“JOURNAL OF THE CONSTRUCTORS CLUB”

Hot Iron

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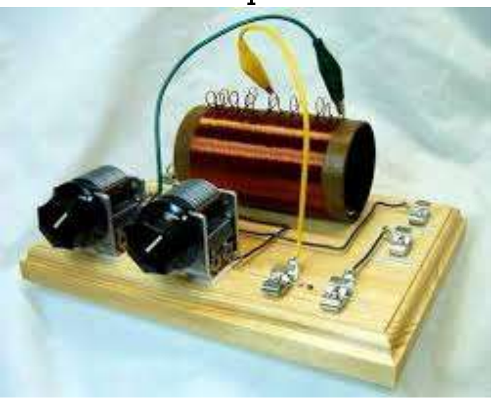
Editorial

Welcome to a new era for Hot Iron – electronic distribution - its 22 years since I started compiling Hot Iron, and now we go one more small step in keeping up with what can easily be done nowadays with modern computers and the internet.

This prompts me to return to a fundamental question; how should the various ‘agencies’ – both Governmental and Voluntary – encourage the uptake and understanding of the technology of radio communication. Many will say that within a few years, all radios will be glorified fast computers where ALL functions are carried out by highly capable software. But, and it is a huge BUT, we live in an analogue world and all our relationships with most forms of technology are essentially analogue. To give one small example, our ears perform their transducer activity by analogue processes (that I don’t fully understand), but which I do know are not digital – the pitch and amplitude of sounds are converted to small signals to the brain which are conveyed in analogue (ie multi-level) form. I can’t tell you if our brains are all analogue or hybrids but I am certain they are not all digital! Our output ports (fingers etc) are analogue too! We can’t get away from this fundamental point that the world out there is analogue, and hence it is essential that we have an understanding of analogue technology – for electronics and rdio in this case. Get anybody to draw out the functional blocks in a radio and they think in analogue processes (gain, bandwidth, filtering etc); even the designer of a software defined radio will start by drawing out the required functional blocks of signal processing needed to select the desired signal – he will only then implement those blocks in routines that use special forms of mathematical software – with suitable A to D input converters. So some understanding the analogue technology (for radio aspects in our case) is fundamental to its enjoyment and technical development – this last aspect is very important because we are not just a ‘user’ group for mobile phones etc - our licences allow us to undertake all sorts of experiments that the general radio using public are not allowed to do.



Hence I think new recruits should be introduced via simple analogue equipment - not by using sophisticated SDRs whose technology is not understood by most of us. They are also often ‘inefficient’ compared to what can be done with half a dozen semiconductors!

Back to the crystal set! (Is that analogue?) Please keep your contributions flowing in! Any topic associated with radio will be of interest! Tim G3PCJ

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Hot Iron is published by Tim Walford G3PCJ of Walford Electronics Ltd. for members of the Construction Club. It is a quarterly newsletter, distributed by e mail, and is free to those who have asked for it. Just let me know you would like it by e mailing me at electronics@walfords.net

Kit Developments

It has been a very busy three months – both electronically and on the farm (my day job!). While sitting on the tractor I decided that my range of kits needed a bit of a shuffle – hence the following! The first intention was to improve the superhet Rode RX and Rudge TX – to make them a little bit easier to assemble, to improve their performance, and possibly to include AGC which many builders have said was an excellent addition. Accordingly I laid out new versions called the Beer and Stout – these are actually small hamlets not far from here! They will use the same 10 MHz IF superhet scheme so they can do any band of 20, 40 or 80m. They now have audio output for driving low impedance loud speakers as well as AGC, and it seemed not too hard to add the extras for CW operation as well as SSB phone. These have become separate new designs because I soon realised they are too dense for relative newcomers, so the R & R derivatives are somewhat simplified. These are now called the Halse and Hatch – still 5W phone SSB rigs with relay TR switching but now using a 9 MHz IF and a single VFO band near 5 MHz so they can do only 20 or 80m. These should be well suited to less experienced builders. None are proven yet!

