**"JOURNAL OF THE CONSTRUCTORS CLUB"**

# Hot Iron

Summer 2004
Issue 44

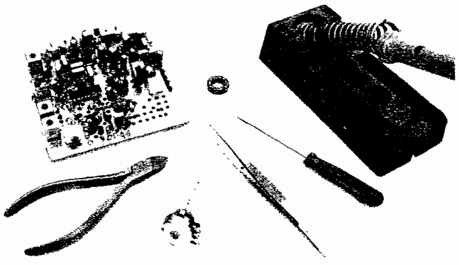
## *Contents*



**Subscriptions AND crystals!**

The Walford Electronics website is also at www walfordelectronics.co.uk

## *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.

## *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

*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.

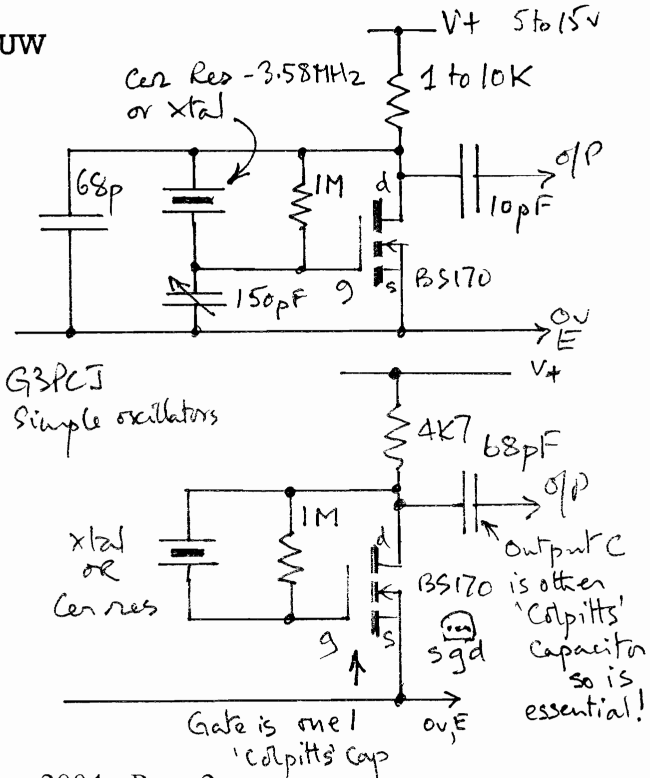
What can you use the VFO for? I have run a Compton receiver from mine by replacing the ceramic resonator and coupling the output of the VFO through a small capacitor and I have added a buffer amp to help it drive the buffer/PA board from MOSFET 4 CW transmitter by VK3XU. My VFO, with buffer, has also 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

