panel and will try it out shortly. With some other ideas, it also holds the prospect of an All (traditional) Band CW TCVR! Tim G3PCJ



Testing n channel MOSFETS

Small MOSFETS, like the n channel BS170 are so cheap, that if there is any doubt about them, it is almost the best thing to throw them away and fit a new one! Nevertheless, this little device will test them just as well as the larger n channel types such as the IRF510, which are definitely worth testing. First of all you need to identify the gate lead. The safest thing is to look that up in a data sheet or on a circuit where it should be given. The next thing is to connect the source and drain leads to the circuit with the gate connected also to its test point/button.

Switch on, if the source and drain are the correct way, the LED should not light; but if it is the wrong way round, the LED will light irrespective of the gate voltage/test button - this is because the transistor looks like a diode when the supply is the wrong way round. If the LED does light, change the source and drain around and check that the LED now goes out! If it still stays on, throw it away, because the device is short circuit! This is an uncommon failure mode.

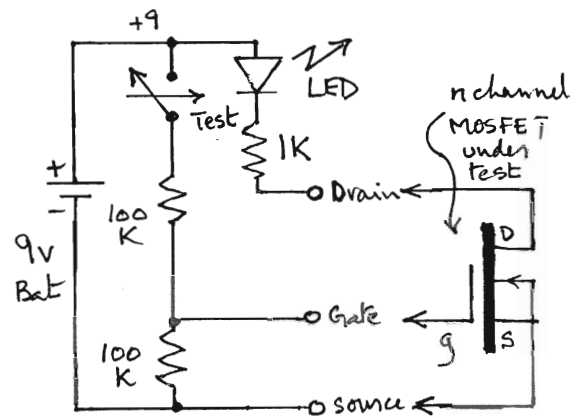
Assuming that it did not light when first connected or went out after changing the source and drain leads, then press the test button; if the LED does now light, all is well with the device. If the LED still does not light, the device is open circuit and no good!

The circuit can also be used to check **diodes**; the LED should light when the diode anode is connected to the drain terminal and cathode to source terminal. The LED should not light when the diode is connected the other way round. If it on both ways the diode is short circuit and fit only for the bin! (This circuit cannot be used for testing p channel MOSFETs.) Tim G3PCJ

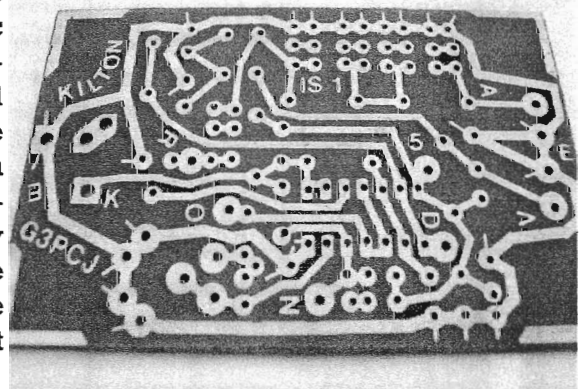
Laying out PCBs

If space allows, the best strategy is for the main signal flow to be in a straight line so that there is the largest separation between low and high level signals. If this is unavoidable, then make certain that adjacent low and high level signals are at different frequencies! Next arrange the layout so that all high current stages have good grounding, short leads and are near output RF filters so that the high currents don't go near the sensitive low level circuits. In the example PCB below (the Kilton CW transmitter), the output transistors are on the top left, feeding the TX low pass filter in the top middle, which in turn feeds the output on the right. A common wide earth track links all these stages and the output. In this example, the driver stages are in the middle in the integrated circuit and the VFO components (trimmer and ceramic resonator) are at the front left - as far as possible from the high current part. The control circuits are at the front right. Although this is actually a double sided board with a copper ground plane on the other side of this photo, all the earthy points are also linked together by tracks to minimise the effects of any forgotten top-side solder points, and to help reduce the impedance between any two grounded points. I find that I can lay these circuits out more quickly using a form of rub down tapes than I could do if I were to use software. (I also don't get the square eyes!)