I also felt that the Yeo DC RX needed a revamp and matching transmitters. Now that the FiveFET serves as the very first introduction to radio projects (it did not exist when the Yeo started life), the Yeo could become a little more interesting and better matched to either CW or DSB transmitters. Although both CW and DSB TXs can work with a 'pullable' ceramic resonator to avoid chirp/FMing, these are only viable for 80 and 160m because higher frequency resonators suffer unacceptable frequency drift. Crystals are too limiting, so we really ought to have a crystal mixing LO scheme for proper VFO operation when transmitting. Hence the Mk 2 Mini Mixer kit outlined later on. Usually the Yeo's VFO would be changed to 6 MHz for input to the mixer kit; its outputs are then at band frequency for use by RX and either TX - the new 1.5W Isle for CW or the Axe for DSB phone. These transmitters are normally for any single band 20 – 80m, but both can also be made to do 20, 40 & 80m with the Mixer kits dividers and the addition of my old Twin Low pass filter kit!

The new version of the Yeo needed several changes so the VFO can drive the Mixer kit at 6 MHz instead of operating at the band frequency when used as a simple DC RX. It would also benefit from a switchable narrow filter for CW. There is also enough space for relay controlled input RF filters for all three bands 20, 40 and 80m! This sounds a bit complex but the various kit options will allow the Mk 2 Yeo to become a three band DC RX coupled to either 3 band Isle for CW, or the Axe for DSB phone!

More details on all these options as they emerge – the PCBs are all laid out but there is much writing and testing of the rigs, & their instructions, yet to be done! However, the Mk 2 Mini Mix kit is now ready. As ever, I am always pleased to have early builders of kits, so if you are interested in any of the above, please let me know.

As an aside, many people might comment that a decent DDS unit would obviate some of the complexity in obtaining suitable LO signals; true – but the usual associated micro processor is complex and not easily adapted, nor is it 'simple' to understand! G3PCJ

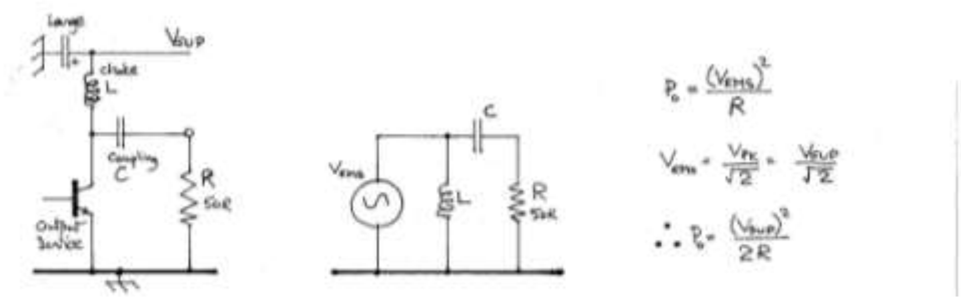
Nothing to do with radio but a picture is always welcome – so knowing that at least one of our members is a keen steam railway enthusiast – this is a recent picture of an ex South African Beyer-Garrett loco on the 2 ft Welsh West Highland Railway!

RF output supply chokes

Craig Douglas G0HDJ asks about the chokes that are often seen in RF output stages and ponders why the range of values used is so large!

First we need to consider the load presented by the aerial 'system' to the amplifying device in the output stage. For nearly all rigs nowadays, they are designed to work with 50 Ohm loads presented by the 'aerial system'; the impedance at the centre of a half wave dipole is usually near 70R which is often close enough for direct connection with a 50R transmission line (coax), or alternatively, there will be some sort of matching circuit (Aerial Matching Unit) between the aerial/transmission line and the TX which will make the load on the amplifier appear to be 50R, when the actual line terminal impedance is materially different from 50R. In both cases the output load is 50R. First consider the simple case where there is NOT any matching circuit between this 50R load and the output device. This is the simple circuit shown below left which is often used in QRP rigs. (We need to ignore any LPF for present – see next Hot Iron!) To work out what power this can deliver to the load, we need to consider its equivalent circuit shown in the middle. This is correct because the supply rail of the actual circuit has very low (negligible) RF impedance, due to the supply decoupling capacitors, so is actually at RF ground for the RF signals. The physical series output coupling capacitor C is also sufficiently large that its impedance is negligible compared to 50R hence it can be ignored. If we temporally omit the choke, the maximum power that can be delivered to the load is generator RMS voltage squared divided by the load resistance – $V^2/2$. The peak RF voltage is equal to the supply so this has to be divided by sq root of 2 to convert to RMS, but when this is squared in the power formula; it ends up only needing to be divided by 2! This explains why most simple 12 volt QRP rigs have a nominal output of about 1.5W – ie 12 squared divided by 2x50!

