"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

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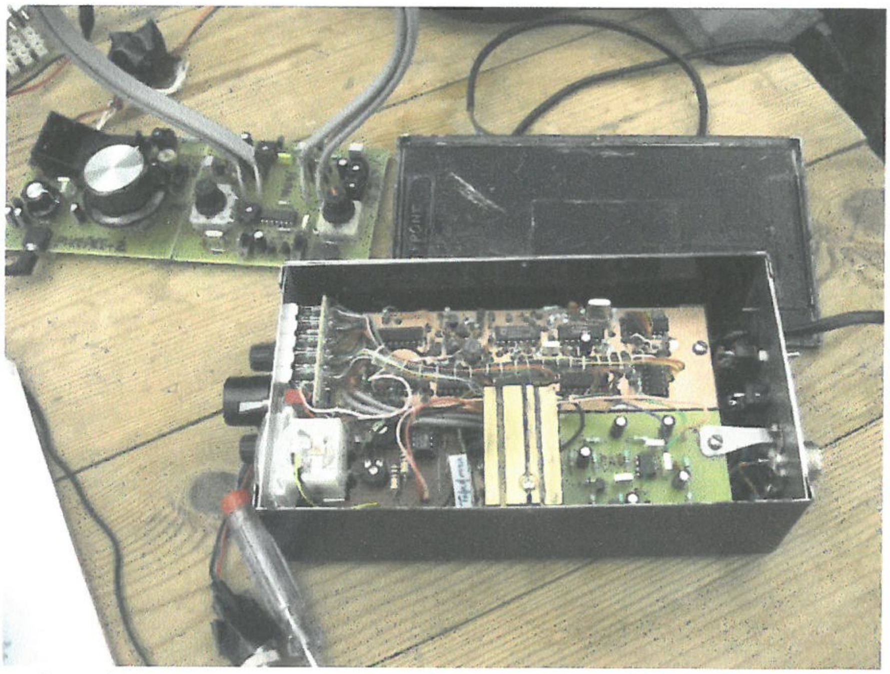
Editorial

Summer is supposed to be here but a little bit of extra wind and overhead darkness did not put off those attending the Weston Super Mare's rally at the Weston Zoyland Trust's 'Steam on the Levels' open day last Sunday May 17th. There was a good show of Club stands and traders etc, which together with a field of vintage tractors and elderly cars, and the Trust's steam engines, made for an excellent day out. It was the radio Club's first rally there and attracted a good attendance for a new event. For those also interested in steam machinery, there was plenty to see, with about 6 large engines and several smaller ones in steam – all powered by a huge 'portable' boiler on wheels furiously burning pallets delivered by the site's own light railway! I know it takes a lot to organise this sort of event but by combining it with the facilities for the public provided by the engine trust, it made very good sense to hold it there. Well done to the WSM Radio Club!



Much of that hard work was done by Mike Jones who happens to have one of my SSB Lydfords which he has turned into a very neat and compact portable rig complete with digital readout, AGC and S meter (see right). He often operates /P limiting himself to only about 1.3W max output into a 20m dipole and has managed to work over 30 countries in the last 12 months. He likes Brean Down on the Bristol Channel coast as a /P site; it happens to be where Marconi did some very early radio experiments transmitting across the water to Wales. (The other rig in the picture, with part of its loop visible, is a FiveFET Mk 2 and Fulford.) Tim G3PCJ

Contents Kit developments, Adding AGC to a RX, Electronics without PCBs, Loop aerials, Eliminating QRM, Solid State Tetrodes, Designing RXs for high HF, Snippetts, Future Hot Irons!

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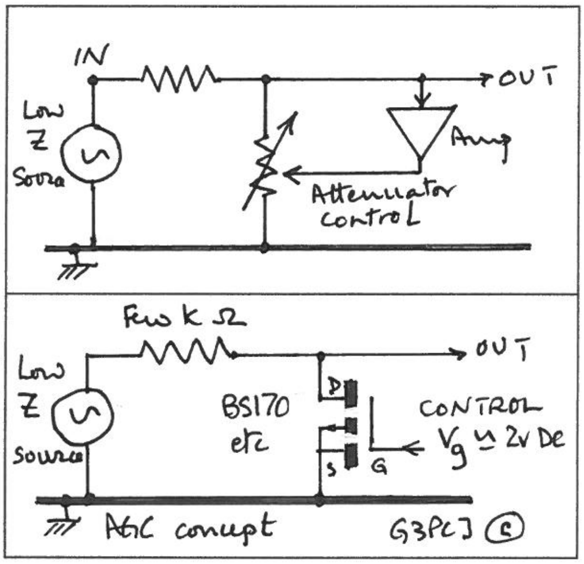
Kit Developments

