

Hot Iron

Issue 16

“Journal of the Constructors Club”

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Editorial



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

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

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

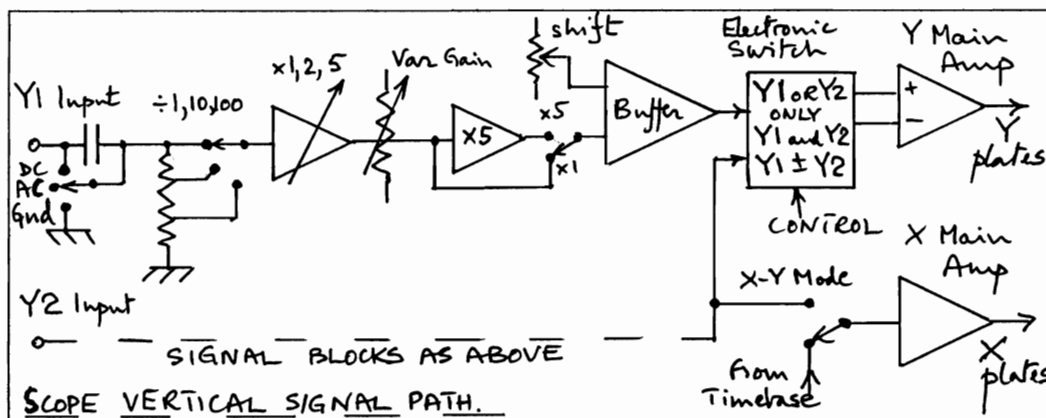
The Street

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

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

Using an oscilloscope by Dick Turpin G0BFU

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



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

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

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

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

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

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

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

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

Snippets!

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

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

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

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

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

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

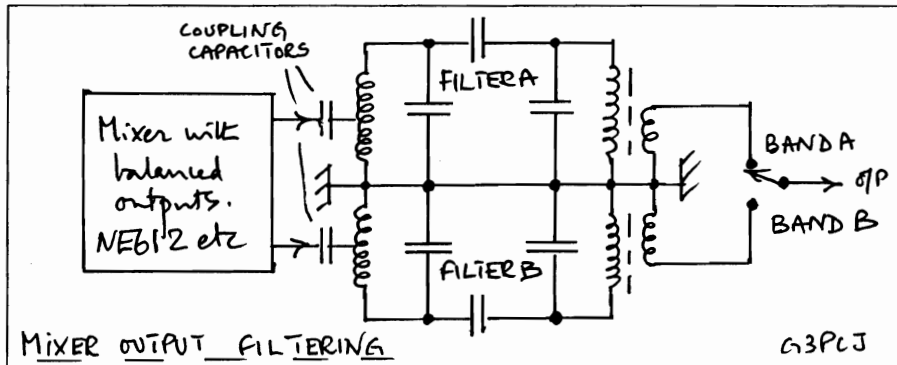
Reverse supply protection.

