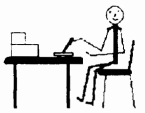
❖ HOT IRON ❖

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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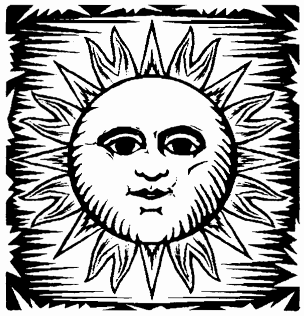


EDITORIAL

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

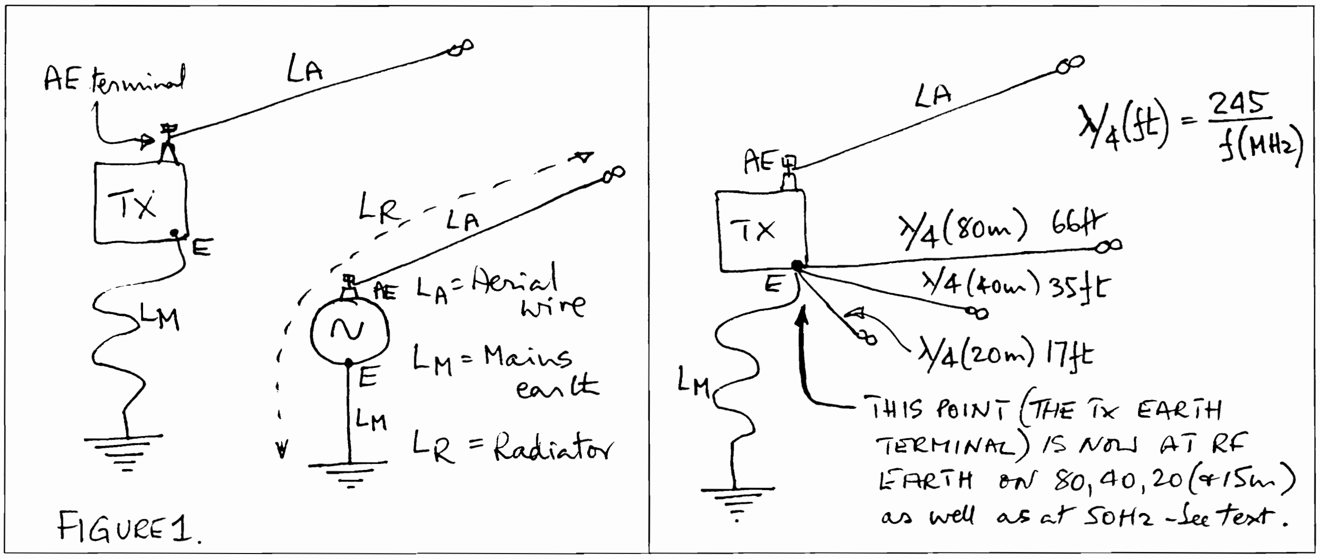
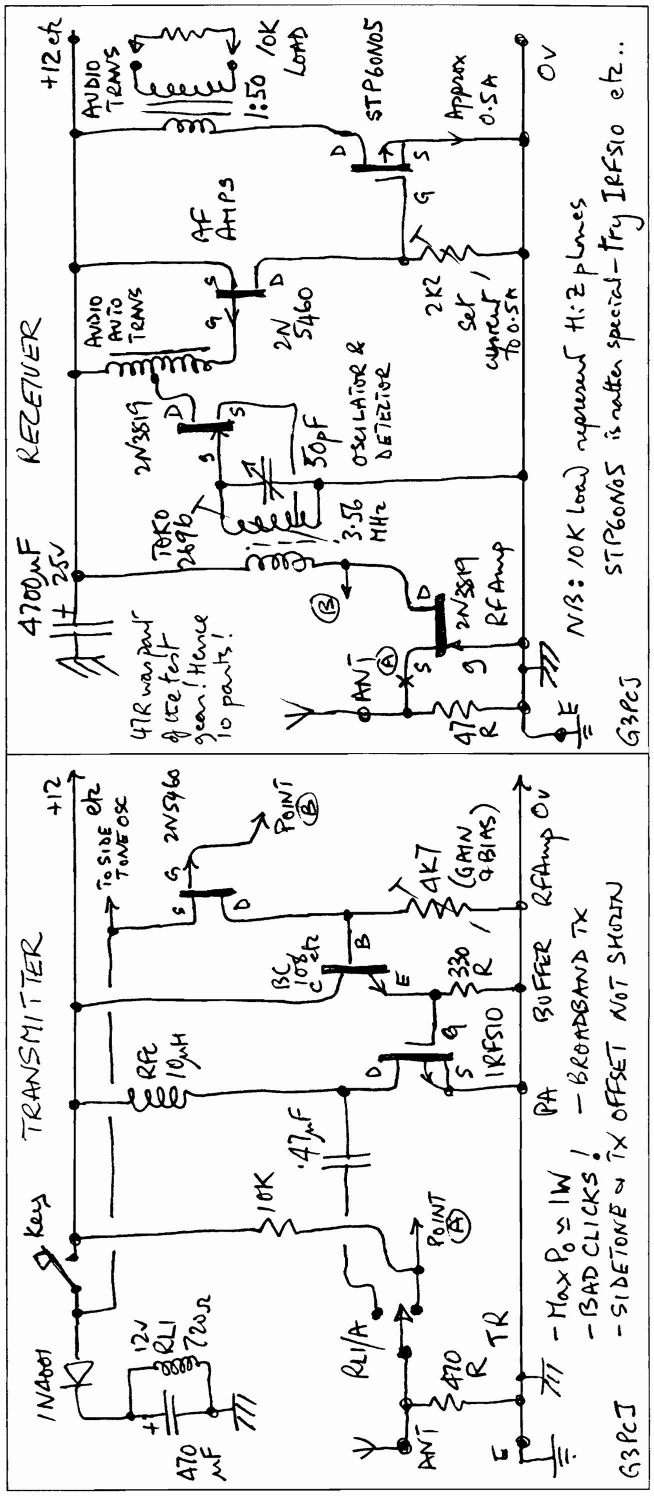