I did begin work on a new 'any band to 20m' Local oscillator kit and associated DC RX with planned DSB phone transmitter - to be named after the Lambrook villages. I built the LO unit and the receiver but concluded that it was a bit too complex for the intended market segment! It is now in the pile of interesting inactive projects, but a Rode Mk 2 is more hopeful!

I am probably going to call these Mk 2 versions the Beer and Stout – believe it or not, but these are two small hamlets not far from each other about 4 miles from here! Feedback on the Rode suggested it needed a bigger PCB to make construction easier so I have added a slice along the front edge of the main PCB. I have also changed the audio output stage into the beefier LM380-8 which can easily drive a 4R speaker – 4R did strain the original design! This change to an audio output IC has liberated an op-amp whose new use is to provide AGC (see below). So there is just enough space to add a CW audio filter selected by a front panel switch. The new Stout transmitter has a better layout and a few minor circuit improvements but the main attraction is the addition of TR control and a sidetone oscillator for semi-break in CW.

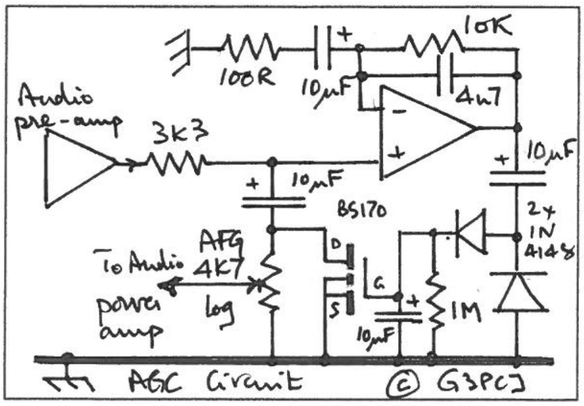
On another front, I had envisaged that the Low Ham design would be suited to the Yeo and Mark simpler receivers but have belatedly realised the TX complexity would be too high for these simple RXs; the plan now is to do a new 1 or 3 frequency crystalised 1.5W CW TX for them called the Isle – this is a tributary of the river Parrett like the Yeo!

Adding AGC to a RX



This approach can be applied to many existing designs, or as mentioned above for the Beer, it can use a spare op-amp. The basis of audio derived AGC, is to pass the audio signal through a variable attenuator which is controlled by amplified version of the desired output. If the applied signal gets to big, the controlling device increases the attenuation to bring the level back down – see right.

The easiest form of variable audio attenuator is a series resistor feeding a BS170 MOSFET whose control voltage is a rectified version of the output. Because the MOSFET needs about 2 volts to turn it on, an amplifier is needed to increase the signal level above that which would give a comfortable listening level with typical AFG settings. If the typical output level at the speaker is about 500 mV p-p, and the audio output stage has a voltage gain of x50 (as in LM380-8) then 10 mV p-p is needed from the AFG pot; that might need 40 mV applied to the log pot for a typical setting. Hence the extra control amp needs to produce about 3 volts p-p (allowing for the rectifier to drive the BS170) from an audio input of 40 mV – ie a gain of x75 or maybe x100 for caution! In the Beer, the attenuator BS170 is placed directly across the AFG pot which has the series resistance in its feed from the preceding amplifier. This driving signal has a suitable DC offset so that by ac coupling to the AFG pot, the preceding stage can also bias the extra op amp AGC stage by feeding the signal to the op-amp positive input with its gain being set to nominally x100 by the resistors on the negative input. G3PCJ



Electronics without PCBs

There are many ways in which electronic components can be mounted and wired to each other to form a circuit. Most of them depend upon a rigid base which is conveniently a sheet/piece of single sided copper laminate. This provides the mechanical strength and the copper sheet is an excellent common ground connection which is often called a ground plane. Such sheets have low inductance (and resistance) between any two points and are hence excellent at ensuring there are negligible voltage differences across the ground 'network'.

