"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Summer 2012
Issue 76

Contents

The Walford Electronics web-site is also at www.walfordelectronics.co.uk

Editorial

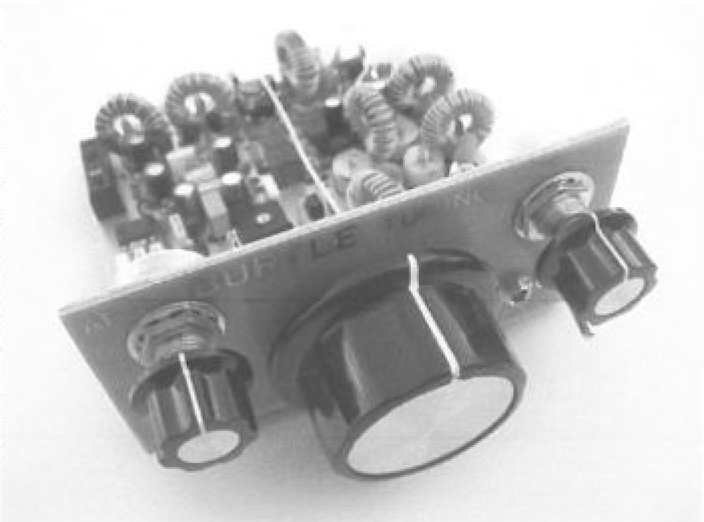
Phew - what a spring this is turning out to be! Glorious weather for most of March and then incessant rain during the last half of April. We got our cattle out in the good weather but the rain and consequent field flooding seriously disturbed them and they are nearly all back inside again on winter type rations! The grazing pastures have been under 3 ft of water and the Environment Agency expect it will take a further two weeks before water levels are back to normal. Meanwhile all the grass that has been flooded has an unpalatable earthy slime all over it! Who would go farming? Me!!

In between I have been mulling over the possible schemes for the Minster Mk3! I am pretty sure of its block diagram now and would like to utilise a strong first mixer similar to the commercial Mini Circuits SBL1 types. They are a bit pricey even in quantity but do indicate a target to aim for! Luckily there are some alternatives that hold out good promise - see later! I would like the Minster in its simplest single band form to utilise the same frequency scheme as the Bridgwater; with a VFO driving a buffer/doubler that makes a single kit possible for any band 20 – 80m. The current challenge is to develop an easy doubler for the strong mixer. I would like some feedback about extra bands. Watch out for news and maybe an early sighting of a Minster Mk 3 at QRPiC 2012! Tim G3PCJ.

Kit Developments

The **Bridgwater** and **Burnham** are now available with encouraging reports from early customers.

I also have my prototype **Burtle** (right) working well on 40m. It is a specialist CW TCVR for any band 20 - 40m with a DC RX with narrow bandpass audio filters, proper crystal mixing VFO, full break in and an output of 1.5W. In principle it should also be possible to use it on any of the other bands10 - 160m but I will not be trying all of them - just too many options to try out! I could do with some early builders if anybody would like to try one. It is pretty dense and is definitely in the advanced category. Not fully priced yet but about £55. Tim



Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £8 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

More Fun in Far Flung Places by Dave Buddery Jnr

The remote area job came to fruition and I was in the thick of it. I had found out that the radio telemetry system ran on a single frequency around 220 MHz, just HF of the old USA 1.5 metre band. This was a problem because in our ITU Zone, this part of the spectrum was not scheduled for commercial radio telemetry purposes. I thought about it for a couple of days and decided to go over to the local commercial HF / VHF radio supplier and sound them out. We went right around the whole problem, and one of them had a REALLY good idea. He said, "Why don't you get yourself up there with a spectrum analyser and a portable antenna?"

We made the arrangements; collected the unit, with a portable antenna, and flew down, and got to rather covert work. To cut a long story short, there was a very powerful telemetry transmitter about 15 MHz LF of our frequency (it was military – I did a very low profile DF job on it and located it at a big military camp about 50 Km away). I went back to town with a plan in my mind. The firm's lawyers said that going out with a spectrum analyser to check frequency occupation was a bit naughty, but probably not actually illegal, however they were concerned about my DFing the military transmitter and advised silence on that aspect! I was overdue to go and see the Ministry, so I had a final run-through of our presentation with the local MD and we agreed to present the whole thing as a request for a temporary exemption and license for use of that part of the spectrum, should it be available. My little exercise with the spectrum analyser would be kept up our sleeve just in case we needed it.

We booked an appointment. The frequency spectrum and licensing guys looked at the paperwork regarding our system and said the inevitable, that our request was not in compliance with the ITU frequency allocations. We countered with the suggestion that no-one was using the bandwidth in the area and we needed only a temporary license for 6 months. I then dangled the bait – 70 or so units, individually licensed! That was a lot of money and we were going to have to pay 2 annual fees as the license fee re-set at New Year and the job would run over into the following year. The ministry guys told us they would be in touch within a couple of weeks and we departed. We seemed to be off to a fair start.

The ministry called us over and said that they viewed our application generally favourably but they were worried about frequency occupation in that part of the spectrum. I said that they ought to know about all the civil utilisation and that we were well clear of the aviation band etc. They looked a little uncomfortable and said "perhaps there is official use of that part of the spectrum". So I looked at them and said "such as the military?" So I let on a bit about going up there with the spectrum analyser and showed the results including a map of the area etc. They stared at me amazed. The senior one said "We were going to suggest something like this and you have done it already!" They looked over all my stuff (the DF matter was not referenced in the paperwork) and said we would be hearing from them shortly. We left feeling somewhat cheered. Four days later we got a call from the Ministry and they told us that we would get our licenses and to expect the official letter. This arrived and I got on with the mountain of ensuing paperwork. The MD was delighted as were our client and I got a bonus for sorting it out. I took the guys from the radio company out for a curry and beers, the least I could do under the circumstances.

I think a lot of the generally favourable treatment we got from the ministry on this occasion may partly have been down to my membership of the radio club and the fact that the word had got around about this CW operator who was suddenly working all kinds of stuff on 7 and 3.5 MHz CW – the locals were not much into DXing on the lower bands and it had caused a bit of a stir of the right sort. Of course the Company got all this "for free" as nowhere did it appear in my job description. But the Company had woken up to what the likes of us can do given the opportunity. (Dave - sorry I had to edit this so heavily to make it fit the available space. Tim)

Dipole Dilemma by Andrew Atkinson G4CWX

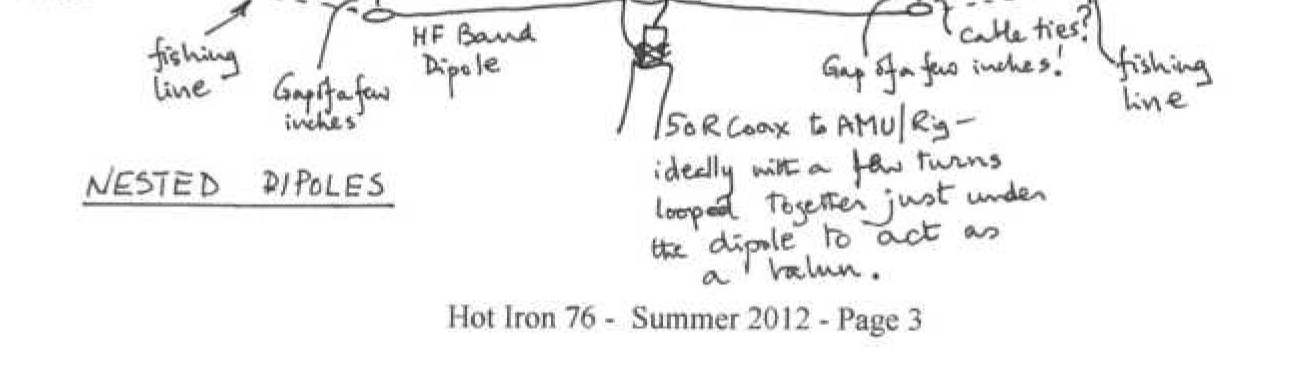
Last year saw me experimenting with one aerial after another. It took a long time to find something that was within budget and which would fit comfortably in my back garden. The end result was suggested by G3OOU and takes the shape of a standard centre-fed dipole with the ends dangling down at right angles. I was so impressed with the results that this aerial achieved I decided to give up on further experimentation and concentrate on a bit of operating for once.

The story thus far is a happy one – except that I was foolish enough to use sub-standard cable for the long arms of the dipole. Needless to say that after a fairly short period of time the rain and high winds wreaked their revenge and I was left with no aerial. Examining the cable carefully, I found that water or moisture had entered the sheathing of the cable close to the "T" connector. Over time this had caused the inner copper strands to deteriorate and eventually fail.

There was only one thing for it, and that was to replace the faulty cable, but this time do a better job of constructing it. I opted for the highest specification of Flexweave cable that I could lay my hands on. A word of caution here: make sure that you buy the genuine article and not "Flexweave Style" cable which is a truly inferior product. I cut it to length and then attached Crimp connectors to the ends. These were duly bolted to the "T" piece and the ladder line. I reasoned that there were two things that I could do at this point to increase the lifetime of the aerial. The first was to ensure that neither water nor moisture entered the cable and the second was to provide a modicum of strain relief for the dipole either side of the central connector.

The ingress of moisture was simply solved by applying five coats of Plasti-Dip. This is a liquid rubber-like goo which never truly hardens, but provides a watertight seal around everything it comes into contact with. I bought a small tin of this stuff a few years back and still have nearly half of it left over. I believe that the current price is about £7.00 per tin and is available from www.plastidip.co.uk. The final task was to provide strain relief for the central connections. I achieved this by using 24" pieces of Kevlar guy rope attached to each leg of the dipole with a series of cable ties (See Figure 2). Before hauling the repaired aerial back up to its rightful height, I gave it a good test by subjecting the central joint to a 75Kgs weight. It passed with flying colours. The aerial has now been in operation for almost a year and has coped admirably with everything that the dreadful weather in this neck of the woods can throw at it. I now feel a lot more confident every time I hear that storm force winds are on their way to us.

Note from G3PCJ. My 'Raw Material' file for Hot Iron seems to have been corrupted - maybe penetrating damp! I have a picture from Andrew of a nested dipole but can't find any accompanying text! I rather like the nested dipole approach as it can allow operation on several bands and often without an AMU. It comprises a number - often up to four - dipoles connected directly in parallel on the end of the coax feeder. The dipoles are cut for their normal (individual) lengths and arranged to be spread slightly apart from each other - this is the slightly more difficult bit! The longest dipole is hung up as normal. The next longest can be supported from the longest, but it will tend to distort the first, so it is better to extend the shorter ones with non-conducting rope/ fishing line etc and support them from the same sky-hooks as the long one. You might find that an occasional cable tie keeps them looking tidy. At their centre, join them in parallel to the coax! Easy.



Some voltage regulator thoughts - by Peter Thornton G6NGR

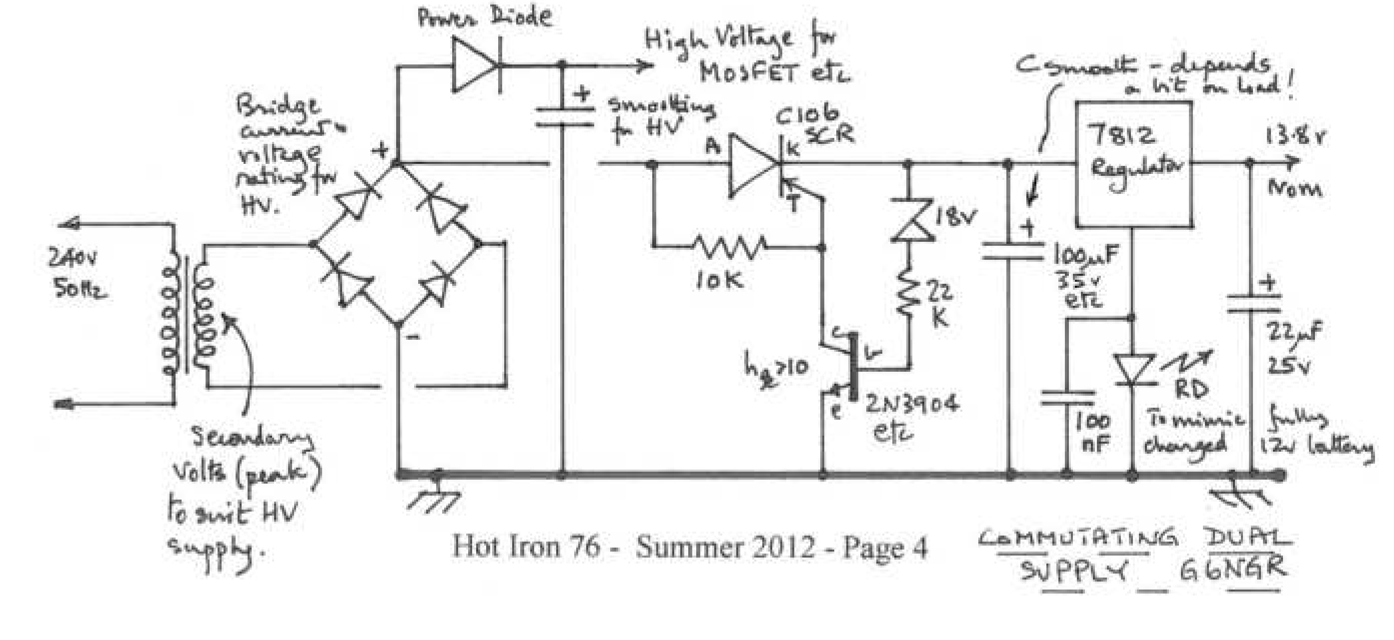
Here's a thought: you want to run a MOSFET PA at +24v [or more] for decent linearity, yet need +12v for the rest of the rig. How to do it with just one power supply and little waste? You could use a dropper resistor from the high voltage; or a linear regulator; or even [may the good Lord forgive you] - a "switched mode wide band interference generator power supply".

I often use a 7805 to run an SA 602 double balanced mixer. For a DSB transceiver design I want my '602 supply near maximum to get the most output. This means +7v. on pin 8 of my SA 602; not a "78XX?" family regulator value. I fit an LED in the common lead, which is normally to 0v, but instead lifts it by the on-voltage of the LED, normally 1.8v. - 2.0v. Thus my 7805's 5v + 1.8v = 6.8v! I parallel the L.E.D. with a 100nF, 50v ceramic capacitor to reduce noise. A 7805 regulator typically runs a couple of milliamps to ground via the common terminal - so my booster L.E.D. lights nicely when my '602 is powered up [on transmit, for instance]. There's my power indicator lamp: and it's not cost me a single extra milliamp from my power supply!

Let's say we're trying a homebrew IRF 510 linear for our DSB transceiver, we're wanting +36v on the drain. How do I reduce +36v to +12v for the rest of the rig? You could use a linear "7812" regulator, but if your rig pulls 500mA, the 7812 will be dropping 36v - 12v = 24v; at 500mA, that's 12 watts. You need a chunky heatsink, just to throw away that 12 watts.

An almost unknown [nowadays] power supply fills the gap between a "linear" and a "SMPS" - a "commutating" supply. They use an SCR - yes, on DC - to pre-regulate, and a light-weight linear regulator to put the final "polish" on the output volts. The circuit runs "zero crossing" so there's no switching "hash" from the SCR. The commutator comprised an SCR, two resistors, and NPN switching transistor and a zener diode. Done. That's it. No watts wasted, the SCR switches automatically, feeding the light-weight regulator with just enough voltage to keep it running sweetly.

Here's how it works. Imagine the smoothing capacitor is discharged. The zener does not conduct; there's no voltage on the smoothing capacitor to break it down. The transistor is "off". The resistor from the SCR anode to the gate feeds current into the gate the moment the full wave rectified half cycle begins to rise from zero - the SCR turns "on", and feeds the full half cycle into the smoothing capacitor, shutting off as the half cycle voltage falls once more to zero. After a cycle or two the capacitor is charged, and the zener breaks over, feeding base current into the transistor. This turns the transistor "on", which shunts to negative the gate current - so the SCR does not turn on. Only when the voltage on the smoothing capacitor falls below the zener voltage and the transistor shuts off, is gate current allowed to the SCR, which turns "on" and tops up the smoothing capacitor once again. The current is fed in half cycles as and when the load demands it - on low current, the transformer "pings" every now and then; under increasing load, the transformer feeds more and more half cycles into the smoothing capacitor, resulting in a curious "bumbling burbling" noise from the transformer. Since the feed to the SCR is full wave rectified, a negative cycle will power the load just as often as a positive, so no dc is introduced into the transformer secondary. Note the power diode feeding the MOSFET circuit: this isolates the "hit n' miss" nature of the commutator from the MOSFET supply. A very small price to pay for such an efficient system.



Ham Radio Revisited! By Colin Wood DD5CF

Having come back to Ham radio after a break of about 13 years I was amazed at the amount of progress and that someone like me can now be active on HF without having passed a morse test! My budget was limited so kits were an obvious answer. I find electronic theory very confusing so the prospect of building a kit was a bit daunting! My first kit was The Brendon for 80m and I was glad to see the very precise step by step building instructions but even with these, I had a couple of problems that were soon resolved.

I have since built Tim's AMU, The Fivehead 40m, frequency counter and Audio extras, all kits are working well and the amount of emails I had to send were reduced with each kit. I have had lot of compliments on the audio of The Fivehead, the kits are used both at home (2 watts) and when portable (1.5 watts), at home I have used a home made full size horizontal G5RV folded into two U shapes to fit in a L shaped attic space, each part of the attic is about 7 meters long and about 1.5 meters wide so the G5RV just fits in with the apex pointing west, it has a 450ohm ladder line feeder directly into the AMU, and I have also tried a ZS6BKW ant which is a modified G5RV so it is resonant on 40m /20/10 with good results, I now use a home made ½ wave dipole for 40m which fits inside the attic with no folding needed, I am also at the moment trying out G7FEK's 80m limited space antenna which I am able to hang outside, the SWR is within the range of the building instructions but I have not had a QSO on 80m with it yet.

When portable I have used another home made G5RV, hanging from any 3 convenient trees usually on the banks of the river Rhine , when caravanning I use a very small (ca 50 cm) antenna for 40m made from a Hairspray can, small telescopic aeriel (for tuning) and about 80 turns of 2.5mm pvc covered wire on a 50mm plastic drainpipe, the hairspray can also fits into the larger opening of the drainpipe , the instructions and calculator for building this antenna can be found on DL7AHW's website (http://dl7ahw.bplaced.net/start01E.htm), I am always amazed at how far I get (to date 3 QSO's over 900 Kms distance) using The Fivehead with 1.5 watts and this hairspray can antenna, I have also built one for 80m using a 3 hairspray cans soldered one on top of the other (please go to G1ZOS at QRZ.COM for pictures) with some success but not as good as the 40m version.

Another portable antenna that I have had a lot of success with is a short dipole resonant for 40m from an idea by G3TKN, the complete antenna with open wire feeder is made from 2 x 11.20m lengths of wire, the dipole are 2 x 8.23m and the open wire feeder is 2.44m with a 5 cm spacing, see this website for details (http://www.dg9sr.co.cc/antennenbau.html) please go to G1ZOS at QRZ.COM for pictures of this antenna. I also use another ½ wave dipole at the moment for portable ops, this one I made for 80m with switches which are two large chocolate blocks on each dipole, cut the wire for the 40m band and put one block each side of the cut but leaving a length of flying lead (about 4cm) on the 80m band wire, use an off cut from a cable tie to join the blocks together with a gap of about 3cm, I also have some cord hanging down from the blocks, I lower the middle of the antenna pull down on the cords and then its an easy matter armed with a screw driver to change bands from 40 to 80m by inserting the flying lead into the 80m wire block, I have also built G4ILO Julian Moss's Wonder Loop, this has a diameter of 80cm and works well on 40m. I am always on the lookout for new antenna ideas either for portable QRP ops, small garden or my "L" shaped attic at home. Vy 73 de Colin DD5CF/G1ZOS

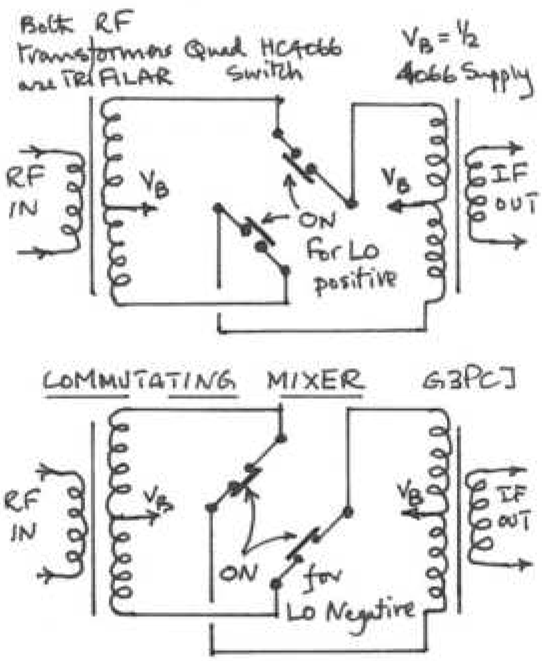
Minster Mk 3 Advice please!

The basic rig is likely to be an any single band 20 - 80m 5W CW and SSB TCVR costing about £100 built on two 100 x 160 mm PCBs with a strong mixer etc - see the next page! I plan an 'RF Extras' kit that will provide at least two extra bands anywhere between 10 to 160m (but probably not 12m due to the need for special crystals!) so making it into at least a 3 band rig. The extras include the RF BPFs and TX LPFs plus VFO/LO mixer using a PPL. This kit could probably also include AGC and a resistive antenna matching bridge. The RF Extras kit is likely to cost roughly £65; however, the scheme could be easily extended to provide 5 extra bands so making the whole rig into an any 6 band rig, probably needing two extra PCBs and costing towards £90 so making the 6 band phone and CW rig cost towards £230 with a counter! This strikes me as too much. I would welcome any comments from potential builders as to how many additional bands I ought to aim for in the RF Extras kit and the facilities they consider important. At the moment I am not sure if it would be feasible to say add two bands and then have a second band pair if builders felt wealthy! Comments please! Tim G3PCJ

Commutating Mixers

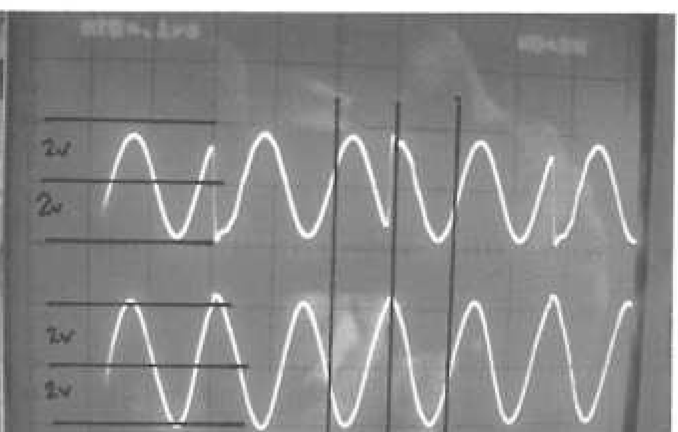
I make no apology for droning on about mixers! They are key to the superior performance of any receiver on our crowded bands where there is such a huge range of signals levels in adjacent channels. Conditions on 40m are the classic example although they are not quite so bad as they used to be now that the commercial broadcasters are moving elsewhere.

Although I well appreciate the advantages of the doubly balanced quad diode mixer, I have never felt entirely comfortable with it when I have attempted home built (and hence lower cost) alternatives. Nothing wrong with the doubly balanced configuration which prevents feed-through between ports - it's the diodes and their required driving power that has made me uncomfortable. If you look back over last decade or more, several workers have used 'electronic switches' instead of diodes. This set me thinking about using MOSFETs but their high gate capacity is a problem and is one reason why the H mode configuration was developed; in this arrangement the switching action is between a signal 'line' and ground so that unwelcome gate capacitance does not affect the signal path. The drawback is that it needs some nasty looking RF transformers!



The action of all these commutating mixers (diode, FET, etc) is really very easy to follow! On alternate half cycles of the LO signal, the output is either the same as the RF input or its polarity is inverted. In effect the RF signal is multiplied by + or - 1 at the LO frequency. This is most easily seen in the two diagrams right for alternate LO half cycles. The mathematics of this switching give rise to a mixer output with sum and difference frequencies of the RF and LO (plus other lesser higher order products). The advantage of the FET approach is that potential large signal handling is better without there being any significant linearity drawbacks.

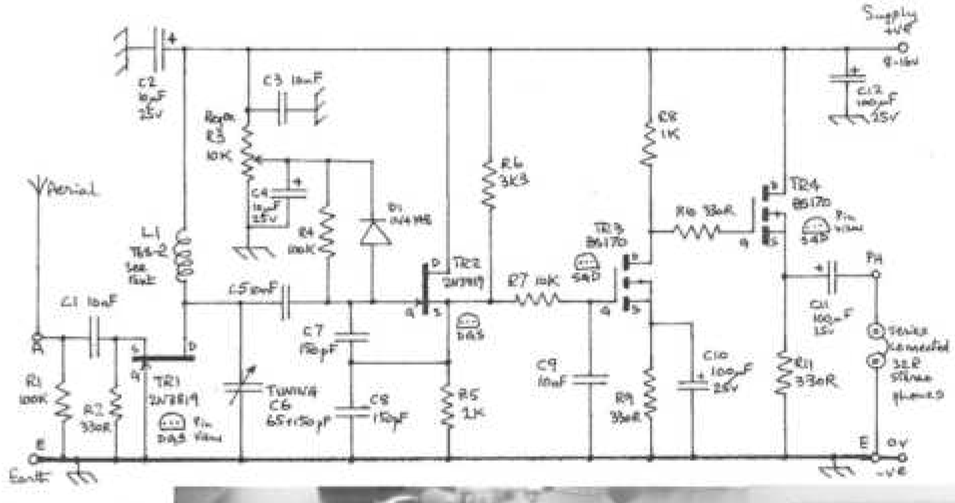
The FETs act as plain switches alternatively linking input to output, so it would appear that the 4066 style of electronic switches that I already use for mixer control in superhets might be suitable. These are available as quad ON-OFF switches and their control by plain logic signals makes them easy to drive without any high power LO stage - but they do need both polarities of LO drive! It is better to use the 74HC4066 device in a 50R system because it has an ON resistance of less than 30R instead of about 80R for the CD4066. The HC version can also take up to 9 volts supply which enhances max signal handling. The scope picture shows a sine wave input (lower trace) having its phase reversed (output - top trace) at the LO frequency; in this test set–up, the LO is at exactly one quarter of the RF signal in order to obtain a steady picture! 2v/div vertical and 100 nS/div horizontal. Looks promising for the Minster! Tim



The Littleton

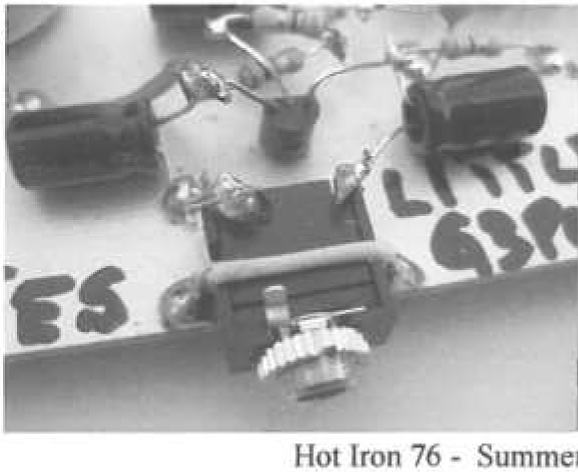
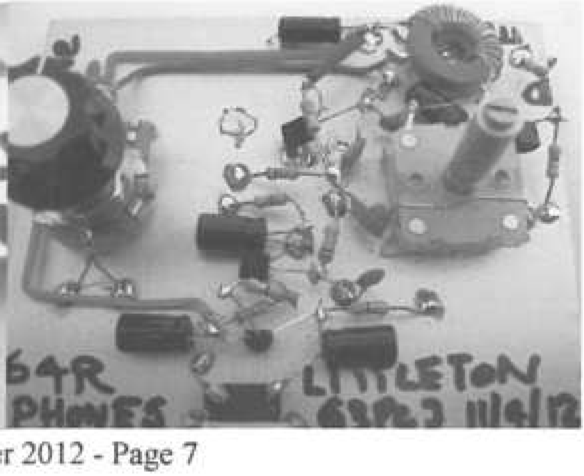
This is relatively simple Regen TRF receiver which most builders ought to be able to make in an afternoon! It is about the simplest RX you can make which is legal (ie does not radiate) and is able to drive the modern style of stereo 32R phones. The Regen TRF approach can copy ordinary amplitude modulation (which is still used by many short wave broadcasters), or amateur CW and SSB signals. The RX uses just four field effect transistors – two JFETS and two MOSFETs. Signals from your antenna first enter a grounded base JFET stage using a 2N3819 whose purpose is to prevent radiation when the Regen stage is oscillating; it also provides an impedance step up to the resonant circuit which defines the frequency the RX is tuned to. The second stage uses another JFET as a regenerative detector whose bias can be adjusted to make it oscillate (or not) depending on the type of signal being sought. Because a JFET would normally always oscillate in this configuration, the source is connected to a voltage divider whose positive level normally cuts off the device - only when the gate bias is increased by the Regen pot will the device become active and then able to oscillate. Sensitivity and selectivity are best for AM just below the point of oscillation, and just above it is best for CW and SSB – the pot allows easy adjustment of this critical point. The second 2N3819 also acts an infinite impedance detector. The two audio stages are also biased from the detector via a simple filter to remove the worst of any RF! The first BS170 MOSFET provides the audio voltage gain while the second is a buffer to provide the extra current required when driving the series connected earpieces of 32R stereo phones.

The circuit is so simple that you can build it 'dead bug' style on a plain sheet of un-etched copper clad PCB material. With reasonably short earthy leads, the circuit will be self supporting and quite rigid enough for casual use. Take care when mounting the phones socket to ensure that the common sleeve contact is NOT connected to 0 volts. The PolyVaricon tuning capacitor can be mounted upside down and secured by a wire strap (after applying tape to insulate the bolt heads!). The circuit includes a couple of parts (R1 and C3) whose role is only to act as mechanical anchors! The tuning 'band' is set by the value of the single inductor L1 – suggest start with 35 turns on the T68-2 for about 3 to 6 MHz, or down to 14 turns for about 8 to 16 MHz. The tuning range is determined by the size of C6. Plenty of scope for experiment here! I have a few basic kits (including all parts but no etched PCB) for £17 or post paid for a £20 note. Good luck! Tim G3PCJ



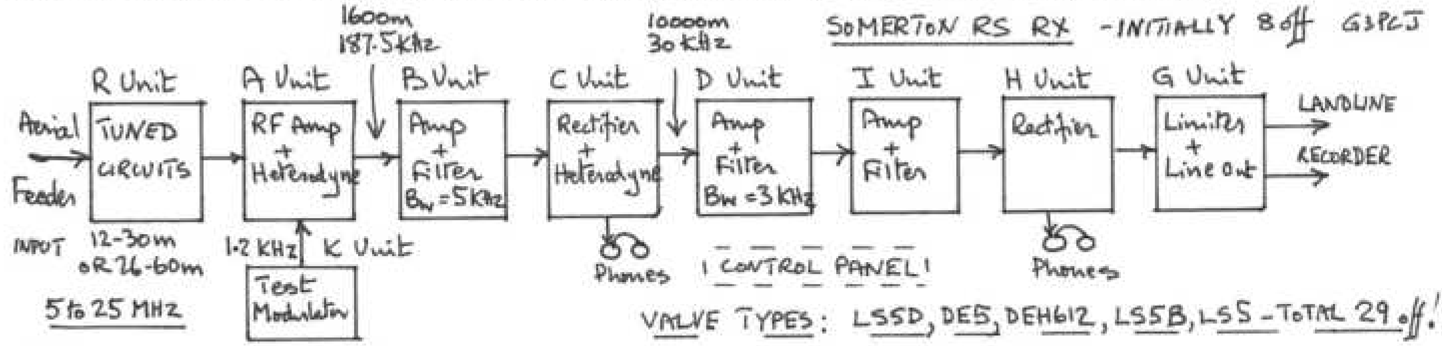
THE LITTLETON

REGEN TRF RX

Snippets!

<u>*Somerton Radio Station*</u> I have just been given a description of the RXs at this Marconi beam RS. In modern parlance they are double conversion superhets but it is not clear what form of modulation was used. By inference it was tone modulated - but might have been plain CW - anyone know?



<u>*CW Keyers etc*</u> Peter Thornton passes on some interesting links about keyers:-

- The "Morse Machine": www.i2rtf.com/html/**cw_machine**.html which does a phenomenal job but it's way, way 'OTT' for me;
- KD1JV: http://kd1jv.qrpradio.com/Butterfly_keyer.HTM which has a text readout;
- KD1JV: http://kd1jv.qrpradio.com/skc/SKC.HTM which is a keyer chip with a unique mute output, very useful;
- PicoKeyer: http://www.hamgadgets.com/index.php?main_page=product_info&products_id=28 a straight keyer chip, with useful message memories.

<u>*HF Transceiver 'chips'*</u> A recent note in Electronics weekly highlights a new transceiver device that can deliver a data rate of 7 Gigabits/sec over an RF link at 60 GHz! That is High Frequency!

QRP in the Country 2012 - July 15th 2012

I hope that most Construction Club members in the south west, and maybe from further off, have already made your plans to visit here for our third QRP in the Country event. Plenty of space is still available for individuals or Club to have a stall and put on a display of some sort or sell off unwanted radio items etc. If you want a stall please let me know before hand. No charges for entry or for stalls! If anybody coming from afar would like help with accommodation overnight let me know. Loads of things to see etc and I am already aware of some entries for my informal **Construction Challenge** that Steve Hartley has kindly agreed to judge! The task is to build a receiver for any MF or HF amateur band using no more than 10 discrete components and if you wish to, also one integrated circuit and one supply regulator. Your choice of types! In addition there will be many Club and individual stalls with of course some local food and drink. I hope to have the G3GC Plank running with an AR88 this year to make reception slightly easier, and there will also be other wartime radio gear on display!! Rob Mannion G3XFD Editor of PW, the RSGB and other QRP personalities will be here! Richard Booth has promised to come down and assist those needing a little technical advice and of course there will be the latest kits from you know who! Gates open 10 am; undercover if the WX is poor! Farm tours by my wife Janet if anybody would like them!

Subscriptions!