Because I make many samples of the same PCB, I use a photo etching process where the track image is first impressed on the board by an UV sensitive chemical; this is then developed to leave a resist that prevents the ferric chloride from etching away the wanted copper track pattern. The standard drilling process that Brian Purkiss and I have developed, is to first drill the earthy holes - these have hairs on them like a chassis symbol. Then Brian countersinks these holes on the ground plane side to prevent their component leads being accidentally grounded. Finally he drills the non-earthly holes. The copper resist is then rubbed off with wire wool and the board sprayed with a lacquer that prevents oxidation but which can be soldered through. Tim G3PCJ



n channel MOSFET Tester G3PCJ



Theory - Low Pass Audio filters

These are an essential building block of all electronic devices! A sweeping statement you might say - but nevertheless it is true! Even the humble coupling network between two stages of an audio amplifier is potentially a low (or maybe high) pass filter.

Let first consider the response of the most simple R and C network shown right fed from an ideal low impedance source and with a very high load impedance, so that both those aspects can be ignored. As the generator frequency is increased, initially there is no change in output level, but at some frequency f_3 , the output level will begin to reduce and then go on steadily decreasing for ever! The output actually decreases by 6 dB per octave or 20 dB per decade - they are the same slope of the response line. This said to be a first order low pass network as there is only one CR time constant. The frequency where the bend occurs, and the response is actually 3 dB down (voltage) or to 0.707 of its DC value, is actually where the impedance of the capacitor is numerically the same as the resistor. So you can work out that frequency from:-

$$f = \frac{1}{2\pi RC}$$

f in Hz
 R in Ohms
 C in Farads

If you now connect two of these CR networks in series to form a second order network as shown right, then the frequency where the response is 3 dB down is slightly lower (for the same CR product values) and the rate at which it falls off as frequency increases to 12 dB per octave or 20 dB per decade. Generally this form of second order filter is *not* often used, but an active one with some feedback mechanism is much more interesting! The third circuit shows one using an op-amp connected as a unity gain buffer. (You can use an emitter or source follower stage instead.) I have omitted the op-amp biasing for clarity. It is now possible to make the response have a peak as shown right where the Q (or sharpness) of the peak depends on the CR values. If the Q is greater than 1, there will also be some voltage gain on the peak! This is the sort of filter that is used to narrow the audio bandwidth of a DC RX to make it suitable for CW purposes. The following formulas apply:-

$$f_0 = \frac{1}{2\pi R \sqrt{C_1 C_2}}$$

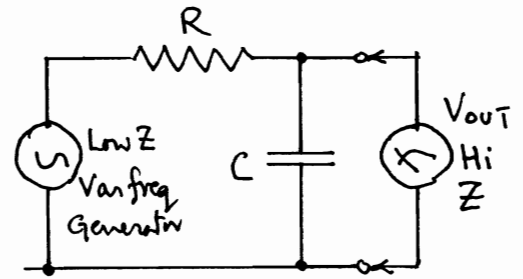
f_0 in Hz
 R in Ohms
 C in Farads

$$Q = \sqrt{\frac{C_1}{C_2}}$$

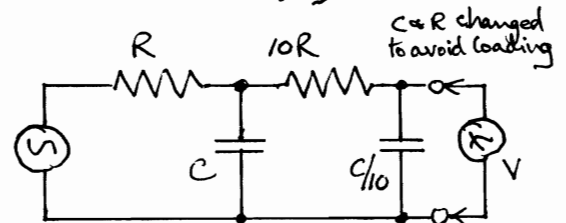
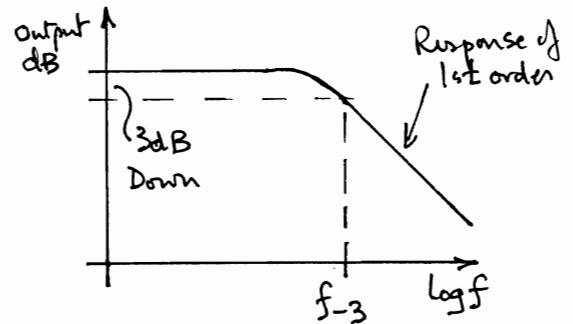
C_1 & C_2
 in same units.