Many builders like to use small insulated 'pads' which can be used as non earthy inter-connection points; often these are made by cutting up a copper clad laminate sheet into small pieces about 2 mm square, which are then glued onto the copper side of the base copper laminate – this has the distinct advantage of providing mechanical rigidity. For RF oscillators, this is an important attribute to ensure the VFO frequency does not jitter (due to vibration) every time the board is jolted! There are many variations of this style – often called Manhattan built!

For less mechanically demanding applications, one can often get away with nothing extra apart from a handful of high value resistors (10M is ideal) and 10 nF disc capacitors. Bought in reasonable quantities, these items will cost about a penny each, and apart from helping with the build, may also improve the decoupling of the supplies! The first thing to do is to sketch out the main blocks of the circuit on a piece of paper, with inputs on one side and outputs on the opposite side – if necessary arrange all of the project's blocks around a large piece of paper so that you can minimise the length of all the interconnecting leads. It is seldom that a block has just IN/OUT points and a single supply, but when you are new to this approach starting with a simple circuit will be sensible.

Apart from the ground plane or 0 volt line with its multiple connections, the next most connected parts of most circuits are the supply lines. Often the circuit is drawn with these lines at the top and bottom of the page and this is an excellent way to also lay out the physical circuit. The 10 nF capacitors are used to support any supply line so that it is insulated from the base ground plane. Many capacitors can be added to any supply line without any fear of it disturbing the performance so be generous with them; fitting one wherever the supply connects by resistor or inductor to the rest of the circuit. If you feel that a single capacitor is a bit flimsy, then add a second at right angles to the first. If these capacitors connection points are physically well separated, connect them with short insulated wires.

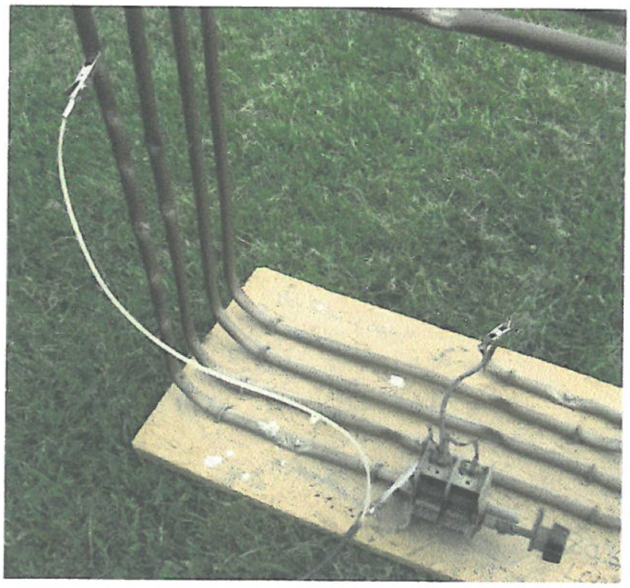
Most circuits will have several parts that connect direct to 0 volts, these can be added by soldering the earth side (eg of electrolytic capacitors whose polarity must be correct) direct to the ground plane. Do all these next working methodically from input across the circuit towards the output. In addition there will be many other components (transistors, decouplers etc) that are connected to each other without necessarily having an earthy lead; electrically these are best left as joints up in the air and so insulated from the ground plane. But if that seems a bit prone to vibration (or mechanical bending where in/out wires connect), then anchor these with one of the high value resistors between the joint and ground. Adding 10M across any point of most circuits (to ground) is most unlikely to disturb its bias or signal conditions, but if all the resistors in that part of the circuit are over 100K then it is best to try and avoid that particular point just in case it might be more sensitive than most! G3PCJ