I regret it is that time of year again! The next issue of Hot Iron is the first of the membership year and I need to receive your payment of £8 for UK members by Sept 1 2012. Overseas membership costs £10. Sorry about the price rise but blame the Post Office! If you wish to pay via Paypal this is fine, but please add an extra £1 for their fee. All I need is your fee and name/address. To keep it interesting your contributions are essential! Any article about your experiences, questions, hints and tips etc. are especially welcome. Hope to see you July 15th! Tim G3PCJ

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Editorial

Another start to a Hot Iron year - the 20th I make it! Without the support and encouragement of you readers it would have died long ago, and I must say a special thank you to our various writers. It takes courage to put pen to paper but its not really all that intimidating so I encourage any of you who think to yourselves that others might be interested in what you do, to jot it down for everybody. It is as satisfying to have somebody else say 'I took up your idea', as it is top be able to say on air that you made the rig yourself. Perilously few are able to say that because factory made rigs are now cheaper in real terms than they have ever been, but being able to say you found the drop down menu for changing the rig's clock does not somehow have the same satisfaction as turning off after the first contact with a new homebrew project!

Having spent many years shuffling designs for semi-conductor rigs, I wonder if I ought to tackle a valved project. The two obvious snags are the safety aspects of high supply voltages and finding a way of mounting valves that is suitable for reproduction in a kit. Jack of all trades Peter Thornton G6NGR suggests using 'Terry' clips screwed to a wooden rail to hold the glass bodies horizontally with push on female connector sockets for the individual pins! The simplicity and low cost of that appeals to me - I do dislike time consuming and expensive metalwork! Tim G3PCJ.

Kit Developments

The very difficult weather has prevented much work on the new projects. Three Burtles have been built but not without a few tribulations which suggest the original wide choice of bands was too ambitious! A Mk 2 version is probable!

Meanwhile we were lucky with QRPiC 2012 - the weather was actually fair and there was a jolly good attendance. G3ROO & his mates came down from Dover which was a grand effort. Plenty of variety of projects were on display, but rather like getting authors to write (as above!), getting Clubs to display their activities is also a challenge. Here Ivan G3KLT exercises the Plank! A good time was had by all! Tim

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £8 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

A 1968 dummy load by Peter Thornton G6NGR

I was very fortunate to be an apprentice at Ferranti Electronics during the 1960's. One department that fascinated me was the Klystron Dept. The klystrons were not two ha'porth things, they were a yard long, and had 40kV on the anodes! My job was to make dummy loads, as these often burnt out during tuning. They had resistors in a "star" pattern around a central connector. They had to be "spot on" or they lit up with blue fire!

The trick was the mounting of the resistors. Obviously, you can't fit 20 plus resistors on the pin of a co-ax or BNC socket; so I was shown how to fit one resistor to the pin and out to the circular wall, the rest using the previous resistor's lead as the next anchor point. This way the resistors are spaced evenly with the shortest leads. See the diagrams.

I wanted a dummy load to test a 40m DSB transceiver I'm building for S.O.T.A. expeditions this summer – so put a "Ferranti" one together, in a round sweet tin. The list of materials is:

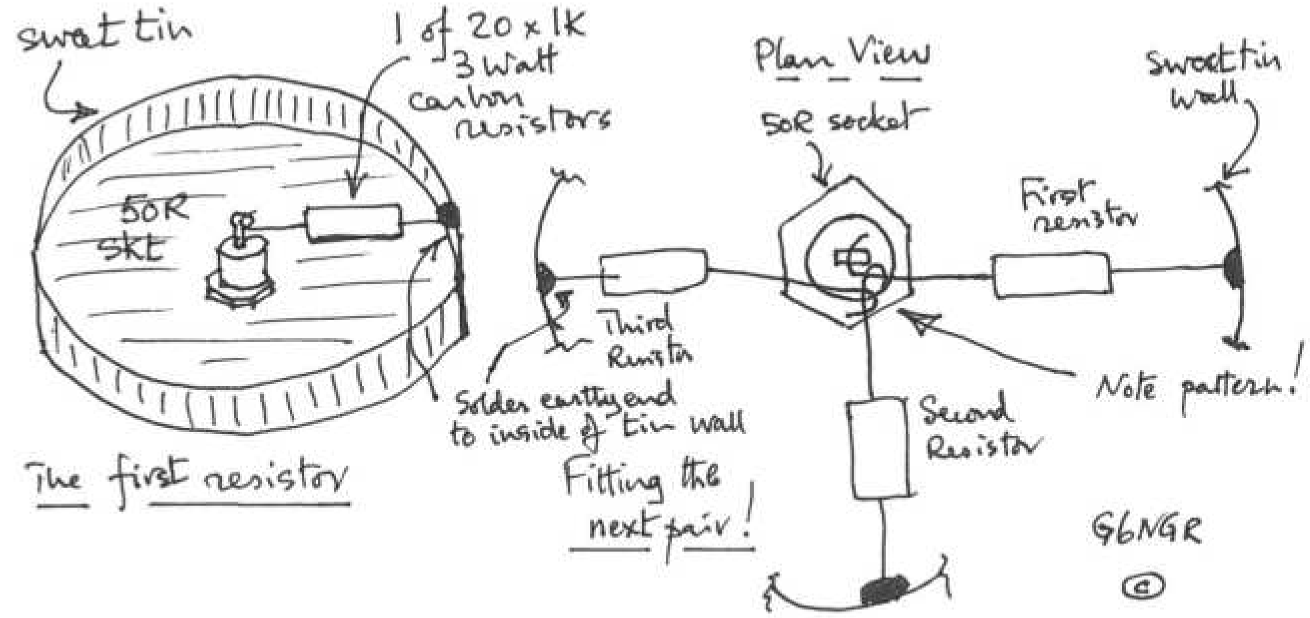
A round [sweet?] tin;
20 off 1k ohm 3 watt carbon resistors;
A BNC, co-ax or N type [or RCA phono?] socket. And that's it!

Start by mounting the socket at the centre of the sweet tin base. Fit the first resistor between the BNC pin and the outer wall at three o'clock; the resistor body closer to the outer wall, they are quite bulky.

Now here's the trick: fit the next resistor, at "six o'clock", by hanging the inner end on the *first resistor's lead*, tight against the BNC pin, and the other end to the outer wall. Similarly, nine and twelve o'clock. Fill in the "gaps" with the other resistors; it's easiest if you make the resistor lead joints as near a right angle as possible, picking up a previous resistor's lead.

I fitted a 1nF / 1 kV ceramic capacitor from the BNC pin to a 3mm bolt through the sweet tin base, insulated through with a transistor mounting plastic washer, and earthed the bolt via a 1N5211 Schottky diode. This makes measuring the power a doddle, the diode handling up to 70 volts peak RF [~100 Watts]. For safety fit the sweet tin lid and secure with a couple of dabs of solder, and don't run it on your best coffee table – it gets HOT!

The load will run 50W continuously, 100W CW / DSB. If you want to run high power continuously, seal the BNC socket threads with silicone, fill the tin with engine oil and thermally bond the sweet tin to a heat sink. Job done!



12v DC to 240v Inverters

Peter also mentions the use of these car cigar lighter units, that are now about £20 from the likes of Maplin etc, as an insulated source of sinewave 240v 50 Hz that can directly feed a HT supply rectifiers for valves producing over 300v DC!

The 10 part RX Challenge (at QRPiC 2012)

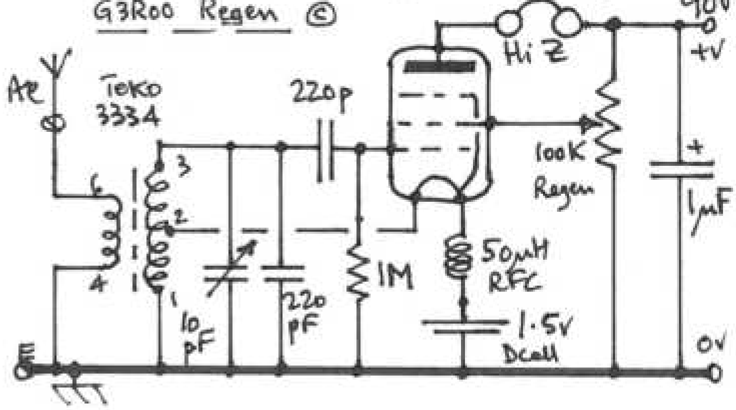
Steve Hartley G0FUW kindly agreed to assess entries for this construction challenge - the task being to design and build a RX for any band using no more than 10 components with an optional single integrated circuit and a single supply regulator if wanted. Steve reports:-

Prior to the event there were a number of questions like 'does it really have to be ten parts?' and 'will I be disqualified if there are eleven parts?'. Tim's view was that it would be better to have a number of twelve part entries than no ten part receivers. There were suggestions of parts being hidden under IC sockets etc.! Judging this was not going to be straightforward!

I pondered over what test equipment to take with me to test the sensitivity, stability and selectivity but ended up in good QRP minimalist style with a crystal calibrator. My unit has a neat feature that switches the calibration signals to provide a continuous string of dots and this is extremely useful when testing receivers, although a guy listening on a nearby rig and oblivious to my receiver testing seemed confused when he was picking up my 'e-e-e-e-e-e' signal across the band!

So, to the Challenge entries. We had five receivers from four builders, but Tim graciously ruled his own effort out of the running; a kind of construction check log with a fantastic 'Wallis & Grommitt' reduction drive/dial. In fourth place was Craig, G0HDJ, with a little one FET regen that had been in July 2012 PW. Third was Peter, M0PKH, with his NE612 based DCRx which worked but with some instability on the audio tone. Pete won a box of chips and other 'sweepings' from Tim's workbench. In second place was Craig's second effort called the Bakers'/Engineers' Ten, which I suspect meant that it had maybe one or two over the ten limit but it worked very nicely. Craig won a copy of SPRAT on DVD.

And the winner is....Ian, G3ROO, with his DCC 10-40V valve regen powered by a 'rack' of 9V PP3 batteries. This little radio was an absolute dream to use with smooth regen and really superb audio. Ian won a bottle of a local Somerset alcoholic beverage. The circuit of Ian's receiver is shown below. I certainly enjoyed judging the entries and the guys that put in entries had certainly taken the challenge very seriously. (I was even offered a bacon sandwich on arrival by one of the entrants, who shall remain nameless, but it wasn't Ian). Here's to next year's Challenge! 73, Steve, G0FUW



Ian's circuit is a classic! I regret I don't have a note of the valve type but I am sure he will be happy to explain for anybody who wishes to contact him through me G3PCJ.

Ian G3ROO on left, then Craig G0HDJ, Peter M0PKH and assessor Steve G0FUW on right, with entries on the trailer.

Regen TRF RX developments!

This style of receiver continues to be of much interest because its performance is tremendous for the relatively small number of parts that they can be made with. As Ian G3ROO's circuit on the previous page shows, a 10 part RX using valves can be very effective. Some designers might argue that a semiconductor version can be equally effective but there are plenty of other builders who have condemned Regen TRFs as the work of the devil! They can be, and often are, challenging to use even when well conceived!

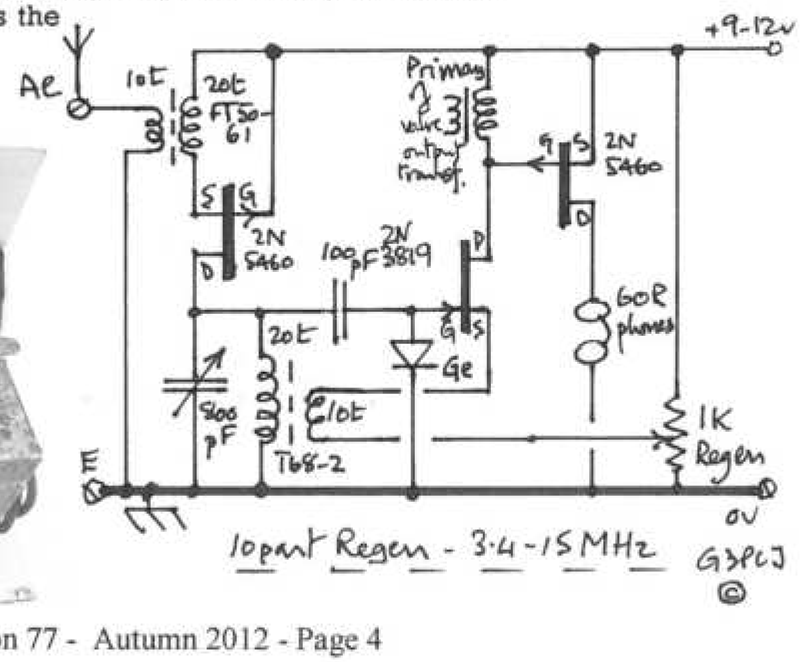
In the 1920s, receivers tended to have an RF stage (or two) before an envelope detector which was followed by multiple audio stages. These were often plagued by RF instability and soon someone (I suspect a Mr Armstrong) decided a little bit of positive feedback could be a good thing provided it was controllable. The effect of adding positive feedback is that it increases the Q or selectivity of the tuned circuits so also increasing the RX's gain or sensitivity. If this feedback is just insufficient to cause RF oscillation, then amplitude modulated signals can be received; if it just a little bit higher and enough to cause RF oscillation, then morse and SSB (or DSB) signals can be heard. The important matter is thus how to control the amount of RF feedback in the tuned stage(s).

In early designs, the gain of the regeneration stage was controlled by adjusting the amount of RF feedback by some form of 'attenuator' in the feedback path - often a variable capacitor in series with the feedback or tickler winding associated with the main tuning inductor. This has the distinct disadvantage that it alters the tuning as the feedback is altered, so making the RX extremely difficult to use because of the interaction between the two controls.

From about the 1950s, the concept of Q multipliers as an adjunct to conventional superhet IF stages became popular, leading eventually to Regen TRFs having their own separate regen stage which is in effect a controllable oscillator coupled to the RX's tuning circuits. Soon it was realised that oscillation, or not, could be controlled by altering the regen (or oscillation) stage bias - altering the stage gain by changing the bias was a huge step forward as 'the controls' were not in the RF parts of the circuit - thus the interaction between the controls was almost eliminated. This is the approach that I have used for many years culminating in the current Cary RX. See later! But.....!

Perhaps the regen detector and oscillator stage could be combined with DC control of the device gain to control the point of oscillation - like the G3ROO RX? This is the approach that I tried with the Littleton RX in the last Hot Iron; but could it be taken further? My attempts at a 10 part RX showed that it was indeed possible to go appreciably further but the circuit below is not viable for a kit because it is a bit unpredictable and uses obscure components. I was keen to increase the RX's overall gain to obtain a reasonable output level into modern medium Z phones so the RX had to have multiple stages. I also wanted an RF stage for isolation between aerial and oscillator stage to prevent radiation when copying CW or SSB. Two design approaches are worth considering to reduce the part count - depletion mode FETs (that have a useful standing current for Vgs = 0) & of both types (2N3819 are n, 2N5460s are p), with transformers (RF and audio) for impedance matching and biasing. I hope these notes will encourage experiments by others. Tim

(Below is what Steve G0FUW refers to as the Wallace and Grommit RX.)



In praise of the straight set - The Cary

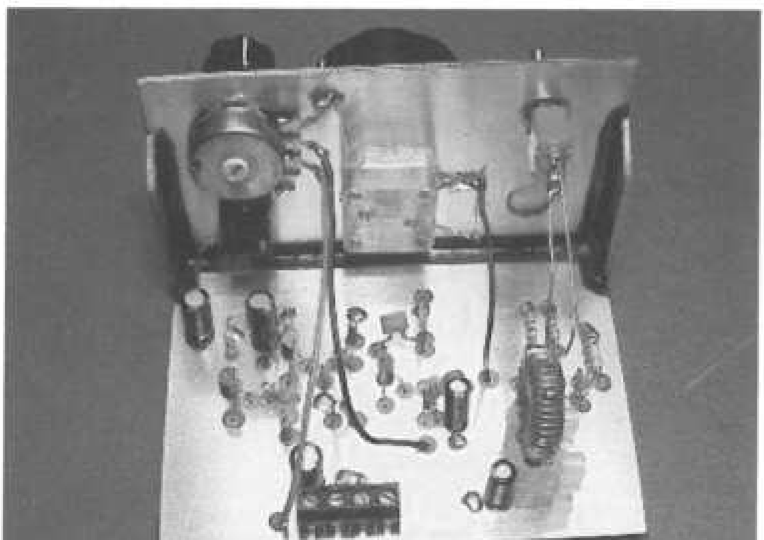
When Tim brought out the Cary, I jumped at the chance of building one, as I, like many others, were brought up on straight sets with reaction. My father built me one when I was 10, with a Mullard DL35 and a 9V grid bias battery for the HT. Then thanks to F J Camm I built many of my own from bits I got from ex-govt. equipment, and eventually a 1-V-1 with mains valves and Denco plug-in coils, on which I did serious SWLing.

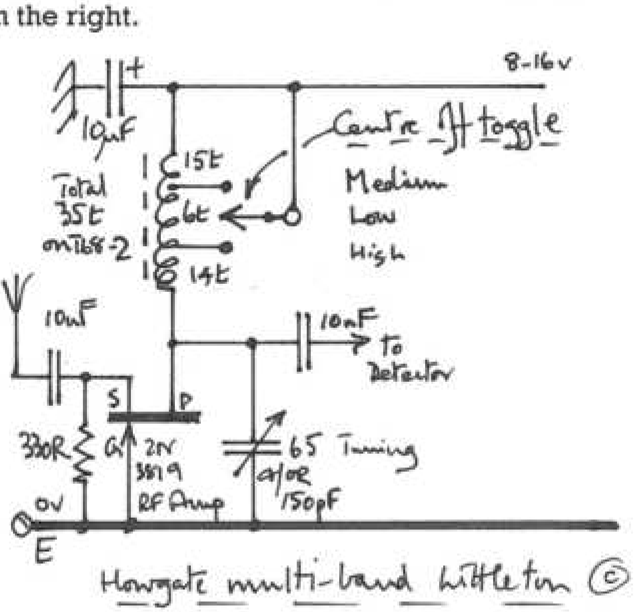
I put the Cary together (not many components but a clever design with the smoothest reaction I have known) and it worked OK. Then I found that it had great possibilities as a portable Rx to put in hand luggage. I dispensed with the PP3 and fitted 8 AA size ni-cads which made it 2cm wider, but this gives 50 hours working. The wider front panel, let me fit the RF gain and AF gain pots (very much operational controls on a straight set) plus an LED indicator and a switch for a simple LPF (one Capacitor). With a small frequency range I set 20m to 14.00-14.07MHz, 40m to 7.00-7.04MHz (the CW ends) and 80m to 3.70-3.81MHz to ear-wig on some phone QSOs. It does drift but very little, so it would be ideal with an XTL TX.

Once you have got used to "driving" a set like this again, it is a very sensitive device and will give lots of pleasure. I suppose that I should put into a sturdier metal box and give it a larger tuning C with a 5:1 reduction drive. To all readers who were brought up on these sets – I recommend the Cary – just like old times! It would n't appeal to the many push button memory superhet operator, because you have to "drive" the Cary, which is what ham radio is all about to me! David Proctor

Andy Howgate's Mulit-band Littleton

Andy has built his own version of the Littleton using a mechanical style that I have seen somewhere before! At first the rig would not work properly and was a scratchy as a fleas nest! It had me seriously worried for a while - what had I got wrong as mine worked very well? Andy's mark 2 version worked properly when the pot was replaced with a new one!! He has made his multi-band by using a centre off single pole toggle switch to short out turns on the toroid which is the main tuning inductance - something like the circuit on the right.





VFO Ideas for multiband CW rig

Experiments, and experience, with the Burtle single band CW rig made me doodle more on the possibilities for multi-band direct conversion CW rigs. I had hoped that the Burtle could be built for many different bands using a frequency mixing approach based on a crystal (and its harmonics) combined with a lowish frequency VFO that might need doubling for some bands. It proved to be a bit ambitious! However, if a VFO is ever to drive a transmitter, then crystal mixing is THE way to avoid chirp and also to obtain good frequency stability on the higher bands. (Chirp is usually caused by RF from the TX output stage getting back into a VFO operating on the same frequency.) Use crystal mixing and then one only has to worry about supply voltage changes during transmission making the VFO alter! The main target bands are 20, 30, 40 and 80m. To achieve easy setting up, avoid all harmonics that might come near the desired output and use a doubly balanced mixer such as the SA602. Keep the VFO below about 6 MHz, preferably operating at about the same frequency for all bands, and ideally do all this with a single set of parts!! Somewhere along the design process using digital techniques has to be considered because such circuits are usually more dependable for most builders! Also bearing in mind the harmonic relationship of 20, 40 and 80m one can obtain a 40 or 80m signal from a 20m one by plain frequency division in a 74HC74 chip. Here are some possible schemes and comments:-

VFO	Xtal	Mixer BPF	Lower Bands	Comments
5	9	14	By division from 14 for 40 and 80m	9 not standard crystal. Needs 400 KHz VFO swing. 30m not done!
6	8	14	Ditto	8 xtal cheaper! VFO still needs 400 KHz swing. 30m possible (with extra BPF) if crystal also divided to 4.
5 or 6	9 or 8	14	Ditto plus tripler from 80m sq wave for 30m using third harmonic	Similar to above but VFO swing has to be even wider to get to exact 30m spot (13.468/4 x 3 = 10.1)
2	12	14 and 10	40 & 80m by division from 14. 30m has own BPF	2 is a bit low for easy VFO! 12 is not a standard xtal. Might need triple tuned BPFs to remove unwanted mix.

Schemes 1 and 2 don't appeal as they don't lend themselves to 30m easily which is an important band for CW operators. In scheme 3 the 20m BPF has actually to pass from 13.47 up to 14.40 which is an uncomfortably large bandwidth if reasonable rejection is to be obtained for the other unwanted mix. Scheme 4 only has to have a 14.0 to 14.4 BPF for 20, 40 and 80m while the 30m BPF has only to pass 10.10 to 10.15; these should be OK with double tuned tapped resonators to avoid the unwanted mix which is only 4 MHz away. Scheme 4 is also probably slightly easier to set up and can easily have all four band outputs available simultaneously for external band selection.

(The single band Burtle type CW rig needs to be a bit different (to avoid cost of second BPF) and is more likely to be a variant of scheme 2 with the crystal divided instead of 20m output.)

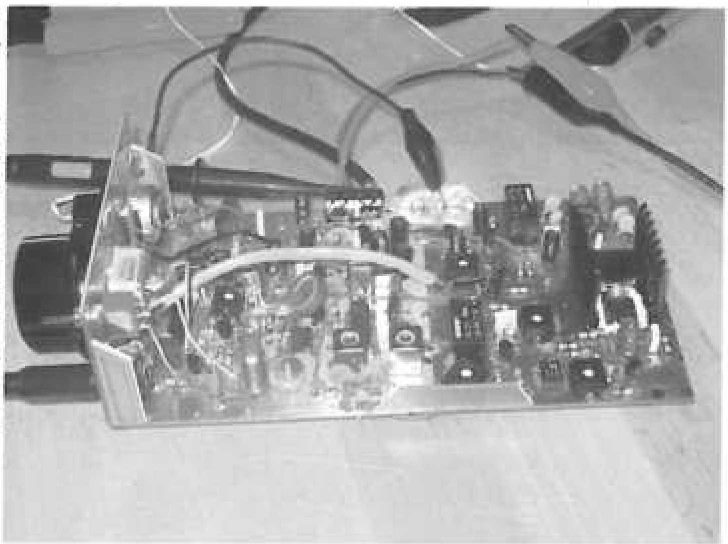
What of the RX and TX to go with this LO unit?! The digital LO output can easily drive a strong doubly balanced product detector (as outlined for the Minster in the last Hot Iron). When used with a resonant AMU you might even get away most of the time without a receiving RF BPF! Follow the product detector with plenty of audio gain/LS drive and narrow filtering for CW. RIT is easily incorporated in the VFO circuits.

The TX could be a 1.5 or 5W multi-band digitally driven - perhaps starting as a single band TX with on board single band TX harmonic filter for any one of 20, 30, 40 or 80m. It probably ought to have sidetone, muting and semi-break in TR changeover. For those wanting all four bands, an optional relay controlled 3 band LPF unit could be added. This looks worth investigating further as a viable medium price rig to achieve four bands CW operation! G3PCJ

5W from the Bridgwater / Burnham by Steve Davies

The Bridgwater / Burnham work together as a 1.5W SSB transceiver. I built mine for 40m, where it works very well. However, just 1.5W can make things a little difficult at times and after I explained this to Tim, he suggested I try replacing the PA RF choke (L3) with a 1:2 output transformer.

The transformer was made using 10 turns bifilar on an FT50-61 toroid. The centre tap was connected to the drain of the IRF510, with the other sides of the transformer connected to the output and the +Ve supply respectively. The mod took just 20 mins or so, and involved drilling one small hole and cutting one PCB track. On 13.8V the power out increased to about 4.5W, and this was via the diode protected main rig supply. On 16V, it gave just under 6W before any signs of clipping.

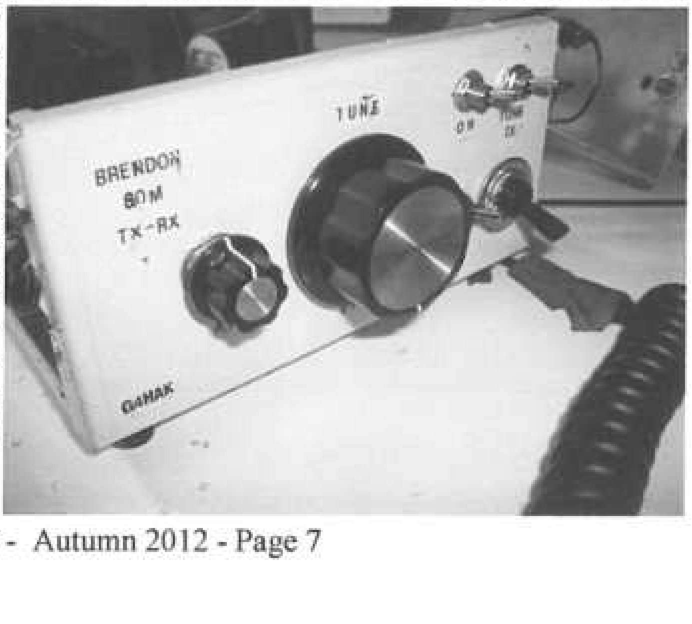


So – a very worthwhile and simple little mod, though it should be borne in mind the heatsink supplied was for a design output of 1.5W, and it does get rather warm at 6W, so care is needed. So far, it's been fine for SSB. Furthermore, it frees up my 10W linear amp for another project. Thanks to Tim for this project, the rig now works very well on its own and all that's left is to box it up! (I don't supply this version as the standard kit because the heatsink is not really adequate! Tim)

Brendon plus Linear Instability?

I am one of the many that thoroughly enjoyed building and using the Brendon DSB kit. Its a charm to construct and a joy to use. Whilst I was soldering in the PA transistor , I already had my eye on the 10W linear so I ordered it. I noted the comment in the Brendon Instructions that there had been a tendency towards "AM ing on transmit when using the linear and it was suggested to change the entry/return point from the point "L" to "L2". (Further down the filter chain). I tried this but with little improvement. The problem manifested itself like this: I would slowly increase the drive on the Brendon and at one point the carrier would suddenly kick in before I could get enough drive for the linear. Nice AM but not really what I wanted! Everything else inc bias etc was ok so what to do? It occurred to me that even though the idea of looping the RF to and from the linear and back through the filter on the Brendon board is a great plan it might just be the cause of the problem? (RF feedback and unwanted coupling?) So "why not put the filter nearer the Linear and Aerial socket? Worth a try.

So remove the following: all Caps 250 –257 and toroids L250 and L251. Mount them on a small board using the original circuit on Brendon Page 20 top left. Fit this somewhere near the Ae socket (I use a SO239). Take a screened coax lead from hot end of C202 (point L) and connect to the IN point of Linear amp board. (Remember E at both ends of coax as well!) Now it would be easy to take the output from the linear to the TX/RX relay on the Brendon but I wanted to avoid any possibility of looping back any RF! So solder a SPCO 12v relay at the Ae socket and connect the OUT point from the linear to one side of the relay and connect other side back to the RX "R" on the Brendon board. The centre connection of the relay is of course connected to the Ae socket centre. I used miniature coax cable for these connections. You can use point VT to power the relay so that it operates on TX only. This cured all the problems and now I have loads of drive and no instability! All the best Pete G4HAK.



Snippets!

Single atom transistor! Researchers at the University of Maryland report the fabrication of a transistor from a single atom of phosphorous embedded on a sheet of silicon. They started by covering the sheet of silicon with a layer of hydrogen, then used a tunnelling microscope to remove hydrogen atoms according to a precise pattern. They exposed two silicon strips plus a tiny rectangle of just six atoms; by then adding phosphine gas with heat it caused the phosphorous atoms to bind to the exposed silicon. In the case of the rectangle, only one atom inserted itself into the silicon! This resulted in four phosphorous electrodes separated by 20 nanometre with a single phosphorous atom between them, that acted like a transistor! No information on its cost, bandwidth or current gain!!

LeCroy promise of 100 GHz scopes LeCroy plans to acquire the specialist Teledyne Technologies who are big in very high speed mixed signal processing using indium phosphide semiconductors. These circuits are crucial for the front end digitising of analogue signals into a stream of digital data for subsequent display at lower repetition rates! Several scope manufacturers have recently released instruments with sampling rates of over 150 Gsamples/sec enabling real time bandwidths of about 63 GHz!

QRP in the Country 2012

A good throng of keen radio enthusiasts turned out this year and were not put off by the threat of rain which hardly materialised for a change! To improve the feel of the event, we held it in just one cattle shed so creating a comfortable squeeze! There were several Club stalls showing off their particular activities, individuals with displays of old and modern equipment, both military and civilian, factory and home made. Steve Hartley very kindly assessed the entries for the 10 part RX challenge as reported elsewhere in this Hot Iron. PW, the RSGB and a few component suppliers were also in attendance. Several individuals took the opportunity to make a little more space in their shacks by selling unwanted gear. Food and drink was from the farm and the next door brewery/orchard! PW kindly presented a years subscription as the main prize for the raffle which my wife Janet organised in support of 'Send a Cow' (to Africa) - this raised the excellent sum of £103.

Amateur Radio in the Country 2013

Date fixed - Jul 21st 2013!

Note the change in name!! I had a bit of feedback that some Clubs and individuals were not quite so interested in QRP matters; so a wider title will, I hope, attract individuals and Clubs who have been hesitant before. My intention is to concentrate on all those amateur radio topics that do not depend upon a huge bank balance to buy the latest piece of expensive factory made kit! The hobby has a huge range of interests and there is plenty of space here for stalls and displays on a huge variety of themes. The date is a week later in the radio year which I hope will avoid some of the worse clashes! Please spread the word and encourage anybody who would like a stall to get in touch. G3PCJ

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Winter 2012
Issue 78

Contents

Happy Christmas to you all!

The Walford Electronics web-site is also at www.walfordelectronics.co.uk

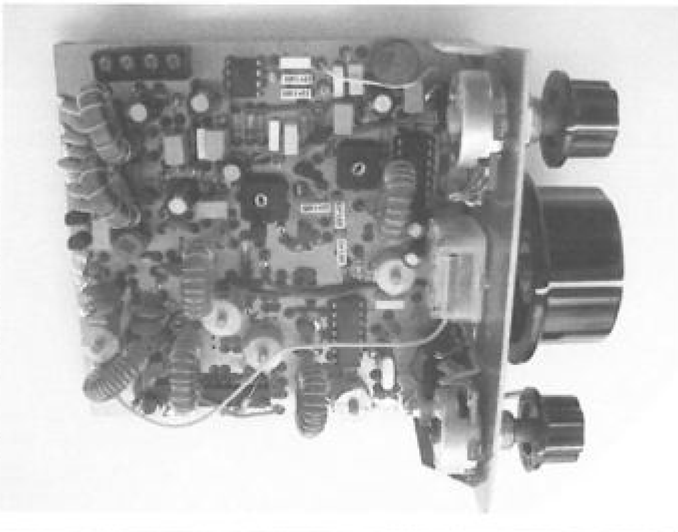
Editorial

Firstly, I must apologise if this issue arrives a little late - I had to have a cataract operation last week and could not see to type properly for a few days. I am pleased to say it went extremely well and I can now see better in the distance, using the previously defective eye, than I can unaided with what was my previously good eye! Great and it only took an hour between in and out of the car! (Best not mention the water hereabouts - worse than I can ever recall - but we (and the livestock) are fine!!)

I had a bit of potential customer feedback the other day which suggested a group might be interest in a 10m AM transceiver kit. When I asked how complex it could be in order to obtain adequate frequency stability and tuning range, I was told that the proposal was to use Direct Digital Synthesis (DDS) and by implication an associated lap-top or microprocessor. I know only too well that this is THE way for a commercially made (in quantity) product but I am not so sure for homebuilt gear. *What do you all think?* Happy to take such items out back-packing on an expedition up a mountain? Can you repair it when it suffers reverse polarity? Is it electrically quiet? Can you understand it sufficiently to make alterations for your particular needs? Does it have low power consumption? If the answer to all these is YES, then great - there are very few of you and I am not among you! Be delighted to hear some alternative views before I am accused of being a boring old ....! Tim G3PCJ.

Kit Developments

The **Berrow** (see right) is now available! This is the revised any single band 1.5W CW TCVR with a proper VFO for any band 20 – 80m. Its early days yet so a special price for Construction Club members - £55. My thanks to the original Burtle builders and their most helpful comments. Meanwhile I have been progressing the **Minster** - some slight alterations to the RX and detail design & layout of the TX. I am planning an RF Extras kit that will add a second fixed band (also in 20 - 80m group) and a third one (for any band) via a band card slot. Its pretty ambitious but interesting! See also the **Cadbury** over! Tim



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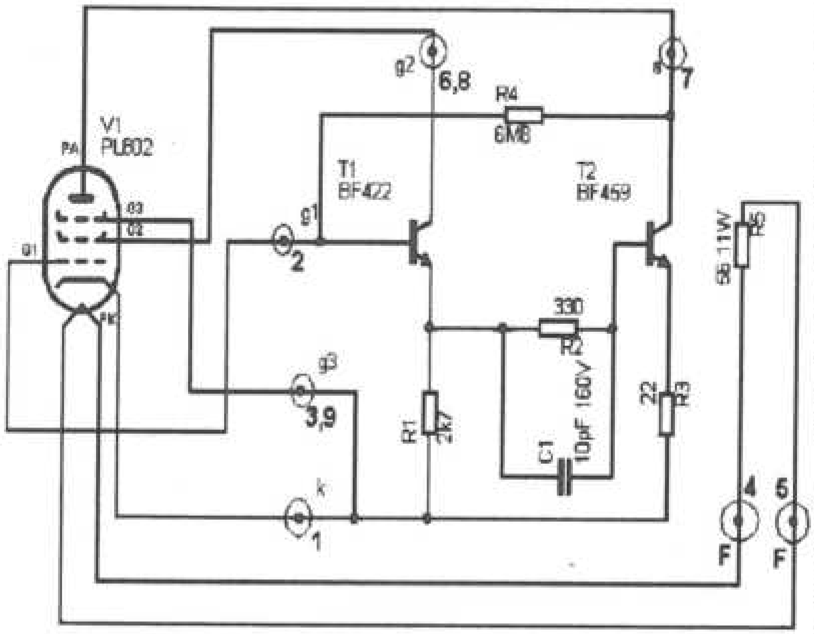
Solid State Valves - by Peter Thornton

For those illustrious valve lads [and their transistor brethren], here is a some solid state valve equivalent. These ideas are very much experimental! I've put some together and tried them, but because of the vast number of valve circuits out there I can't try them all - it's over to you! My interest in rock climbing [which parallels amateur radio perfectly - - - ??] means I fancy doing a bit of SOTA, where the simplicity of valve gear becomes attractive. The power supply is easy, with 100 watt "car cigarette lighter" mains inverters available under £10 on EBay, and weighing a few hundred grams. Years ago, PL802's became very hard to find as Philips had stopped making them. Some bright spark came up with this below. The diagram compares the valve on the left with it's solid state equivalent on the right. For our purposes, ignore the "F" terminals and 56 ohm resistor; they were for television series heaters. The transistors can be MPSA 42's. T2 will need some heat sinking! Nowadays N channel power MOSFETs are cheap and can cruise with a kV on the drain. Replace T2 with a power MOSFET to suit your supply voltage [times two to be on the safe side]. Note that the suppressor grid [G3] is NOT implemented - no need.