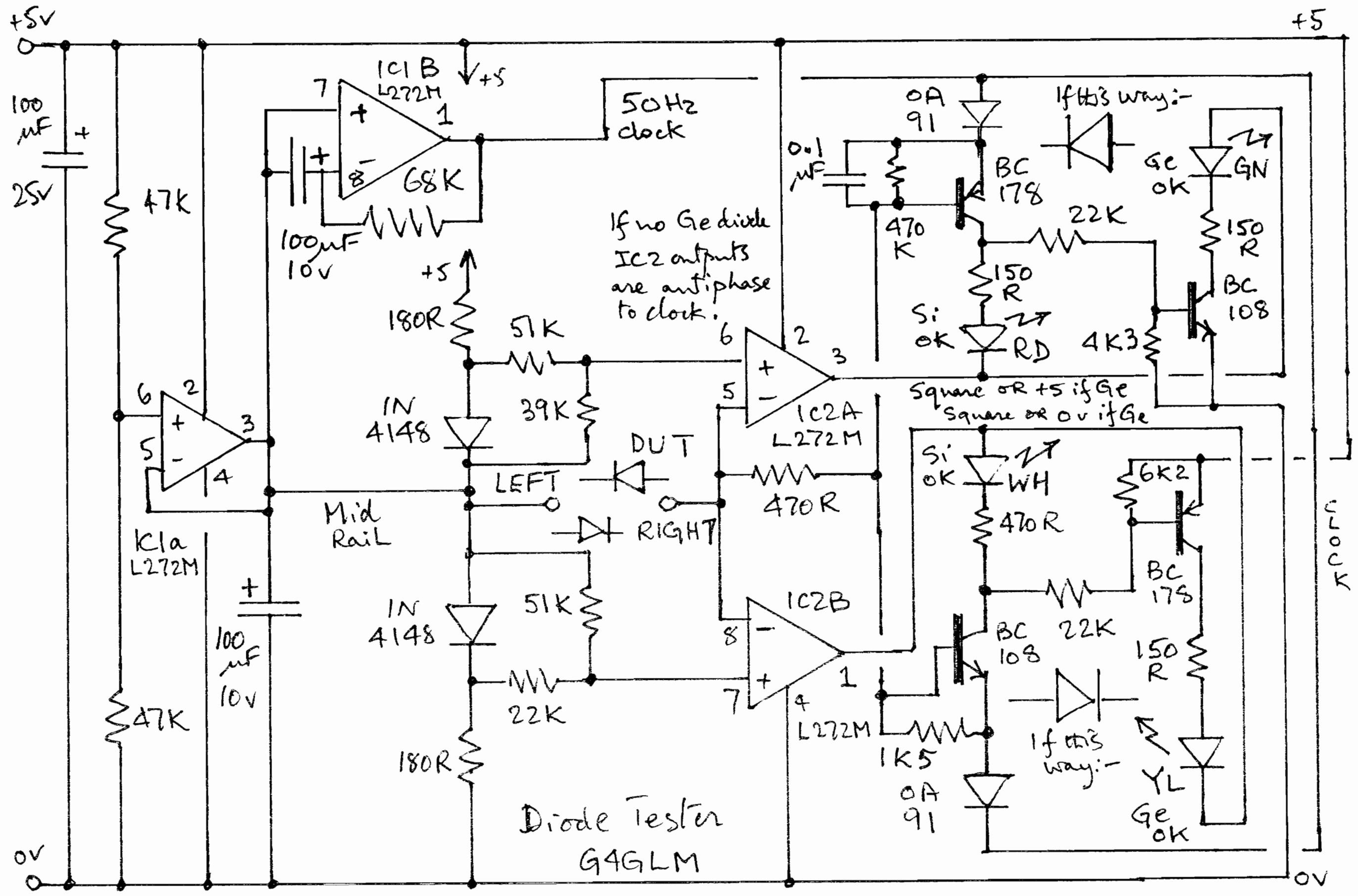


## *Versatile Diode Tester*

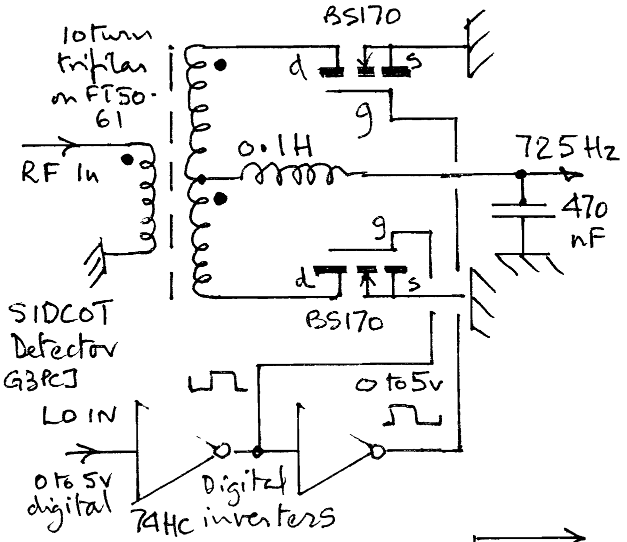
Godfrey Manning G4GLM has kindly sent along a design for an instrument if you want to know what sort of diodes you have just acquired at a rally! The original article is a bit too long for this journal so I have taken the liberty of condensing it - I am pretty sure that if anybody wishes for more explanation, 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).