Loop aerials

Mark Bywater kindly suggested this topic – so here are a few thoughts! When sized in fractions of a wavelength, loops radiate or receive the electro-magnetic element of the RF wave-front - conventional large aerials operate on the electro-static element. Usually formed into some sort of electrically complete loop or composite circuit, their self inductance is brought to resonance on the desired operating frequency usually by a variable capacitor. For best effect, their loop material needs a very low RF resistance, so they are often made of large diameter copper pipe which also provides the mechanical structure. There is obviously a wide range of loop inductance and tuning capacitance that will resonate on the desired frequency but usually it is the size limits of the inductor (loop) which is decided first. Generally the larger the better, as long as it can be made to resonate – I like to imagine that it's area is a good guide to what RF it can capture! Multiple turns are certainly in order if permitted loop area is restricted but of course the inductance goes up and the corresponding required capacitance goes down! One point to watch out for though, is self capacitance between turns, which will add to that from the tuning capacitor. (I once thought a flexible multi core mains cable, with its 4 wires linked end to end giving 4 turns, formed into a circle of diameter about 4 ft, should work well by resonating with a few 10s of pF on 80m – it would not go above about 1.5 MHz and was very lossy - useless!)

In what direction do they radiate? Counter intuitively, they radiate in the same plane as that of the loop itself; so when using one for a bit of direction finding work, looking across the face of the loop will give you the direction of the RF source (or its reciprocal behind you). Purists will fuss about the symmetry of the loop affecting the pattern of radiation in all directions in the plane of the loop – this is why most commercial designs will have the tuning capacitor either at the top or bottom of the loop – with no connection to any sort of RF ground. For handling high powers, the voltage rating of the tuning capacitor does have to be very high; this is because the loop itself will have a very high Q so that several thousand volts of RF are likely at full legal limit! Incidentally, at these power levels, one should not permit humans to be anywhere near the loop – for fear of RF heating and or an RF burn - I don't have any suggested safe distance figures but would suggest not less than 30ft or 10m. Hence remotely controlled stepper motors are often used to control high voltage vacuum variable capacitors to resonate the loop. With small multi-turn loops, and only a few Watts of RF, such precautions are not essential and the likely proximity of other metallic items will influence the radiation pattern unpredictably anyway.

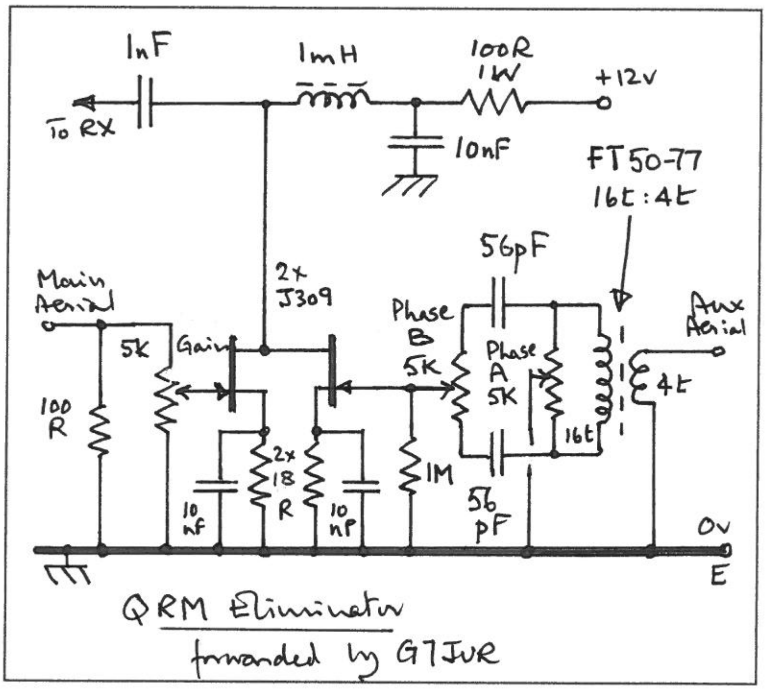
How does one feed RF to loop aerials? Purists wishing to retain the loop's symmetry will use a small coupling loop connected directly to the transmitter's 50R output. These small loops are usually about one tenth of the area of the main loop. The techniques for adjusting the size and location of such loops have always struck me as being very unscientific! Much easier is to use a 'gamma' match feed. Coax screen to one end of loop, with the inner tapped part way round the loop for best match to 50R! Right is my 80m portable loop – 4 square turns of malleable 15mm water pipe of 450mm side resonates with about 150 pF from the variable. G3PCJ



Eliminating QRM

Philip Lock G7JUR sends along this useful circuit. The concept is to null out an interfering station on the desired (or very close frequency) by adjusting the signals from two aerials so that they cancel each other out. Both aerial signals are fed to the extra circuit which is then connected to the normal aerial input terminals of the RX. (If the same main aerial is also used for transmission, don't forget to make certain the antenna changeover switch or relay, is between the main aerial and this unit!)

