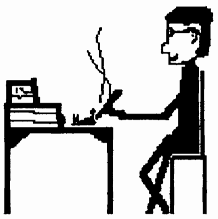
# Hot Iron

Issue 34 | "Journal of the Constructors Club" | Winter 2001



## Contents



## *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!

## *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!

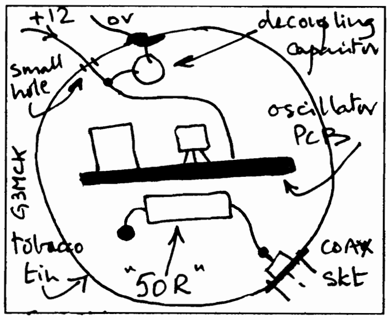
Plenty there for you to build! All the best for Christmas, Tim Walford G3PCJ, Editor

*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  Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

## *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 issues project shows how to overcome this drawback.

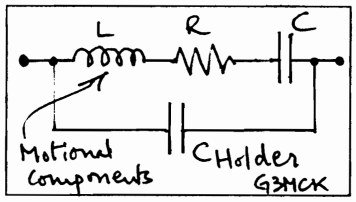
First of all put the oscillator in a metal box. Anything will do but a tobacco tin is great as they are cheap and you can solder to them. Solder the oscillator to the tin, a piece of 16 SWG wire is all that is necessary. Drill a small hole to take the DC input wire; if you want to do a better job, bypass the lead at the hole, 0.01 mF (10 nF) will do, or better still sue 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 ½ inch away from it. See right.



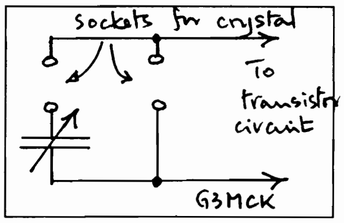

You now have made a signal generator that has a 50 Ohm output impedance and an output level that is the same for all your rigs. From experience I have found that I get S9+/- 10 dB from this sort of set up. S9 being 50 micro-volts PD across 50 Ohms. The level can be altered slightly by changing the spacing 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.



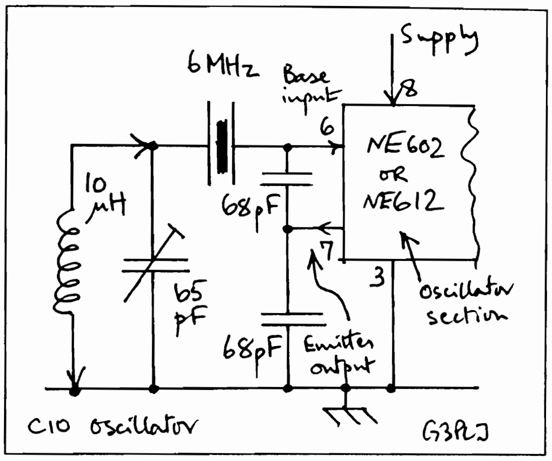

Firstly, putting capacity in series with the crystal will raise the frequency. I find that a 50 to 100 pF variable is a good value. Once you get to a certain maximum value there is no further pulling. At low values the oscillator may stop. In this case either remember that this happens or put a small 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 µH RF choke 187LY101, and various other RF chokes of values between 22 to 47 µH. 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, its 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!*

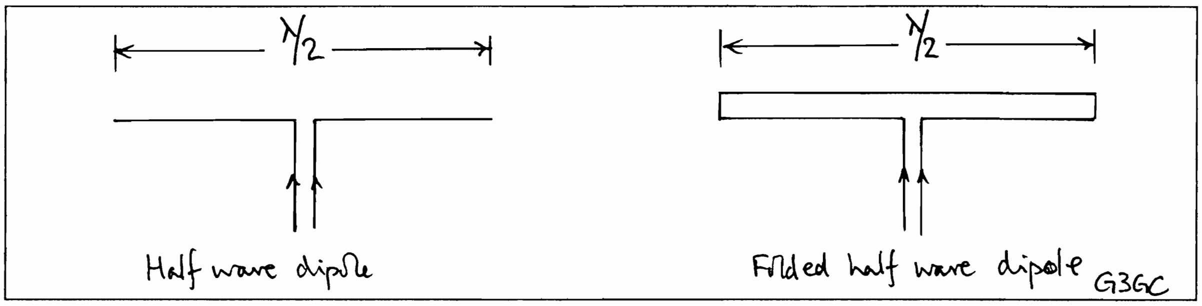
No, this is not about how to cram your radio bench into the spare room! I am advised it is the centrepiece of virtual prototyping! Still no wiser? Its actually about laying out printed circuit boards! For very fast circuits such as in most computers, the length of PCB tracks within a board is now terribly 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 x $10^{-12}$ 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