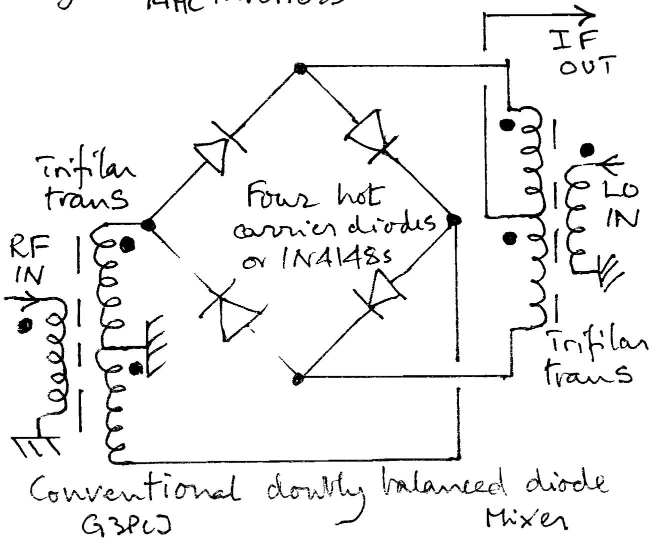
Dual power L272M op-amps are used in both linear and comparator (open loop) modes. To determine whether silicon or germanium, the voltage across the diode under test is compared with 0.5V references. The diode under test has 470R in series to define the current which is critical in ensuring good discrimination 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!***

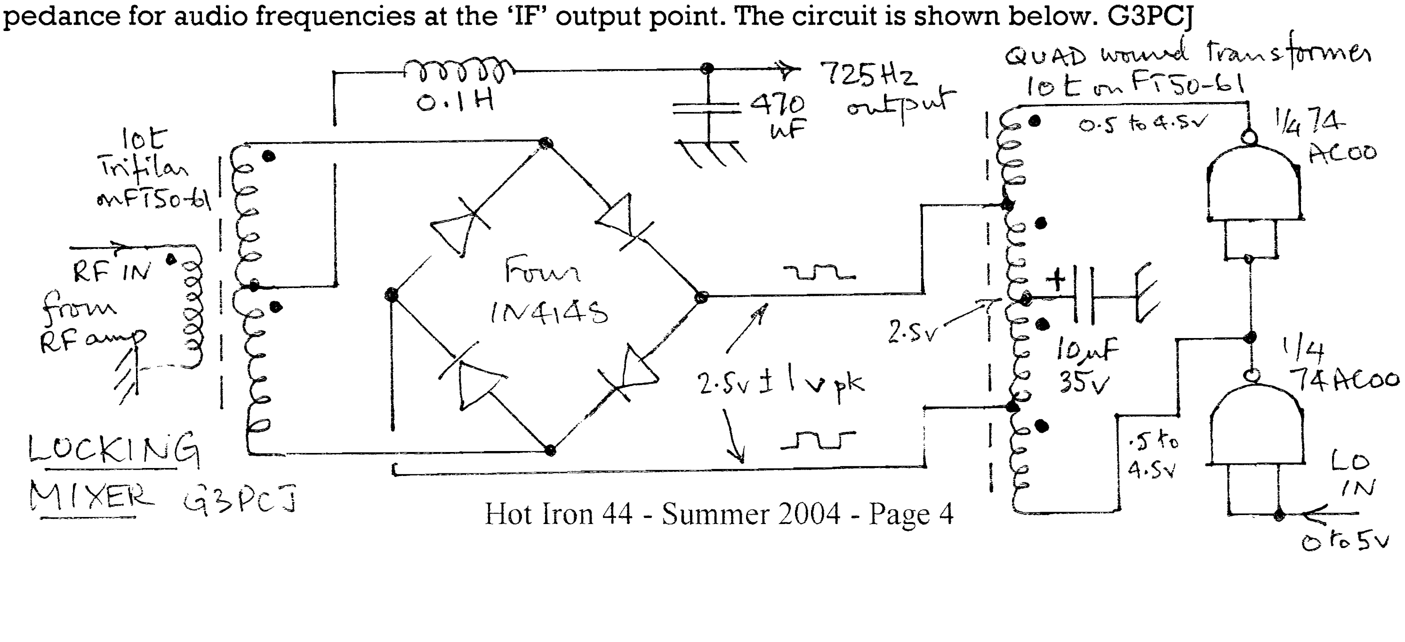



I had thought that the mixer which I used in the Sidcot might also be suitable for the Locking; it is a simple design which lends itself to a CW receiver with drive from a digital VFO - I don't mean a synthesized micro-processor controlled 'oscillator' but a simple oscillator that directly produces a 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.