FIGURE 1.

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 definately 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.

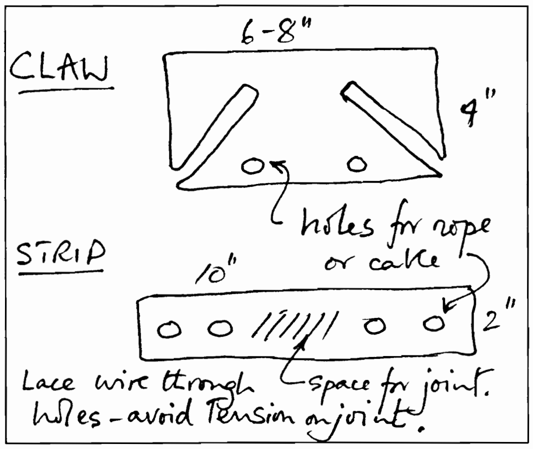
I have sketched on the right the original idea for the TX part, which I soon realised needed more thought! TX output matching: add two high voltage Cs with toroid coil for higher output and better harmonic filtering, add 1W resistor to dampen tendency to half frequency output, add two decoupling caps 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 off set: 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 possiblities. 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 proffessional! Fistly 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 Polyfilla 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.



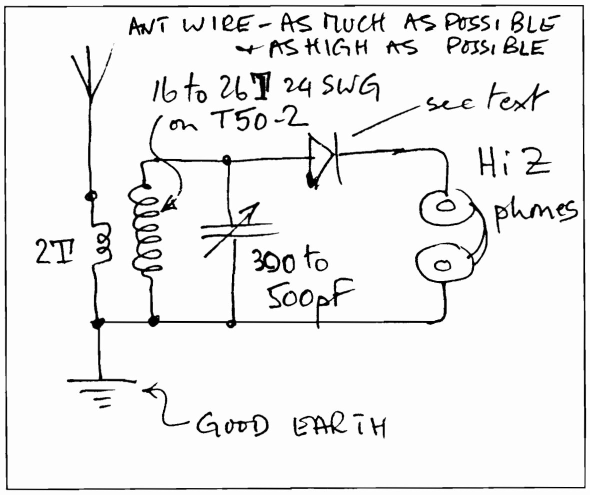
Aerial rigging etc. Rev. Tony Measures G3WUC follows the advice of John Heys (Practical Wire Antennas from the RSGB) that whenever you erect a wire antenna to the top of a pole or tree, that you should put up a continuous loop of rope around a pulley at the top. This does not directly support anything 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. 1 watt 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.

