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Hot Iron

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Contents

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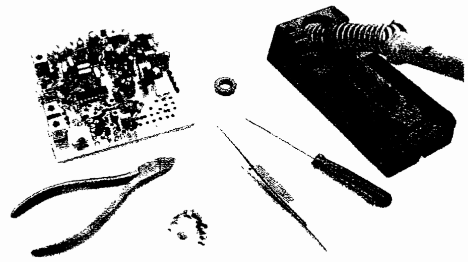
Editorial



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.

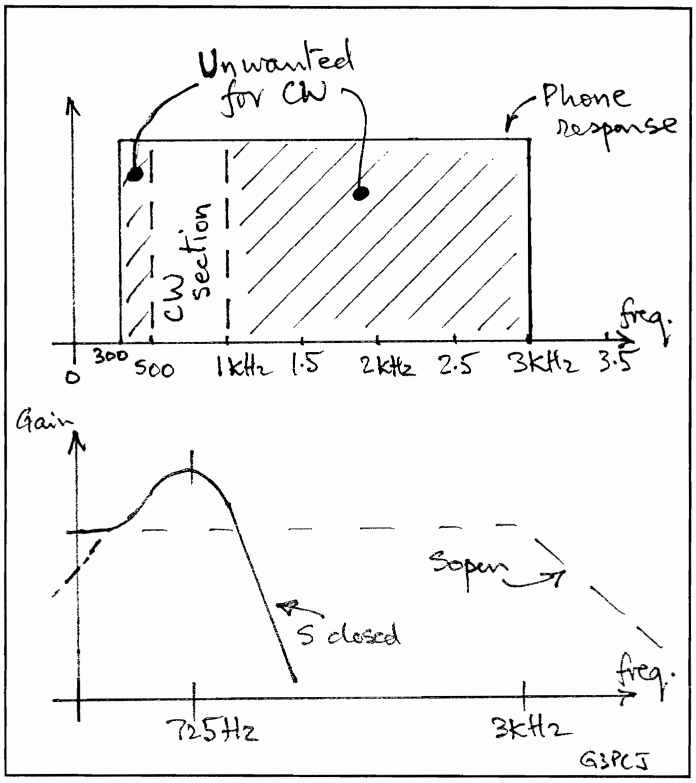
For CW reception a much narrower bandwidth may be used and it is not uncommon for this to be around 500 Hz. As before, this might be the bandwidth of the IF filter used for CW, or it might be the bandwidth of the baseband audio filter - however the centre of the audio filter can be anywhere in the audio 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.