Useful stuff! Tim G3PCJ

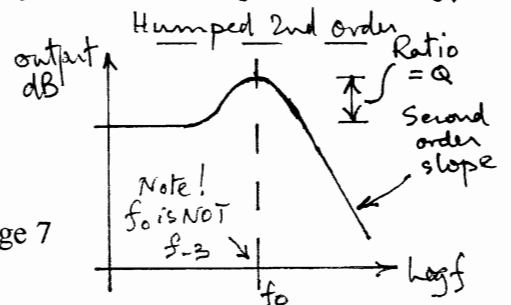
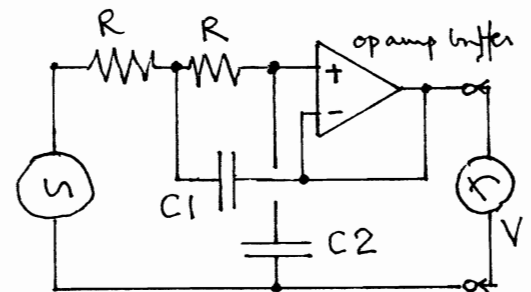
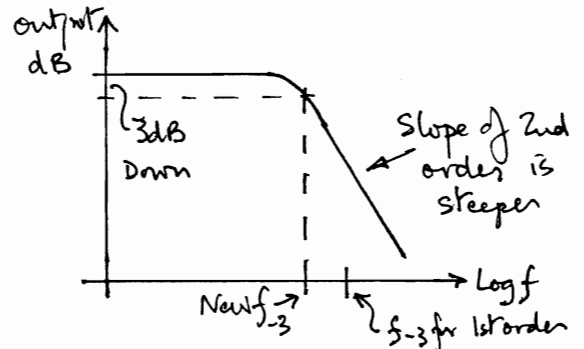
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FIRST ORDER LOW PASS



SECOND ORDER LOW PASS



Snippets

Phono Plugs Jim Gearey writes of the good suitability of these low cost plugs for RF purposes but warns that, because the central pin is supported by plastic, it is advisable when soldering them to have it installed in a socket to maintain the pin alignment while the plastic is soft. He sometimes also finds it necessary to file their tags to make the solder tin well.

VFO Enclosures John Teague comments that he puts his main oscillator resonator parts (L and C) in a die-cast box separate from the rest of the circuitry. This separates the heat source and improves stability. However, do give plenty of space around the coil! I think I have read that the gap between it and any metal work should be at least two coil diameters! If not, any RF currents in the box walls will alter the inductance and hence tuning. Years ago I had a chirpy transmitter, that I eventually traced to output RF currents at same frequency as the VFO getting into the walls of the VFO compartment. Tim G3PCJ

Somerset Supper

Steve Hartley, the Radcom Newcomers columnist, very kindly came along and took a very keen interest in the diner's entry tickets! For those who haven't been before, diners had to bring an item of home built gear with them as their entry ticket; these were displayed and a couple of prizes awarded. This year the standard was very high and there was a tremendous range of 'items' on display. Bob Woolridge G7LNJ was presented with the first prize - an appropriate bottle of Somerset

cider brandy for his masterpiece - an oscilloscope made from a World War 2 surplus radar tube surrounded by lots of glowing valves! Although Bob was willing to demonstrate it, no suitable power source could be found for any of the signal sources also on display! Jim Gailer G3RTD earned high praise, and the runners up prize, for his surface mount DDS based signal source for 2m satellite working.

The provisional date for the 23rd QRP Convention is April 15th 2007 and I am expecting that Ben Nock of PW fame will be our



Subscriptions!

I am afraid its that time again! If you wish to continue receiving Hot Iron, let me have your cheque for £7 before Sept 1st for the next issue. I still have loads of crystals which I am unlikely to make any use of, so let me know if you would like any of the following frequencies - free apart from the packing & postage - as many as you like within reason! I will send these out (when I am here - see front page) on receipt of your sub so please add two first class stamps for the packing/postage of the crystals or increase the sub figure to £8. The following are available:-

Parallel Resonant - MHz - 5.0688, 5.6914, 5.752, 6.0177, 7.20, 9.30, 9.60, 10.2775, 10.44, 11.0258, 12.73819, 14.84830, 15.375, 16.5888, 16.623333, 17.9, 18.26, 20.105, 20.78

Series Resonant - MHz - 15.0, 18.0, 20.0, 21.0, 24.0

I have some TTL oscillators (sq wave output) £2 for P & P please - MHz 24.0, 30.0, 32.0

Send off your cheques now!

But don't forget I am out of circulation for most of July!