The circuit (right) uses an RF phase shifting network in the path from the Auxiliary aerial which can adjust the phase over a wide angle relative to the signal from the main aerial. Inevitably there will be also differences in signal amplitude from the two aerials so both paths have gain controls to enable them to be equalised when the come together at the drain of the FETs. Philip advises that the auxiliary aerial needs to be 10 to 20 ft long and ideally be better at receiving the unwanted than the main aerial! He finds the circuit very effective on the 80 and 160m bands. In use, the three controls are adjusted for best rejection of the unwanted signal.



The J309 FETs are getting a bit hard to find and I was slightly surprised by the low value (18R) of the two source resistors; but Philip pointed out this is probably to give the devices a good signal handling ability before they overload in either direction. The J300 series of JFETs do generally have much higher drain current for zero gate bias – Philip measures the voltage across them as 0.23 volts DC which implies a current of 12.7 mA – not actually as high as I had expected. I am pretty confident that the approach (as above) can be used with most other JFETs that you can obtain. I would certainly try 2N3819s but would be tempted to raise the source resistors to say 100R. All FETs do have an unusually wide spread of characteristics but I would guess the 2N3819s would typically draw nearer 5 mA amp each with 100R in their sources. I suspect this circuit is not intended to provide any extra gain.

The drain supply choke is shown as 1 milliHenry which is large (and quite difficult to obtain!). I guess the circuit has its origins for use on the LF broadcast bands (say 200 KHz) where the choke's reactance needs to be much larger than the nominal 50R of most receiver aerial inputs – say at least 500R; for use on the HF/LF amateur bands, I suspect 100 microHenries would suffice. If even that is unobtainable, I suspect replacing it with 470R might work reasonably! I am not sure what sort of ferrite the FT50-77 is, but again try whatever you have to hand; but do recall that this is a ferrite with a high inductance for each turn, not a black coloured powdered iron toroid! Ferrite cores are usually a dull grey or grey/black slightly dusty material – quite unlike the smooth powdered iron coloured cores used for HF tuning inductors. G3PCJ

Solid State Power Tetrodes - farewell 4CX250B?

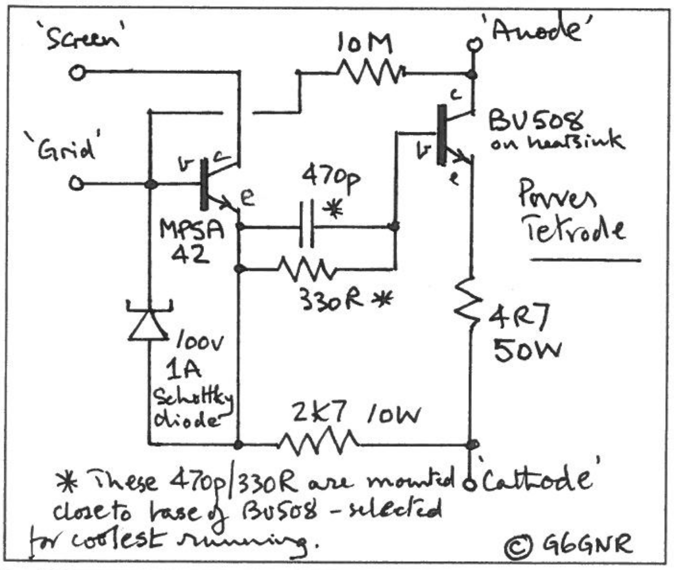
I was recently repairing an industrial RF generator, used for induction welding service. The power tetrode at the heart of it had given years of valiant service, but cathodes don't last forever, and a replacement to fit the socket, housing and equipment was unobtainable. The original tetrode *could* be rebuilt and pumped out to a really hard vacuum, but the cost put that out of the question, as was replacing the entire RF generator.