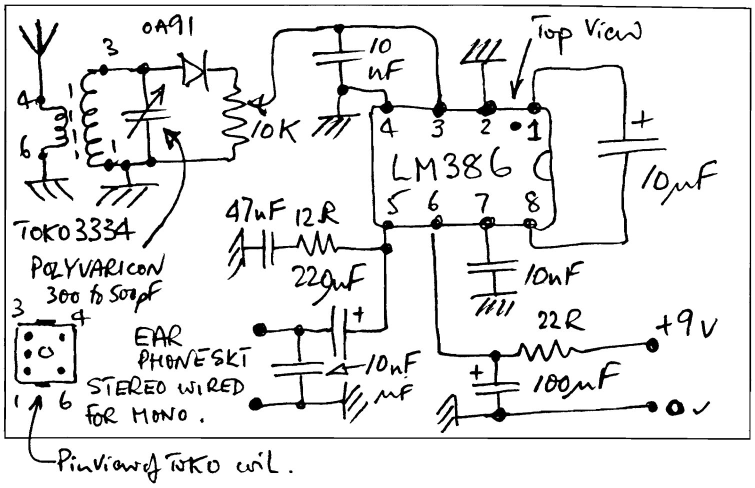
Yeovil RF amps. Noting the interest in extra RX gain, I felt that the easiest solution was to put a 50 Ohm RF amplifier in the receive path around the transmitter. A MAR1 having 20 dB gain, two 10 nF coupling caps in and out with 390 Ohms from output to + 12v suffice - cheap and easy to install. This 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

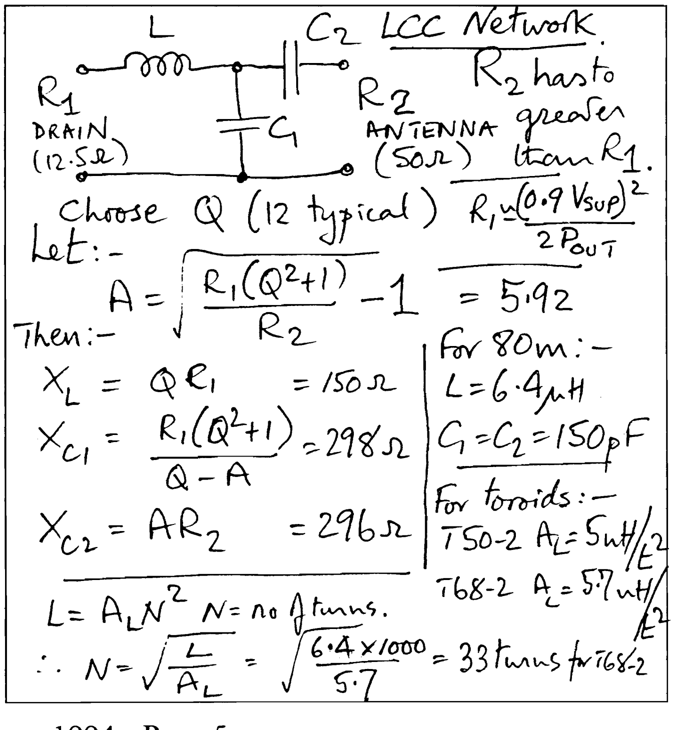
Craig Douglas G0HDJ offers that on the right which has proved very popular with the pupils at GX0PCS as an introduction to building and SW listening. A piece of copper clad board is used, mounted near vertically on a block of wood with chocolate block connectors. The parts are kept in place by their 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