Now consider the supply choke which is actually in parallel with the load because the supply rail is at ground for the ac signals. For it to have negligible effect on the circuit, its impedance has to be much larger than the 50R load. In practical terms, this is usually taken to mean its impedance at the operating frequency should be at least four times the load, or greater than 200R! So for a typical 80m rig, to obtain an impedance of 200R the inductance needs to be at least 9 µH – the nearest convenient larger value is 10 µH. If the inductance is even larger, then it is of no consequence because the impedance will be even greater than 200R. So in principle, this output stage could work on any higher band without changing the inductance. But if the rig were designed for 10m upwards use, or 35 MHz (10 times higher for mathematical convenience), then the inductance need only be about 1 µH. So in practice, the choke size can vary hugely as long as it is several times the load impedance at the lowest operating frequency. It also needs to be able to pass the peak supply currents happily, so low resistance is also important. The upper frequency limit would come from it having too much self capacitance but usually the output device runs out of steam long before the choke is useless!



For higher powers, the load on the output device has to be lower – for example, a 5W rig will need a 12.5R load on the transistor when used on 12 volts. Often this is done with a 1:2 turns ratio RF transformer that will perform the four times impedance step up to 50R. Now the supply choke (or inductive reactance of the transformer primary) needs be larger than 50R. G3PCJ

QRO & MOSFET drivers

Peter Thornton G6NGR writes that modern MOSFETs working in Class C can behave like valve circuits with several advantages! MOSFETs with drain ratings of over 1500 volts and current handling ability of a many Amps are now readily available, with the ability to produce hundreds of Watts of RF without the very awkward extremely low load impedances (near an Ohm!) that are typical of low voltage high power transistor stages. Load impedances for such MOSFETs are much higher and can use valve style coupling/matching networks – very often in the Pi configuration with easy matching to a wide range of transmission line load impedance, with just a pair of variable capacitors instead of additional relatively complex AMU circuits.

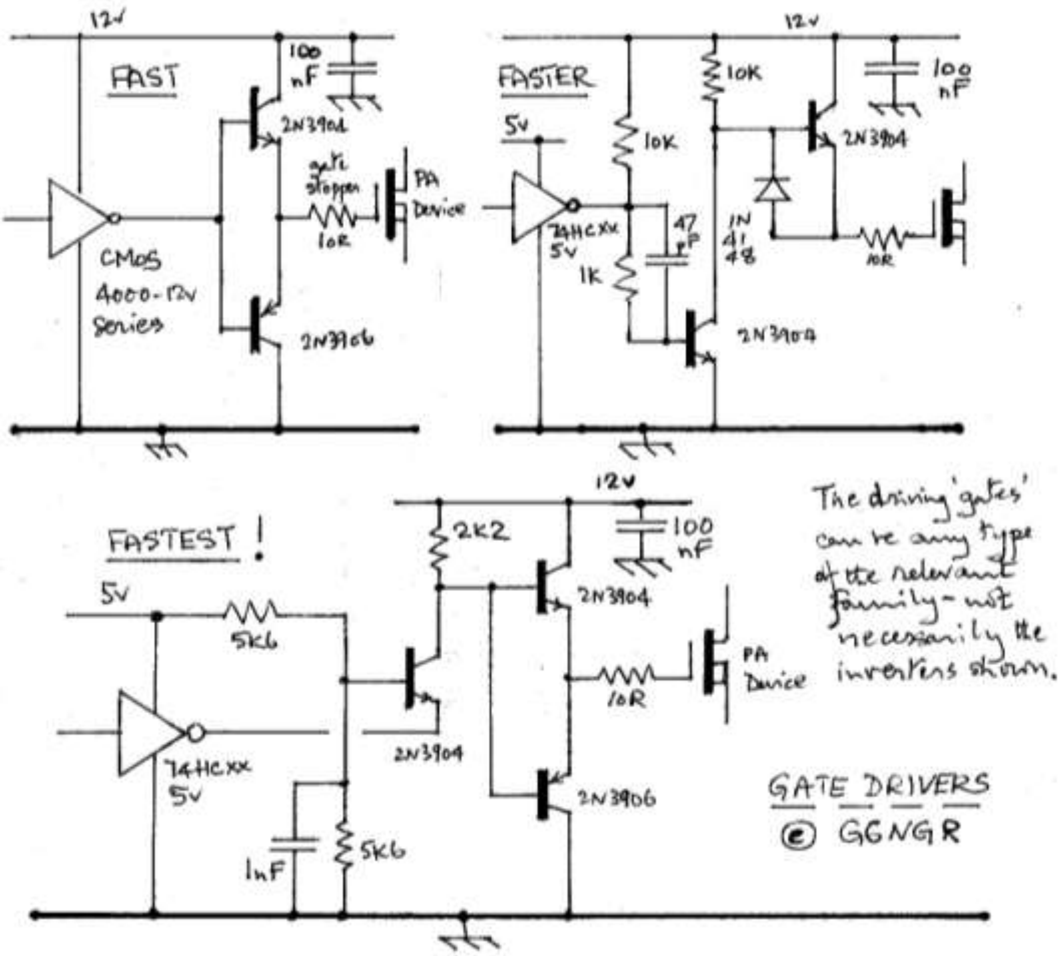
So what is the drawback of these MOSFETs? The answer is their high gate input capacitance – this can range into a few nanoFarads for the meatier devices, which makes them challenging to drive at higher frequencies. Often these MOSFETs are fundamentally high speed devices in all other respects, so if the gate charge can be overcome, viable HF (or even UHF) applications are possible. So getting the device to operate quickly is all about large charge and discharge currents into their high gate capacitance. The harder and quicker that the device can be turned on/off leads to less device dissipation, better efficiency and more RF up the spout! For this class of operation (class C), it is best to use fast edge digital signals instead of sine waves, so the interface between these logic driver circuits and the high power MOSFET is the area of interest. For anything over QRP levels, special gate drivers (like these below) are necessary.