(I had to edit Peter's original note down quite a bit. I think anybody likely to use this info can make sensible deductions from what follows but please ask if you need more. Tim)

This would be my approach when using a solid state valve in the classic single 6V6 crystal controlled (Colpitts) CW TX; it goes like this, using a MOSFET PL802:-

1. PSU = 100w "car cigarette lighter" mains inverter, 12v dc to 230v ac. Output rectified for ~ +350v dc with 1N4007 diodes. NO mains transformer, 6X5, choke, &c., but plenty of smoothing - 2 x 47uF 450 volt capacitors [from an ex-PC power supply].
2. Remove the rig's normal screen grid gas stabiliser tube and the 2.2nF capacitor; increase the 10K screen grid resistor to 180K, 1/2 watt.
3. Use an MPSA 42 as T1 in the "PL802" circuit, with 2 x 47v Zeners in series with the collector, to keep T1's collector - emitter voltage below blast off.
4. Use an N channel MOSFET with a Vds rating of 800v for T2.
5. Fit 3 x 1N4148 diodes [or a 1.5v Zener] in series with the 2K7 in T1's emitter to lift the MOSFET bias.
6. Experiment with the external 390 ohm cathode resistor to get ~ 3 mA in the MOSFET key up, and 50mA key down [5 - 10w output].
7. Because a MOSFET PL802 has vastly higher gain than a thermionic PL802, keep a handful of ferrite beads, grid stoppers, &c. handy! Keep the anode stopper close to the drain!
8. Tune up with a 15w 230v [filament] light bulb in series with the 350v dc supply, to keep the current down till everything is tuned up.
9. For receivers, use the MPSA 42 style PL802, and the supply at + 200v dc. The MPSA42 has an Ft value of 50 or 90MHz [depending on manufacturer], so low HF regenerative receivers should respond well to the solid state valve treatment. Having a "screen grid" terminal means that controlling the regeneration via screen voltage is possible. You could use two MOSFETs - but MPSA 42's are around 6p each, good for 300v, 100mA, and in my book, that's value for money!

Easy Inductance Calculations by Gerald Stancey G3MCK

While the toroidal coil has taken over most of the applications in QRP where an inductor is needed, there is still a place for the classic air cored coil. This is particularly the case for AMUs where it maybe necessary to tap the coil or vary its inductance. This article looks at some quick and easy ways of finding how many turns your coil needs. The inductance in microHenries µH, of a single layer air cored coil is given by Wheeler's formula (right) with dimensions in inches. For millimetres divide by 25.4.

$$L(\mu H) = \frac{a^2 \times n^2}{9a + 10b}$$

n = number of turns
a = coil radius in inches
b = coil length in inches
G3MCK

Text books state that the formula should only be applied to coils whose length to diameter ratio lies between certain limits. My tests suggest provided b lies between a and 4a there is very little error. If you know a, b, and n, it is easy to calculate the inductance; but is much harder if you wish to decide on size and number of turns, for a desired inductance, because there are many solutions! If you have a handy former, hence known a, then you can calculate the inductance for a range of b and n values choosing that which suits you best. I find it helpful to assume that all coils will be 2 inch diameter and 2 inches long. The top formula in the second box makes working out the inductance simple. Its easy to turn this formula around to find the number of turns for a desired inductance - this is the lower one. For example, how many turns are needed for 2 µH? In this case, n is the square root of 58 which is 7.6. Your 8 times table tells you that 8 x 8 = 64, so 8 turns would be a good starting point.

$$L(\mu H) = \frac{n^2}{29}$$

$$n = \sqrt{29 \times L(\mu H)}$$

G3MCK For a=1 & b=2

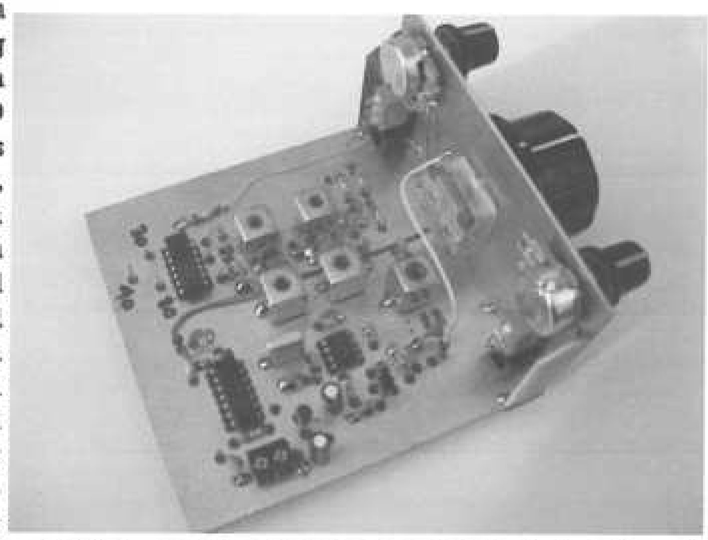
The same formula can be corrected for use with any coil whose diameter is the *same* as its length. This is done by correcting by the ratio of actual diameter to 2 in - so for a 1 inch x 1 inch coil, the inductance value is multiplied by 1in:2in or multiplied by 0.5. In this case, for the same desired value of 2 µH, the answer from the turned around formula becomes sq root of 116 which is 10.6. The nearest whole number of turns which should be used would be 11.

In practice, the actual values of inductance needed in an AMU are often quite wide as you adjust the taps, coupling and capacitor value to match the feeder/aerial load. Variation of the value of the inductance is often done by shorting out turns or using a core. However it is feasible to take a leaf out of VHF practice and vary the inductance by altering its length. Going back to the original formula, consider a=1, b=2, and n=10 which produces an inductance of 3.4 µH. If the length is doubled but a and n are unchanged, the inductance falls to 2.0 µH. Simply compressing the coil to halve its length increases the inductance to 5.2 µH. In other words the inductance can easily be varied over the range 2 to 5 µH. This is truly a wide variation in inductance which can be helpful when making single band AMUs. I recently used this approach with an L match AMU to obtain the desired 50R load on the rig from an indoor dipole, which due to bends etc, could not be trimmed to better than SWR of 2.5:1. G3MCK

The Cadbury

This is a new project that has four main elements. I am hoping this will feature in PW so I cant give too much detail yet! It stems from an idea for an article on VFOs - originally this was to be about getting them frequency stable by using 'quality' inductors and temperature compensating capacitors but it got too heavy going for PW, and anyway, the Editor Rob M had suggested something for 20, 40 and 80m. Achieving adequate stability on 20m (and the likelihood of chirp with a transmitter) exclude a free running design so the obvious approach is a crystal mixing scheme.

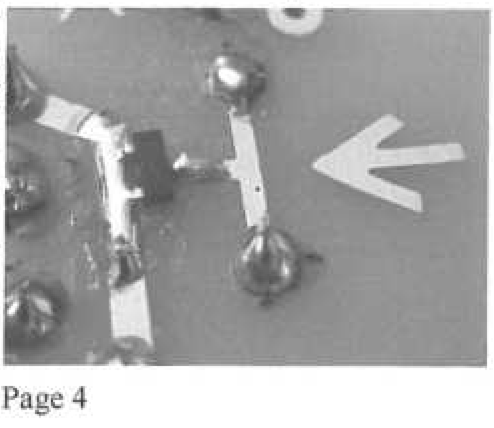
Mulling over the choice of common (thus cheap) crystals to go with a VFO working below about 7 MHz for stability, soon led to a 12 MHz crystal working with a 2 - 2.4 MHz VFO producing an output at 14 - 14.4 MHz. This scheme, if the VFO can go down to 1.85 MHz, would also cater for 10.15 MHz or 30m. Add a SA602 mixer chip with its two outputs each driving a bandpass filter and it can do 20 and 30m direct. Make the output signals digital and add a couple of divider stages working from the 14 MHz output and it then also does 40 and 80m! I have christened this unit the Four Band Local Oscillator - Four BLO! (To distinguish it from an earlier all band unit - the ABLO!) To make construction easy, both sets of output filters can use 3335 TOKOs and the VFO can use a TOKO 3333. As can be seen in the photo, it is not a complex PCB and the four individual (& simultaneous) outputs in top left corner, provide for easy band switching of any associated RX or TX!



With an in-band local oscillator signal, a simple **receiver** has to be direct conversion, so we need a design that can do any band 20 - 80m, driven by one of the Four BLO outputs. Digital techniques in the VFO suggested a commutating mixer using 74HC4066 type electronic switches; these would provide a strong mixer that might work well (negligible BCI) without any RF filtering apart from that provided by the station AMU! Add an RF amp to prevent LO radiation, low noise audio amplification, CW filter and an audio output stage and this becomes an interesting RX! This has been named the North Cadbury RX! I have had this working but slow driving of the HC4066 switches on 20m has required an extra chip with quite a few track modifications needing a revised layout; this has also permitted a number of other minor layout improvements.

A 5W CW **transmitter** (S Cadbury) to go with this has been laid out and etched but not yet built. CW transmitters are usually less risky than RXs, so I am hoping for less problems! Its designed for any band 20 - 80m with its own sidetone oscillator and muting, RIT cancelling etc. I am keen for it to be full break-in which is a bit more difficult with the slightly higher RF voltages associated with 5W or more of RF if run on higher supplies. The need is to prevent damage to the RX front end. A scheme of diode limiting at a relatively high (500R) impedance point is worth exploring - this is easily provided by a simple series tuned circuit (on RX PCB) between TX (after the LPF) and the RX RF amp input. Back to back diodes are then installed at the high Z point between the C and L to deck. To avoid tuning complications of this simple RF filter, it can be a single or a pair of fixed inductors (series or parallel) installed to suit the chosen band & tuned by a trimmer.

The fourth element is a band kit to make it into a full **four band** rig called the Cadbury Castle! This has also been etched but not tried. It has relay switching of three extra TX LPFs and three RX tuned circuits. Given the simple transmitter tuning arrangements, it also includes four tuning offset presets so that a single tuning dial position serves your preferred spots on all four bands! I cant find a suitable wire ended varactor so you will have to start on surface mounting - just one easy three legged component to fit near the arrow!



There is also a possibility that the RX might be able to take a phasing optional extra unit to get rid of a sideband - but it needs trials! Tim G3PCJ

Old Sentimental Top-band

Are you one of those people for whom Top-band holds a special affection? I suspect many of you in this category encountered Amateur Radio on the family 'wireless' in the parlour or living room.

In my case, my grandmother gave me a piece of walnut furniture when I was age ten which, almost incidentally, had a radio inside its polished exterior. The radio was built by the Pilot Radio Company Ltd around 1950 and had four bands and two short-wave bands covering from around 11 meters to medium-wave. Frustratingly it had valves with 12 volt heaters and when one of them eventually failed, I found it impossible to repair (then!).

I was intrigued by "Amateurs" labelled on the dial at 160m and found by connecting the radio's aerial up to the coils of my bed frame I could listen to a net of mostly two letter calls, such as G8CB and G6BX. When a station used sideband, I found that my medium-wave tranny could double-up as a beat frequency oscillator and unscramble the SSB!

My 'furniture' was duly upgraded and a procession of receivers took its place. I still have a Trio 9R-59DS and a few years ago a good friend of mine gave me a Yaesu FRG-7, which I couldn't afford when it first came out. These old receivers were spending all their time asleep however as the transceivers were the ones that were woken up and pressed into service on a regular basis. So, a little while ago, I decided to build an AM transmitter for 160m that could be used as a companion for the receivers.

With the ever rising tide of domestic QRM generators near my urban QTH, I planned to build a 10 to 20w (peak-peak) transmitter and Tim's 'Cam' AM transmitter (no longer available) with linear was a perfect match. On a previous project, I managed to get a sustained 20w output of double-sideband or CW from Tim's linear after feeding it with 21v and mounting a fan above the heat sinks.

The construction went very well with Tim's instructions taking me step by step. I had only one hitch - I fried the two BS170 transmitter output transistors due to inadequate grounding of the capacitors in the low-pass filter which badly upset the output impedance! I included transmit-receive switching using a relay to route the aerial through to my chosen receiver and mute it whilst in transmit. As I wanted the transmitter to run off the nominal 12v supply and the linear to run off a 24v supply (tweaked down to 21v), there are two power supply inputs. The end result has been better than expected with good audio reports and peak-peak output will go as far as 35w however, in my arrangement, it is very comfortable at 20w for long waffle 'overs'!

This project has got me thinking however and my next one will be a much simpler design based on a one-transistor AM transmitter. GQRP and PW have published various designs over the years and I reckon a simple design coupled with Tim's linear and some low-pass filtering would make a simple and accessible top-band transmitter to companion an old receiver and bring some nostalgia back to life. David M0EZP

PCB Production – Ironing Method by Derek Alexander G4GVM

Since the method was first introduced to me in an early edition of Hot Iron, I have made tens of PCBs, nearly all of which have been not quite perfect, though workable. The main problem for me has been 'pock marked tracks and pads'. I had put this down to bad etching, wrong grade of paper, poor printing, poor ironing etc. Having experimented with the four most obvious snags with little improvement, I was left with the printing. How could I increase the thickness of the Toner ? Putting the first printout through a second time resulted in, at best slightly, off-set pads and tracks. It came to me in the night – Hi.

Go over every pad and track a second time to double the thickness of the Toner. Or, as I have subsequently discovered, more easily by 'highlighting' the finished artwork then 'copy' and 'paste' will double the toner thickness.

Be aware that to make corrections after this procedure will mean doing the correction twice. Also, removing the toner after etching needs more energetic scrubbing – careful scraping with a blunt knife before the wire wool will help !

Although still not absolutely perfect – probably due to my particular printer - I have found the result a big improvement, so good luck. Derek, G4GVM.

New atomic element found!

The CSIR in collaboration with the Large Hadron Collider (LHC) has discovered the ***heaviest* element** yet known to science.

The new element is **Governmentium (Gv)**. It has one neutron, 25 assistant neutrons, 88 deputy neutrons and 198 assistant deputy neutrons, giving it an atomic mass of 312. These 312 particles are held together by forces called morons, which are surrounded by vast quantities of lefton-like particles called peons.

Since Governmentium has no electrons or protons, it is inert. However, it can be detected, because it impedes every reaction with which it comes into contact. A tiny amount of Governmentium can cause a reaction, normally taking less than a second, to take from four days to four years to complete.

Governmentium has a normal half-life of 2- 6 years. It does not decay but instead undergoes a reorganisation in which a portion of the assistant neutrons and deputy neutrons exchange places. In fact, Governmentium's mass will actually increase over time, since each reorganisation will cause more morons to become neutrons, forming isodopes. This characteristic of moron promotion leads some scientists to believe that Governmentium is formed whenever morons reach a critical concentration. This hypothetical quantity is referred to as critical morass.

When catalysed with money, Governmentium becomes Administratium, an element that radiates just as much energy as Governmentium since it has half as many peons but twice as many morons. All of the money is consumed in the exchange, and no other by-products are produced.

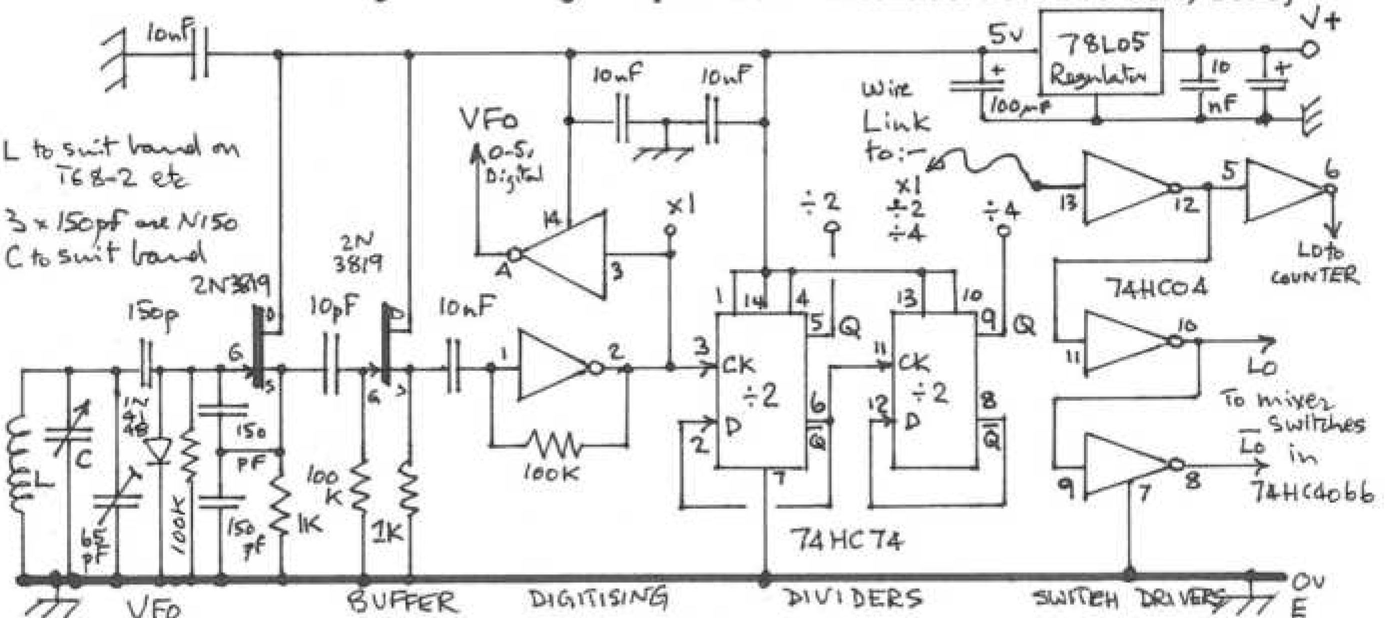
Multiband Superhet VFOs!

One of my long cherished desires has been a superhet TCVR kit, with a single set of parts, that can do any band 20 - 80m: this is at the core of both the Bridgwater and the Minster designs! THE challenge is the VFO frequency range that has to be catered for! The table shows the nominal VFO frequencies for a 6 MHz superhet for both additive and subtractive first mixers:-

Band - MHz	Additive - LO MHz	Subtractive - LO MHz
14	20	8
10	16	4
7	13	1
3.5	9.5	2.5

The additive VFO range figures (for a simple rig) are all uncomfortably high for good stability without doubling from half those figures, and even then, 20m is still too high! The subtractive ones are much better but there is now a different problem! An oscillator at 2.5 or 1 MHz needs an uncomfortably large inductor - not easily done on a toroid! The Minster's digitally driven first mixer eventually made me realise that a 1 MHz LO is not hard! Divide twice by two from 4! The 2.5 for 80m comes easily from 5 MHz too!

Thus one set of VFO parts has only to cover 4 to 8 MHz; this can easily be done with one toroid, whose turns are adjusted for the required band inductance, and a trimmer for setting up to the band edges! This discussion ignores the question of which sideband is to be used - it does not matter for a single band rig because its easy to set the carrier insertion oscillator either just above or just below the IF as required for the desired sideband. The approach of using a divider to get 1 MHz for 40m will provide a considerable stability improvement over doubling from 6.5 MHz to get to 13 MHz. The only drawback is that the VFO ought to be buffered before a digital 'gate' of some sort that is needed to drive either the digital dividers for 40 and 80m, or the mixer electronic switches direct on 20 and 30m. This is a small cost/space penalty but does have the advantage that the spare gates in the gate chip can easily drive a counter for a digital readout without loading the main circuit! This approach is incorporated into the basic single band Mk 3 Minster using essentially the circuit below; wire links are used to select the divider stages when they are needed for 40 and 80m. When converted for multi-band operation, the Minster will do all bands by crystal mixing (possibly with a phase locked loop) because of the wide LO range, especially for 10 - 17m; this makes a simple LO chain impossible - especially with a single CIO frequency since that cannot be easily changed from band to band to suit the wanted sideband! In this multi-band form, it will use the VFO at 4 MHz (without division) just like the single band 30m version. (This LO division approach is not used in the Bridgwater but might be possible! I will consider a Mk 2 version!) G3PCJ



SUPERHET LO CHAIN FOR 20-80M TCVR

© G3PCJ

RF Amp architecture

A recent note in Electronics Weekly considers the problem of low energy efficiency of mobile phone transmitter output stages which have to handle rounded pulsed modulation waveforms. The note points out that with a fixed supply voltage, operation in the linear or intermediate section, efficiencies are down near 30% (poor!) but at the peak (full power) they are up near 60% in the compressed or saturated region. The same problem also applies to amateur radio transmitters! Researchers have suggested high speed modulation of the supply voltage to match the desired output pulse shape. Thus for the low amplitude portions of the transmit waveform, the supply voltage would be lower so that the stage operated in the compressed region at high efficiency. This produces a need for a power supply modulation bandwidth of the order of 60 MHz for use on an RF channel that itself has a bandwidth of the order of only 20 MHz - albeit at a carrier frequency of a few GHz! Quite a challenge!

Snippets!

Data over power lines ARM have developed a chip for transmitting metering (water/elec etc) data over the 50 Hz distribution system. It is claimed that using dynamic information (collected every 15 mins or so), it will be possible to save about 1% of total electricity consumption. The article did not explain the intended transmission distance but I guess it's a few miles! The modulator will squeeze 130 Kbits/sec onto carriers between 45 KHz and 90 KHz - in the 3KHz - 95KHz CENELEC A band. This is all a bit worrying for radio amateurs - it cannot do anything to help keep electrical noise low.

Hydrogen Fuel cell for smart-phones Rohm, with Aquafairy Corp and Kyoto University have developed a small cell that is 25% smaller than lead batteries with the same capacity, making it possible to provide 400 Whr of energy from a device weighing only 3 Kg. The devices are targeted at locations where mains power is not available or cannot be used due to safety. Production aims for April 2013.

Fast digitisers Agilent reports that its digitisers have been used in the hunt for the Higgs-Bosun particle at the Large Hadron Collider. They were used for precision measurements of the collision results at 8 Gigasamples per sec with a resolution of 8 or 10 bits! The process starts by generating 50 MeV protons that are fed into a booster, which takes the level to 1.7 GeV before injection into the synchrotron which gets them to 26 GeV. Over 20 minutes the level is raised to 450 GeV and then injected into the main ring where they are accelerated to 7 TeV. The bunches circulate in opposite directions with controlled collisions occurring at four possible locations. Each bunch lasts for a few picosends (10^{-12} sec) as it approaches the speed of light. Depending on the accelerator's circumference, the transit time ranges from a few nanosecs to tens of microsecs. Strong RF fields (details not reported) are key to achieving high gradients of acceleration.

This splendid replica spy set by Charles Wilson conceals a Five-head and Linear! And a great deal of skilled workmanship!

Don't forget the date for **Amateur Radio in the Country 2013 - July 21st**. Make sure its in your diary! Those of you who came this year might be amused to see the current occupants of the barns! More details of the Construction Challenge in the next issue of Hot Iron. I am please to report that Graham Firth G3MFJ of the GQRP Club is going to 'judge' the entries. G3PCJ

Happy Christmas to you all!

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Spring 2013
Issue 79

Contents

The Walford Electronics website is also at www.walfordelectronics.co.uk

Editorial

The sun is out once more! Hurrah and the water is receding too - we will soon have a draught! My notes in the last Hot Iron about DDS and micro-processors did produce some welcome comments. One member, who is a keen builder, said they were jolly good things and were right for modern home built radios! A more widely held view was that they were excellent devices when kept apart and should not be combined in home built radio gear! Often the overhead of running any form of digital processor outweighed the simplistic approach that the rest of the radio might employ! Thank you to all contributors anyway - comments on any topic are always very welcome!

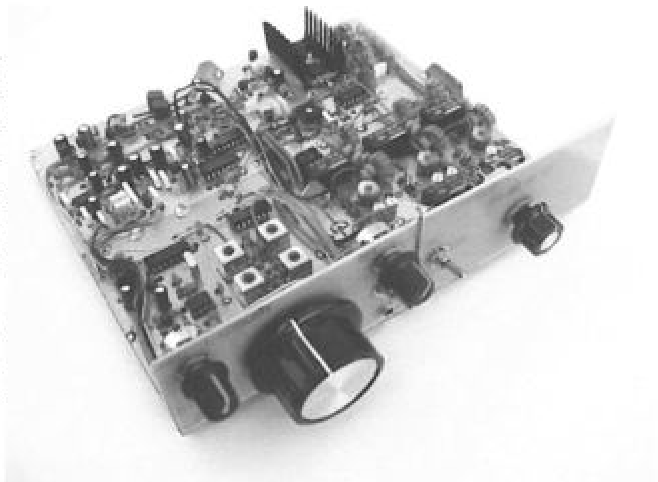
One member has recently suggested that I ought to address the new low frequency bands - 472-479 KHz and lower. I would be interested to hear of anybody else who would be interested. The circuits ought to work easily at these low frequencies, perhaps with larger coupling capacitors etc, but where an inductor is required that might be a bit more challenging - too many turns to fit sensibly on a powdered iron toroid so ready made inductors would be needed! Also the maximum value of trimmers is hardly enough for easy adjustment of resonant frequency. Measurement of frequency will be more important to make sure you remain in band! I must look in my store of old adjustable TOKOs!

Tim G3PCJ.

Kit Developments

The **Cadbury Castle** (right) and all its component kits are now in 'production' form after a small mod to the TX that required PCB alterations. I shall be writing this up for PW shortly and would be delighted to have any early builders who might be wanting a full break in 5W CW four band DC TCVR - all bands 20 - 80m!. I have laid out (but not yet tried) the phasing optional extra kit. Ask me for details.

I have also etched the prototype **Lydford** SSB 5W TCVR - single PCB - any single band 20 - 80m. This is a modern Tiny Tim for those with long memories! I also now have a Minster TX PCB too!! Tim



Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £8 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

Measuring inductance - by Peter Thornton

I recently bought an L-C-R "digital meter", from a well known on-line auction sales outfit. I checked the ranges using components I had to hand; the instrument readings came very close to expected, and I was impressed by the instrument.

A project I have on my bench at the moment calls for a 60W linear amplifier, and before running a linear, I always connect a 50 ohm dummy load to the output. I recently built a new dummy load, and checked it's resistance with my L-C-R meter: 50.02R.

Because I could, I checked the new dummy load's inductance - it should be purely resistive. It read 280 micro-henries! What? Metal oxide resistors are non-inductive, where had 280uH come from?

A idea presented itself. The L-C-R meter doesn't measure inductance directly, it infers it from pulses through the coil - and a coil is almost a "dc" short circuit. A dummy load has *resistance*. The meter interpreted 50R as 280uH! A simple test proved the point: a tiny 1/8W 47R resistor, when measured, gave similar big "inductance" readings - but the resistors were so small the inductance could only be a few nH.

Suspicions proved: the inductance measurement is thrown by resistance. Job done, linear runs fine!

Sorting out unknown ferrite cores

Peter Thornton has written a note on his experiences trying to do this but it was too long to include here, so I will attempt to summarise it. If you are seriously interested I can put you in touch. (G3PCJ)

Ferrites come in four main categories which are the intended frequency of use bands - 1, Very Low Freq types for power line filters for under 1 MHz; 2, switch mode PSUs - good for use on 40 –160m; 3, cores intended for HF 'chokes/transformers' good to 30 MHz; and 4, V/UHF types used for convenience in things like aerial splitters. Almost always, the higher the inductance for each turn, the lower the frequency of use. Get an idea of what this critical A_L figure should be by looking up manufacturers data sheets - Fairite etc.

Then put on a few turns and resonate with a capacitor, and measure resonant frequency with a dip meter. This will often need a separate turn or two around the GDO coil connected in series with the unknown L and the known C. Its handy to have a range of small capacitors available - 22 pF to perhaps 470 pF. Experiment with the Cs and GDO ranges until you find a strong dip. Then work out the inductance from the standard formula for resonance. Peter reckons you can obtain an impression of the inductors Q by judging how wide the resonance dip is but my experience is not good at that! Most often we want devices that are suited to HF applications, so if the resonant frequency is either below 1 MHz with 470 pF or above 30 MHz with 22 pF, then its unsuitable! A bit crude I know! Finally Peter suggests putting some RF power through it into your dummy load. Ideally one would aim for the inductive reactance of a single winding at the operating frequency to be over 4 times the impedance, ie 200R. So wind on whatever number of turns is required to give 200R! Then put on another winding with the same number of turns. Connect one winding to the TX and one to the dummy load. Gingerly send some RF through it (up to say 5W) and see if it gets warm. If not, then its suitable!

This seems all a bit questionable and needs a fair bit of mathematical skill as well as patience! I must admit to never bothering with unknown cores - the potential troubles are worse than the cost of buying a few known devices from the GQRP Club; keep them in suitably labelled boxes! Do not mix up black unmarked ferrite cores with the easily identified coloured powdered iron cores that are so valuable for making RF inductors. Tim G3PCJ

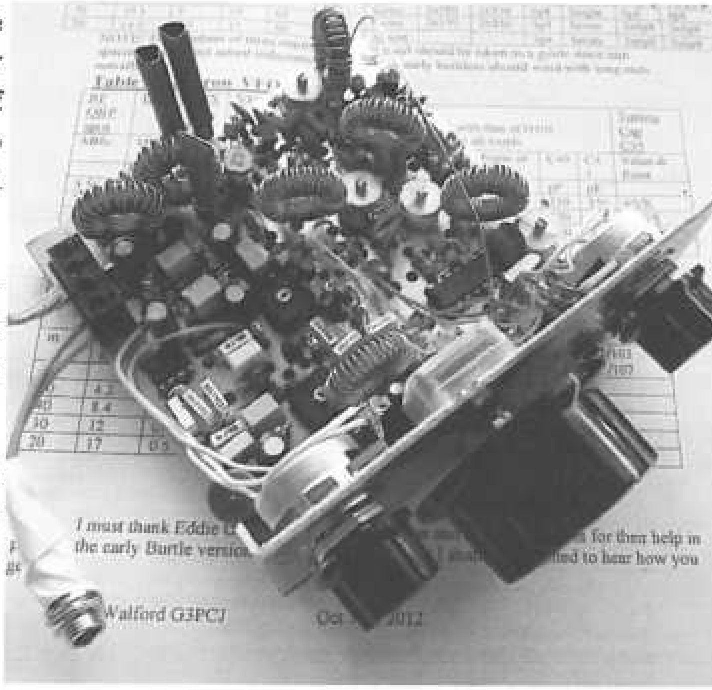
Tweaking up the Berrow - Phillip Thompson G4JVF

I've recently had great fun building one of Tim's new Berrow kits. Just what I wanted in a rig and it worked flawlessly. I initially had it set up on 40 metres but soon wanted to tweak (as you do), and try it on other bands. Doesn't take too long to swap out the coils and capacitors to suit whatever band.

Sadly, I don't have much test gear, a multi-meter and an L/C meter being about it. I also don't own a commercial Ham Radio rig of any sort. In recent times, I've leant heavily on using my Softrock Ensemble 11 SDR receiver as a sort of "Swiss army knife" test rig whilst building various QRP projects.

The beauty of my SDR receiver is that I can align it to known signals such as WWV or whatever, resulting in an accuracy of a few Hz. So, it can tell me exactly what my Berrow VFO frequency is by simply dangling a short wire from the SDR receiver near to the Berrow VFO toroid coil and taking note of where the trace is on the waterfall display of my computer SDR software.

Same idea for sniffing the signal in the mixer, which is VFO and crystal oscillator combined. Whilst watching the trace of the mixed signal, I could peak the two variable caps in this mixing stage with ease.



Last but not least, I can "view" the TX output on my SDR and put my mind at rest that there are no out of band signals to be concerned about.

So far, I've tried this Berrow on 80, 40 and 30m with success and my SDR receiver has made it possible to do the tweaking with ease and accuracy each time...

Next job to try 20 metres..

Softrock Ensemble 11 kit comes from Tony in the USA

http://fivedash.com/index.php?main_page=product_info&cPath=1&products_id=6&zenid=8360bc445bcd2e27da78c0e55de3c88

Phillip sent me an e mail confirming it also worked on 20m the next day! Look at his lovely chimneys on the output stage! Although this rig is marketed as being for any single band 20 - 80m, the method of generating the Local Oscillator signal can be easily adapted for other bands with a different crystal. In principle the set should be viable up to 10m but, because the higher bands will need 16 or 24 MHz crystals, I have not included those bands in the normal offering. With a few minor modifications it could also do 160m. The TX output low pass filters also need different values instead of the normal single set of parts that does any band 20 - 80m! If anybody wants to do a special, let me know and I can easily manage it. Tim

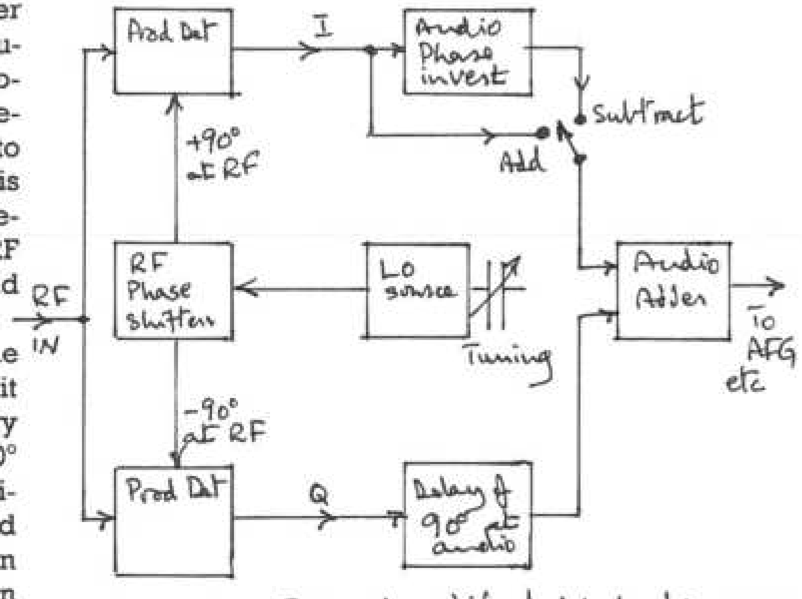
Philip tells me he has just added the Mini AGC kit to his Berrow; and says 'It completely transforms the listening experience with phones - no more head thumping large signals - fantastic!'