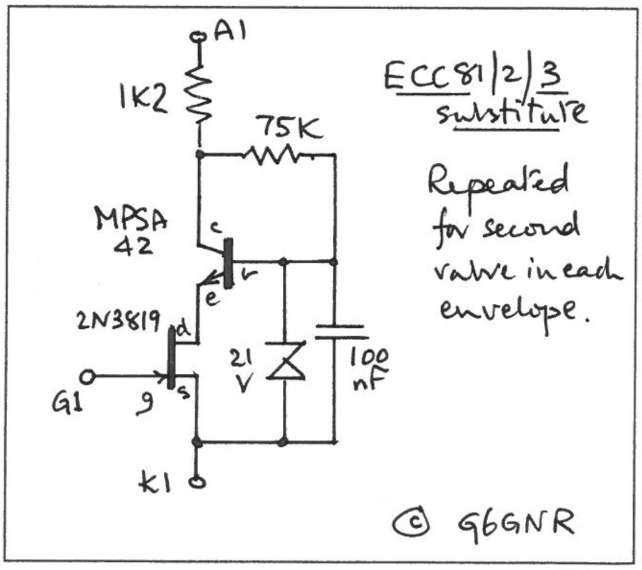
This dredged up memories of replacing valves with solid state devices. This tetrode was a big glass enveloped job, fan cooled, with an open circuit filament. The screen grid bias was used to control output of +200v to +350v DC. TV line output NPN transistors sprang to mind: cheap and available, and a working result emerged (phew!). The basic requirement was judged to be: 650v DC supply requires 1300v DC capability; anode currents 3 to 6 amps typically, to run at several hundred kHz. The eventual circuit is shown bottom left.

This worked well, after fitting a (much!) bigger heatsink and tweaking values. But after completing the weld, the operator would hung the work coil on the side of the machine with RF still being generated! The sudden load change blew the BU508 - probably due to avalanche breakdown, collector to base, caused by the sudden mismatch. Time for plan "B"! Replace the BU508 with an STW9N150 MOSFET and alter the base (now gate) bias resistor to increase the drive voltage. Voilà! One solid state power tetrode - full output, at a fraction of the cost.

I have many circuits for replacing valves with solid state devices, but space doesn't allow illustrating: I would be happy to pass these on to amateurs, email equieng@gmail.com please, should you wish to resurrect some ancient valve gear. A solid state 807, perhaps....?

Employing high voltage rails allows high impedance "valve style" designs to be very easily implemented, but please be aware, frequency response, power output and voltage capabilities are much like aerial bandwidth, efficiency and size: you can never get all three at once! This does mean, however, useful "valve" circuits, oh so simple, can be implemented very economically without all the wasted heater power. Figure 2 is how I implemented ECC81/2/3's in solid state: ideal for audio and other straightforward duty. Tetrodes and pentodes of various powers and capabilities can be created, given a bit of cut and try. You can replace the MPSA 42 with a BSS139 MOSFET - in common gate this will be very fast, but if it won't run at 100MHz, don't blame me! Peter Thornton G6NGR





Designing RXs for high HF

This is another topic suggested by Mark Bywater – thank you! Apart from the obvious aspects of the physical arrangement and supplies, the three most important electrical characteristics of almost any RX are the three **Ss** – stability, selectivity and sensitivity.

In days of yore for CW and AM, where a receiver audio bandwidth of up to 3 KHz or so was necessary (and could also be used for CW), the aspect of frequency stability was not quite so important as it is for SSB and the even narrower data modes. For SSB, it becomes difficult to read a signal if either the TX or RX drift off more than about 20 Hz from their nominal same value which is required for best reception. Hence one needs to prevent your RX VFO from moving more than about 20 Hz during the course of a QSO – say over 15 minutes. (One usually assumes that the transmitter is perfect and rock solid! This is valid for the majority of situations because most transmitters are commercially made and use some form of Direct Digital Synthesis DDS – whose stability is based on a crystal ultimately, and hence almost perfectly stable). Long term stability over many hours is not essential due to retuning between QSOs. Often this stability aspect leads to more complexity than either of the other two Ss!