The simplest driver circuit is a pair of complementary emitter followers, as shown left below. The 'mid signal swing dead band' (about 1.5v out of 12v of drive) when neither buffer transistor is conducting is not important – its all about what current is available at the signal extremes! This simple driver works with 4000 series logic having a 12v signal swing, but they cannot sink or source more than about 1 mA so cannot provide base current above this level to the complimentary buffer transistors. The 74HC logic series are beefier but usually have only a 5 volt swing so needs some sort of level shifter to provide a 12 volt swing to the PA MOSFET gate. All the circuits should have a low value gate stopper resistor (typically 10R) to prevent UHF oscillation in the PA stage which is often very difficult to detect and is often destructive!

A 'faster' scheme is to use a discrete higher current inverter stage and 'half buffer' running off the 12v line as on right. The first transistor has a higher base bias so that the device can directly ***sink*** a higher current from the MOSFET gate through the 1N4148 diode; on the other half of the RF cycle, the second transistor acts as an emitter follower so that it can ***source*** the higher current for the MOSFET; thus it is faster on both haves of the cycle! The inverter stage can be driven comfortably by any device of the 74HC series, which usually run on a 5v supply. (Incidentally it is best to avoid the 74HCT series devices intended for driving TTL logic that do not have symmetrical logic levels.)

The 'fastest' scheme (bottom) uses a grounded or common base inverter stage driving complimentary emitter followers. This form of driver for the output emitter followers is even faster and reduces dissipation in the driving logic gate. It permits a lower value base resistor to the 12v supply for the emitter followers so permitting even higher currents to/from the high capacitance of the PA MOSFET! This approach was dreamed up by our Ferranti colleagues!

Diagrams on the next page! Many thanks to Peter Thornton G6NGR for these suggestions! Tim



Peter adds a postscript that there is a new 'driving' chip causing much interest in the USA for providing 50W or so for driving high power tetrodes running AM on 75m. This is the IXD 614 series devices made by IXYS that can deliver up to 14 Amps of peak current into loads of 15 nF with rise and fall times of about 20 nS when running on a 18v supply! Quite a beast!