The Cadbury Phasing kit

Early trials of the South Cadbury TX (CW) showed it to be struggling on 20m! This turned out to be the usual problem of the high gate capacitance of the IRF510 in the 5W output stage FET. With a little encouragement from Peter Thornton, this was easily solved with a bipolar complimentary emitter follower stage to provide the necessary low impedance drive. The rig is now working well on all four bands 20 - 80m.

The North Cadbury RX is direct conversion and therefore allows use on either sideband of the wanted station. Unfortunately, the unwanted strong one on the opposite sideband is also present! One way of removing him, and boosting the wanted, is to use the *phasing* detection technique. This is especially suitable for direct conversion receivers because it avoids complicated RF filters/mixers and maintains that clean sound for which DC RXs are renown.

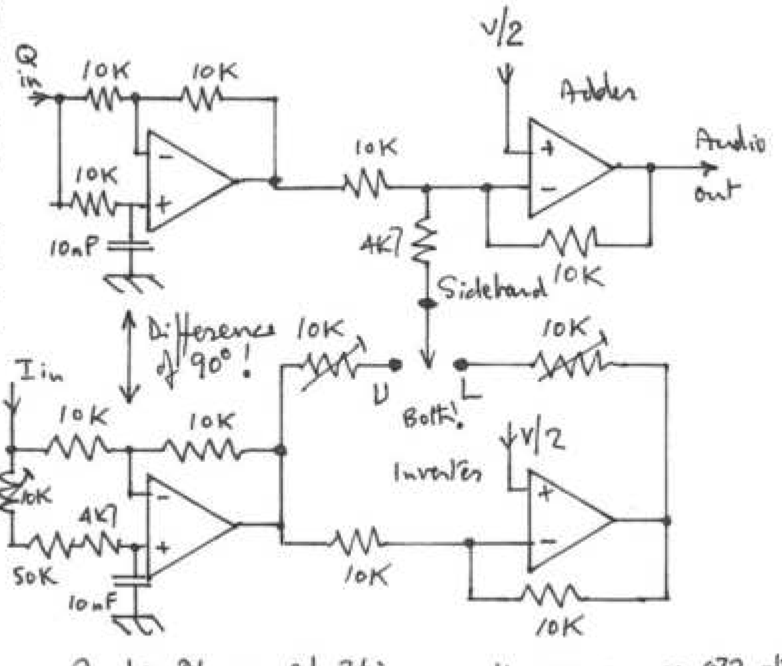
The block diagram right shows the principle, the incoming low level RF is split into two channels which feed two ordinary product detectors whose LO signals are 90° out of phase. After (the normal) audio amplification, one of the audio signals is delayed by a further 90° so that the resulting audio in the two channels is 180° out of phase. By then adding or subtracting the two audio signals, the output is either enhanced or removed!



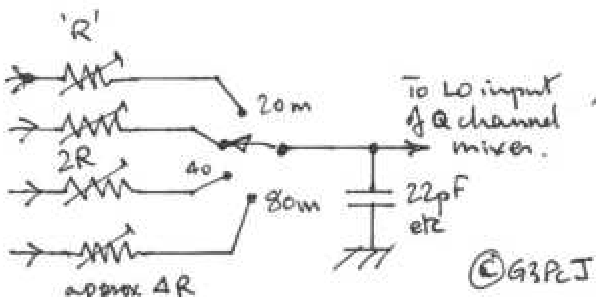
Phasing RX - simplified block diagram
© G3PCJ

In reality life is always a bit more complicated but is still rather easier than making a multi-band superhet like the Minster!! The North Cadbury RX has 74HC4066 switches for the product detector - only two are required for each channel so the second pair can feed the extra audio channel and phase shifting circuits. Its unwise to do the phase shifting and nulling/addition at very low level so some of the RX audio amplification and filtering is duplicated in the second channel. If the audio phase shifter were perfect it would delay one channel by 90° over the whole audio bandwidth from 300 to 3000 Hz - this is rather challenging! So bearing in mind this is primarily a CW RX, maintaining the 90° difference over say 500 to 1000 Hz will be adequate. This is most easily done with two *All-pass* filters which have unity gain but delay the signal depending on the C and R values at the op-amp positive input. The circuit is sown right.

The final item is the RF phase shifting - because the product detectors are digitally driven from the Four BLO, a simple CR for each band (below) looks possible! I will try it shortly! G3PCJ



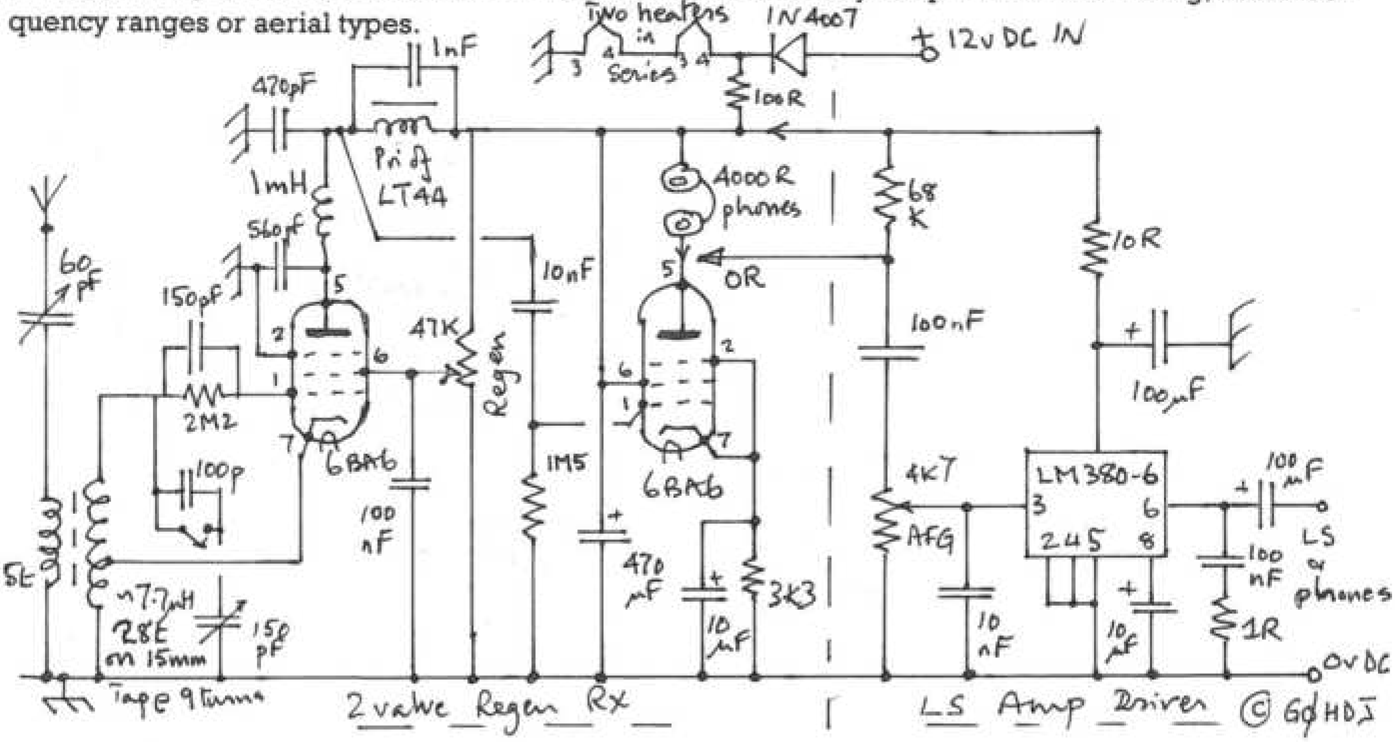
Audio Phase shifting - all op-amps 072 etc
© G3PCJ



LO Delay circuit to provide one quarter of period!

Valved hybrid Regen RX - by Craig Douglas G0HDJ

Craig responded to my comments in an earlier Hot Iron and sent along this design which he has built successfully. Unusually, the supply is 12 volts both for the two series connected heaters of the 6BA6s but also for the High Tension (HT)! My valve consultant tells me that the recommended 6BA6 is an RF pentode that should not be much good with such a low HT but Craig says it works well! The circuit is an adaptation of one by W3IRZ which only had the two valves feeding a pair of 4000R phones. Not having such rare items, Craig has added a semiconductor LM380 LS driver stage also running off the 12v supply. The valve part of this circuit should work quite happily with HT supplies up to 150v or more! The tuned circuit can be easily adapted for finer tuning, other frequency ranges or aerial types.



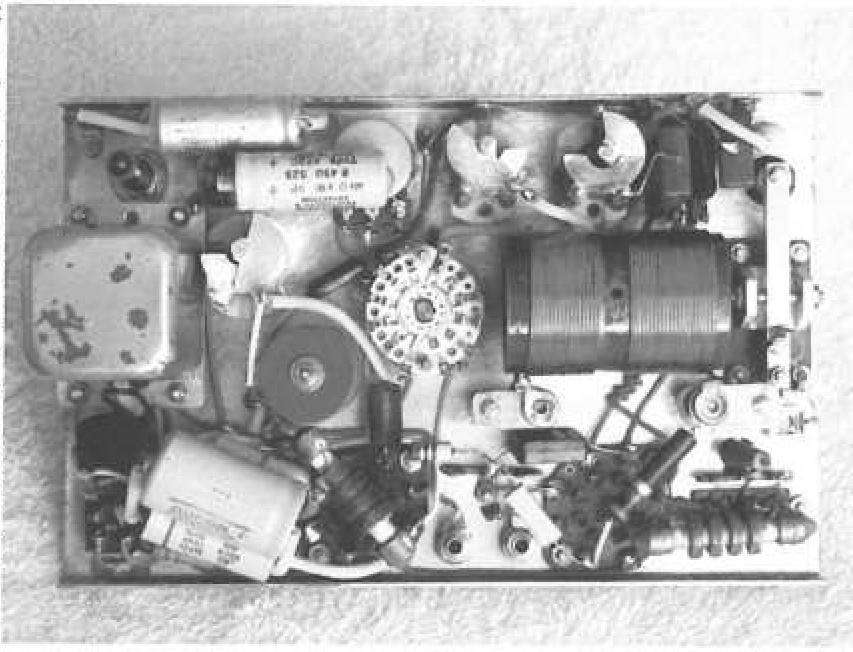
I had thought that I ought to do a valve RX kit but new valves are expensive and have many disadvantages compared to the cheapness, ease of use and performance of semiconductors. My expert on these matters suggests that the best use for glass envelopes is for storing that special amber liquid from Scotland, or for encasing 4CX250's! All other uses should be forgotten! G3PCJ

Test Box Competition!

The prize for this informal competition is a two band transmitter low pass filter kit complete with relay switching for any pair of bands 20 - 80m. I have often thought that for all those people who like going portable, they should really take some simple test equipment with them because this method of operating can be quite demanding. (It is actually what makes military manpack sets so expensive!) Several factors are against you - probably poor battery supplies, small inefficient antennas and a challenging physical environment, where the elements may intrude into the equipment or the temperature change quite suddenly! So tell me what facilities you think ought to go in a portable operations 'test box'. I have seen some American suggestions for a piece of kit that would not be out of place on many home benches let alone up a mountain, but knowing that all you fellows love going out unsupported in the wild, I expect rather simpler items! In the event that I am overwhelmed with suggestions, I will consult an expert on such operations! Write me a brief note for the next Hot Iron complete with circuits as appropriate please. Tim G3PCJ

Replica Paraset

by Rob Firman ZL1CV



Around about 1956, as a teenage lad, I read a book called ' TWO EGGS ON MY PLATE ' by Oluf Reed Olsen and my imagination was fired by the thought of someone Parachuting into Norway and setting up a clandestine radio to transmit information back to the British Military. I was at that time becoming interested in Ham radio eventually gaining my ZL callsign and as a retirement project in 2001 I decided to build a working reproduction of the Paraset as used by Oluf Reed Olsen. There were many versions of the MK7 Paraset and mine is in an oak box with a 230 Volt power supply. From memory I made only two departures from the original circuit. One was to isolate the final tuning capacitor from HT to prevent the chance of shock at the spindle knob and the other was to use a MK1 ZC1 output audio transformer as I was unable to find a suitable period choke. Although a key is fitted to the set I included a socket into which I could plug an external key as was done on some of the original versions. The whole out fit goes into an old leather suit case and it looks the ' Spy Set ' part and yes, I still have to engrave a suitable name and serial number plate.

The little suitcase set goes very well and thanks to the internet we now have access to much information on these past gems. I doubt that I will ever make a G contact on the Paraset but perhaps with a Whaddon MK3, for which I am currently collecting parts to go with my HRO receiver, I may well have a CW contact into the UK.

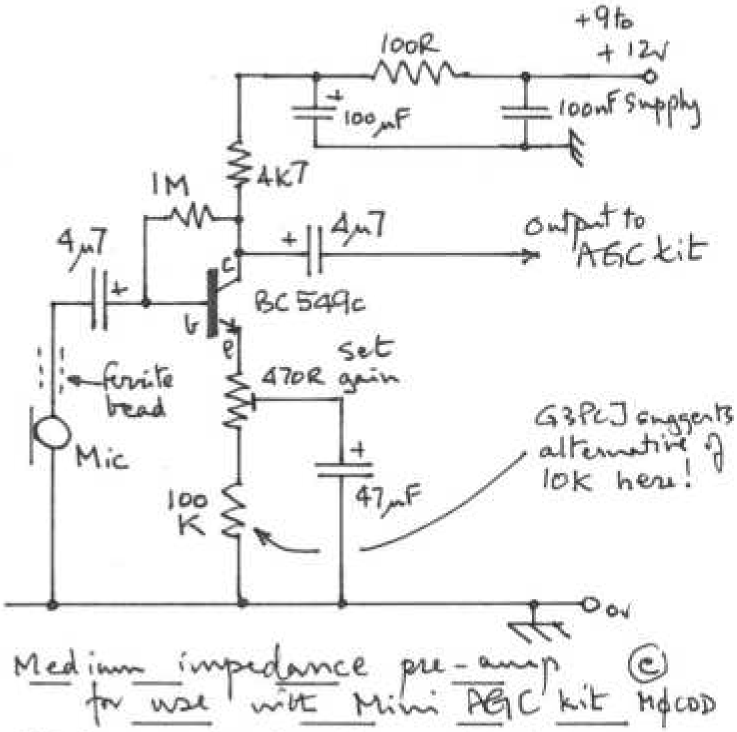
I hope the photos will be of interest to fellow clandestine radio enthusiasts and thanks to Tim for letting me share them.

(This project looks so good I felt it deserves slightly larger pictures than normal! Tim

Audio AGC for microphones by Chas Wilson M0CDD

Normally in my shack I use a desk mic which is amplified by a single stage pre-amp, powered by its own battery. This works well enough but as I have a tendency to go 'off mic', so I have been looking for a some sort of audio Audio Gain Control (AGC) circuit for my mic. A design from an electronics magazine had been tried and rejected, not least of all because it had three pots to adjust - I never managed to get pots in the right place to suit all my rigs!

I was intrigued by the spec of Tim's Mini AGC kit and thought it was worth trying to adapt it. The kit was purchased, constructed and on the bench with the mic feeding into it and monitoring the output on a scope, I realised its potential. A small amount of extra mic gain was needed from the low output desk mic; the existing pre-amp was duplicated dead-bug style and fed into the AGC kit input. This originally gave too much gain so the preset and series resistor were added to control the gain. Now by adjusting the preset I can set it so the audio falls off when I am over about 24 inches from the mic, which allows plenty of room for movement, reaching coffee cups and log books etc. The output of the Mini AGC kit is fed direct into various rigs mic inputs without modification; power lines are well decoupled and ideally the pre-amp/AGC kit might be installed in their own metal box with internal battery! Too much gain will make the audio sound like a speech clipper but will not over-modulate. Users of high output fist microphones might find that a 4K7 preset would be better so the gain can be further reduced if necessary. One could also try feeding the audio from the AGC kit (with or without pre-amp as necessary) into a speech processor so as to raise the average speech level closer to the peak level and thus increase 'talk power'!



The Importance of ESR in choosing electrolytics

A recent note in Electronics Weekly points out that Equivalent Series Resistance (ESR) of electrolytic capacitors is often overlooked. ESR is particularly important in applications with low duty-cycle high peak currents. Power supplies are good example; this applies whether the PSUs are linear or switch mode because there are often high peak currents at the input - in the reservoir capacitor as it is charged up on small duration supply voltage peaks; and also in the output filter capacitors from a load that changes more quickly than the regulator can respond to. 'Wet' aluminium electrolytics have an ESR that is significantly affected by temperature - typically reducing from 1R at –60 °C to about 0.03R at +100 °C. They also dry out with use due to heating with high peak currents, and with age - both of which reduce capacitance and increases ESR. So called 'solid' aluminium electrolytics and hybrid capacitors have a much more stable characteristic that hardly changes with temperature giving an ESR of the order of 0.04R over the usual temp range. In tantalum capacitors, the construction is different with a higher contribution to ESR coming from the end leads.

My own experience is that the extra expense of tantalum caps is only justified where low leakage current is important, eg. in decoupling a varactor tuning voltage against bad supply transients. Normal aluminium electrolytics are fine for most amateur applications but continuous use near their rated voltage is not wise! Better to use a higher voltage one if possible! They also have a very wide tolerance, so if value is critical, double the value! I have also noticed that the more modern ones definitely do not like reversed supply voltage without a current limited supply - quite exciting and messy - but not recommended! G3PCJ

Snippets!

Biodegradable electronics! A team led by John Roberts of the University of Illinois, is developing 'circuits' so thin that they dissolve on contact with just a few drops of water! Comment - it would not be any good in this part of the world or this house - far too damp!

David Buddery G3OEP

I am sorry to report that Dave has died recently after a spell in hospital. Dave did a tremendous amount helping others get into amateur radio and had very wide experience of amateur radio design and operation during his long life. Dave told me that he took part in the very first RSGB field day back in 1937. They used then to have an A and B station, the former on 40 and 80m with the latter on 10 and 20m; they shivered in tents with battery supplies and mostly home brewed gear. Input power was limited to 10W and, for wealthy clubs, the Eddystone All World 2 was a popular RX. This used 2v heater valves in a regenerative detector and audio amp arrangements feeding high Z phones (see G0HDJs design in this Hot Iron). Dave was a good customer of mine, who started with one of my earliest regenerative receivers called the Pitney - a long time ago! He was a regular writer to me on all sorts of radio related matters - often about his knowledge of wartime radio characters. It was he who started me off investigating an interesting man called Bayntum Hippesly who lived originally not far from here in Somerset, who was an early radio enthusiast, and who started off the Royal Navy's Radio intercept activities in Norfolk that were so important in the run up to the Battle of Jutland. This led me literally into a hunt round Hunstanton looking for the sites - the whole topic was most interesting and even helped fill a few pages in Hot Iron! This topic directly led to my subsequent interest in a wartime bunker built for the Auxiliary Units SDS, and its unusual TRD radio, down in Devon. Dave B Snr will be much missed but I pleased to say that his son - another Dave - has the same interests and has also contributed often to Hot Iron! Tim G3PCJ

Pat Hawker G3VA

I am also very sorry to have just heard that Pat died this week. He will be most remembered for his excellent long running **Technical Topics** in Radcom which 'reported' all sorts of old & new ideas.

Amateur Radio in the Country 2013 July 21st.

Make sure the date is in your diary! The night before party is nearby (walking distance), in a friends grain store barn. The theme is a Caribbean Night out complete with a live band, hog roast etc... Those staying nearby overnight have to come as it will certainly be good fun! We should be able to accommodate a few campers in the field close to the barns where the event will be held. Please encourage your local Clubs to put on displays etc.. - plenty of space! Let me know your plans please.

I am pleased to announce the theme for the informal **Construction Challenge** that is to be 'judged' by Graham Firth G3MFJ of the GQRP Club. The task is to build and demonstrate to Graham a CW sidetone oscillator for a TCVR. This might also act as a keyed audio generator for morse practising. It has to feed modern series connected 32R phones presenting a load of 64R. The output should be free of thumps when the key is operated! Nominal frequency to be about 800 Hz and is to run off a 12 volt supply. It is to be keyed either by ordinary contact closure, OR by sensing the RF from a 1.5W transmitter. This latter aspect is to make it both more representative and a bit more interesting as a technical challenge! Construction style is not important as long as it works! Graham's decision will be final! (Meanwhile Ivan G3KLT enjoys a beer and the Plank at QRPiC2012!) Tim G3PCJ

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Summer 2013
Issue 80

Contents

The Walford Electronics web-site is also at www.walfordelectronics.co.uk

Editorial

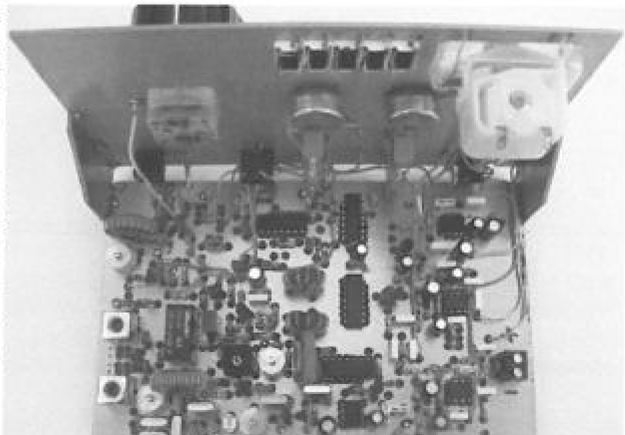
Summer is now truly with us - what a great improvement on last year! I really must get my big aerial up again - I had a 160m half wave dipole fed by open wire line slung between trees and a building with the house propping up the middle, but it came down in a storm and I have been using a roof mounted dipole which happens to be resonant at near 7 MHz. Owing to some criticism about unsightly wires, I need to re-arrange it from the house over to a different building which is about 100 ft away; thus it could take a 66 ft top element easily but I am then faced with end feeding it and perhaps not so good for all bands! This makes it need open wire line to one end in the format known as a Zepp. I have never like this owing to one side of the line at the antenna being unconnected - what does the RF do when it comes across this? Shoots back and goes all over the place! I would much prefer a balanced scheme, or even off centre fed so that it is N quarter waves on some higher band such that on the lowest band there is at least a length of radiating wire on both sides of the feeder, even if not fully balanced or resonant all the way to 160m! Please one of you keen aerial experts or experimenters, tell me what I ought to erect!

Tim G3PCJ or walfor@globalnet.co.uk

Kit Developments

Last time I mentioned the **Cadbury Castle** (all 4 bands 20 - 80m 5W CW TCVR) that I have offered to PW. I will be making up some early models shortly, so let me know if you wish to have a crack at one.

The **Lydford** (any single band 20 - 80m phone SSB 5W) has been kindly proven by Brian Pilcher & Steve Davies; Keith Woodward's is not far behind so I am now happy to take orders. Ask me for details and discounts!



I am also pleased to report progress at long last on the **Minster** Mk 3! Its been some years getting there but I have the RX (right) working well on 20m. Minor troubles with AGC etc now overcome! I am part way through writing the TX words and have etched the PCBs for the RF Extras kit that will give it a 'two chosen bands plus a plug band slot' for all other HF bands capability.

I also have new simple FiveFET regen! Tim

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £8 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 or walfor@globalnet.co.uk

Testing Electrolytics by Peter Thornton

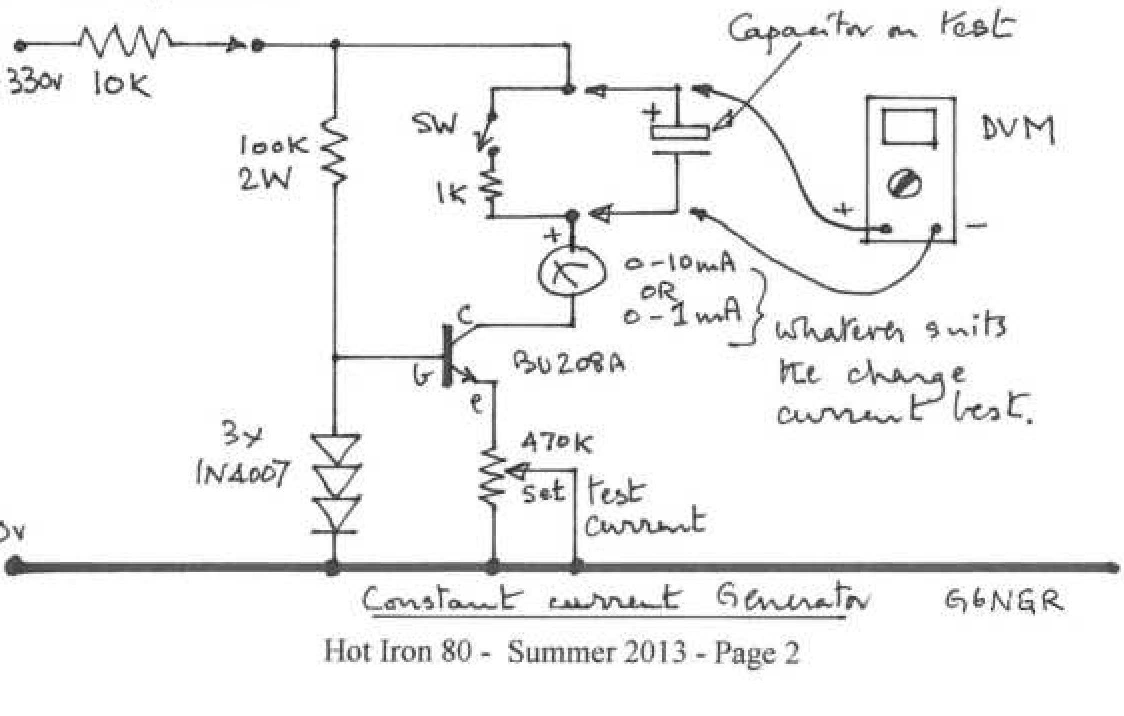
Here at G6NGR all sorts of daft problems land on the bench, and a recent problem had me scratching my head. I was trying to find the source of "noise" on a 300 volt 150mA dc supply, which showed up when reviving a valve receiver. I like to keep a reliable HV power supply to hand for valve jobs. I couldn't find the source of the noise: very obtrusive, not mains hum. I replaced all the decoupling capacitors in the receiver, but still "no go". I turned my attention to the power supply; old faithful, seen service man and boy. I changed the main electrolytic capacitors; problem solved! So just what had gone wrong, with proven good performers, the trusted workhorse electrolytics?

Most folk know about the "ESR" of electrolytics – it means "Equivalent Series Resistance" – a phenomenon in that shows as a resistance, gradually increasing during the electrolytic's working life, until the electrolytic is all but useless; ESR is not the easiest figure to measure! And that's not the only problem (as I found in my HV supply) that they suffer. How about checking the value? Are they still 330uF? Here's how to check those little rascals, and see if they are still up to service. The basic formula for a capacitor is 1 Farad, fed 1 amp, for 1 second, will show a terminal voltage of 1 volt. That's the definition of a Farad. So, I knocked up a "constant current" source (below) from my odds-n-sods box. Don't omit a means of discharging the capacitor on test SW1. I set the current in the collector to a convenient value to give a reasonable charge time; do this by closing SW1 with no capacitor connected and adjusting the emitter resistor.

Now, if my capacitor is 1micro Farad, 1 amp will make 1 volt in 1 micro second. Measure the voltage after a known number of seconds, apply a little grey matter, and out pops the capacitor's value. The maths: $Q = CV$; $Q = iT$. Therefore $CV = iT$; C therefore equals iT/V (Q = charge, Coulombs, C in Farads, I in Amps, T in seconds, V in volts). I found my capacitors had a value of 190uF (330uF marked). But that wouldn't explain the "noise", but would cause an increase in mains hum.

I put a 1mA (or 10mA if more appropriate) meter in series with the capacitor. Sure enough, a steady current as the cap charged up. I expected the current to shut off when the capacitor was "full" – but no! Some current still flowed: a sniff, but still a current. I upped the supply voltage to 330v dc, via a 10k-ohm resistor; 20 volts below the rated capacitor voltage of 350v dc. Whoa! The current was jumping about, no steady value. The capacitor was leaking almost to the point of breaking down, and the leakage current spikes were creating the noise. Job done!

You can use this method to test and check the polarity of unmarked / flea market purchased capacitors. An electrolytic, charged the wrong way, leaks like a colander! Oh, and it's important to use a 10M-ohm DVM to measure the capacitor voltage; the DVM must pass minimal current. You can use this set up to test diodes, transistors (or anything else, come to think of it) that you suspect leaks. The current even if the device on test is a short circuit, can never exceed the set current – so your milli-ammeter is protected.

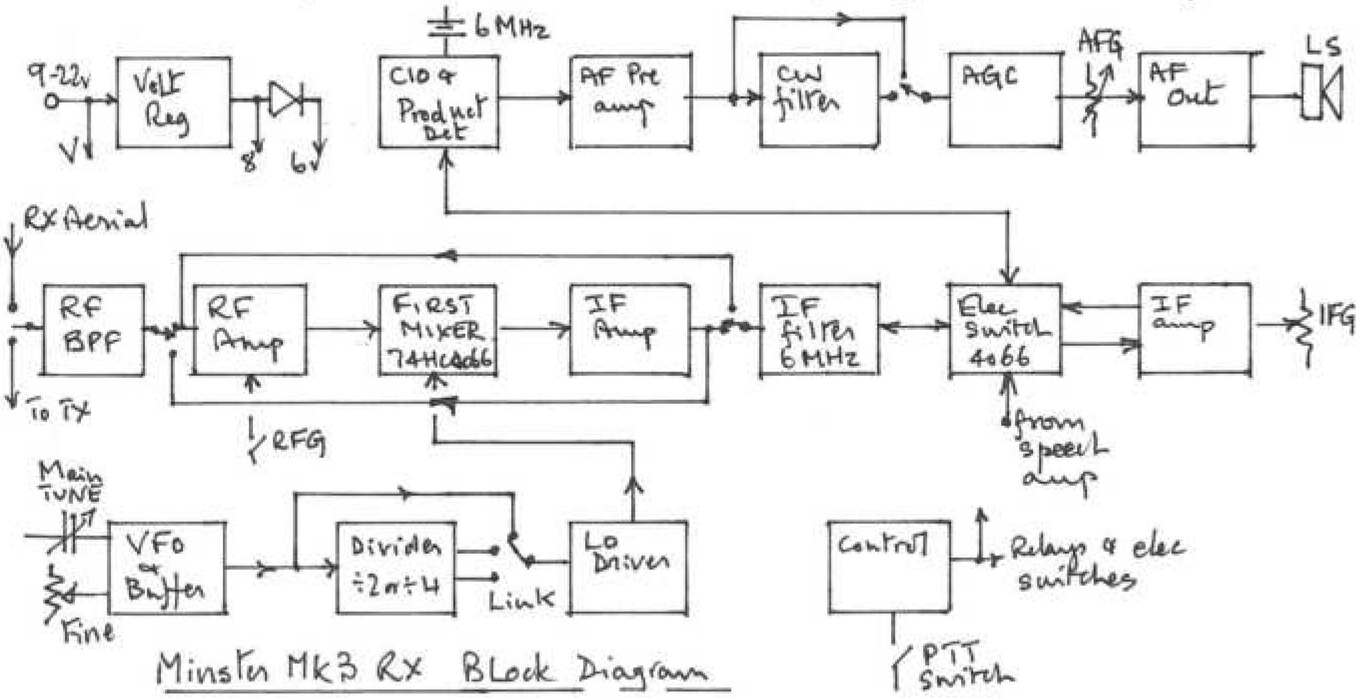


Minster Mk 3

Now that you and I can see (on front page) that there is progress, I think I might risk describing the main elements of the RX! In most transceiver projects, it is the RX that is most challenging and the Minster Mk 3 is no exception. The plan is to make this sufficiently different from my other phone superhets that it becomes top of the **Somerset** range; accordingly it has CW and audio derived AGC included in the RX. The basic TCVR is for any single band 20 - 80m but with the optional RF Extras unit adding another single band in that group, and a slot into which a card can be installed for any single band. There will be three band kits with a crystal for the desired band; band groups are 10 - 17m, 20 - 40m, and 80/160m. The IF is 6 MHz using my standard 5 crystal ladder filter. Another very important feature is to have a strong first mixer to avoid BCI, with enough sensitivity (and low noise) to make reception on 10m viable - these features rule out using 602 or 1496 style mixers - instead it has four 74HC4066 switches in a quad doubly balanced low impedance configuration. This is similar to doubly balanced diode mixers like SBL1 except that switches are used instead of diodes - these can be driven by much lower power logic signals.

An SSB transmitter has to use basically the same functional blocks as a RX but with the signal flowing in the opposite direction. This is easily done with 4066 switches directly connected to the inputs and outputs of 602 mixers (as in the Lydford) but not with 50R circuits of the balancing transformers in this RX! It seemed sensible to add a 50R 10 dB RF amp (with switchable gain) and another 50R 10 dB post mixer amp in the RX path - both are also useful in the transmit path. Electronic switches are not ideal for this task so a relay is used to reverse the flow through the RF amp, mixer, and post mixer amp. They change to IF amp, mixer and RF amp! Another little difference is the need to change impedance up/down from the 50R of the mixer/amp circuits to the 1K5 approximately of the IF filter - this is done with a 6 MHz LC network. To boost RX sensitivity a bit more, I have also given it a post IF filter tuned JFET amp whose gain can be controlled by a front panel DC control! The RX block diagram is shown below. In the basic form, the VFO frequency changes with band but inclusion of a dual digital divider makes life easier on 40m for the 1 MHz LO! For multiple bands with the RF Extras, the VFO is near 4 MHz with crystal mixing & LO BPFs.

In transmit, the RX literally ejects the low level SSB out of the RX antenna terminal! The TX stages are all broadband with a DC controlled variable gain stage to cater for slight variations in gain between bands. The RF final is an RD06 FET because this is a bit easier to drive to 5W on 10m than would be an IRF510. The RD06 is followed by band dependent low pass filters with all the usual TR switching and also a resistive antenna matching bridge as standard. G3PCJ



Minster Mk3 RX Block Diagram
G3PCJ

On line discussion forum?

I am very new to ham radio and especially electronics and kit building but I am not new to discussion forums! They are a great way of getting help when you need it, sharing ideas and building a sense of community. My first kit was the Yeo which is a basic kit but if you have never built anything before it can still be a bit of a challenge. I got stuck a few times and had to try to find help from all over the place. None of the people I talked to - although they were very knowledgeable - were familiar with Tim's kits so they were of limited help. It would have been great to talk to people who had built that kit before and could offer relevant advice.