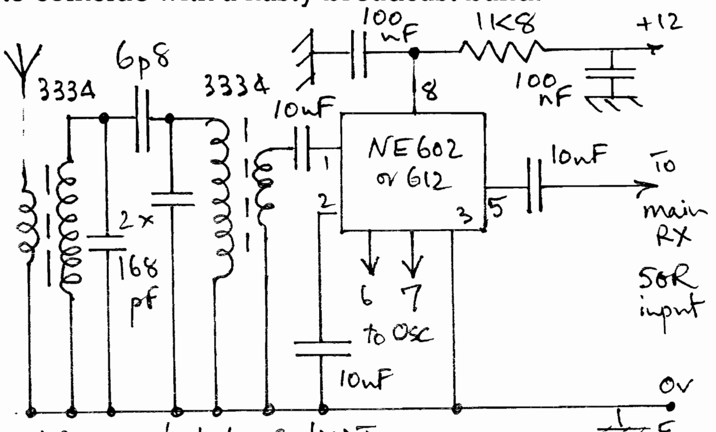

The Locking has a VFO with 5 volt digital outputs on all three bands so a broad band solution was required. The classic diode doubly balanced mixer is shown next down but suffers from the need for relatively high LO drive levels. Diode mixers, with a range of signal handling abilities, are available 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.

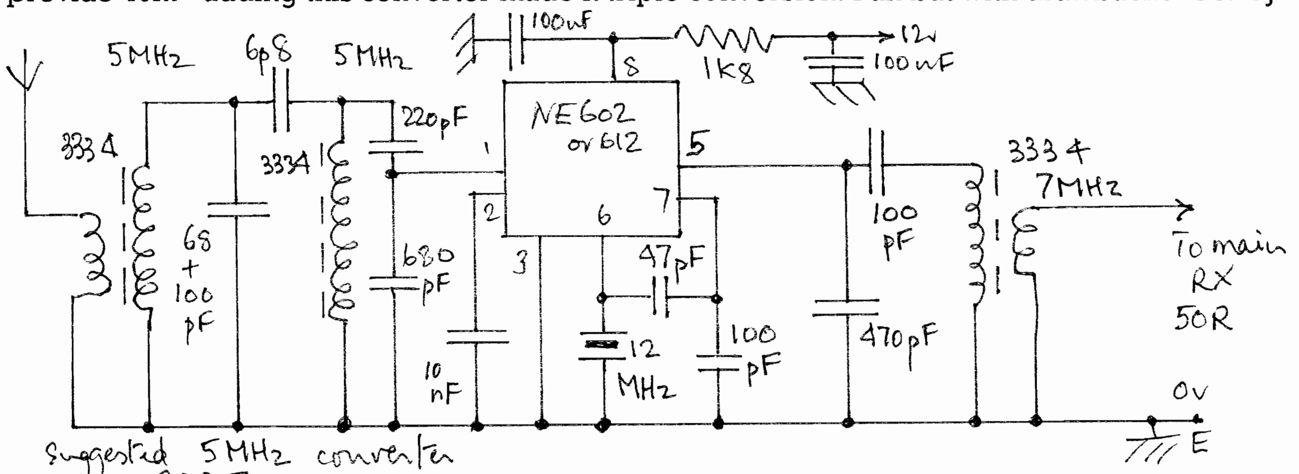



'Converter' by G0HDJ

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!!

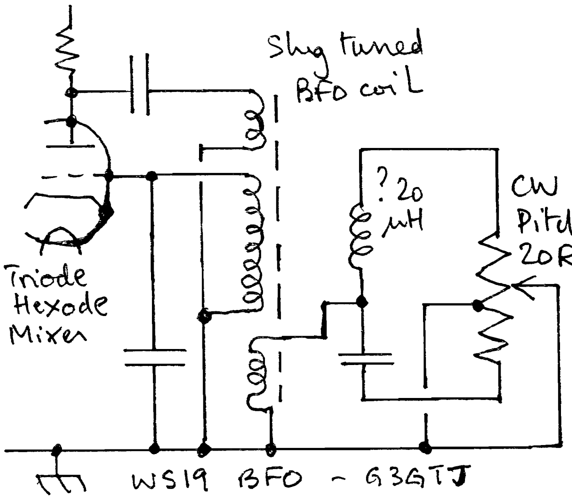
A multi-conversion RX can be disappointing if not properly designed for front end noise, birdies and non-linearity. Craig was using a Yeovil superhet which already has a converter added to provide 40m - adding this converter made it triple conversion! Fun but with drawbacks! G3PCJ