Snippet - SA602 LO input level

Philip Lock reports that his Rode and Rudge combination, suffer far less image reception problems with reduced LO drive to the first mixer. This is a SA602 device and in my existing standard design is unfortunately over-driven by the VFO stage. He added a small attenuator that reduced the LO voltage input to the 602 to about one third its previous value so that it was nearer the recommended 200 - 300 mV p-p drive, suitable for when the internal oscillator facilities are not used. This dramatically reduced the unwanted image response and was still able to get full output of 5 Watts when transmitting.

I have corrected this defect in the Halse and Beer receivers which are the new derivatives of the original Rode design. Please consult me if any Rode owners needs assistance with modifications etc. G3PCJ

More Snippets

Passive mobile radio handsets NASA reports a technique that could much improve running time between battery recharges, by making the handset passively reflect the base stations RF back to the base station for the 'uplink' exchanges. So far it has only been done over ranges of a few metres! It involves using CW from the base station with nulling to direct the reflected beam.

Very high frequency real time scopes Tektronix report a concept for real time data acquisition at up to 70 GHz, repeat 70 GHz! For use above the fastest sampling rate of analogue to digital converters, it is necessary to split the incoming signal into high and low band sections. The low band section can directly process all below about 35 GHz, while anything higher has to be first down converted in a mixer/local oscillator into a second 0 to 35 GHz channel. Both input channels then need samplers, filtering, track and hold stages, followed by the main analogue to digital conversion into a high speed data stream memory. The two slices are then re-united for display purposes by signal processing software which of course can work in slower time – this is no trivial task though because of the time/phase differences between the two data channels. The techniques are beyond me but I am sure the sampling theories of Mr Nyquist are very relevant!

Baird Archive Between Nov 1926 and April 1927, John Logie Baird experimented with the transmission of television pictures via phone lines across the Atlantic. Much paper archive material, with Phonovision discs, has come to light which it is hoped can be kept in the UK.

Boys Toys! The UK designed Bloodhound SSC is to do some preliminary 200 MPH testing in Cornwall at the Newquay Aerohub. Later in 2016 it goes to South Africa to attempt 1000 MPH!

Valve HT supply

From time to time I get asked about valve based kits and have shied away from them, because they can be dangerous! Obtaining HT supplies without using the mains directly is one problem. I might try is using MOSFETs running off a 12v supply, in push pull to drive a mains transformer working backwards at 50 or even 200 Hz. Nothing radical about this, but plain square wave drive at 50 Hz into a 12-0-12 to 240v transformer is far from ideal – better to leave gaps (matching the sine cross over region) between the hard on periods. Hence this scheme has cross over 'delays' and a 9-0-9v transformer. 9v is used because its peak is 12v - nearly matching the supply with similar energy per half cycle. Excess output just stops the inverter! I plan to do a PCB soon. G3PCJ