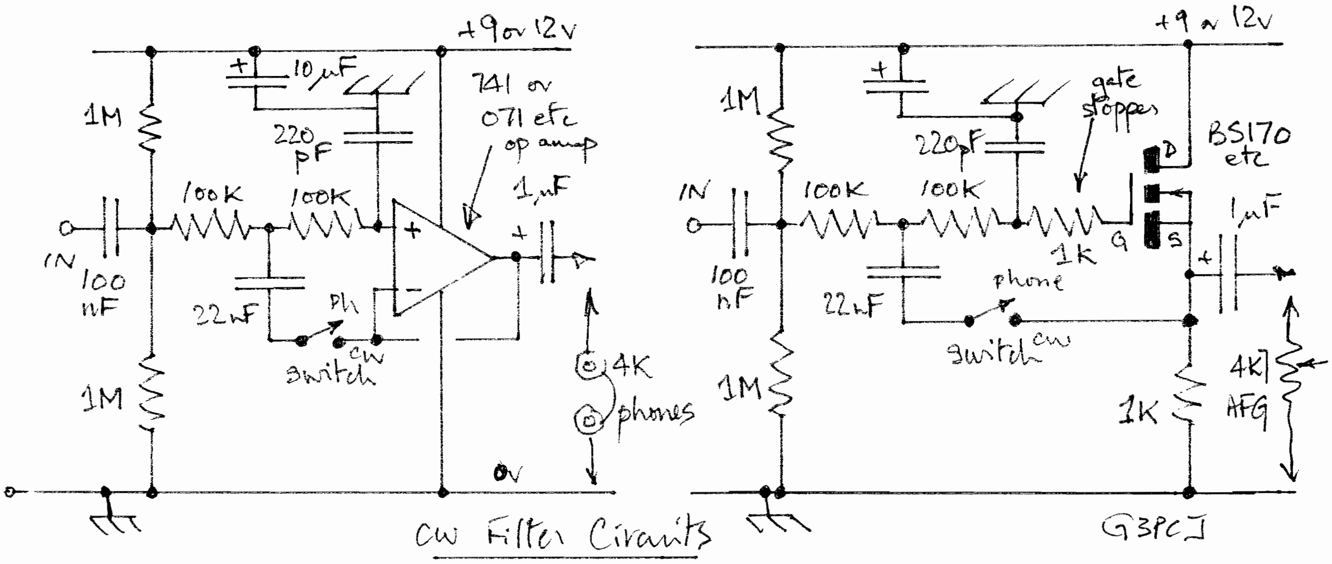
Eric Godfrey, G3GC

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 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 M0WOB 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!

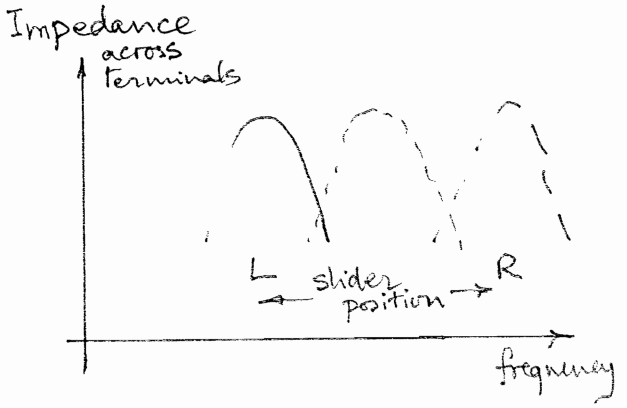
In the Jan 2004 edition of Electronics World (what used to be Wireless World) there is an interesting suggestion that you can make a variable frequency oscillator using a pot to change frequency. I haven't tried this out but hope to at some stage because of the problems of getting good variable capacitors. 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:-

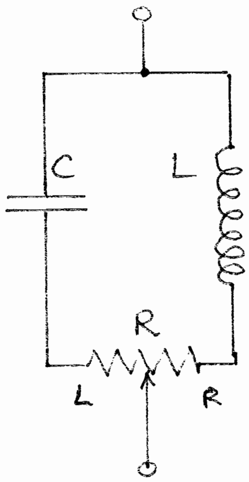
$$R = \sqrt{\frac{L}{C}}$$

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.

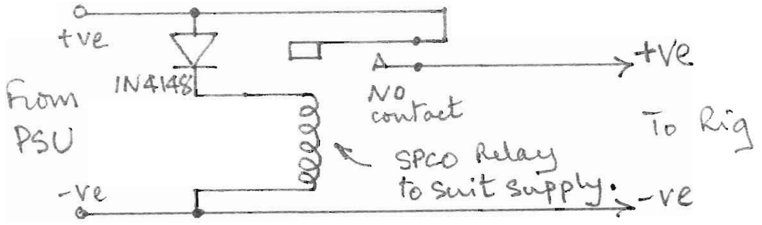
This test is of course a bit crude but maybe handy even at HF for testing cables that are old or possibly degraded through age but untried etc. Of course the test is done at the designed impedance of 50R and the dummy load at the end which is 50R so if coax is duff it will soon show up by the calibrated 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



Rig supply protection

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:-

$$X_L = 2\pi f L$$

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

$1H = 1{,}000\ mH = 1{,}000{,}000\ \mu H$
$= 10^3\ mH = 10^6\ \mu H$
$1\ mH = 10^{-3}\ H$
$1\ \mu H = 10^{-6}\ H$

Plastic moulded inductors are usually marked in micro-henries, or μH, as two digits & a decimal multiplier. So 333 is 33mH & 100 is 10μH.

Key strokes	Display
4	4
7	47 Entered in μH
×	operator
3	3
.	3.
5	3.5 entered in MHz
×	164.5, operator
2	2
×	329 operator
3	3
.	3.
1	3.1
4	3.14 } value of π
= calculate	1033.06 Ohms.

1033 enter impedance
÷ operator
2
÷ 516.5, operator
3.14 value of π
÷ operator 164.49....
3.5 frequency in MHz
= calculate 46.99 value in μH

which is pretty close to 47μH!

G3PCJ