If there was a forum connected to 'Hot Iron' I could have uploaded my questions maybe with a photo or two and got an answer so I could get on with the build more quickly. It is also nice to show off your completed work and chat about what you have learned from the experience. I know I could have emailed Tim and asked his advice but when you are very new to a subject you don't want to keep bothering people with countless questions at odd hours of the day and night.

Years ago the airwaves would have been filled with discussions on rig building and home-brew projects and people would have passed on their knowledge to the greater community that way. Unfortunately the average ham operator these days is just that, an operator and discussions of home made equipment is not so common on the air.

If there was a place where we could all discuss the projects we are building, suggest modifications, test ideas and generally chat about home-brew ham radio the way it used to be, newcomers like myself would progress quicker and in turn be able to help others to benefit from this fascinating pastime.

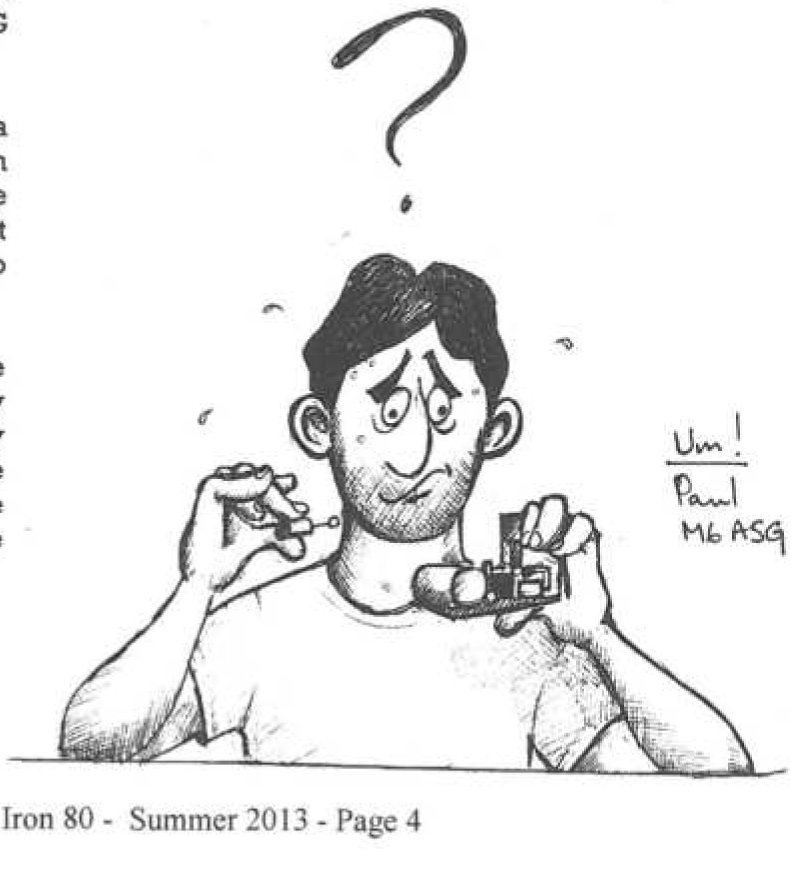
If anyone thinks that having a 'Hot Iron' discussion forum is a good idea then please let me know using the email address below. Simply setting up a forum though is not enough. The only way the project will work is if you the members log on regularly and contribute to the discussion.

Knowledge is one of the few things in life you can give away but still retain.

Thank you and I hope to hear from some of readers shortly, Paul M6ASG studio@skarekrow.co.uk

Comment from Tim G3PCJ - this is a great idea and I hope that enough Construction Club members will take advantage of Paul's offer to make it worthwhile. I will of course continue to be available as and when needed!

I am quite sure the gentleman on the right is not Paul since it is definitely not a Yeo that he is having difficulty with!! Wait till he comes to the surface mount varactor diodes that are the only sort that I can obtain at sensible prices now!

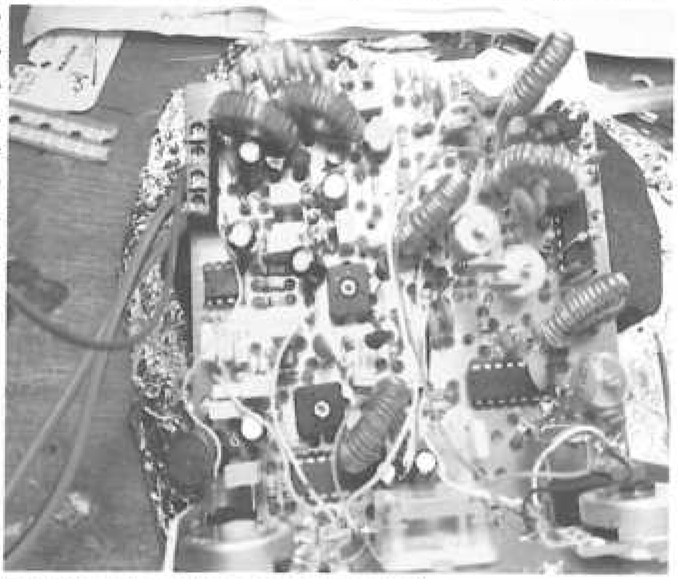


Building the Berrow

During 2012 I decided to get to grips with homebrew for CW, something I have never really been happy with. I am not very experienced with building but prepared to give it a try. Prior to tackling the Berrow I had done a few things decades ago - a Lake ATU, a Lake RX, an Oxo and so on, small stuff and not very difficult. I chose the Berrow (single band CW true VFO DC TCVR) simply because it was the newest shiniest kit from Tim Walford's stable! Tim suggested I'd be okay but to bear in mind that as an early-builder I was rather a guinea pig for the instructions. This fact has given me far more "learning experiences" than any one kit has the right to give. I enjoyed it and the instructions were, on the whole, very good. Would I build another Walford kit? Yes!

Opening the packet was an eye opener for me...cor! What a lot of bits! I went though everything first to make sure I had the lot! Remember I am very inexperienced so had some small difficulty identifying what was what, and the parts count helped where I struggled. Despite my inexperience all the bits went together. I had great difficulty identifying some parts and as a result, and since building this radio, have now also built a C and L meter (Clara) and am looking into building an antenna analyser (the VK5JST) one so that I have a GDO as well. I don't have a scope!

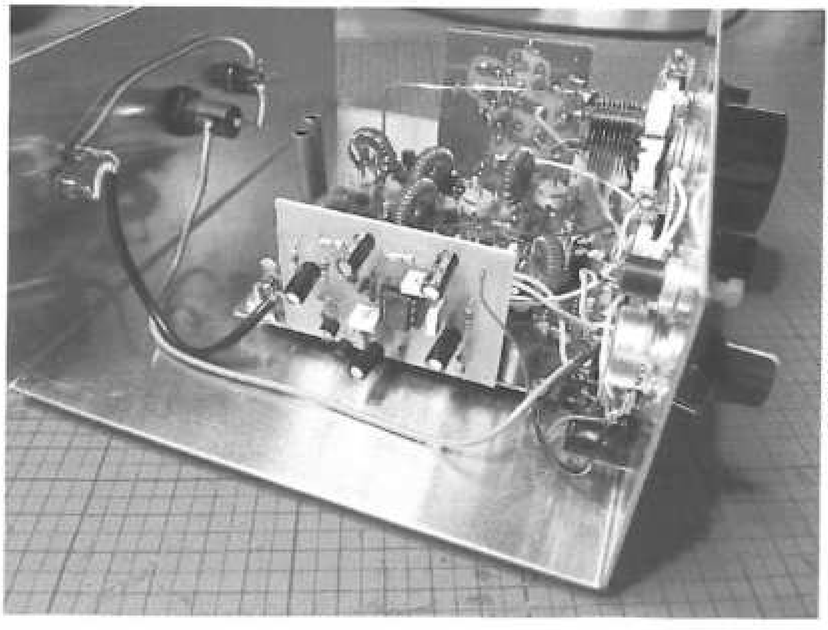
The test stages all worked fine, although I had made one or two errors of my own and a couple that were the result of typo errors. My friend Jim, G4NWJ, had almost as much fun helping fault find as I did building it in the first place. Eventually we got the voltages and frequencies all spot on! The great day came at last, the radio was back from Jim's shack and hooked up into my aerials and...nothing. No output. Grrrr Back to Jim's. Somehow a logic chip had died, changed it, and we then had 1.5 Watts of RF! Back home again and my first call was answered by Guy, F8GFA in Anger and I was delighted! Twice now I have worked with homebrew gear - initially an Oxo 30 years ago and now the Berrow. The sense of delight never diminishes . I learnt a huge amount from this project, it was immensely enjoyable and I was sad when it all came to an end! The photo right is part way through the build.



A quick look through Tim's catalogue provides much to whet the appetite; I do like chocolate, especially Cadbury's...

73 David Perry
G4YVM

(David, my apologies for having to shorten your original note quite severely. Tim)



Here is another Berrow built by Philip Thompson G4JVF, this time with the AGC kit nearest camera and what I think might be a keyer beyond the air variable. This is the one that has been tried on all four of its normal 20 - 80m bands! It also has the two chimney heat sinks! I am awaiting Philip's reports of experiments with higher bands when he has nothing else to do! G3PCJ

Home build electronics lament.... By Peter Thornton

It had to happen; ever since I stopped using "ZTX" (Ferranti) transistors in "E-Line" packages (the Collector was *always* at the "Z"), I had a circuit that showed all the signs of having a transistor installed the wrong way round. Lousy gain, drawing mA's with no base drive, yes, this surely is "wrong way-itis". That's what no text book tells you: a silicon transistor WILL work (just) if installed the wrong way round!

So: check the pin-out. 2N3904, here we go: looking at the "flat", E-B-C. But that's how I'd installed it - I HAD got it the right way round. Back to the data sheets: here's a Philips 2N3904. Looking at the "flat" - C-B-E! Wait a minute...! Take a look at the various data sheets for 2N3904's. Different manufacturers use different pin outs! I decided to check my little store of 2N3904's. I found a mixture of C-B-E and E-B-C; and some C-E-B!

After that episode, I test every device for polarity and orientation. My "el-cheapo" LCR meter has test sockets for testing Hfe in bipolar transistors; I use this to find the collector. The highest Hfe reading is the right way round. If you don't have a gizmo with Hfe test sockets, you CAN use a multimeter to find the collector, despite almost everybody telling you it's not possible.

Promise not to tell anybody else, and I'll tell you how to do it... Take a 47K resistor, and solder it to a 12" bit of thin pvc covered flexible wire. Twist the end of the wire round the +ve prod of your multimeter for NPN (-ve prod for PNP), and set your meter to "diode test". By the usual method of diode testing a transistor, find the base and if the device is NPN or PNP. Put your prods (any way round) on the two leads now known to be C and E, then dab the 47K resistor on the previously identified base lead and note the meter reading. Reverse your meter prods, repeat the 47K dabbing. Note the meter reading.

The connection that gives the lowest reading (i.e. the highest Hfe) identifies the collector: it's the lead on the +ve prod for NPN; -ve for PNP. Higher Hfe = higher collector current = lowest reading.

The only snag - and it's Catch 22 - you need three hands...

Snippet! Paul Coddington has been kindly trying out my 10W Linear with the alternative RD06 FETs instead of the normal IRF510s which do struggle above 20m. The PCB is laid out for either. Paul says it is working OK on 20m but there is a suspicion that his low pass filters are not right for the higher bands and is investigating! More later I hope. G3PCJ

Competition!

The three old gents.

Robin G3TKF of the South Bristol Club has kindly lent me this photo for a caption competition after he used it - it produced a comment about my grandfather here at the farm many years ago!

I offer a small prize for the best new caption in my judgement! E mail entries by Jul 20th please! G3PCJ

The FiveFET

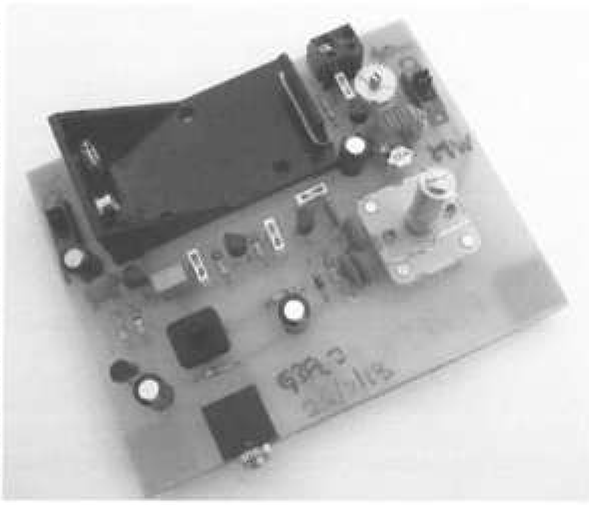
Members will know that I have long admired the performance that can be obtained from the very simple Regenerative style of receiver. Hence my almost continuous doodling with semiconductor versions of these classic valve projects that were so widely used between the First and Second World Wars.

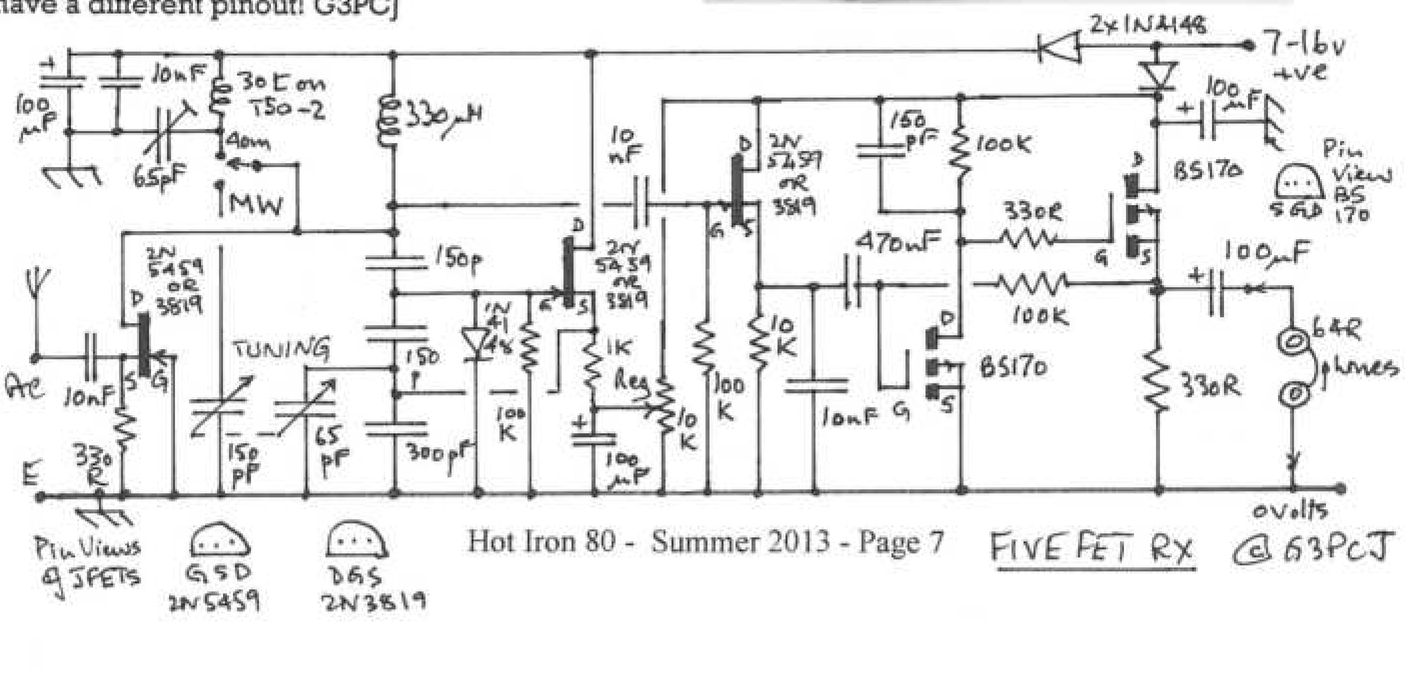
Their origins lie in the straight Tuned Radio Frequency receiver which often had a RF tuned detector followed by audio amplifiers. In the search for better sensitivity, just adding more audio amp stages had a finite limit so somebody tried an RF amp as well. This was often given an extra set of tuned circuits to improve selectivity so that it then looked rather like a tuned grid - tuned anode oscillator; this is exactly what it proved to be! Eventually a way was found to just prevent the RF stage oscillating, and lo and behold, both gain and selectivity then shot up!

The worst challenge nowadays is to overcome the lack of high impedance phones because most builders only have modern lightweight 32R phones or a small loud speaker. Luckily stereo series connected 32R phones can be driven at low levels by MOSFETs like the BS170 in a source follower configuration. Adding another BS170 in common source form can give it high audio gain with the added advantage of a very high input impedance. They can be readily arranged as a DC feedback pair to set the bias currents.

These audio stages need to be proceeded by a detector and here the Infinite Impedance version using a JFET like the 2N3819 is suitable; it can be connected directly in parallel with the main tuned circuit with suitable audio filtering in its source lead. While this stage can also be made regenerative (so potentially saving one device), I have not found control of the point of oscillation to be so good as when separate stages are used. Hence my preference for another JFET to act as the regen stage, or Q multiplier to give it one of its other names.

The final addition is an RF amp because it is no longer considered acceptable to connect your aerial direct to the regen/detector stage when it is oscillating as required for CW and SSB reception. Adding a grounded gate RF amp JFET provides a degree of isolation between aerial and regen stage; it can also do the large impedance step up between a low Z aerial and the high impedance of the tuned circuits in the regen/detector. This also makes providing 3 bands easier when using simple single winding inductors! So a simple five FET circuit is easy, with MW (for ease of getting it to work on short aerials) and one other amateur band, normally 40m, for a good introduction to the airwaves. I shall very shortly be releasing this kit at £24 but am happy for Construction Club members to have it at £22 + £3 for P and P. Early version on right! Note that 2N3819s are getting scarce so this kit actually uses the alternative 2N5459, but beware it does have a different pinout! G3PCJ

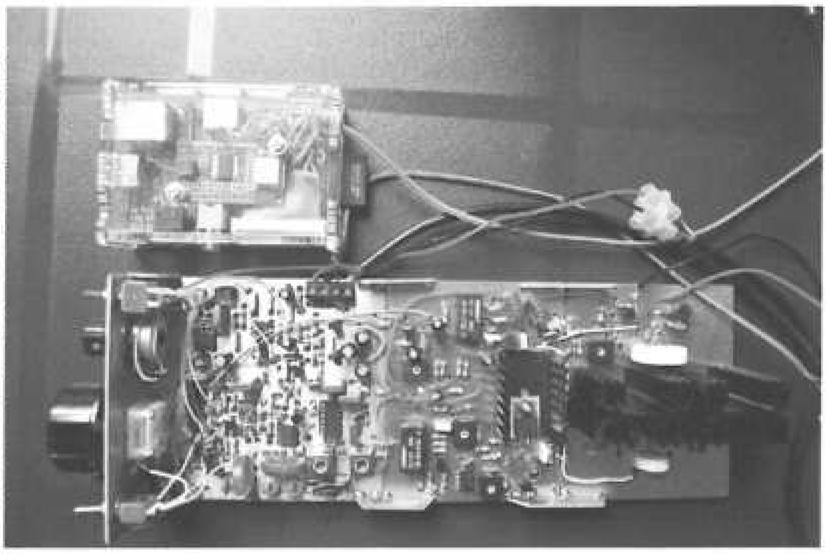




Test Box Competition!

I am sorry to report that nobody responded to my request for suggested facilities and circuits! So the prize remains for another day - or the Three Old Gents competition on an earlier page!

Interesting combination!



Another challenging little project on right built by Simon Dowson. The obviously homebuilt section is a Bridgwater and Burnham 1.5W SSB TCVR but with the 10W Linear added on the rear. Then above it is a Rasberry Pi micro computer controlling a Direct Digital Synthesis chip as an alternative to the Bridgwater's VFO. While I am not too keen generally on computers mixed up with analogue radio gear, this combination does make sense because the Pi is not out of proportion to the rest of the rig. If it had a Cray computer alongside, I would not be showing it here!

Amateur Radio in the Country 2013 July 21st.

I hope all of you living in the West Country have made plans to attend here at Upton Bridge Farm, Long Sutton, Somerset TA10 9NJ! Plans are well advanced now with a good number of stall/ display takers - but there is room for plenty more still. So if you have something interesting to show off or sell then please bring it along! (Let me know beforehand so I can arrange the necessary facilities.) The night before party is nearby (walking distance), in a friends grain store barn. The theme is a Caribbean Night Out complete with a live band, hog roast etc... Those staying nearby overnight have to come as it will certainly be good fun! We should be able to accommodate a few campers in the field close to the barns where ARiC 2013 will be held. Please encourage your local Clubs to put on displays etc.. - plenty of space! Let me know your plans please.

Time to remind you that the informal **Construction Challenge** this year is to produce a decent sidetone oscillator. It will be 'judged' by Graham Firth G3MFJ of the GQRP Club. The task is to build and demonstrate a sidetone oscillator for a CW TCVR. It might also act as a keyed audio generator for morse practising. It has to feed modern series connected 32R phones presenting a load of 64R. The output should be free of thumps when the key is operated! Nominal frequency to be about 800 Hz and to run off a 12 volt supply. It is to be keyed either by ordinary contact closure, OR by sensing the RF from a 1.5W transmitter. This latter aspect is to make it both more representative and a bit more interesting as a technical challenge! Construction style is not important as long as it works! Graham's decision will be final! Tim G3PCJ

Subscriptions!

I regret it is that time of year again! The next issue of Hot Iron is the first of the membership year and I need to receive your payment of £8 for UK members by Sept 1 2013. Overseas membership costs £12. If you wish to pay via Paypal this is fine, but please add an extra £1 for their fee. All I need is your fee and name/address. To keep it interesting your contributions are essential! Any articles about your experiences, questions, hints and tips etc. are especially welcome. Hope to see you July 21st! Tim G3PCJ (My apologies for being slightly late in publication, farm and elderly relatives held it up!)

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Autumn 2013
Issue 81

Contents

The Walford Electronics website is also at www.walfordelectronics.co.uk

Editorial

Start of another Construction Club year! Time flies by and it seems to be speeding up as I increasingly fail to do many things in the allotted time! (Including getting this out on time!) The list does not seem to get any shorter and helpful people keep on suggesting things or projects that might be worth developing. The most recent was the observation that few black box rigs include 4m - most seeming to stop at HF plus 6m. This was a good point and would strengthen demand potentially. I had thought some months back that a single TCVR kit that could do 6 or 4m would be interesting and tried to find a frequency scheme that used a single crystal mixed with the a low frequency VFO to get to 50 or 70 MHz. For simplicity I had considered a direct conversion scheme. But I failed to find anything that looked really good - a crystal derived 60 MHz (20 MHz xtal tripled) signal +/- 10 MHz VFO looks relatively easy for a DC scheme LO until you realise that 10 MHz is a bit high for good stability and has band edge birdies! Other options are lower frequency crystals but with higher harmonics! Apart from the LO chain complexity, which is inevitable even with a low VHF rig, a linear and easy TX for a few watts needs the expensive RD06 VHF version. Back to the doodling book!

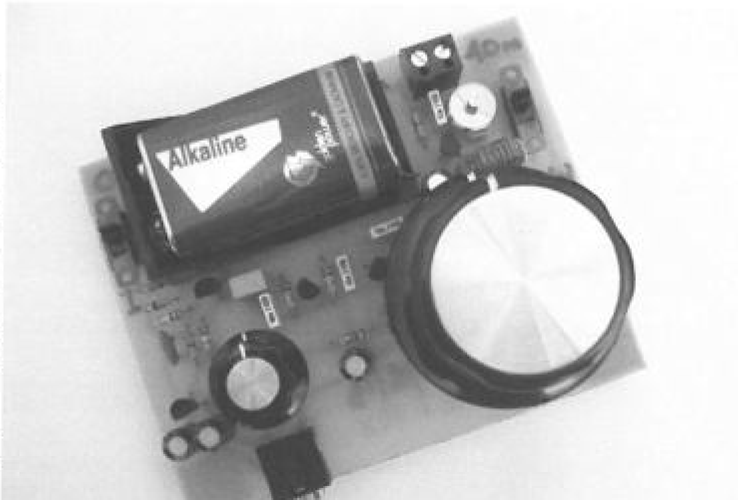
Tim G3PCJ or walfor@globalnet.co.uk

Kit Developments

I have had a very nice report from Luis EA5HWP about his experience with the Berrow (see later). Getting ready for ARiC2013 took much time so about the only new product is the **FiveFET** (picture on right) which I mentioned last time. Steve Hartley very kindly built one and made some helpful suggestions which needed a slightly modified PCB. This is now available and details are on the website.

Next job is to finish building the Minster TX and then write and add the RF Extras.

Tim G3PCJ



Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £8 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 or walfor@globalnet.co.uk

"F_t" for Birdwatchers by Peter Thornton

If you design an RF circuit, the books say the transistors you choose should have an "F_t" value 5 to 10 times the frequency of service. What is this "F_t" figure? How is it measured, and what does it mean?

"F_t" means "Transition Frequency"; the frequency at which the gain has rolled off to unity. The transistor's gain is assumed to "roll off" linearly as the frequency rises due to the "Miller Effect", the multiplication of the collector - base capacitance by the hfe (ßeta, the current gain) of the transistor. The gain multiplies the capacitance, so a few pF collector - base can become much bigger in (electrical) effect. Take for instance, a BC109. Listed F_t is around 900MHz, so why won't a BC109 work on 2 metres?

It's how F_t is measured. The transistor is set up in a class A amplifier circuit, and driven by a signal generator at a test frequency, say 1, 10 or 100MHz, depending on the desired frequency of service. The input signal is kept low to avoid output distortion (which corrupts the measurement), and the output is measured - giving the gain of the device at the stated frequency and circuit parameters.

Here's some figures. Consider the BC109, a very high gain audio transistor, with an F_t of 900MHz. BC109's are usually tested at 10MHz, and let's say the gain comes out at a respectable 90 - not surprising with a BC109, an extremely high gain audio transistor.

"F_t" = (gain) x (test frequency) = 10MHz x 90 = 900. Since "gain" is a parameter-less number, then the resultant "F_t" value is given in "MHz".

As a guide to application, "F_t" helps, but it won't assure operation anywhere near the quoted Ft. That's because "F_t" doesn't measure the frequency the gain has fallen to unity; it estimates it from a much lower frequency measurement. And that's where the "5 - 10 times F_t" advice comes from.

Mosfet manufacturers rarely if ever quote an "Ft" value - this is because mosfets have such high drain - gate - source capacitances and large (~ infinite) current gain, the "F_t" is meaningless. Better with mosfets is to look at the capacitance (more accurately, stored charge), gate to source, and drain. A bipolar transistor for RF service will have very low input and output capacitances, a few pF. Unless the mosfet has been designed for RF service (and they are extremely hard to manufacture, hence the price) then the massive capacitances of general purpose mosfets have to be taken into account. Just to add insult to injury, mosfet capacitances (remember this is really stored charge) are drive level dependent: they are varactors. Keep that in mind when designing "linear" mosfet amplifiers that refuse to behave!

G6NGR Rule of Thumb: choose a transistor with an "F_t" 5 to 10 times, *and input / output capacitances appropriate to*, the frequency of service. Job done!

Here is Peter G6NGR at ARiC 2013 measuring the Ft of some very basic device (a glowing bulb!). G3PCJ

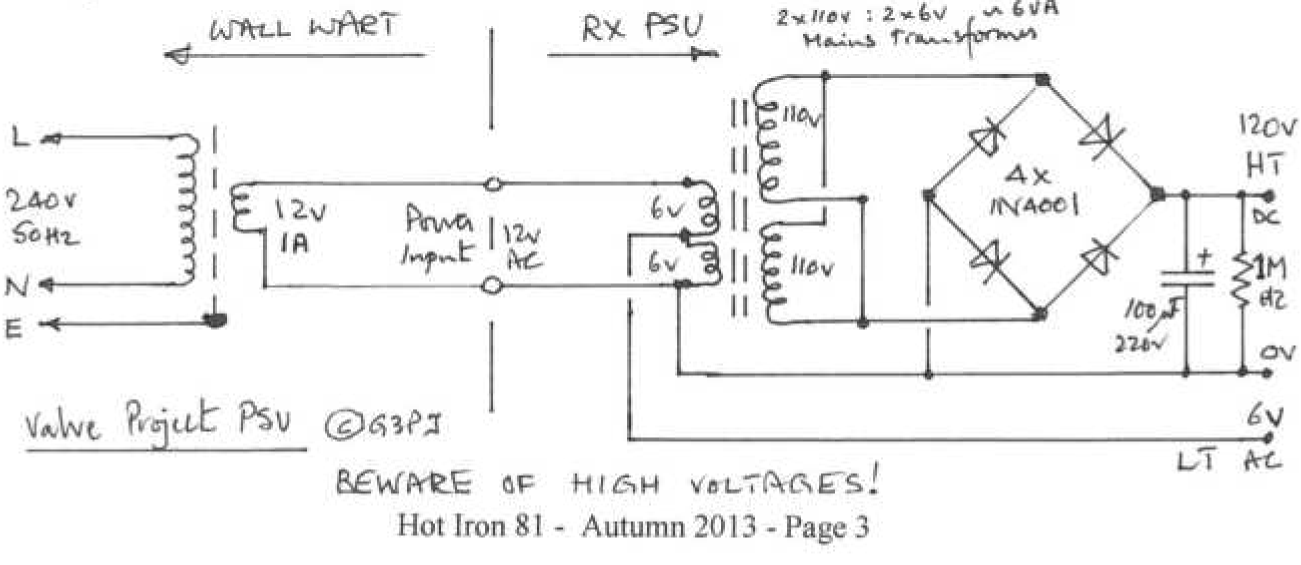
Valve project supplies

Peter Thornton and I have been investigating convenient ways of generating the voltages needed in projects using valves! Don't ask why just yet! There are two main problems to overcome, the first and generally more serious is how to be legal and safe! The other is to be able to use common and readily available (so cheapish) parts.

The first approach is to try and run valves off low HT voltages! Many people have experimented with normal tubes run with supplies way below normal but it gets very challenging when wanting to operate way down with the common 12v supply. Sometimes it works with normal high supply valves but it is not dependable. In the 1940s several valve manufacturers developed tubes specially for low voltage use in cars - using 'space charge' technology. This also turned out to be a bit unreliable due to the wide tolerances on performance. It was also wasteful of power as the heaters were generally run at higher temperatures, and the control grid was often at incoming HT supply voltage so that it too dissipated power wastefully! Not a viable line of approach for most valve experimenters, and the special tubes are also now getting rare!

So having given up on a DC supply, how to generate the high voltages needed from AC safely! I must emphasize the need to be extremely careful with any voltage over about 25 volts. The next plan is to use a mains incoming transformer (with great care!) and hope it can meet the various wiring regulations! Are there suitable ones? Plenty with 110 volt centre tapped secondaries, for use with portable tools on building sites etc but the smallest often has a VA rating of many tens VA - hence too big for our needs and unduly expensive! So consider a transformer with the next lower secondary voltage in smaller frame sizes! This turns out to be 24v commonly, so a plain bridge rectifier on its output will only produce about 25v DC on load. Not enough, so consider a voltage multiplier form of rectifier. They work perfectly well - a quadrupler will get to about 125v nicely but they have two snags - output ripple is very spiky and they need at least four large capacity high voltage electroytics. These are about £1.50 each so not a cheap solution! And then there is the need for another transformer for the heater supply!

Next consider a low voltage AC main input at either 6 or 12 volts to suit the valve heaters and use a standard mains transformer backwards to get the high voltage. Plenty of suitably VA rated small 6 or 12v transformers with twin 110v primaries. Feed them with 6 or 12 volts AC, provide a simple bridge rectifier and single smoothing capacitor and you get about 120 or 240 DC depending on whether the normal 110v primaries (but actually working as secondaries) are in series or in parallel. The ripple is also now lower and has a less aggressive shape! By luck there also appears to be a UK source of 'wall warts' which have a 12v AC output! These units conveniently solve the wiring regulation problem! With a centre tapped 12v winding on the transformer working backwards, you can also power 6 or 12 volt heaters! Job done - circuits below! (If you need to operate portable from 12v DC, then buy a cheap static inverter that produces the 240V AC!) G3PCJ



Updating the AMU kit

My existing AMU kit, actually the Mk 4 design, has been around for nearly 10 years! It works perfectly well but as with many projects, one particular part is no longer available at sensible prices! The troublesome part is the inductor which is actually a flexible printed circuit strap with 40 conductors laid side by side and bent into a hoop, with the coil turns completed by linking tracks on the underside of the PCB. The last batch were expensive at over £7 each plus VAT!

So what next for the Mk 5 design? The device has to handle QRP power levels using Poly-Varicons with an RF floating output that can drive balanced or unbalanced loads. Load impedances of about 12R to 2K over 10 to 160m! Its worth having a brief re-examination of the common AMU schematics on the right.

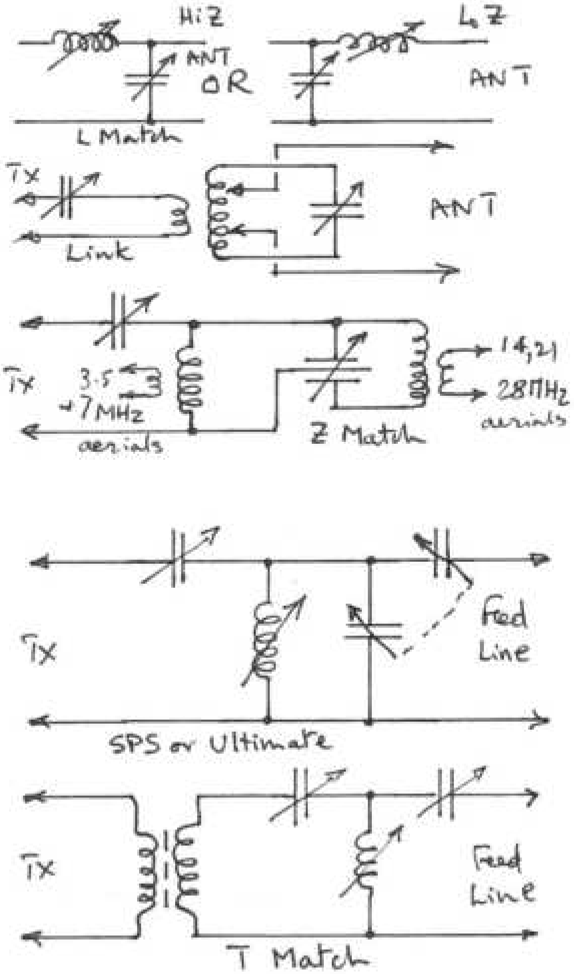
L match Needs an input balun for floating output. Only 2 LC relatively simple components but not as versatile as 3 LC part AMU because Q uniquely defined by impedances.

Link coupled No need for balun. Needs relatively complex main coil format with several taps and switching for load impedance variations. Needs subsidiary coils for the higher bands and variable capacitor always has high voltage RF!