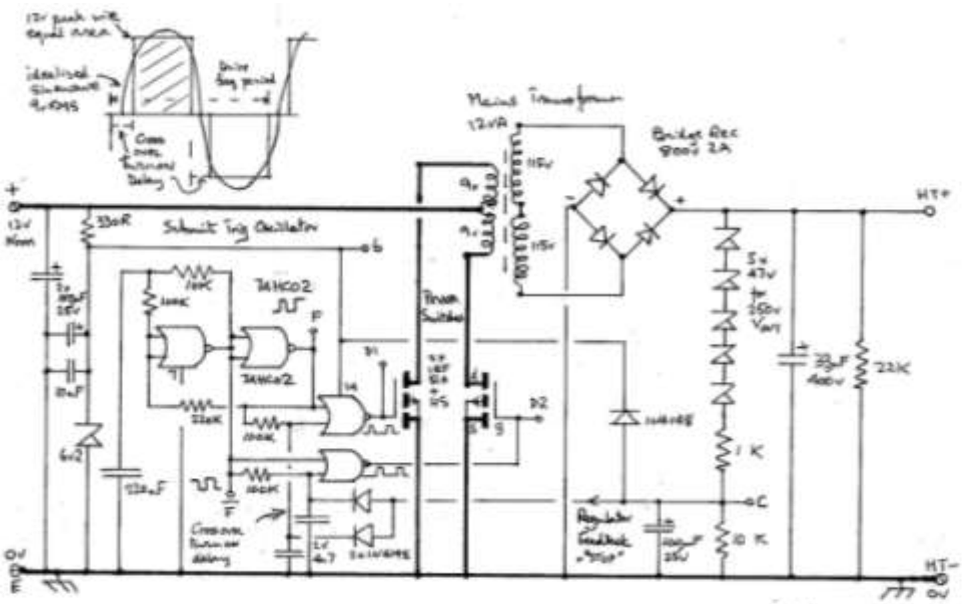
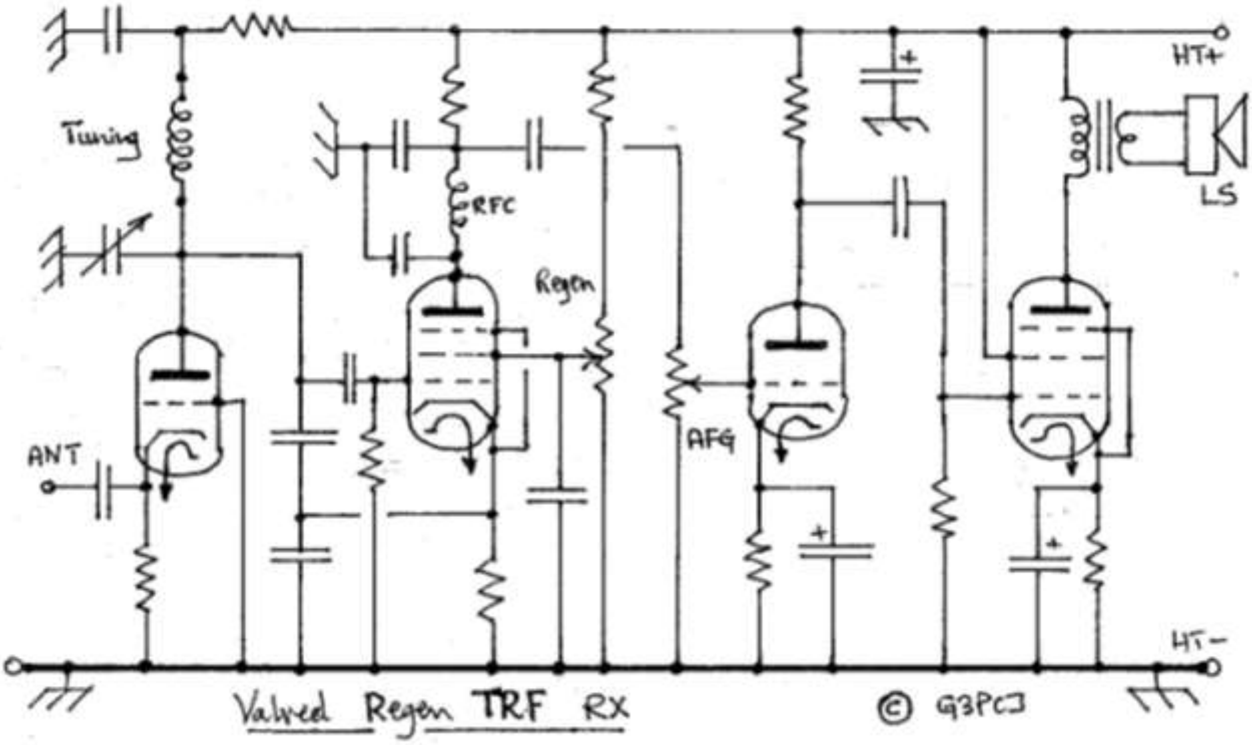


FIG : CIRCUIT OF HT PSU - Take Care - High Voltages!

Valve Rx ideas

The main hurdle to overcome here is the audio output transformer, which in conventional designs has to match the low impedance loud speaker load (say 8R) to the low current/high output impedance (5K) of the typical audio output stage. One could cheat by using a transistorised output stage but I don't feel this is aesthetically in order! Suitable audio transformers are not readily available now so the best I can suggest is one intended for 50 Hz mains supplies – a turns ratio of about 25:1 is required which just happens to be 250 to 10v. The actual transformer proposed for the HT supplies (as in previous note) could be used but a smaller lower power one would be adequate.