Suggested 5MHz converter G3PCJ

## ***Tuning by Variable Resistors - Part 2!***

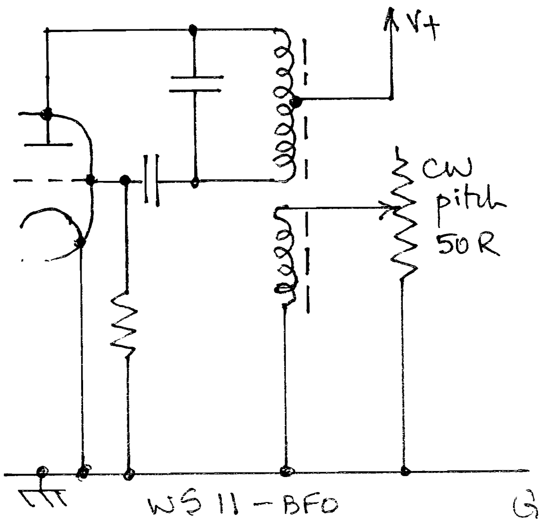
The note last time prompted two responses! Great! John Teague G3GTJ asks 'what's new?' and writes 'This article rang a bell. Sure enough I was soon able to confirm that the British Army Wireless Set no 19 - possibly the best known military radio of WWII with over 150,000 produced in three factories in 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'.

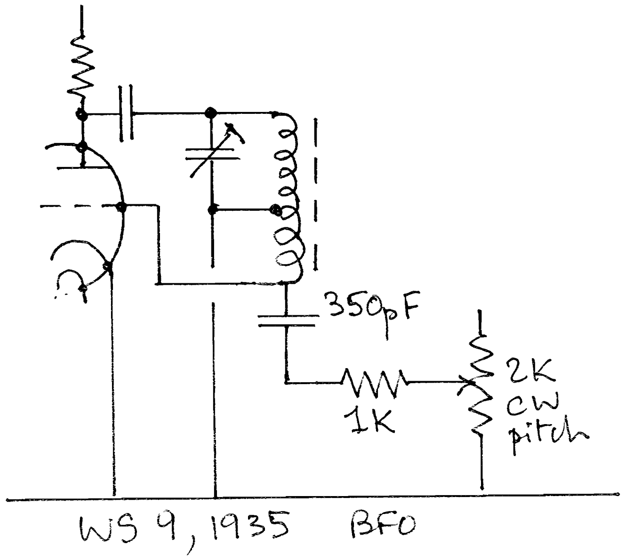



'The circuit used is one in which an extra winding on the oscillator coil provides a low impedance connection to the resistance tuning arrangements. These are, typically, a low reactance inductance (actual value not known but probably around 20 microhenries) in series with a 50 nF capacitor and a 20 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.'

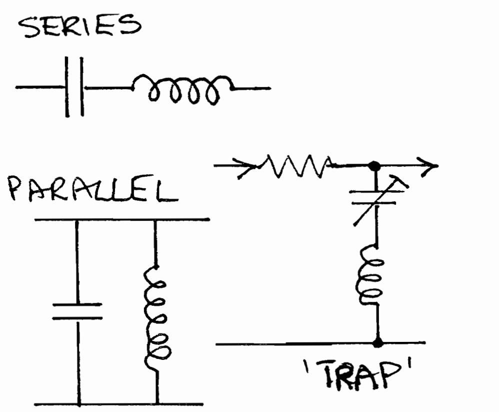



Tony Green M0NRB also writes 'had an idea to use such an oscillator in conjunction with an SA612 double balanced mixer with built-in oscillator. So I tried a number of variants of the circuit, but without any joy at all. So far I have come to the conclusion that whilst the tuning of the circuit does 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.