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

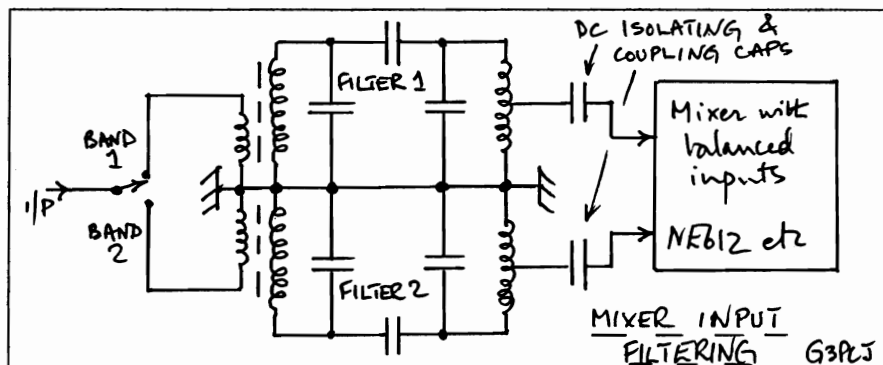


Two band mixing with NE612s

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



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



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

Tim Walford G3PCJ

Noise by Eric Godfrey G3GC

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

INTERNAL NOISE

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

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

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

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

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

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

EXTERNAL NOISE

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

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

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

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

OTHER INFORMATION

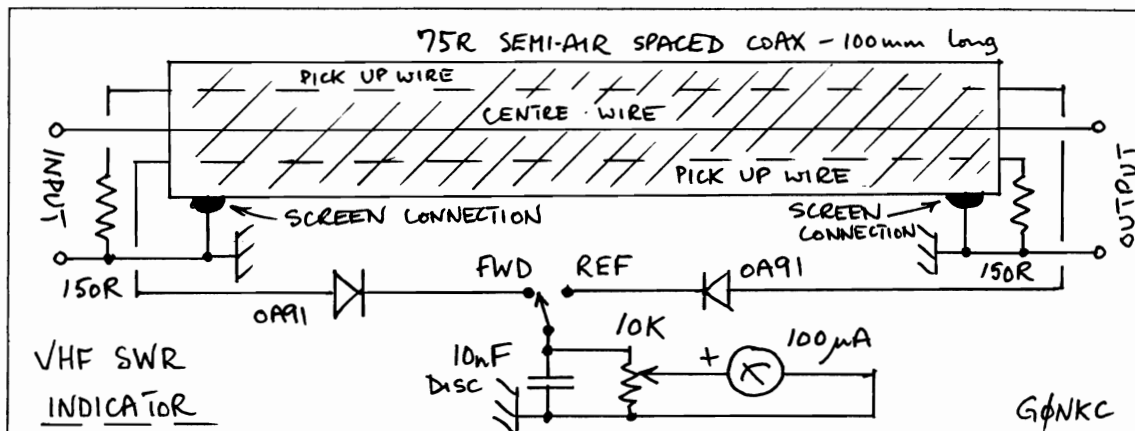
It sometimes happens that although a receiver passes the "connect aerial" test above, there is a lot of noise in the output. This must be due to noise being generated after the first stage of the receiver. This is probably a fundamental design fault.

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

VSWR Indicator by Mike Connolly G0NKC

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

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



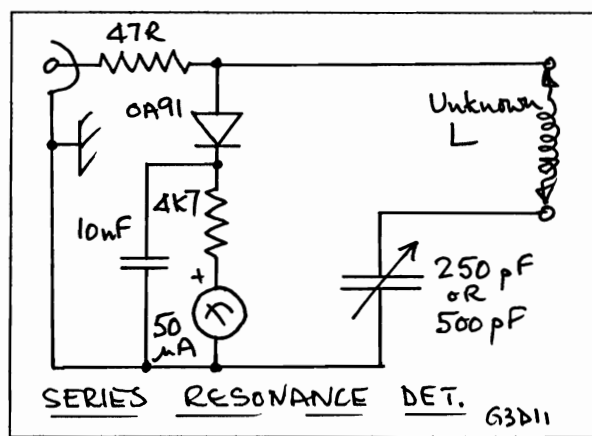
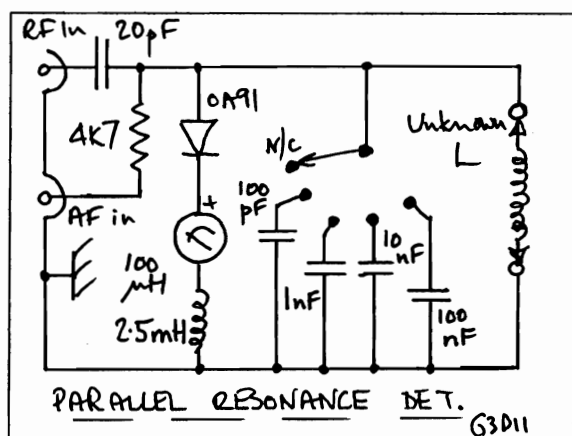
Measuring unknown inductances by Joseph Bell G3DII

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

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

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

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



Subscriptions!

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