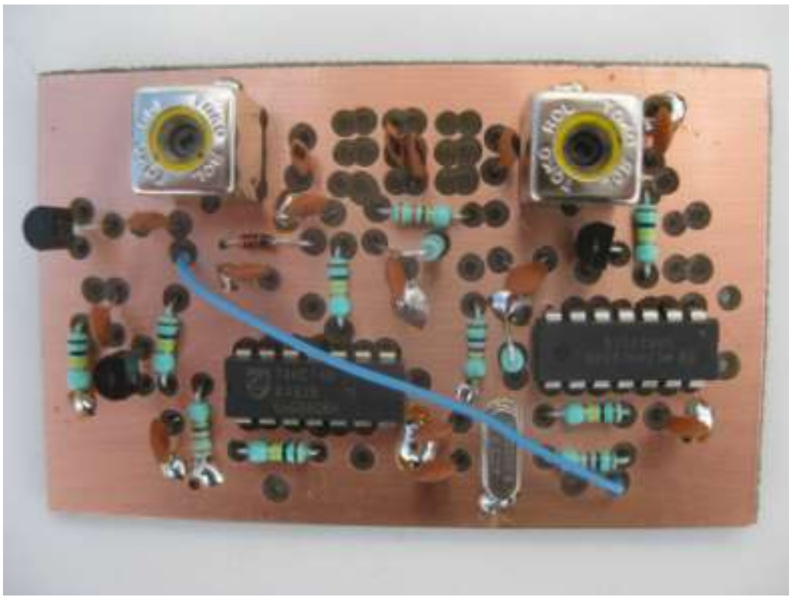
So what form of receiver should it be? It could be a superhet but that is really rather too complex! A Regen TRF is much more in keeping. Assuming that 12 volts is the main supply for the HT generator, this can also be used for the heaters - either with nominal 12v heater valves or for two 6.3v ones in series. A practical design needs at least three stages for convenience – a regenerative detector with the tuning arrangements, followed by a first audio for voltage gain, and then a second audio for driving the LS. To avoid the tuning of the Regen detector being influenced by capacitance changes from swinging aerial wires, and to avoid it radiating directly when oscillating for copying CW, it is prudent to have a broad band RF amp isolating stage ahead of the detector. Hence two envelopes, each with a triode and pentode, looks a good bet! The pentode's screen grid voltage provides an excellent means of controlling the Regen action in a Hartley or Colpitts style oscillator/detector stage, without having a front panel control carrying any RF currents. An outline of such a circuit is below! Not tried out yet – hence no component values! PCB valve holders are now available so I suppose I ought to lay out a PCB for something like a pair of 6U8 triode pentodes! Anybody interested? I must admit to not being quite so sure of my valve circuit design skills so it might take a while! Tim G3PCJ



FET Mixers

Gone are the days when you could obtain 40673 dual gate JFETs which were so commonly used in the ARRL published designs, that many of us grew up on! Junction FETs (JFETs) are becoming a bit like hen's teeth – unobtainable – if they are available they do tend to be a bit expensive. I did secure a large quantity of 2N3819s, and 2N5459s which appear to be similar devices but with alternative pin-outs just to keep you awake! A pair of series connected JFETs, with easy biasing, can act as dual gate devices and can be easily applied due to their high input & output impedances. This means the main signal input gate can be driven directly from the high impedance top end of a receiver's input RF bandpass filter; or alternatively it can be used to buffer the signal from a VFO in a frequency mixing application. The high drain (parallel) output impedance allows direct connection to a similar high impedance point of any following RF filter.

These qualities are excellent for a local oscillator signal mixing scheme intended to avoid a VFO operating either at an uncomfortably high frequency, or on the transmit frequency that might cause chirp etc. A low frequency VFO producing about 1 v p-p can feed the lower JFET with the top device gate being driven by a 0-5v signal from a digital crystal oscillator. This is the basis of the new Mk 2 Mini Mix kit shown right. The two JFETs are on the left with 8 MHz crystal oscillator bottom right.



Although this type of mixer is not balanced for either input, it can perform well where the desired output is well removed in a frequency sense from the two inputs; this allows a double tuned filter (top of PCB) to be used for selection of either the sum or difference signal. To improve its versatility, the middle chip is a pair of digital dividers which can be arranged to divide either the crystal or the output by 2 or 4. This allows a 6 MHz VFO to be mixed with 8 MHz from a crystal to provide 14 MHz, then squared up & divided for 20, 40 and 80m. G3PCJ