So how to get that frequency stability? A crystal oscillator can very easily achieve that but has the major disadvantage of very limited tuning range – so low that, a crystal based rig is considered fixed frequency. The modern alternative to crystals are ceramic resonators – they have a lower Q and can be pulled over useful ranges; quite good enough for benign environments on bands up to 80m, but above that, they change too much with temperature variations. The traditional way to overcome this is a frequency mixing scheme – signals from a VFO and a crystal are mixed and the desired sum or difference then selected by filters before use in a typical direct conversion RX or TX. This is also essentially what goes on in a superhet where the VFO is mixed with a signal very close in frequency to the filter's IF. Proper VFOs are generally not sufficiently stable above about 8 MHz so if one aiming for an RF of 28 MHz, a VFO at 4 MHz would need mixing with 18 MHz to make an LO of 22 MHz for a superhet with 6 MHz IF (eg the Minster). Hence all the crystals, mixers, filters and complexity of analogue multi-band rigs. Allow yourself to go digital and a small micro-processor driven DDS unit will give you multi-band rock solid stability to 100+ MHz, for the LO signal into the superhet's first mixer.

Enough selectivity is much easier to achieve! In a DC RX, the tuning bandwidth is the same as the audio bandwidth – so can be easily altered! For a superhet, the IF filter is designed to be so narrow that the unwanted sideband is rejected near the pass-band peak of the IF filter. The rejection of all signals (IF image and strong out of RF band signals) away from the filter's nose is generally good enough with only 4 crystals in the IF filter – add more crystals and the sides get even closer together! Ladder IF filters are no longer the most expensive part of the rig!

Adequate sensitivity does become more important as the rig's frequency is increased – unwanted atmospheric noise collected by the aerial decreases as frequency rises, and the smaller wavelength, with smaller element sizes, mean there is also less signal for any given field strength. All this dictates that a high HF RX should have high front end gain which does NOT generate its own noises. However, just increasing the front end gain is not the answer because this will directly reduce the largest signal that can be handled before the first mixer begins to overload. The classic test of whether you have enough sensitivity is to listen at max gain without the aerial connected, and then see if the noise level increases when the aerial is connected. If it does, you have enough sensitivity and you will hear any signal that is above the noise. G3PCJ

Snippets

Sellotaped Front panels One recent kit constructor explained that he had overcome the problem of assembling the main PCB to a printed circuit front panel, with its side braces, by temporally holding all pieces in place with sellotape; then checking for 'squareness' and correct location/room for front panel parts prior to making the soldered joints for final rigid assembly!

Interesting book! Good friend Robert Van de Zaal recently sent me a copy of newish book about the Second World War French resistance radio operators and their equipment. It is a fine collection of photos of the operators and a whole host of their radios – Polish, English and American. 112 glossy pages of American sized near A4 – although published in France, the text has been translated into English (a little quaint in places!). I had no idea that so many different suitcase style radios (nearly all with Regen TRF receivers and plain CW crystalised transmitters) had been used. Brief details of all radios have been included but not circuits. Title is The Clandestine Radio Operators written by Jean-Louis Perquin, published by Histoire & Collections in 2011 with ISBN 978-2-35250-183-1.

All change but this is not the last Hot Iron!

The cost of posting Hot Iron has become excessive compared to the printing costs so I think its time to get a bit more up to date and send it electronically in future! I swear heavily every time I am forced to use the MERGE facilities of Word to do the labels – I find it terribly counter-intuitive – it takes me over an hour to find the right steps every time! (I suspect I am heard in Microsoft Towers!) Going to a pdf file format, and despatch down the wire, will also permit the colour in pictures to be retained! I am not quite sure how I will compile the list of who it goes to, but certainly it will/can go (if wanted) to all who currently receive the paper version and maybe to anybody who asks, and whom I am happy to send it too. There is a need for a little bit of caution to keep the material out of unscrupulous hands so I reserve the right to refuse it!

So please, all of you who would like to continue receiving Hot Iron, just drop me an e mail with the address you wish it to be sent to.

At the moment, I am not expecting there to be any charge either!! I may automatically include those ordering 'intermediate complexity' kits and those in the publishing world (who have been so helpful over the last 20+ years!), but if in any doubt, please ask to be included. However, this is not an entirely 'free lunch' for readers – I do need you all to help with compiling the material for it – it is quite challenging to come up with enough new material without repeating topics from last year! So please throw me (electronically preferably) any articles, or topics that you would like to see covered. Don't worry about your writing style etc and any problems about copyright etc can always be addressed. As ever, any suggestions whatever for its style and content are always welcome to me - Tim Walford G3PCJ at electronics@walfords.net