Z Match Interesting design but not possible with PolyVs and has two sets of outputs! Balun not needed. Complex coils.

SPS Match Various versions but most use split stator caps so not possible with PolyVs. Needs a balun.

T Match Needs a balun. Very versatile because all three parts (two C and one L) can be adjusted to achieve suitable Q. Simple coil format but does require several taps. This is the format used in the existing kit so I know its OK!



The above suggests stick with the T match and find a new coil design. To cover 160m the coil needs to have a maximum value of about 50 uH with 11 taps connected to a 1 pole 12 way switch. I started by considering small diameter plastic conduit for the formers but this needs too many turns for convenience when making several taps! I have failed to think of a former that most households would already have (apart from insufficiently rigid loo rolls!) so have to now consider 40mm PVC waste pipe. PVC is not ideal because it is lossy at VHF, but with low power at HF it is adequate. G3MCK gave us the formulas etc in Hot Iron 78 so lets see how many turns are needed with a coil diameter of 1.57 inches (40 mm) and say 1.5 inches long:-

$$L(\mu H) = \frac{a^2 n^2}{9a + 10b}$$

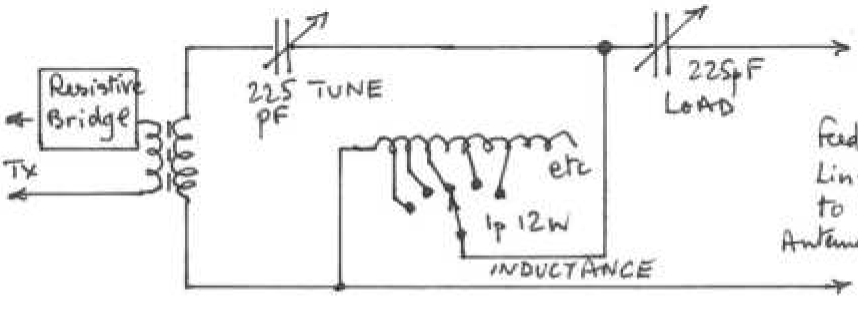
a = radius in inches
b = Length in inches
n = no of turns

$$n = \frac{\sqrt{L(9a+10b)}}{a}$$

$n = 33$ turns

L = 50uH
a = 0.75 inch
l = 1.5 inch

The answer is 33 turns which is just about possible to wind and make 11 taps as you go by twisting a loop in the wire and then continuing with the winding. The taps are needed at something like 1,1,1,2,2,2,3,3,3,4,5,6 turns between them. The kit needs to retain a resistive matching bridge and a balun, or 1:1 RF transformer at the input of the matching section so that it does not have to handle the wide range of feed line loads that are seen at the AMU output. G3PCJ



AMU Designs © G3PCJ

Building and operating the Berrow

This note was originally intended to reflect Luis EA5HWP's experience with this rig - he has worked 44 countries in 5 continents in 40 days of use - one of the first to KZ1H near Boston (left) but also to China at 9783 km - darn good with 1.5W, DC RX & 20m half wave dipole! But he and another builder have had some problems so it might be instructive to see how they were overcome! The main problem was that with RF & AF gain controls fully advanced there was a tendency for the audio to squeal - not quite a sustained oscillation! Luis had soon found that the best way to operate the RX was, in his words, like they used to, 'years ago'! AF gain high and only sufficient RF gain to hear background static with his aerial (or BCI)! The other builder had observed that the instability had only become apparent when the RX RF amp stage was added.

The classic cause of audio instability is the earth return lead for the LS (or phones) being shared with the earth connection of the AFG pot. Not so here! It was soon evident that peaks in the supply current, on audio peaks, were causing the main supply rail to droop a little and hence affecting some earlier stage. Thin incoming supply wires can cause this affect. Usually extra very large decouplers dabbed onto supply lines, can help indicate what is wrong but it did not in this case! I tried adding large amounts of extra decoupling in all stages using the main supply (and also the regulated 5 volt line), but this had no effect whatever! I eventually realised that variations in incoming main supply could (in principle) pass directly to the RF amp because it is directly connected to the TX side of the low pass harmonic filter so as to give full break-in operation. This is not easily changed but I will be altering the coupling capacitors here to be as small as sensibly possible to reduce the feed through of audio frequency signals. But the problem persisted!

After a while I realised that it was the audio filter (a humped band pass design) that was almost oscillating and causing the tendency to ring/squeal. This was intended to have a Q of 5 which is about the maximum recommended for CW work. It is easy to reduce the stage gain (and hence Q) of this filter, by changing a feedback resistor. There will be a slight loss of selectivity but the loss of gain can be compensated by upping the gain of the following output stage.

While experimenting with it on the bench, I did find that parts of the circuit were tender to be being touched - particularly in the LO driver section, where this design has digital stages with consequent very short rise and fall times. I decided this does not need attention because it was not evident till you fingered it! A few tens of pF on the LO gate output, would slow these edges down.

I thought Luis had also noticed a tendency for the VFO to jump a small amount when the key was closed. This could be due to poor supply regulation, ie similar to thin supply wires. A 12 volt regulator near the rig would help. The line and load regulation of the rig's 78L05 regulator is not all that good, so incoming supply variations could possibly get through to the 5 volt line which feeds Fine tuning varactor diode. Changing to a 317 series regulator (which has better regulation) would cure this - see circuit below. Re-reading his mails though, I think he meant the VFO shifts as something warms up when the key is down. Better ventilation or heat sink tubes on the output devices (or a small fan) might cure this, and or fitting of some sort of heat shield (polystyrene) between the RF output stage and the VFO area might help. Luis's rig left! G3PCJ

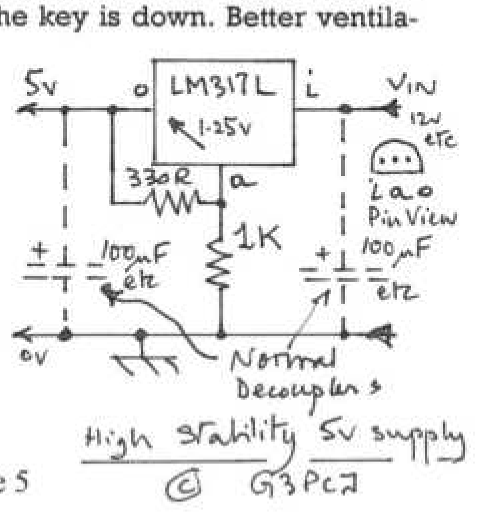


Photo Caption Competition!

I received two suggested captions for the Three Old Gents photo on right.

First prize, a small regen TRF informal kit called the Littleton, goes to Rob Mannion G3XFD who suggested "I do wish that Tim Walford's Amateur Radio In The Country event could become a casual dress day out!"

The other entry was from David Proctor who suggested "Ebenezer, you did charge the accumulators didn't you?"

Snippets!

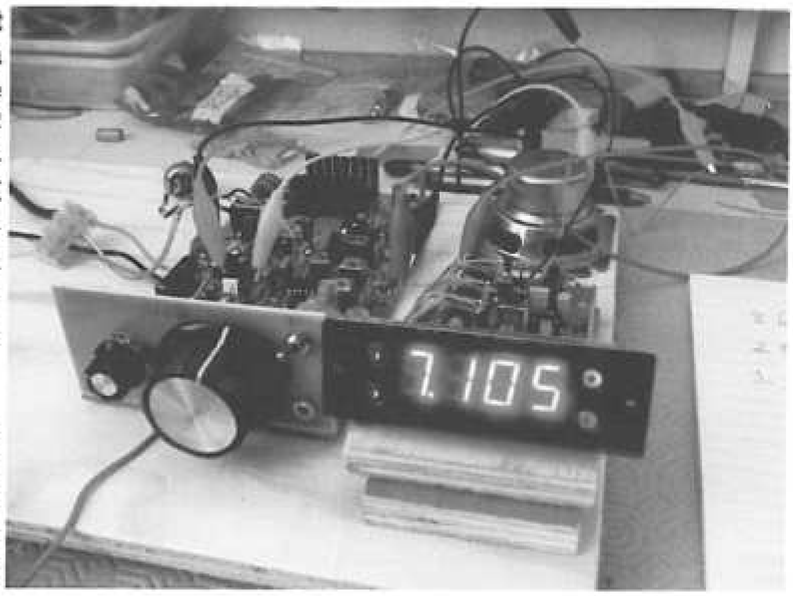
Novel dielectric! A team from the National Physical Laboratory has come up with a new lead free dielectric aimed at high temperature automotive applications. It is good to 200 °C and does not suffer the capacitance reducing phase change at around 125 °C experienced by the modified barium titanates ($BaTiO_3$) used to produce X7R and Y5V class capacitors. Dielectrics fall into two groups - linear materials like Al_2O_3 which are not ferroelectric, so have low dielectric constant and are used for high performance low dissipation (0.1%) COG style capacitors (these have a nominally zero coefficient of change of capacitance with temperature, very similar to NPO specimens!), and those that are ferroelectric like $BaTiO_3$ which do dissipate much more heat and hence suffer much larger changes in capacitance. The new material is bismuth ferrite-strontium titanate $(BiFeO_3)0.6(SrTiO_3)0.4$ and is aimed at making X9R class capacitors. It has dissipation of 0.3% so is almost as good as COG types but can be used for 5 nF to 100 nF and up to 1kV with a capacitance change of only about 17% when at 200 °C. The normal $BaTiO_3$ X7R material is much worse!

MEMS Oscillator matches quartz! Silicon Labs have introduced new MEMS (micro electromechanical system) resonator technology which achieves +/- 20 ppm over 10 years from –40 to +85°C. Within the 4 pin chip is a voltage regulator, variable frequency oscillator in a phase locked loop, temperature sensor and the new resonator in its own oscillator circuit that provides the reference for the PPL. The new resonator is built from a combination of poly-SiGe and SiO_2 over processed CMOS. The resonator is suspended by springs from its corners and sits on a central post with transducers around the edges all inside a vacuum! The special material has passive temp compensation which is an order of magnitude better than quartz which enables the electronic compensation to be much simpler. The initial Si504 can generate any frequency in range 32 KHz to 100 MHz, adjusted by a one-pin serial input with a consumption of just 1.7 mA with a foot print of 3.2 x 5 mm.

Mounting surface mount Varactors One of our Construction Club members is investigating the possibility of having commercially manufactured small PCBs made up with surface mount varactor diodes already fitted - so called 'break-out boards'. The intention behind this is to make it rather easier to use these parts by those whose eye-sight, or general facilities, are unsuited to handling very small surface mount parts. A couple of my recent kits do include 3 tab surface mount varactors because I cant get anything else at sensible prices and in quantity! I reckon that these 3 tabbed (or terminal) devices are not as bad as many fear provided you take reasonable precautions in handling them so they don't disappear down cracks in the floorboards! They can be soldered with a narrow tipped 18W iron satisfactorily. A device with more pins or smaller size would be challenging! If any body is interested in the alternative of a small break out board, please get in touch via me - Tim G3PCJ.

Building the Bridgwater and Burnham by Mick M0GWD

After originally getting hooked on kit construction by making Tim's Tone Receiver kit at the 2012 Bath Buildathon, I decided to take things further earlier this year and bought the Burnham / Bridgwater combination and the 10W Linear Amp kit. The plan was to make the 10W Transceiver along with some of the accessory kits, including the 3-Digit Counter and build it into a metal case with the best 'professional' layout and appearance that I could achieve.



Although progress is somewhat slow due to other commitments, I am now at the stage where I have built the Transceiver, the Linear Amp, the AGC Board and I have a working S-Meter after building the small add-on board. I have also completed and tested the 3-Digit Counter, and with my proposed layout I have decided to mount it immediately above the transceiver board, with the main tuning moved to the right.

To make installation into the case easier, in particular the front panel, I made the 3-Digit Counter into a self-contained module, which requires just two fixing screws. The module is made on a sub-chassis made of 1mm aluminium, which holds both the PCB and the counter displays. As I have built the 40m option, I have added a hard-wired digit '7' and a decimal point, following Tim's instruction sheet. The displays are attached to vertically-oriented strip-board, which is itself fixed behind some 3mm grey-smoked acrylic sheet. Using strip-board with the copper running vertically allows for easy breaks to separate the pin connections, whilst leaving the top and bottom centre-ground connections unbroken. Also with the hard-wired digits, the resistors can be fitted to the board, making for a neat installation.

The module can be screened if required, by fitting aluminium sides to the angle sections, with the top screening completed by the transceiver case, forming a box. Only three wires connect the module. The input wire, which when installed will be about 40mm in length, plus the two wires for power and ground. The display works very well, and I hope to give a further report on overall progress of the transceiver in due course. M0GWD

Amateur Radio in the Country 2013

About 300 people turned up here on July 21st for what turned out to be a very fine and hot day! An excellent attendance and thank you to all readers of this publication who came. There were many stall takers who had come in previous years, local Club exhibits as well as a few new displays. It takes an appreciable effort to put on these displays etc so a big thank you to all who 'exhibited'. I must also say a big thank you to my wife and her catering team (below) who managed to cook a prodigious amount of bacon, sausages, burgers etc.

Robert Van de Zaal also came all the way specially from Holland to oversee the beer barrel supplied by my next door neighbour! In addition, that farm also produces some excellent cider which was a total sell out! (When I came to settle up with the cider maker, he asked if we would act as wholesalers!) In view of the anticipated heat, many had opted to have their stalls in the barns, so the photo above is the rest in the field! My wife also collected for the farming charity Send a Cow which helps those in many parts of Africa, with a raffle. First prize was a years subscription kindly presented by PW Editor G3XFD Rob Mannion. This raised the splendid sum of £146.

With the help of Graham Firth G3MFJ of the GQRP Club, who kindly came all the way from Lancashire to judge, we had set the informal Construction task to be that of designing and building a 'good' sidetone oscillator that could be keyed either directly or by sniffing RF from the transmitter. There were two proper entries apart from the demonstrators produced by Graham and myself! Regrettably one of the entries failed to work on the day, the other was from keen constructor Craig G0HDJ who pressed a 555 timer into service as an oscillator controlled by the key/RF. Accordingly he won the prize which was the ARRL book Radio Frequency Design by Wes Hayward. This prize was also presented by Rob Mannion (above). Judge Graham (in the middle) reckoned his demonstrator was superior to mine, but this depended on interpretation of the entry notes!

Finally I must say a big thank you to Rob M G3XFD for all his help and encouragement in the holding of radio events here and elsewhere over many years. With his partial retirement from Editorship of Practical Wireless about to happen soon, we wish you the very best for the future and hope that we will continue to see you round and about at radio events for many years to come. G3PCJ

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Winter 2013
Issue 82

Contents

Happy Christmas!!

The Walford Electronics web-site is also at www.walfordelectronics.co.uk

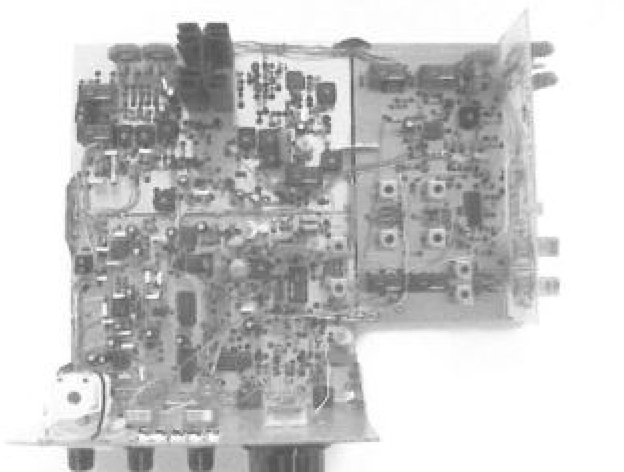
Editorial

In various ramblings about future rig possibilities with Peter Thornton, I was led to various sites and designs for clever simple rigs that managed to squeeze high performance out of a very limited number of active devices - transistors of one type or another. Ingenious ideas have led to viable receivers (mostly) with the absolute minimum of devices. Often, especially where these are 'high impedance' active devices like valves, there is a large dependence on transformers - both for RF and audio with consequently lots of iron and copper! The latter are now like hens teeth in comparison to the transistors or even valves - more or less unobtainable and certainly not viable in a modern kit! The transistors cost a few pence literally (though definitely not true of valves!) so there is absolutely no need to complicate circuits trying to minimise the number of transistors! In fact, in my recent designs, the cost of the capacitors has been higher than that of the resistors and both are quite hard to weed out of a design!

But then try and do without some of these wound components - its very challenging; especially where there is a need to push a few hundred milli-amps into a low resistance load (eg a loud speaker or modulator). Even in a transistorised rig, the once ubiquitous TOKO adjustable RF coils and trimmers are becoming relatively expensive. So the design emphasis has to change from cutting down on active devices to getting rid of the wound parts! For a valve project you now need to do both!! Tim

Kit Developments

Some good review publicity recently in PW has kept me busy making up FiveFET kits but meanwhile the Minster has also made good progress. The Basic TCVR is now working well and I have added the RF Extras option (right) that turns it into an any two fitted bands 20 - 80m plus a plug-in card for any or all bands 10 - 160m! Its quite a project & writing it all up is taking ages! Watch the website for progress.



I am also now working up some ideas for a two new projects - firstly a specialist CW RX/TX pair, and secondly a new entry level superhet RX with an intended phone TX option! See later and let me know your thoughts please! G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £8 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 or walfor@globalnet.co.uk

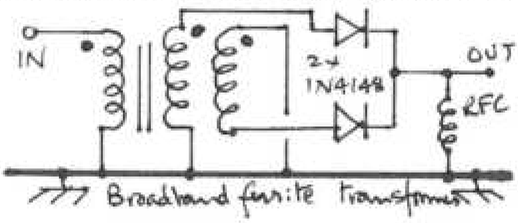
Mr. Fourier and DC Harmonics by Peter Thornton

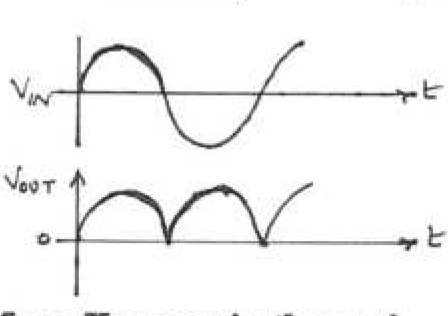
I bet you always thought "harmonics" were bits of a sine wave, didn't you? (I hope not! Ed.) All to do with distortion, frequency multiplication, low pass filters on transmitter outputs, etc?

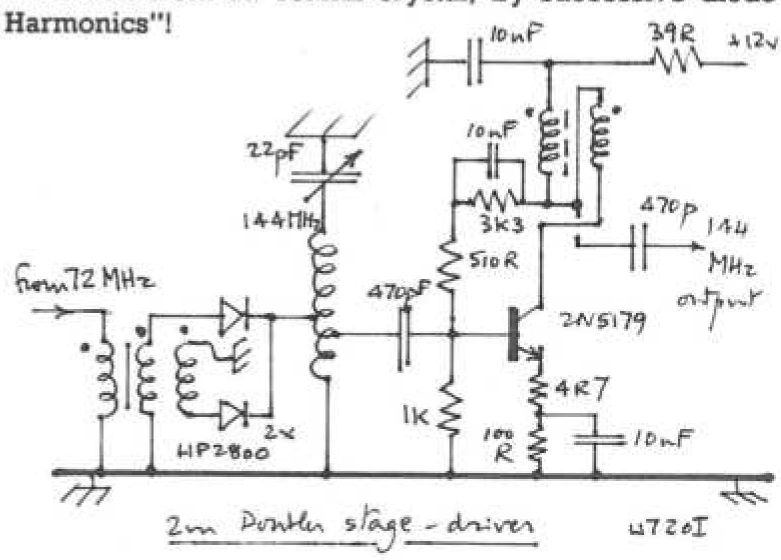
Well, here's the outcome of a recent discussion regarding harmonics, mixers and transmitters. I was asked "does a 'triangle' wave contain odd or even harmonics and how does the amplitude of the harmonics decrease, as the harmonics go higher and higher?" Mr. Fourier, an 18^{th} Century mathematician, discovered how the various harmonics add to create ANY waveshape. That's at least 100 years before anybody knew about electricity, sine waves, or radio! Mr. Fourier was one exceedingly bright cookie; as well as maths, he first described the Earth's "greenhouse" effect!

Much WIKI searching, memory dredging and text book blethering produced this rather amazing answer; thanks to Mr. Fourier, a triangle wave, square wave, (or any other *symmetrical about zero* waveform) is composed of only ODD harmonics added together; it's different amplitudes of the ascending harmonics that create the different waveshapes.

That means, then.... if you select EVEN HARMONICS of a sine wave, the result is NOT symmetrical about zero – which means there is some DC component! How do we normally make DC from a sine wave? Diodes? Full wave rectification is pure frequency doubling and Wes Hayward, W7ZOI, and Doug DeMaw W1FB use this in "Solid State for the Radio Amateur" (pages 198-199) to generate an ultra-pure local oscillator for 144MHz from an 18MHz crystal, by successive diode doublers: hence, the title of this note: "DC Harmonics"!





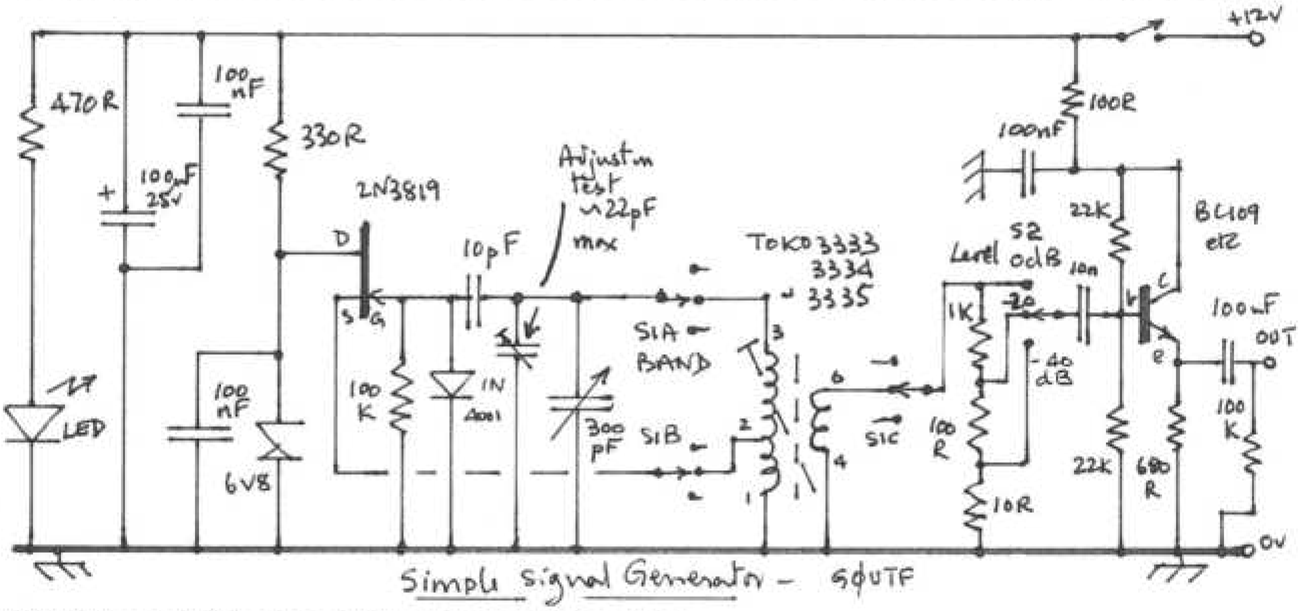


More Harmonic theory!

When the RF Extras are added to the Minster, the desired LO of 8 MHz is produced by adding the 4 MHz VFO to a 4 MHz xtal source. Hence the second harmonic of both sources is directly in the output band! This is far from ideal but the basic scheme of using a 4 MHz VFO, with various crystals, suits all the other bands so well that these 20m snags are worth tolerating! In earlier rigs with this scheme (Taunton and Bristol), it made setting up the 20m LO quite a challenge! For other reasons, in the Minster, the 4 MHz VFO signal is a square wave; Mr Fourier tells you it has odd harmonics that decrease as the inverse of the harmonic number, eg the third harmonic is one third the amplitude of the fundamental etc. But he also tell us that for a triangle wave, there are still only odd harmonics but they go down inversely as the ***square*** of the harmonic number, so the third is now one ninth of the fundamental and the fifth is one twenty-fifth instead of one fifth etc.. Clearly if the waveforms are not perfectly shaped there will also be some even harmonics but they will be much less pronounced in the triangle 'wave' than if a square one is input to the LO mixer! I was able to easily alter the Minster 4 MHz VFO output to a triangle wave by changing one resistor in the attenuator prior to the LO mixer, to a capacitor. This immediately reduced the unwelcome second harmonic of the VFO in the LO mixer output so making the 20m LO Bandpass filters much easier to adjust! (The fixed frequency second harmonic of the crystal is not so troublesome!) Nasty theory does have its uses!! G3PCJ

A Simple Signal Generator by David Proctor G0UTF

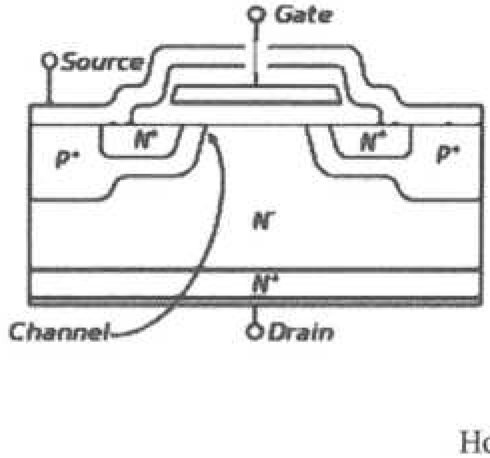
After years of "going to make one", here is my version of a sig. gen. It cost me nothing – made from bits in my junk box – even the metal case was once a QRP CW TX (hence the redundant hole!). The metal box keeps the RF at bay, only coming out of the coax socket. It is quite simple, although it took some time to get the correct circuit to obviate spurious oscillations. In 3 bands it gives 0.9 - 2.6MHz, 2.6 – 7.0MHz, 6.0MHz – 15MHz. These ranges can be changed by tweaking the TOKO coils. It has a 5:1 reduction ratio on the tuning knob and a large scale. It was built very quickly in the "ugly " style, as the photograph below right show. Output level is constant, but at the band ends is +/- 2dB. The Output level = +14dB (can be changed by the zener voltage). There are also -6dB & -26dB outputs by inbuilt attenuator. The waveform is "sinusoidal", but enough harmonics can also be heard in an RX. Does it deserve a place on your work bench?

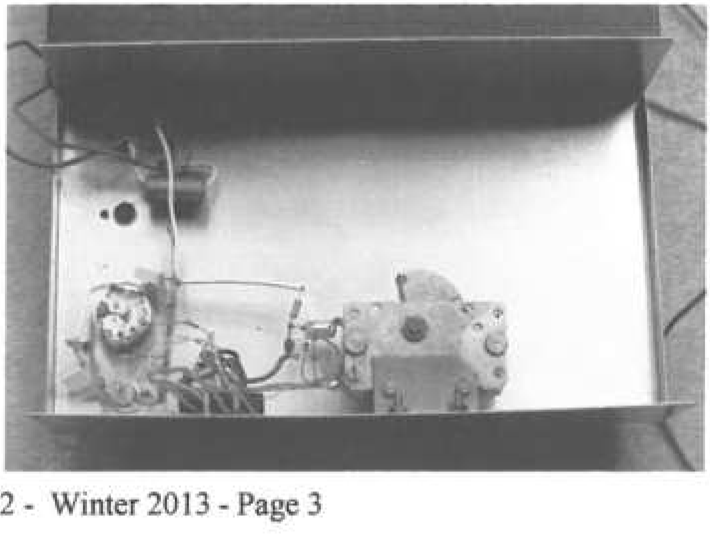


MOSFETs and the Devil by Peter Thornton

We often think MOSFETs are a panacea for all RF power amplifier ills. Whilst they are very fast and cheap, they do have some little Devils built in.

Here is a cross section of a typical MOSFET transistor. A real device will be thousands of these individual transistors in parallel, interconnected by aluminium tracks created by photo-lithography on the silicon wafer surface. The electrodes are connected to the outside World by bond wires from the aluminium tracks to the device pins; the drain connection is usually the metal tab the silicon die is bonded to, the metal tab in a TO-220 package, for instance. The device shown is indicative of the structure; many different structures are used in real devices, but this diagram serves to illustrate. (Diagram below left courtesy Wikipedia)





MOSFETs and the Devil Contd

Without going into semiconductor physics, the device works like this. Voltage applied to the gate with respect to the source "inverts" the polarity of the source, from P-type to N-type, by virtue of the electric field imposed via the gate to source insulation – the region surrounding the gate in the diagram. This insulator is made of silicon dioxide and is less than 100 nanometres thick. There are 40 *millionths* of a metre to every thousandth of an inch, so 100 *nanometres* is 1/400th. of one thousandth of an inch. For comparison, a human hair is ~ 5 thousandths of an inch diameter!

The electric field created gate to source being so high (because the insulator is so thin), the P-type semiconductor inverts to becomes N-type, thus creating a continuous N 'channel' between the source and drain, conducting electrons from the source to the drain. Thus we have a transistor: by biasing the gate, we can change the conductivity of the 'channel'. The conductivity of the channel, the N drain region and the bond wires form the 'Rds on' resistance.

Let's find some Devils! Without any gate bias or signal applied, the channel is P-type; now let's follow the semiconductor type from the drain tab upwards. N+ and N for the drain region; P for the channel; N for the source. That's an NPN transistor! And we have several P-N junctions, too, visible in the diagram; the biggest diode is the N+ and N drain to the P-type source, drawn as a diode source to drain on the device's symbol.

NPN transistors have gain and capacitances: but in a MOSFET, you can't get at the transistor to bias it, use it or neutralise it. But it's an NPN transistor all the same, and if signals can get into it, with volts applied, it will amplify them! All diodes are capable of charge storage and are voltage dependent too; thus the MOSFET is far from a simple device. To analyse MOSFET behaviour at HF, VHF and UHF is very difficult, so taking an empirical stance, several features are observed:

As the gate drive rises, the capacitances within the device can (depending on device structure and drain volts applied) shift in a distinctly non-linear manner – it's not a true capacitance, but more charge storage, the energy stored being $\frac{1}{2}CV^2$;

The parasitic NPN transistor will switch if current can get into the "base" - for instance, via capacitances; the transistor can, in some structures, form a part of an NPNP thyristor;

The P-N junctions act as varactors, and combined with the extremely fast nature of MOSFET's, cause some transistors within the device matrix to become UHF oscillators.

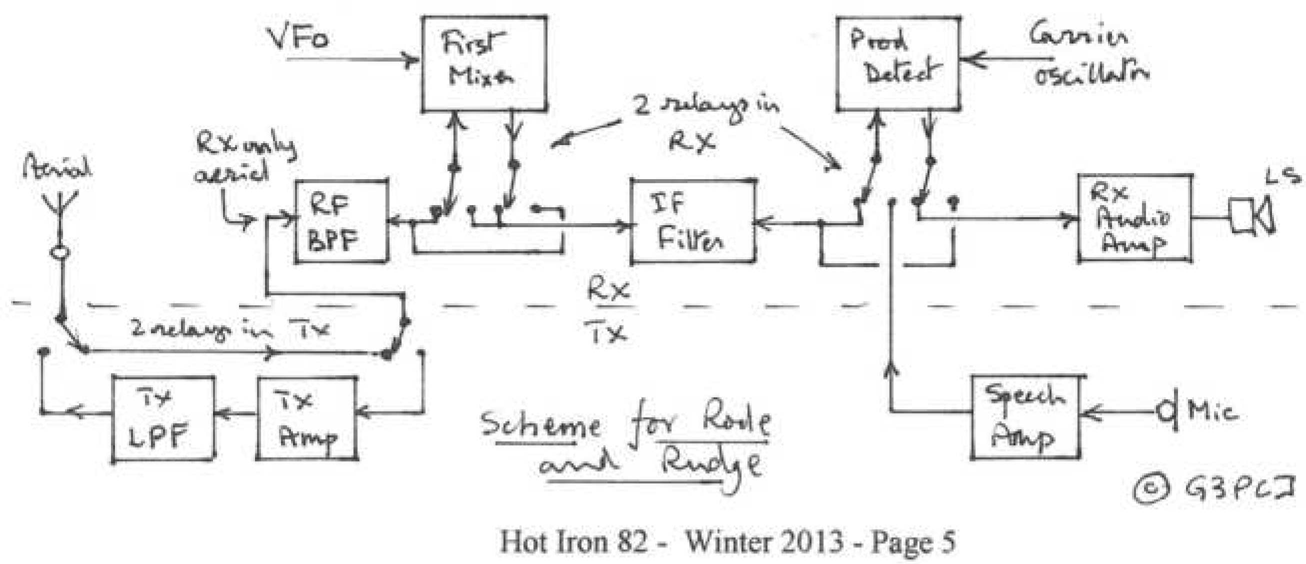
An effect in power MOSFET's designed for switching (IRF510, for instance) used in RF amplifiers, is the higher the drain supply, the more efficiently the device seems to run at high frequencies. This is (probably!) because higher drain voltages widens the inherent diode depletion layers, decreasing stored charge and base current in the parasitic NPN.

Despite their inherent Devils, MOSFET's are useful and cheap devices that can give valiant service in arduous (amateur!) roles. But they are not a universal fix; MOSFET's can cause unexpected parasitic oscillations and non-linearity. A bipolar BD139 has an Ft of >180MHz, 80v Vceo and 1.5 Amp Ic with a Vce-sat of ~ 120mV (corresponding to Rdson of 0.08 ohm), costs £0.20p and won't be unstable if used sensibly. By all means try MOSFET's, but keep in mind bi-polar transistors can also give robust, excellent service at low cost.

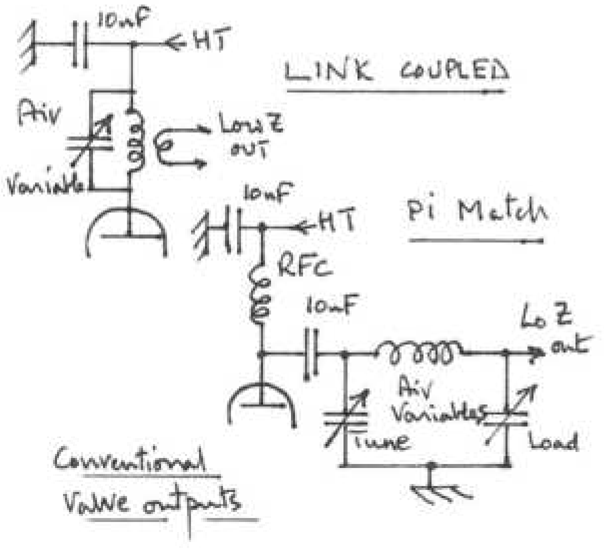
Rig Ideas!