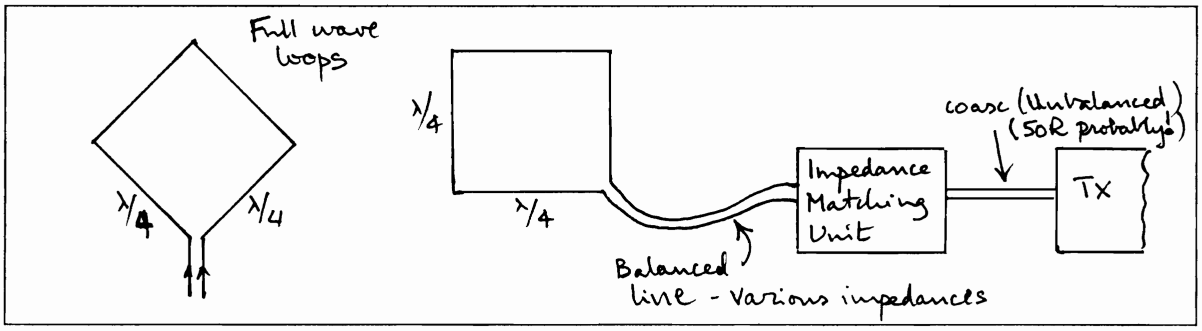
## *Antennas for small spaces*

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.



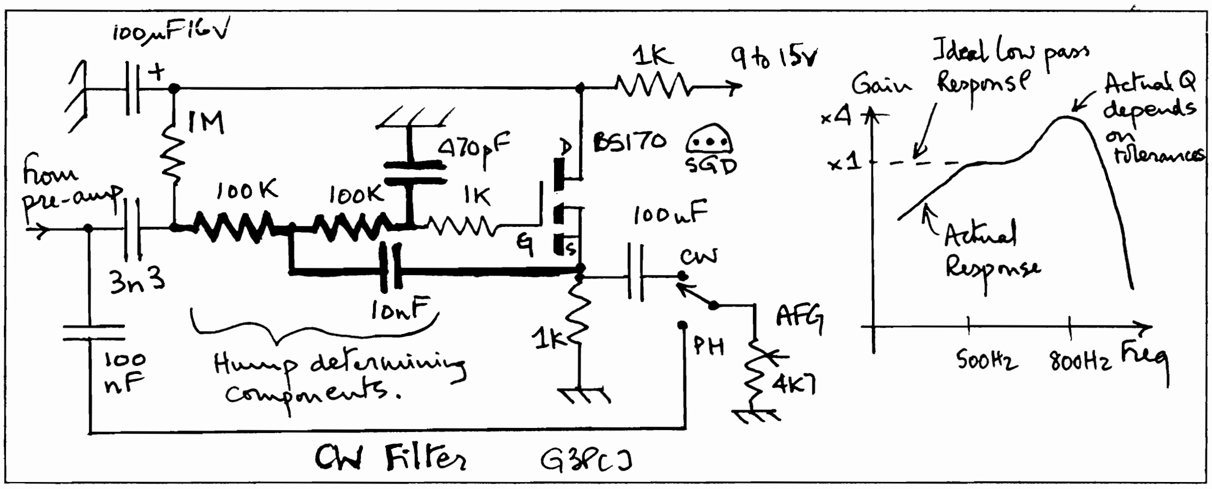

As with all balanced aerial systems some form of transformation from balanced to unbalanced is required before the system is connected to a concentric feeder, such as the output from a transmitter. Baluns are made for this purpose but have the disadvantage that in order to work correctly they should 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 made 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*