Resonant circuits G3PCJ

| Keystrokes | | 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 | 0.00000064 |
| X | multiply | |
| 2 | | |
| X | multiply | 0.000000081 |
| 3.14 | | (π) |
| = | CALC | 0.000000255 |
| 2nd F | | |
| 1/x | Reciprocal | 3920111 Hz |
| ANSWER | | = 3.92 MHz |

G3PCJ

### *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 microHenries 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 microHenry coil and a 330 pF or 0.33 nF capacitor. Note that 1 μH is $1 \times 10^{-6}$ Henries and 1 pF is $1 \times 10^{-12}$ 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

G3PCJ

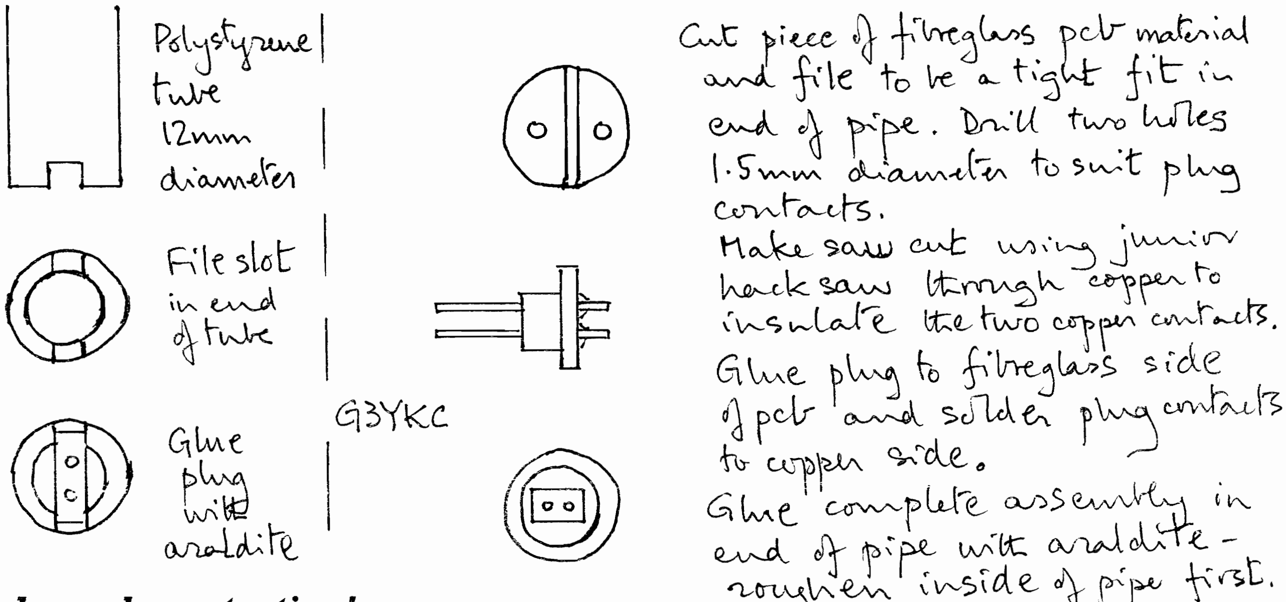
| | | |
|---|---|---|
| 2 | | |
| X | | |
| 3.14 | π | |
| X | | 6.28 |
| 3920000 | (value of f) | |
| = | calculate | 24617600 |
| X | square | |
| = | calculate | 60602622.14 |
| X | multiply | |
| 330 | | |
| EXP | | |
| +/- | | |
| 12 | (value of C) | 330. -12 |
| = | calculate | 199988.6558 |
| 2nd F | | |
| 1/x | Reciprocal | 0.000005 H |
| ANSWER | | = 5 μH |

## ***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.

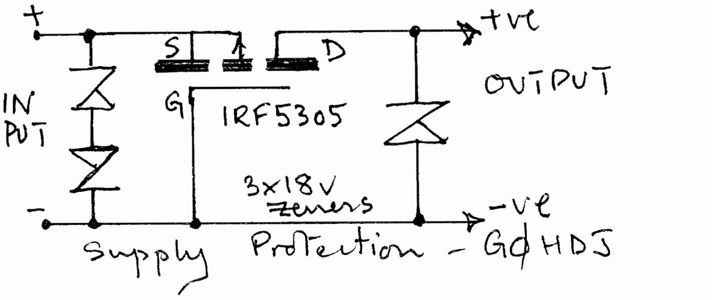
*PCBs Another Way* Derek Alexander G4GVM tried Richard Booth's approach for making PCBs (Hot Iron 43) but without full success! Richard replies 'I think Derek's problem is the paper he is using - it's probably too "good" quality, it appears to have an extra more waterproof layer built in. I sent him 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.




## ***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!