Now the Minster is getting near release, it has been timely to review my range of rig offerings because I might have nothing new to think about! At the bottom end, the FiveFET is about the simplest that one can make a usable RX suited to newcomers and electronic construction. This has made the single band version of the Cary redundant and I have now retired it. I had thought of making that into an any HF band regen RX but the options are too great for the probable demand. But it did throw up the fact that a matching simple CW TX would have to be crystal controlled, and hence need a stock of them for 'all' bands! Furthermore, my current simple CW TX (the Kilton) could do with an update to add sidetone etc. Adding these possibilities together, I am now mulling over a new regen RX for 20, 30 and 40m. (The regen approach makes band switching much easier than with a conventional DC RX.) This RX would be aimed at CW primarily and a later variant might do 30, 40 and 80m instead - when 80m becomes more active! The matching CW TX would start as a single band crystal controlled rig with the inevitable few kilohertz of tuning range - but most keen QRP operators don't stray far from the band calling frequencies so that is perhaps not the problem one might expect. The PCB would be drilled for 3 crystals. The output low pass filters need a bit of thought, but luckily an old kit design with twin relay selected low pass filters is just the job to add to the new 1 or 3 band TX! This RX & TX are likely to be called the Mark and Meare. They are a better proposition than the complex four band Cadbury design so I have decided against progressing that project, BUT, I do have four sets of PCBs for the Cadbury Castle and I did do all the writing, so I am happy to turn these into specials - contact me if interested please. (The Castle has a direct conversion CW RX with VFO operation on all bands 20 - 80m; full break in1.5W TX with sidetone. £80)

Steve Hartley also advises me that often his Buildathon students want to build a superhet RX for 20m, or sometimes 40m. The latter is challenging with an IF of 6 MHz so I am toying with a 10 MHz IF approach that could more easily do 20 and 40, or even 80m without too much trouble. One idea is to layout the PCB for relay switching of the IF strip and RF BPF, so that it could drive a simple SSB transmitter after a few tracks had been cut around the normally absent relays in the plain RX! The RX would then eject low level RF out of its antenna terminal when transmitting which then drives a conventional RF transmit amplifier; for cheapness, this might only be a 1.5W design using three BS170s in parallel like the Fivehead years ago! The only other function required in the transmitter is a speech amplifier so this will easily fit onto a half PCB that can be easily installed behind the RX. As a precaution to prevent pulling, the VFO in the RX ought to be a separate device from the SA602 first mixer, but in other respects it needs nothing else for its transmitter driving role! Partial block diagram below. They have provisionally been given the names of Rode and Rudge for RX and TX. G3PCJ

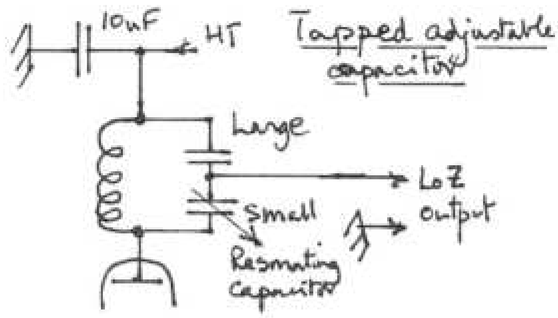


Valve TX output networks

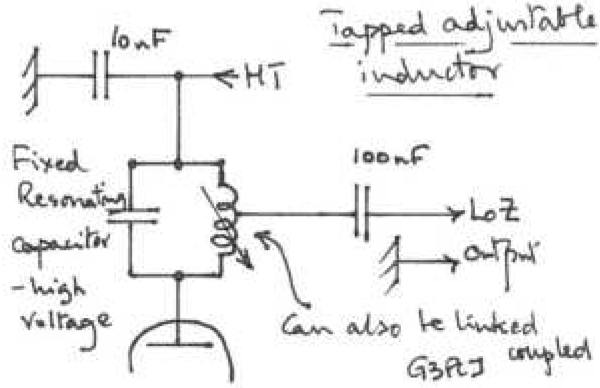


There are at least two commonly used networks for matching between the output valve load of a few Kohms and the normal 50 Ohm antenna 'load' - see right. Even obtaining as little as 5W with a 2K load implies a 100 v RMS voltage! So apart from any DC voltages also present on the valve anode, there are also quite a lot of RF volts - neither of which are welcome with modern components intended for semiconductors! There is a particular problem in obtaining variable capacitors that can stand more than a few tens of volts that are possible with PolyVaricons! Sadly, low cost air spaced variables are just not available and the kit designer cannot sensibly use them.

What about using a non resonant RF transformers? Certainly possible and it would make any following matching network use a smaller impedance transformation ratio, which will of course also help reduce the RF voltages at the high impedance end. However, one might argue that if you use any broadband RF transformer to get down from say 2K to 500R, then you might as well go all the way from 2K down to 50R in one go! But beware! Conventionally, the output circuit is resonant at transmit frequency with a Q of about 12 in order to remove unwelcome harmonics, particularly with a Class C output stage. Un-tuned would not do this!



So can we use some other network? Maybe! In receiver tuned circuits, the 50R aerial is often matched by tapping down either the resonating capacitor or inductor. In principle this approach can be used at higher power levels so that a slightly larger resonating capacitor acts in series with a large one which actually drives the load - this causes the high voltage to be across the smaller one. Small high voltage caps are available but not in adjustable form so maybe you need vary the inductor to tune the network! The obvious alternative is to use a tapped variable inductor with a single resonating low value capacitor.



Variable inductors are perfectly feasible - its just a case of how to do it! Years ago one would use a variometer but that is a bit challenging mechanically, an alternative is to move a tuning core in or out of the coil. Ferrite or brass are possible materials and I have seen adjustable lipstick holders pressed into service for an AMU! The hunt is on for cheap coarse threaded mechanisms!

Snippets No 1! You can now use your inkjet printer to directly print a metallic film straight onto an insulating board to make your printed circuits! The cartridge is re-loaded with a suitably conductive ink and away you go! I shall stick with copper clad fibre-glass for while yet!

No 2! One home constructor (un-identified!) wished to use a small simple medium wave RX (with a ferrite rod antenna using AM) around his house while listening to his favourite audio tracks! He cobbled together a series emitter follower audio modulator stage (driven by the audio source), with the RF output derived from a 1 MHz clock oscillator plus MOSFET driving a wave-wound large coil resonated to 1 MHz! Legal?? I think not. Tim

QRP vs. serious QRO in Riyadh by Andrew ZL2PD

I'm in the final stages of finishing off one of Tim's Lydford transceivers. I'm building it for use on 40m. One of the main reasons for selecting that band is interference – I expect it to be less of a problem listening to signals on that band here than if I built the kit for, say, 20m. The main source of interference also is a bit closer for me than most. It is located a little way up the road from where I presently live, in Riyadh, Saudi Arabia.

Just a few kilometers away, there's a Medium Wave and Shortwave transmitting station where a large number of 250kW, 500kW, 1MW and 2MW broadcast transmitters are located. These feed a dedicated array of high gain curtain array antennas on shortwave, some AM verticals, and at least one large log periodic antenna. The curtain array's 49 towers (by my count) are arranged in three radial arms, the transmitting station at the centre. The antenna farm is clearly visible when driving east out of the city.

The truly vast area of land set aside for these transmitters and arrays is completely surrounded by literally miles and miles of high sandstone walls topped with barbed wire. Unless you are some distance away and slightly elevated, there is little to see. And, frankly, it's unhealthy for a number of reasons to attempt to look at (or still worse, photograph) the site close-up.

The towers hold up the somewhat outdated HF curtain arrays on each of the three radial arms of the main HF array. These curtain arrays can easily add another 10 or 20 dB to the signal level in the target receiving region. I was also told that when the nearby National Stadium steelwork was being erected a few kilometers away, the induced voltages from the high RF levels were high enough to generate severe arcing across the gaps as the large steel trusses were being moved into position for final bolting. You might also notice a log-periodic antenna, although it's not clear if it is still in use.

Naturally, a power supply is needed for all these transmitters. My Lydford is powered by a small recycled 12VDC 4A DSL router power supply which weighs about 500 grams. In this case, there is a very large power station with multiple generators a little further up the highway supplying power to these transmitters, along with a vast collection of oil tanks to fuel the generators. Don't the problems just grow when you're not running QRP?

Depending on the time of day, these transmitters operate on 9, 11, 15, 17 and 21 MHz. The schedule suggests there's also a brief mid-afternoon burst on 7MHz but I've not heard that one. Probably while I'm at work.

As expected, the double-tuned front-end on the 40m Lydford receiver has adequate selectivity to deal with these 9 – 21 MHz signals, especially given my modest receive antenna. I can hear a little interference as a varying mushy low level background noise when the 9MHz transmitters kick off. That's hardly any surprise given their power and proximity, and it presents little bother to me. On 20m, however, things can be distinctly more difficult for receivers as a result of the numerous nearby high power carriers. I have to use a receiver with a seriously high performance front end to survive in that RF environment.

I used a full size Rhombic some years ago on a remote island in the middle of the Pacific. That was a real treat to use with my Icom HF transceiver. I enjoyed my S9++ reports from placed many thousands of kilometers away.

It's a wonderful dream, but sadly completely out of the question, to try one of those curtain array or that log periodic antenna. Still, for the sake of argument, could I still call it QRP if I used a 16dBi gain curtain array with my Lydford?

Note by Tim - I did have some photos of similar towers and aerial arrays etc to give you an idea of what this lot must look like, but I know they will not photocopy well, so I am afraid that I decided against including them.

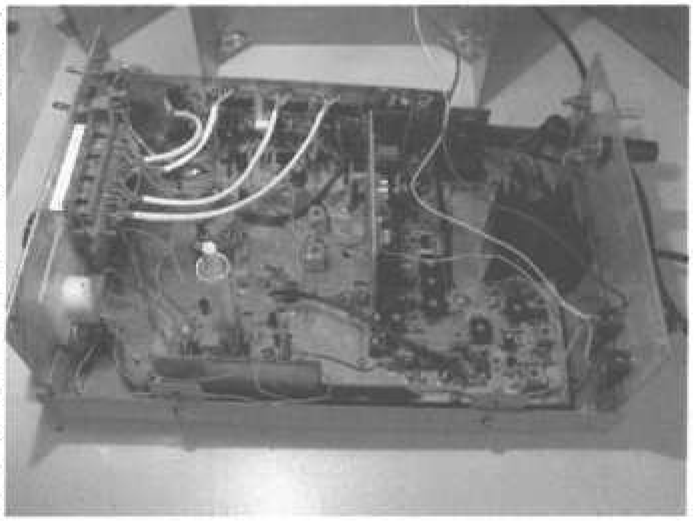
I also know that Andrew has been experimenting with an alternative DDS VFO to drive his Lydford. I hope he will be writing that up for us next time! As ever, I suspect we will hear that it is all about compromises!

Encasing Rigs by David Seabrook G4LJG

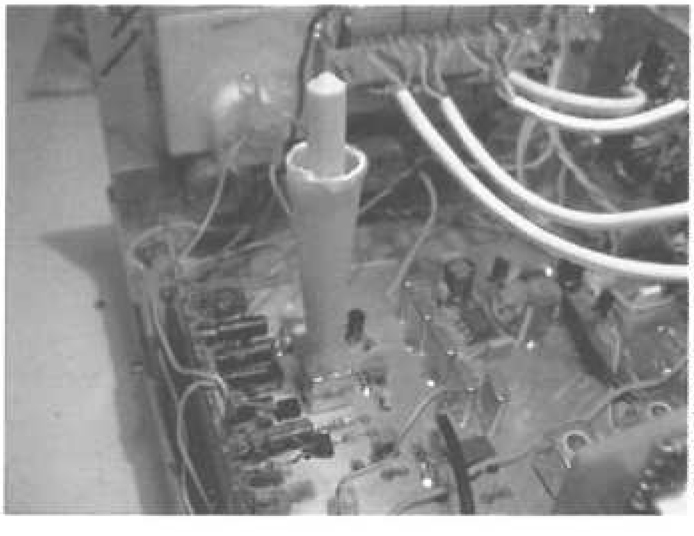
David has sent along some excellent photos of his two Midneys and Kingsdons, complete with counters and other add-ons! He says:-

"My method of making cases uses double sided PCB material cut to size using an electric diamond wheel tile cutter, which cuts them (either fibre glass or paxolin) much more cleanly than a saw or Stanley knife. You must use water because the dust of both is dangerous! First I tape the top and bottom boards together so they cannot move, set the saw to the measurements needed and cut both boards together, using the same method for front and sides.

I then spray-paint them usually with Hammerite as it is very hardwearing. For the front and back I usually use a matt colour (often cream) and then apply Lettraset transfers when it is dry. This is then covered with clear film that is used for covering car number plates or plastic signs as that is also very hard wearing! It is very sticky and once it touches any surface, it cannot be moved!



My method with the film is to cut it about 3/4 inch oversize, and then peel back about 1 inch starting at one end, applying it from one end while rubbing the film onto the panel with a side to side action thus making sure no air bubbles are trapped and only exposing the film as I go, otherwise it is likely to touch the surface before I want it to, or to fold onto itself and hence become impossible to correct! I then cut the corner across and fold the film over the edge, then cut the holes for controls.



David also comments on his special tuning control as seen left! He got fed up having to remove the cover to adjust between band sections for CW and SSB! All he did was to cut a silicon tube nozzle to fit the top of the TOKO coil can, then used an epoxy glue to attach an old tuning tool filed to suit the core. "I was doubtful at first whether it would work all right" but since he has had it working he has logged up VE, CU, SP, UA, DK/J, IK on both phone and CW! The counter makes adjustment so much easier! He gets good reports especially on the audio so feels there cannot be much wrong! I should explain that David also makes proper sized fishing rods so knows what he is up to in mechanical matters! Tim

Happy Christmas to you all!

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Spring 2014 Issue 83

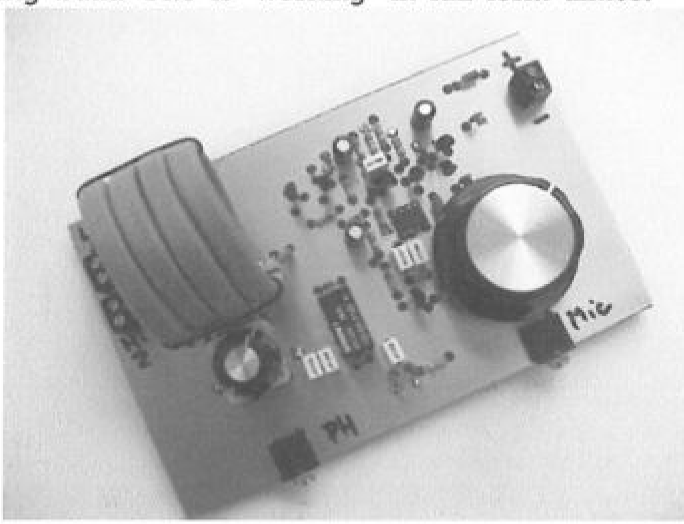
Editorial

Many of you know that my main occupation is farming on the Somerset Levels and have been kind enough to inquire how we are getting on with this terrible winter and all the floods. I am pleased to say that we are fine! As I type (started on Feb 15th) my feet are about 33ft above sea level, while the general flood waters are at about 27ft above sea level. Our house, all the buildings and cattle are dry except when the rain is horizontal! Your concerns are much appreciated. I am pleased to say the forecasts are better now and the EA have just started some huge pumps putting the water back into the rivers and hence to the sea. Tim G3PCJ

After writing the above (it is now Mar 8th), I must apologise for the late despatch of this Hot Iron. One way and another I blame Mr Gates! I was part way through writing it and was forced to change my computer. Unfortunately the new machine did not have MS Publisher (which I was using for writing HI). When I eventually found and installed my old Win95 Publisher software, all was fine for 12 hours till it did an auto update overnight. Publisher got updated and then would not open my old files, nor could anybody else locally for some while. In the meantime we had to go to Amsterdam for a short break booked many months ago! But the good news is that a friend did manage to retrieve the text of the part completed HI while we were away; that is a great step forward – even if I do now have to redo all the diagrams and pictures!

Kit Developments

Five early Minsters Mk 3s are now being built. One is 'working' in full form almost properly and one in its basic form, with a couple more close behind. The usual typos and a few comments that will need minor text alterations but nothing dramatic yet! All will eventually have the multi-band add-ons. Keep an eye on the website for news of its release.



Meanwhile, I have made early prototypes of the Wick and the Mark. The **Wick** (on right) is a very simple starter phone DSB TCVR - see later. Revised versions of the Wick are now working on 80 and 160m. The **Mark** is a 3 band CW regen for 20, 30 and 40 or 80m, which also needs a second prototype which I shall build soon. I have laid out and etched, but not yet built, the matching Meare 3 band CW TX! Tim

Contents

Modulation for "readability"? By Peter Thornton

If you're trying to communicate over a noisy, fading and QRM riddled path, which modulation is best for "readability"? FM? SSB? CW? No, AM! Not my opinion, but that of Aviation Authorities world-wide. But why, if it's no use for amateur communications nowadays? AM uses twice the bandwidth of SSB; yes, the carrier is (for some receivers) useless. So what are the advantages of AM the professional radio men pursue?

It's simple - AM is far more "readable" than SSB. The voice sounds natural, without the distortion SSB introduces in the crystal filters removing the unwanted sideband. Problems plague FM too - FM receivers suffer "Capture Effect", where a receiver will lock onto a strong signal, over-riding the desired (but weaker) signal.

Traditional AM has a carrier power twice that of the sidebands; since AM has two sidebands, the upper and lower, then each sideband has one quarter of the entire transmitter power. Thus, thought the pro-SSB men, we can get more transmitted power by doing away with the unwanted carrier and sideband, and put all the transmitter power into a single sideband. Pity it doesn't work like that, though! AM produces natural, clear speech; not so SSB!

And - AM is dead easy to produce! "But surely you need huge transformers, and massive power supplies?" No Sir! There are many simple circuits for the production of AM and can even be generated by our old friend, the SA602/612. You can also make perfect AM with CMOS gates, in a Pulse Width Modulator circuit - digital AM! You will find a multitude of AM transmitter circuits on the web, take your pick combined with the contents of your junk box!

Many amateurs running AM are on the bands today. Calling frequencies for AM World-wide are listed below. Hope to hear you on AM soon!

All Frequencies in MHz

160 Metres:

1.885, 1.900, 1.945, 1.985 (USA)
1.850 (W. Europe)
1.933, 1.963 (UK)
1.843 (Australia)

80 Metres:

3.530, 3.650 (South America)
3.615, 3.625 (VMARS, UK)
3.705 (W. Europe)
3.690 (AM Calling Frequency, Australia)
3.825, 3.870 (West Coast), 3.880, 3.885 (USA)

40 Metres:

7.070 (Southern Europe)
7.120, 7.300 (South America)
7.175, 7.290, 7.295 (USA)
7.143 (UK)
7.146 (Australia)
7.195 (Italy)

20 Metres:

14.286

Home built circuit board techniques

With several new Construction Club members, who I would like to very much welcome, I need to address some simpler topics for those who I guess might not be so experienced as old-timers! George Dobbs G3RJV does a grand job with his regular construction column in PW but I wonder if it is really necessary to use any extra parts for the assembling a circuit? I build most of my wilder ideas literally in free air using a copper sheet without any form of mechanical anchoring for connection joints. This makes it extremely simple to alter a circuit but the mechanical rigidity is awful! Generally this does not matter in a protected environment such as your work bench; but there is one major exception! Frequency stability of oscillators is very dependent on mechanical rigidity so when doing long term tests of them, you must use either a proper PCB or some form of anchoring for the joints and other parts; but for most experiments etc, such techniques are not essential except to make it look good!

How can you avoid drawing pins stuck into wooden boards, loads of tedious hacksaw work to make stick on squares, or much 'drilling' to make isolated pads? The first point is to layout the physical circuit in a manner that makes following it easy! Generally, you will be building something from a circuit diagram which is usually drawn with the main ground, or negative supply line, at the bottom; with the main positive supply line at the top of the page. Stick to this in your physical layout! The next stage is to keep input and output parts of the circuit well separated at opposite ends of the 'board' - again following the circuit layout may help. I use 'board' here in its most general meaning; some people like to use ready made pre-drilled boards, with or without tracks on them, that can be cut as required, but a piece of plain copper is fine! You don't need to go to a metal merchant - plain copper clad laminate is available from Maplin & the regular electronics suppliers (Rapid, Farnell & RS) in various sizes that can be cut down as required. I use old scrap double sided PCBs from failed projects but you may not have that source! The benefit of these is that the copper ground plane sheet (even with random holes in it) forms an excellent ground plane or 0 volt supply 'line' for your project.

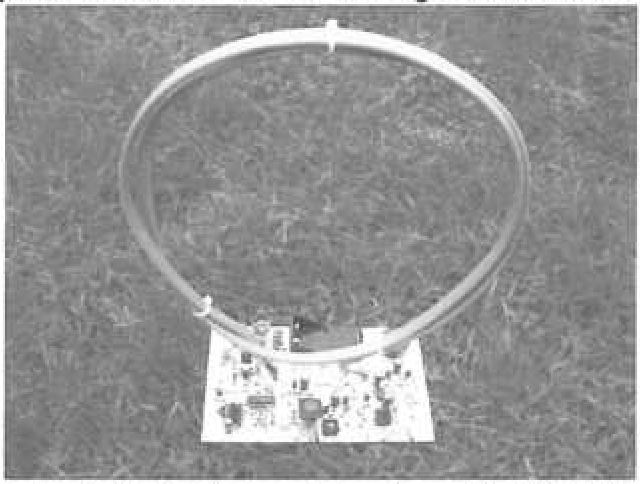
So how do you mount parts? Easy - by soldering their ground leads to the copper plane! (Beware that people like me tend to refer to earth or ground or chassis when they actually are referring to the same 0 volt line!) Cut the ground leads of these earthy parts to about 1/4 inch or 3 mm long and solder them directly to the copper ground plane leaving the other end slightly up in the air so it is not in danger of touching the ground plane. Then add the components from the input towards these earthy parts. Some of these will not have any earthy connections so a bit of support might be needed, fit a high value resistor between that point and the ground plane - use at least 1M resistors (or even 10M) and their value will be many times (> x30 desirable) the circuit impedances at that point, and so will not upset matters. If in doubt, avoid them at high impedance points – associated high value resistors in the circuit are a warning sign!

At the top of the circuit, you probably have a positive supply line; here a bag full of cheap 10 nF disc capacitors are useful! They can be added across the supply lines with gay abandon to give extra rigidity and better decoupling. As before solder one side to the ground plane along the top of the layout, with the other lead up in the air, and then link them with stiff wire to complete the supply rail. If extra rigidity is required at any particular point (say for the incoming supply lead), fit two of them at right angles!

So what do you do about integrated circuits? Consider using a IC socket if you like, but with a published design where you should not need to swap devices, then solder it in permanently. This will also be a good thing for any RF circuit where short leads are desirable, or even essential at UHF etc. If they are being soldered directly in place, they should be mounted upside down. Consider the best orientation, and then mark the copper sheet with a star for pin 1; I also write the part number on the copper for when I come back to the project years later! Then bend down the earthy leads of the device so they can be soldered directly to the ground plane. (Beware about static charges and wear a wrist strap if you work in a hot room with synthetic carpets!) The supply line to integrated circuits can also have their own 10 nF discs between supply pin and ground to help with anchoring. With care one can make quite smart layouts like this – not like my example of Dead Bug Construction on the last page! G3PCJ

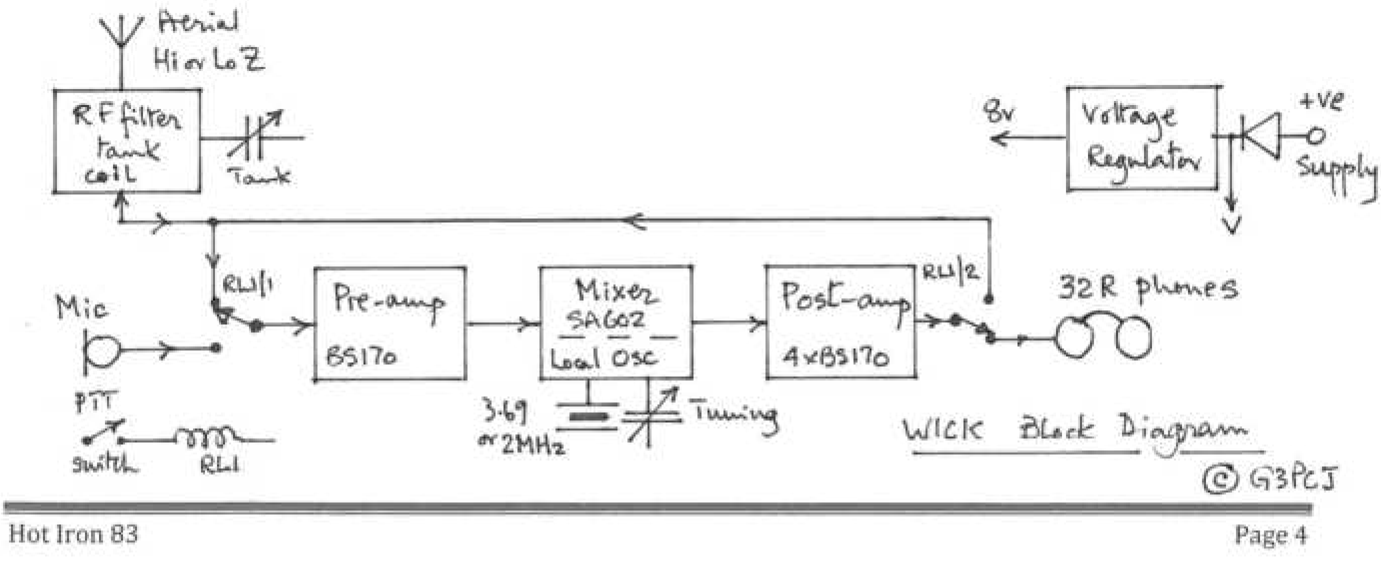
The Mark!

This rig was inspired by a sketch of a Japanese idea kindly sent by Peter Thornton. The key point is that a mixer can perform either as a product detector, or if balanced, as a modulator producing double sideband suppressed carrier phone. The Japanese design used the ubiquitous SA602 mixer chip. (Incidentally, I have been warned that this chip is no longer being made!) The design had almost no other semi-conductor devices, and so lacked sensitivity and transmit output power - but it did set me thinking! Because Peter T had been thinking about 6m operations (portable with the shorter aerials), my first ideas were for something rockbound on 6m possibly with an integral loop antenna like the Radlet (right) of many years ago! But 160m local nets seemed like another potential candidate for a simpler TCVR!



Eventually it has developed into a ceramic resonator based phone TCVR for 80m, (or 160m when ordered). There are standard in band resonators for these bands so it can have 50 KHz or more of tuning range which is far more appealing. The Radlet's loop idea eventually led to the use of semi-rigid mains twin and earth PVC cable for the single RF tuned circuit. As the photo on page 1 shows (of an 80m Wick), it needs a reasonable sized four loops which produces a 12 turn coil by connecting the individual cores in series on the PCB. By a little juggling with the tuned circuit connections, it will work with 'long wire' or a balanced low impedance feeder to a conventional balanced antenna. This approach is an easy way to obtain the high inductance, and robustness, needed for a transmitter tank coil on 80 or 160m!

Another interesting point about the earlier design was that (apart from the 602) one other aspect was used for both transmission and reception. My design uses all active stages for both transmission and reception to get the gain up! See the block diagram below where the switching is done by a single relay. This means that both input and output amplifiers need to work from the RF right down to the low end of the audio range - say 4 MHz down to 300 Hz! That's quite a challenge when inputs and outputs are switched in close proximity, so this is a design that will be a bit more layout dependent than usual! To get most of a Watt of RF output power I decided on a pair of my favourite BS170 MOSFETs working in parallel. On reception their drain load is the series connected 32R phones, so it includes an automatic reduction of their drain current to let them stay cool during long reception sessions! To keep it simple, the only controls are for the main tuning of the local oscillator using the ceramic resonator, and a second PolyVaricon for the RF tuned circuit which is used both for reception and transmission. In view of its simplicity, it will be cheap and should be good for Buildathon type Club construction projects. G3PCJ



Linear Experiments! By Paul Coddington M1BKL

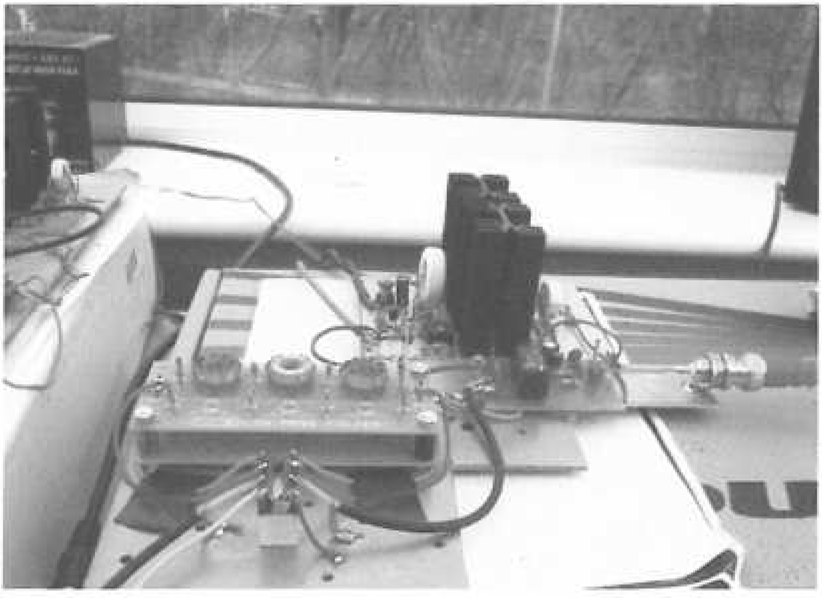
I am new to Tim's kits but I am not new to kit building & have built a number of Softrock Ensemble RX/TX kits. Many of you will know these have a nominal power output of around 1 Watt. I have been using two of these, one with band pass filters for 40, 30 and 20m and one with filters for 17, 15, 12 and 10m for digital (BPSK,QPSK, RTTY etc) contacts over the last 18 months and collected some 60 to 70 countries in the process.

About 6 months ago having obtained an additional external sound card for my PC I decided to configure the SDR software for SSB. The SDR software I use is mostly PowerSDR for SSB supplemented by HDSDR and Rocky for digital. However I quickly realised that for SSB contacts it would be good to have a little more than the 1 watt. I came across Tim's Linear Amplifier so I ordered one (with IRF510s) and got building - it was easy and straight forward. It was then attached to the Softrock with the 40, 30 and 20m band pass filters and it delivered a good clean 10 watts. This Softrock/Linear amplifier combination has been progressively enhanced to include: a PPT aerial change over relay using the switched 12v supply from the Softrock, and two switched LPFs - one with a knee at about 7.5MHz and one at about 14.5 MHz. (They are 7 pole Chebyshev types.)

During building I noted an alternative version was available with RD06HHF1 MOSFETs which might extend the upper usable frequency towards 50 MHz, so I ordered one to give it a try with the other Softrock. The Linear with the RD06HHF1's (for HF use) is identical to the IRF510 version with the exception that since the source is connected to the body of the MOSFET the insulating washer is not absolutely necessary. The one big difference between the two versions came in the setting up.

First following the instructions, the bias was increased until the current rose by about 250 to 300 mA, and the RF input was adjusted until the output stopped increasing.
However this did not produce the expected power out even at a frequency of a nominal 14 MHz, so the bias was increased keeping the RF input constant until the RF output peaked. At this point the standing current was between 0.5 and 1 amp. In the final version the bias was subsequently reduced by a small amount, however the standing current is still more than 0.5 Amp. This Linear with the RD06HHF1s, was then attached to the Softrock together with a PTT aerial changeover relay, driven by the Softrock switched 12v volt supply. Two switched 7 pole Chebyshev LPFs were added to the output – that for 17 and 15 m has a knee at 21.5 MHz and the other for 12 and 10 m has a knee at 29 MHz.

So what about the results? With my simple test equipment - power meter, 50 ohm dummy load and 50 MHz scope, I obtained ~ 10W on 20 and 17m, 5W on 15m, 8W on 12m & 6W on 10 m – all with a nice clean signal. Why there is a dip for 15m I do not know, maybe the output on 10m is being reduced by the LPF. I have now done extensive on-air testing on 17, 15 and 12m with many SSB contacts over the past two months in Europe, USA and Canada, with the best DX being Brazil and Guadalupe. The RD06 Linear and Softrock combination works well!

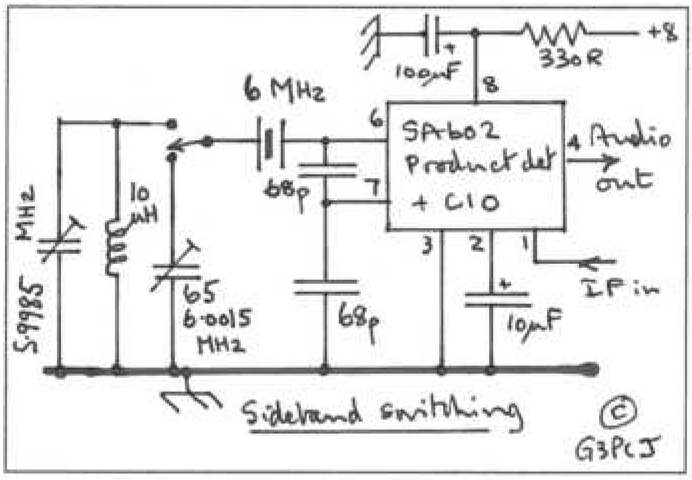


Paul is currently trying out the VHF version of the RD06 devices in another Linear! More news later.