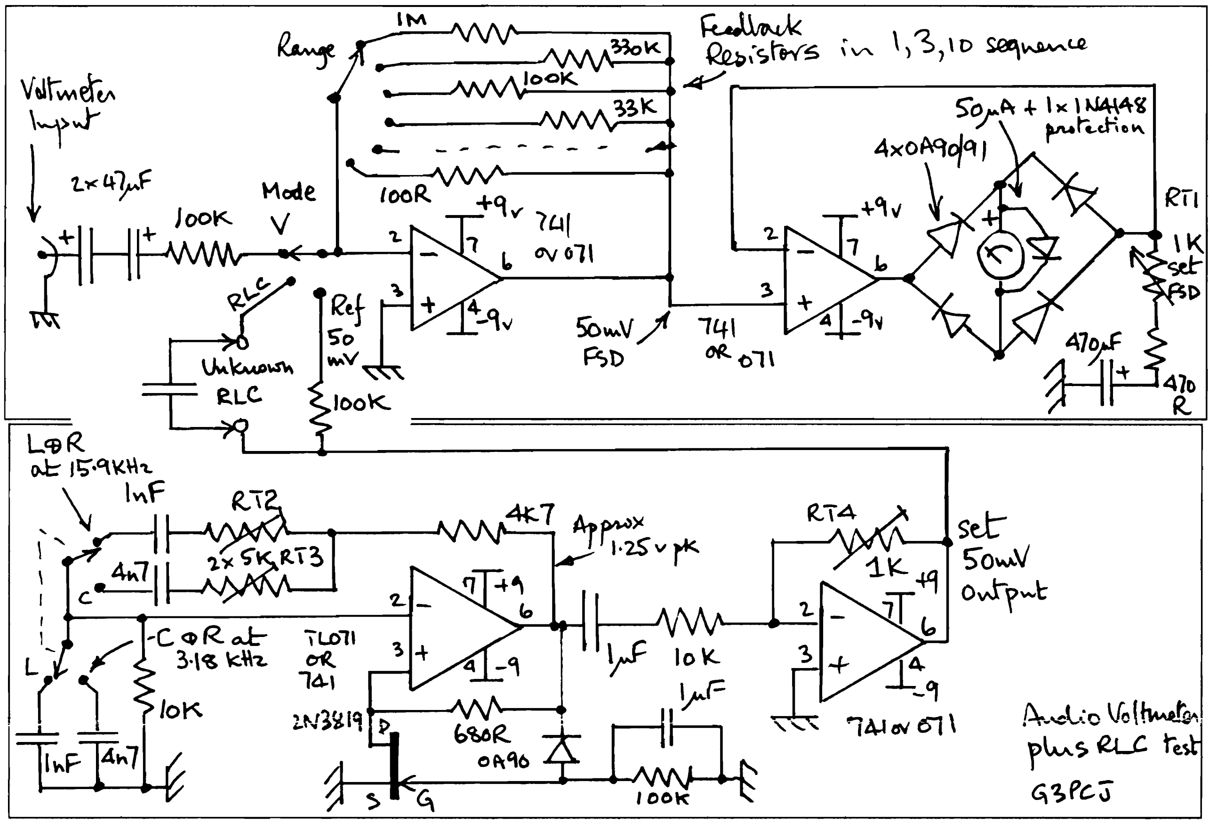
Craig Douglas G0HDJ has found the following advice for safely disposing of spent etching solution. The spent ferric chloride solution should be slowly added to 10% sodium carbonate solution which is more commonly known as washing soda. After leaving overnight, the liquid can be drained off and flushed 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!*

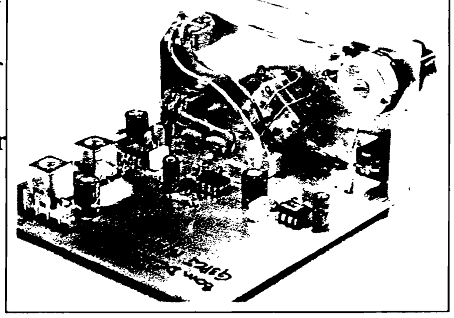
I built this gadget nearly 20 years ago but it still gets use to measure those difficult to read capacitors! The circuit in the top box below is a switched variable gain (audio) amplifier which feeds a detector using diodes enclosed within a feedback loop to make them effectively into perfect diodes! 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***