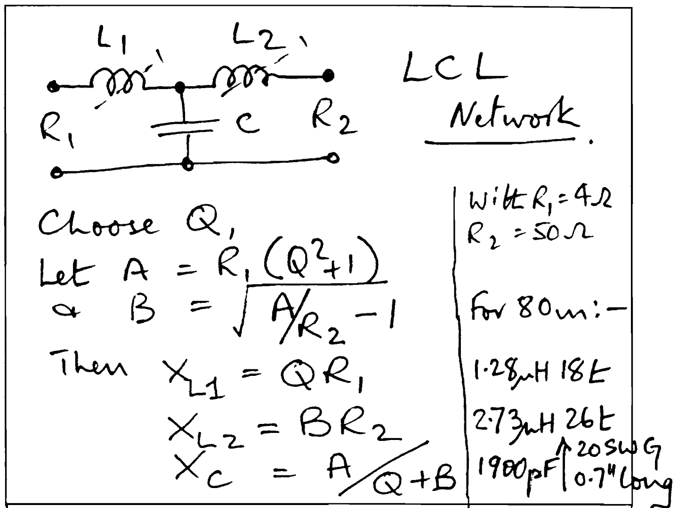
John Shaw G3ZKZ asks if I would explain the cost and impedance aspects of the output of Tiny Tim. In view of my admission on page 1, I do this with some trepidation! Once you have decided what output power the rig is to have, it is easy to decide what the load impedance presented to the output transistor 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 its 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 µH. 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 turn^2 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



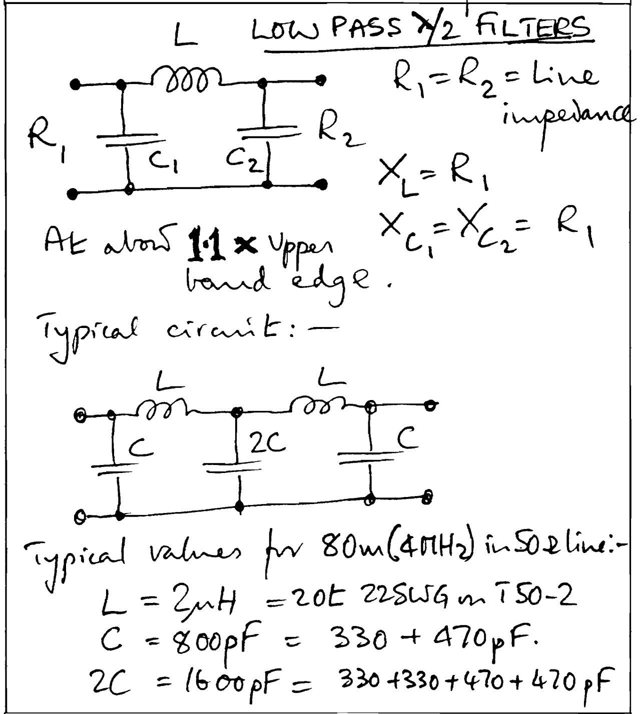
capacitors, there is a good chance that tuning to suit will not be required - if it is necessary it can be done by adding or subtracting a turn on the toroid.

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



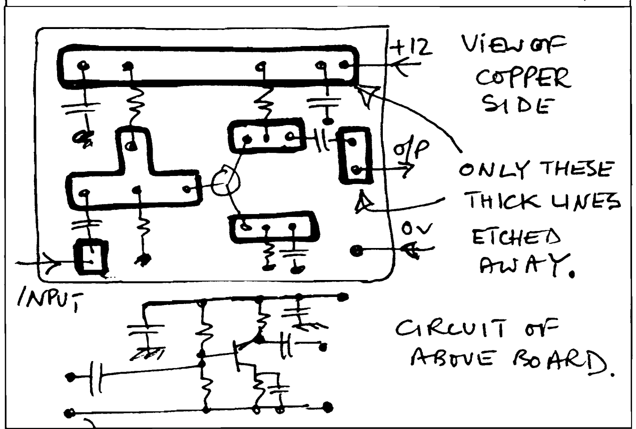
Output Low Pass Filters

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.

DON'T FORGET TO RENEW YOUR SUBSCRIPTION NOW!