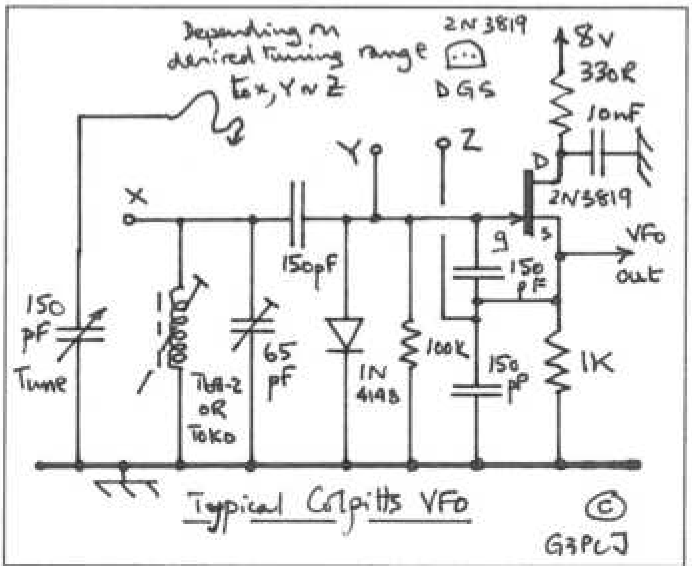
Lydford TCVR Experiences

Several builders have reported their experiences and modifications to this rig! Here are a selection of them:-

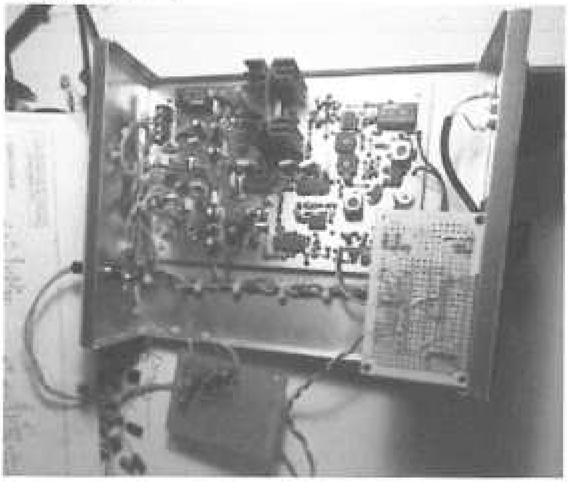
Sideband switching This something I have shied away from because it really needs short leads owing to the Carrier Insertion Oscillator operating at 6 MHz. The normal Lydford CIO can be made to work on either sideband depending on whether its 10 /uH coil is fitted for the lower frequency of 5998.5 KHz, instead of 6001.5 KHz with just the plain trimmer. All that is needed is an extra 65 pF trimmer and a single pole on/off toggle! The leads to the switch should be short and stiff so if you need to have a distant front panel switch use a small single pole relay mounted near the trimmers!

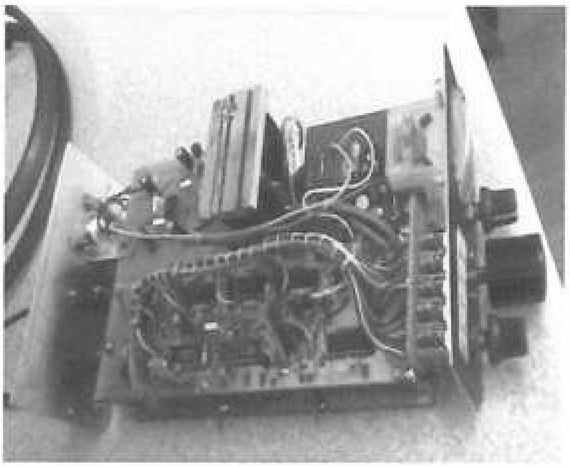


VFO tribulations One builder's VFO refused to work – how was it cured? See the circuit right. This is typical of Colpitts oscillators. If all is well the DC current through the 2N3819 JFET will increase very slightly when the oscillations are stopped. So monitor the DC voltage across the drain supply R and see if this alters when the inductor is temporally shorted out – if not, then its not oscillating! If there is no voltage across the drain R, then the device is not conducting – check its orientation and for bad joints and that the gate resistor is present! It is very unusual but TOKO coils do occasionally go open circuit, so measure their DC resistance – it should be nearly a short circuit! This was the troublesome fault!



Enhancements Many variations have been added or tried - DDS instead of the LO chain, various frequency readout counters, CW and or AGC kits – too many to detail! Thank you to all who have reported back! Judging by the good reports on the basic rig and the many modifications made, it appears to be a very successful kit - DDS version left and with counter right. G3PCJ



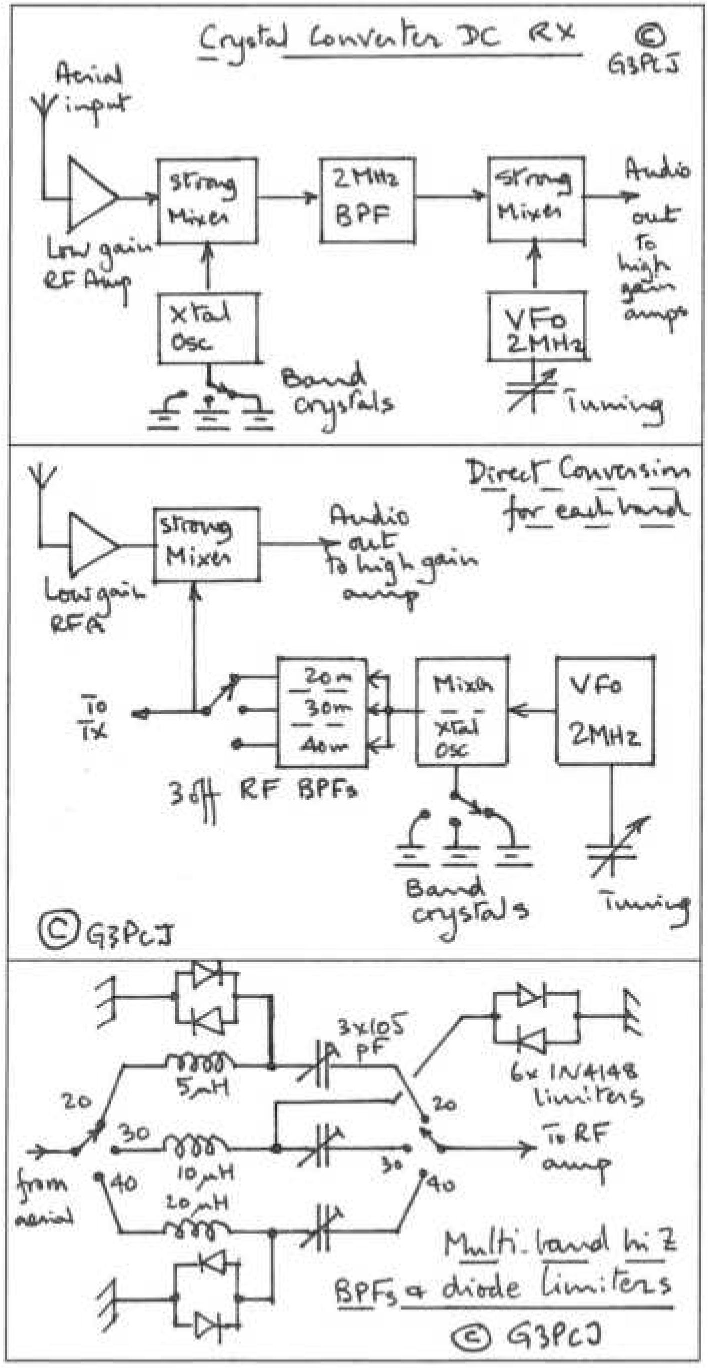


Design ideas for a multiband DC CW TCVR

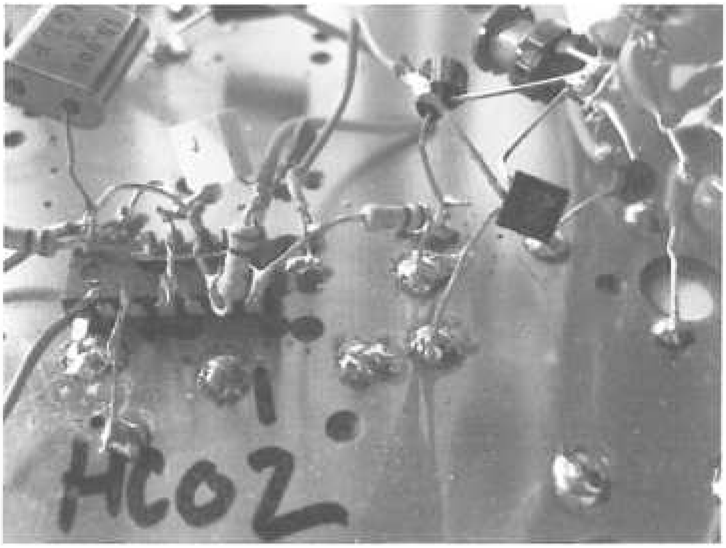
I have been contemplating a new CW DC rig but the block diagram is challenging if you want to minimise the number of resonant circuits and have full break in operation without TR relays! I hope to simplify/reduce the cost of the earlier 4 band Cadbury design. What frequency scheme is best? To avoid chirp and achieve stability on 20, 30 & 40m bands, a LO crystal mixing scheme is almost essential (unless you fancy computer driven DDS!). A 2 – 2.15 MHZ VFO added to the common 5, 8 & 12 MHz crystals is a good scheme; the only snag is a potential 7th harmonic birdie of the VFO at 14.00 MHz – but to some people, this is a useful band edge marker! A 3 MHz VFO would cure this but that needs more obscure crystals. I hope that a strong commutating HC4066 mixer without RF filters will avoid BCI when a decent AMU is used.

Two approaches for the RX are possible – crystal driven converters ahead of a 2 MHz DC RX (needing two strong mixers), or a LO chain (with the VFO, crystals, mixer and LO filters) driving a single strong mixer for DC operation on each band. The first approach (top right) is probably a bit simpler/cheaper (owing to lack of RF filters for each band) and it also readily adapts to an optional phasing kit for single sideband reception. The second approach has the advantage of needing only a single strong mixer with most of the gain provided at audio. For both approaches a low gain RF amp is desirable to avoid unwanted LO radiation. However the generation of the LO at operating frequency in the second scheme has the strong advantage that it can be directly used to drive the transmitter without further LO filtering. The transmitter for either approach will need low pass harmonic filters.

Another challenge is how to obtain full break-in TR switching without burning out the RX front end! The Cadbury used the scheme right but without any RF filters, one can only shut down the RF amp and pray! This may not be good enough for a 5W TX. I would like to avoid diode switches owing to their losses but that maybe acceptable at HF. G3PCJ



Deadbug Construction



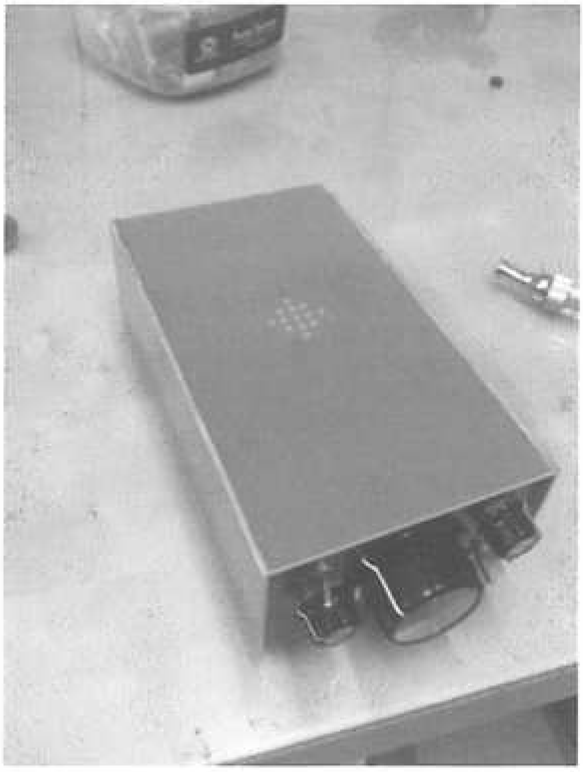
This is an untidy example of how you can mount an integrated circuit upside down. The transistors on right are actually a pair of BS170s in the output stage of an experimental 50 MHz rig! I made many attempts to photograph this but failed to get a decent one! Sorry!

Tape Radials

Craig Douglas G0HDJ sent along an unusual idea for constructing a temporary ground plane antenna. Go to your local tool shop and buy four steel retracting tape measures which can be locked in an extended position. Extend three of them to the same approx quarter wavelength for your band and arrange them in a star shape spaced equally around a central point in the horizontal plane. Make the three ends overlap each other and clamp with a small G type clamp to which you also attach the screen of the antenna coaxial feed cable. The fourth tape measure is similarly extended to a quarter wavelength and held in a vertical position by a suitable 'sky hook' (fishing rod or bamboo pole) attached to the body end of this fourth tape measure. The free end of the extended fourth tape is then attached to the feed coax inner. You will need a little ingenuity to keep this lot in the air! (These 'arms' will have small capacity hats so might need to be slightly shorter than normal.)

I am struck that this concept is much more practical for a high HF band dipole! Two tape measures can be extended equally for the quarter wavelength on the band in use; with their free ends connected to a low impedance feeder. Ideally this would be balanced but if coax is used it can be coiled up just below the tape arms to form a choke balun. The two body ends of the tape measures are then hung between suitable sky hooks. Obviously, a few extra holes and hooks etc will make this much easier to erect! Tim

Upton TCVR



Dan White sent along a photo of his Upton DC TCVR which he acquired un-built from Chris Fleet. The box is made from PCB material and encloses several small kits including multiple low pass TX filters. The design uses a multiband crystal mixing VFO and a doubly balanced strong diode mixer without any receiving RF filters – thus it relies on just the AMU and a strong mixer to avoid BCI! Dan did comment that when originally built, it suffered from many internally generated birdies coming from the digital VFO mixing process. These were cured by extensive use of small coax for most of the sensitive internal RF connections. Unlike the screening of audio circuits where multiple ground loops need to be avoided, in RF circuitry, the screens should be connected to the ground plane at both ends. Originally this design did not have a proper ground plane throughout so it was doubly important to bond together and screen the RF leads to make certain they neither radiated, nor received unwanted signals. G3PCJ

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

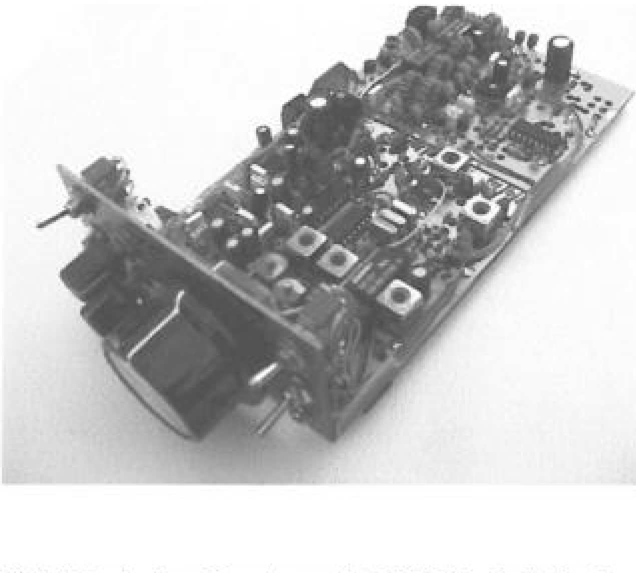
Summer 2014 Issue 84

Editorial

There has been some debate in amateur radio circles recently about where the hobby is heading! Pretty contentious stuff and I hesitate to join in! On the one hand we have Peter Cochrane suggesting in Radcom (Feb & March 2014) that the hobby is lacking an adventurous spirit with fantastic opportunity to be had by using the huge untapped potential of ultra high RF frequencies and the power of modern computing engines to achieve extraordinary filter performance which is behind spread spectrum technology. This is the view of a professional electronic engineer but who was inspired to enter the field by his early experience with amateur radio. At the other end we have people who like doing things with their hands, who don't have all the skills to design modern high tech kit but who do enjoy using it, and are also able to use their more 'mechanical' skills associated with antennas and the like. There is another large group who love restoring, and keeping working, much older equipment - often with glowing things! So where does the kit builder come into this picture – I am bound to say 'right in the middle'!! It is an unavoidable truth that the world is fundamentally analogue, and most of the signal processing techniques that underpin radio technology are also essentially analogue. The projects offered by nearly all the world's kit suppliers, are mostly 'analogue' and hence they offer that fundamental understanding of how radio communication works. These simpler 'analogue' radios can be understood, built and altered, without having a degree in advanced signal processing! This is not to decry or deny the many advantages that computing can bring to the hobby in multiple ways – be it in operating convenience, or in the actual radio technology. Commercial radio equipment (made in quantity, will increasingly use these computer techniques for advanced signal processing, but for those who want to understand the basics and conduct simple experiments, the world remains basically analogue! Tim G3PCJ

Kit Developments

Sales of Minsters are starting to happen! Meanwhile the Marsh and the Mells (right) are working and about to be put on my website. The Marsh is a three band DC RX with a proper VFO that also drives the Mells CW TX. Let me know if you are interested in building an early model.



Meanwhile, with encouragement from Steve Hartley G0FUW, I am working up the Rode and Rudge aimed at Buildathon events/constructors. These are a simple phone superhet RX and TX with relay switching and an IF of 10 MHz to make the VFO easier for any band of 20, 40 and 80m. Tim

Contents

"Roaring Mick" 80m Transmitter by Peter Thornton

At first glimpse a "Mickey Mouse" transmitter – but this mouse roars!

Please let me introduce "Roaring Mick", a design by W9SCH, Charles Rockey* - one of the most capable, no-nonsense radio amateurs ever. Initially, "Roaring Mick" looks like a keyed oscillator transmitter, which we're told is completely unacceptable on today's HF bands. Don't be fooled; "Roaring Mick" has some very subtle design features which make "Mick" ideal for the service I have in mind.

Before I explain why I'm working with "Roaring Mick", let's run through the design to see the subtleties W9SCH implemented. Take a look at the winding details of L1 and L2, the grid and anode coils. L1 is twice the turns of L2; yet both the parallel tuning capacitors are similar values. The grid circuit resonates at *half* the frequency of the anode tuned circuit.

Similar calculations for the anode show tuning for 80m; but how is the frequency doubling achieved, grid to anode? W9SCH's first trick: the oscillator section uses the screen grid as a virtual anode - note how the screen grid is connected directly to the B+ rail, no resistor or decoupling capacitor. His second trick: he sets up the half frequency VFO with a tuned circuit of special characteristics. Note too the resonating capacitor is large compared to the valve and stray capacitances; the VFO is, therefore, stable, as the very high C to L ratio swamps the drift causing strays, and high C:L ratios create high Q as capacitors are much less "lossy" than inductors.

The electrons flowing from the cathode to the screen grid and anode pass through the control grid but the flow is non-linear as the control grid acts as a virtual anode. When the control grid swings positive during oscillation, electrons flow from the cathode to the control grid, setting up a voltage drop across the 100k grid resistor and the 47pF capacitor auto-biasing the grid negative. This rectification causes a non-linear anode current - perfect for doubling in the anode tuned circuit. Since the coupling between the grid and the anode is purely by the electrons, there is NO interaction between the control grid and the anode circuit – perfect isolation plus power gain. Now we have 80m power in the anode, the link winding L3 feeds the antenna.

Why did I choose to build "Roaring Mick"? I need a robust transmitter as a test bed; and "Roaring Mick" will withstand gross mismatches, dead shorts, indeed, any amount of abuse an experimenter could cause. The experiments I want to run include:

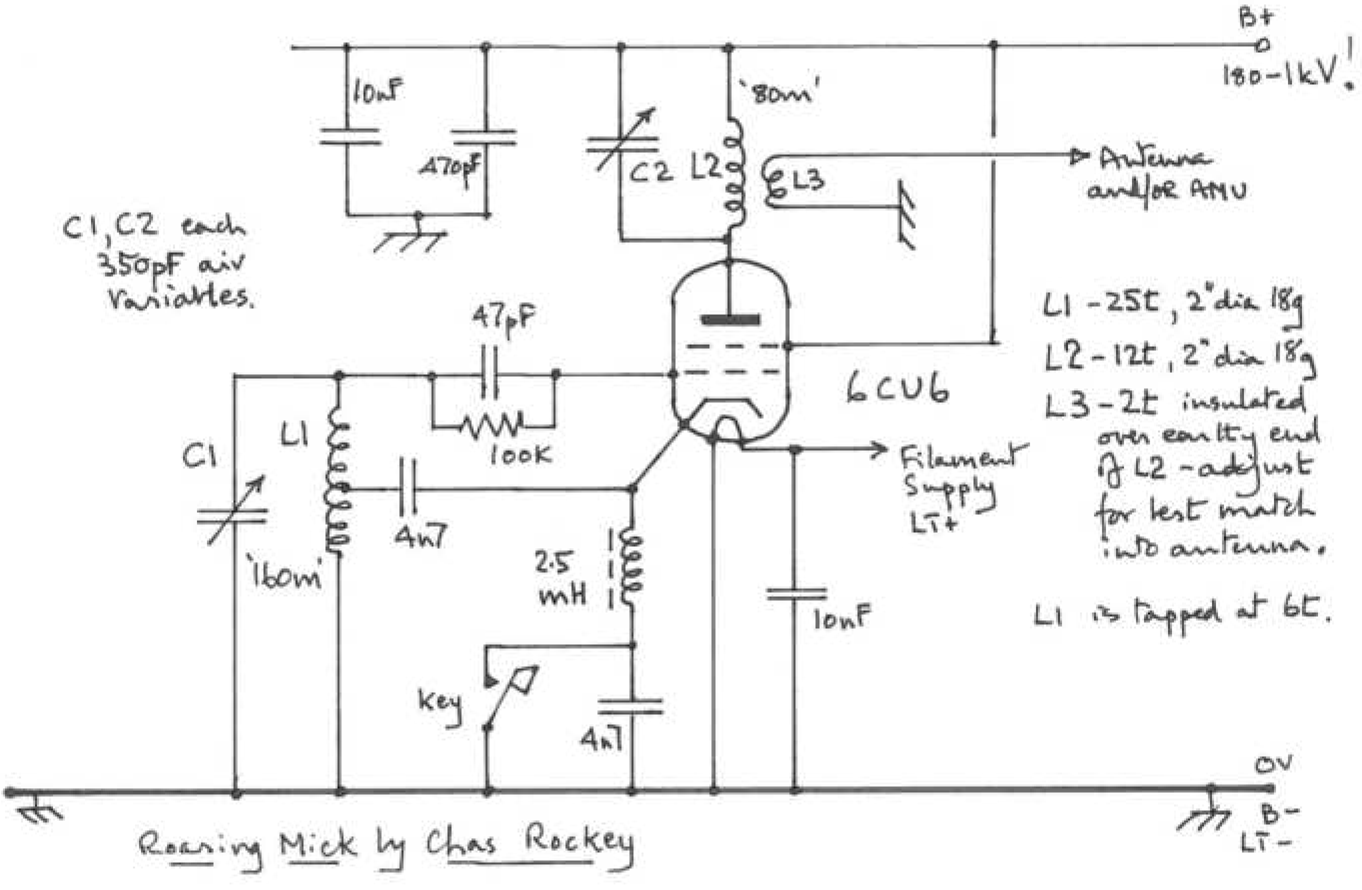
- Make the simplest, cheapest, "bomb proof" and safe 80m transmitter to drive *any* antenna and survive *any* fault conditions without damage
- Eliminate ALL variable capacitors as they are as rare as hen's teeth
- Adapt "Roaring Mick" for EL34's - probably the best beam tetrode ever made
- As far as possible "home made" using items readily available and cheap parts
- Test if a simple VFO is adequate for 80m service, CW and AM
- Adapt a ceramic resonator to run in a valve "VFO" oscillator without over-heating or damage
- Run A.M. phone using a MOSFET for cathode "efficiency" modulation

- Design the cheapest, safest power supply to run "Roaring Mick" to at least 50W output

I am hoping to give you my version of "Roaring Mick" in due course in a later Hot Iron!

* Chas Rockey W9SCH is unfortunately recently SK. His designs are no-nonsense with subtle electronics; he had great respect for radio engineers of bygone days, who had none of the technology we take for granted. He sent signals across continents and oceans with the simplest equipment, including.... tuned bedsprings. Now that's amateur radio!

This is the original W9SCH circuit:-



Peter has set himself some pretty challenging objectives! The avoidance of air variables is tough! He has a scheme for the anode adjustable inductor but I await with interest the VFO variable inductor! It is hard enough to make a fixed value stable L, but this task is much worse because it involves some mechanics usually! There would be a strong case for a 2 MHz ceramic resonator in the grid (VFO) position but pulling them down far enough for the AM usual frequencies might also be a bit too far! My own intentions to do some valve project starting with a regen RX have come to a temporary halt owing to the output stage transformer problem. I suppose I shall have to reconcile myself to using a small mains transformer instead – but any transformer with iron in it goes against the financial grain! Some would suggest using a semiconductor output stage like a LM380 or 386 but they don't glow! Enough rambling, too many other interesting ideas for the present – Tim G3PCJ

The Super FiveFET

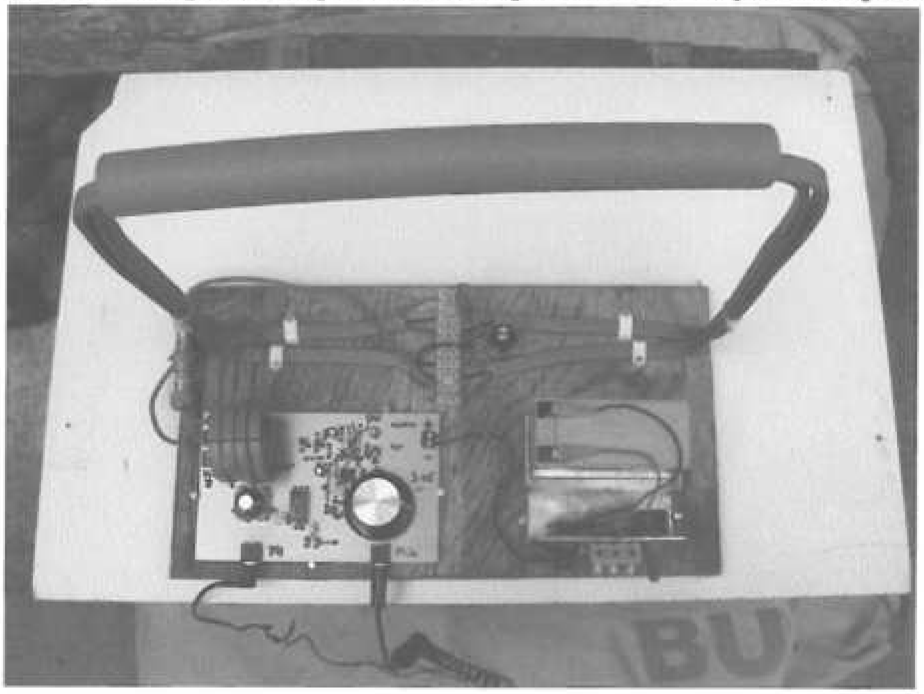
Ian DJ0HF/G3ULO has sent along some comments and suggestions – "I know that you consider the FiveFET an entry level Regen receiver but it impressed me not just with it's sensitivity but also how stable the oscillator was when confronted with strong SSB or CW stations. Most Regens tend to pull resulting in distortion on SSB and chirp on CW unless you attenuate the input signal but this effect is almost absent with the FiveFET. Also the coils are simple single winding coils. On that basis I decided to add coils for 5 bands 80/60/40/30/20 and see what else might be covered by accident in the way of broadcast bands etc. A quick check with a freq/LC program indicated that the coverage could be quite good.

I used simple chokes (from China) as the extra coils with a band-switch; the coverage then became 3.4 - 4.3 MHz with 15uH for 80M, 4.9 – 6.25 MHz with 6.8uH for 60M, 5.7 – 7.3 MHz with 5.0uH for 40M, 8.2 – 10.5 MHz with 2.5uH for 30M and 11.7 – 15.2 MHz with 1.1uH for 20M. So it has almost continuous coverage from 3.4 to 15.2 with a few small gaps. I could probably have added 160M but haven't done so.

I put the board in a plastic case and mounted the controls on the front including the Band switch, plus some other additions in the form of a Fine tune, Fine Regen control (very useful) and a pot in the antenna input as an RF gain. I put a photo on my website at www.spencerworld.com/Ian_and_Julie/Hobbies/Amateur_Radio/FiveFet_Regen/fivefet_regen. html As you can gather, what started out as a simple receiver to show my Grandson has developed into what I consider to be a really useful little receiver!"

The Wick or Mark!

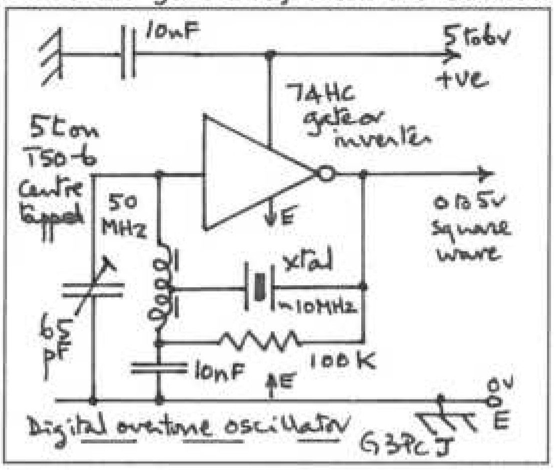
In the last Hot Iron I mistakenly called the Wick a Mark at the top of the note about it! For the Yeovil ARC QRP event at Sherborne, this year I put the Wick on a wooden board and was able to demonstrate it across the hall to a Brendon! Both are double sideband suppressed carrier phone TCVRs and both were using 80m loop aerials! The photo below maybe a bit poor but it shows the Wick with a loop aerial made of two complete turns of semi-rigid 1 mm mains triple and earth cable. They are threaded through the piece of pipe to form a carrying handle. The wires are connected with a chocolate block, using one wire turn for the low Z input from the Wick. Only five turns in series were needed for the main loop (resonated by a PolyVaricon) due to the high inter-wire capacity of the mains cable. G3PCJ



6m CW overtone TX

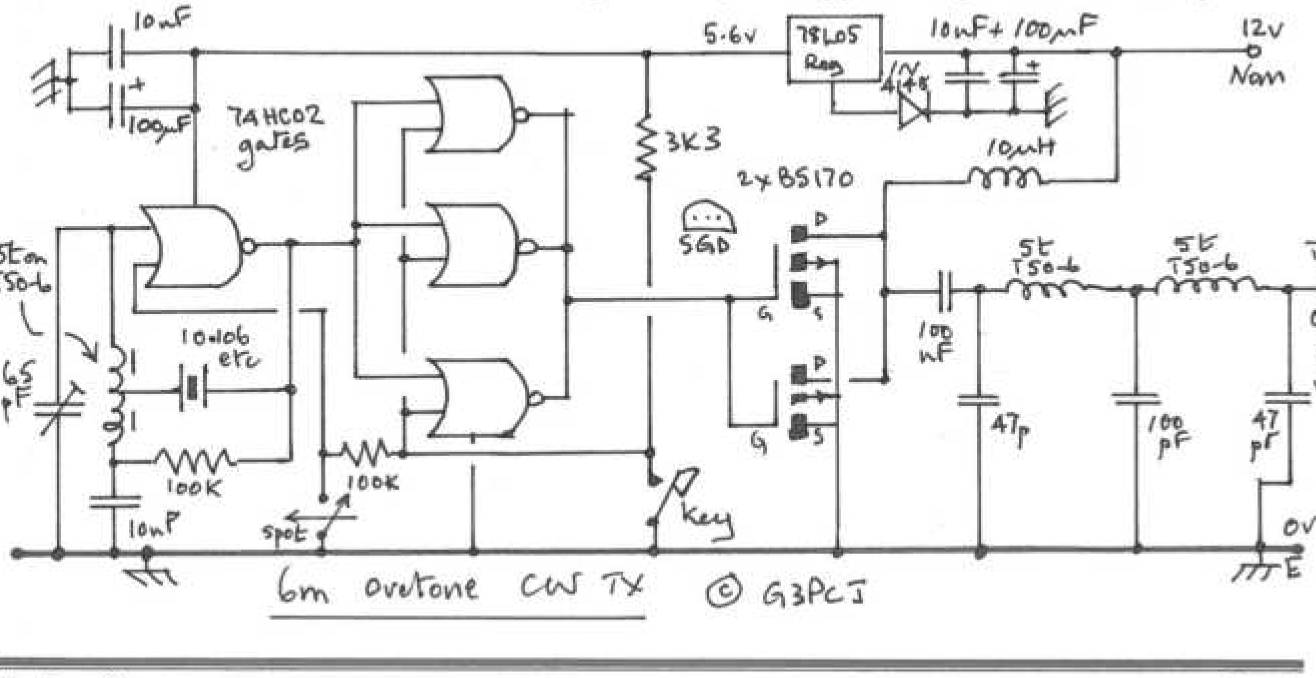
Over the years I have tried several ways of generating signals for 6m – I have to admit with only mixed success! Last year Peter Thornton pointed out to me that the fifth harmonic of the usual 30m QRP crystal on 10.106 MHz gives 50.53 MHz which is a good spot on 6m for all sorts of modes. One might also try pulling an ordinary 10 MHz crystal up a bit for CW! This led us both into overtone oscillators which I have always felt to be a bit of a black art; meanwhile Peter had a 6m overtone oscillator circuit that refused to work on any overtone for me!

So back to basic oscillator and crystal circuit ideas! At the back of my mind was the intention to drive the TX output stage digitally from 74HC gates which will just work on 70 MHz, especially if the supply is increased by a volt to two above the normal 5 volts. The crystal has to be in the oscillator feedback path and will exhibit low impedance (or pass signals) at its fundamental and odd harmonics. So how does one reduce the gain away from the desired harmonic? Often this is done by plain impedance loading of the crystal but that's the bit that seemed risky (or the black art) to me! Better to have a conventional resonant circuit tuned to the desired harmonic. Not as hard as you might expect with a plain inverting 74HC series gate! To avoid the tuned circuit interfering too much with the crystal, the latter is connected to a tap about a third to half way up the inductor. The DC feedback to ensure the gate amplifies in its 'linear' transition region is best applied to the earthy end of the coil to avoid the feedback resistor loading the tuned circuit. With care the 30m QRP crystals will run at 6 or 4m but layout does need to be good!



Using this approach in a 'digital' CW TX is straight forward (again with good layout)! One quad NOR gate of a 74HC02 can be the oscillator, with the other three driving a pair of BS170 MOSFETs, it will produce just over a Watt on 6m. The twin pi half wave filter gets rid of any harmonics and you could even contemplate amplitude modulation if that takes your fancy. The main parts of a CW TX are shown below but I leave the TR and sidetone for your creation!

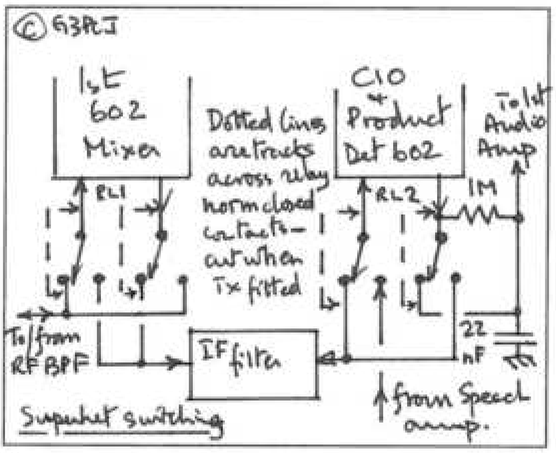
What RX could one use with this? AM will be easy with a regen and, if built well, might be stable enough. DC and Superhet RXs need something more advanced but one might be able to use the same gate oscillator to also drive a receive mixer. The question is then how to pull it a whisker for a beat note etc! I have not attempted that yet – suggestions please! Tim G3PCJ



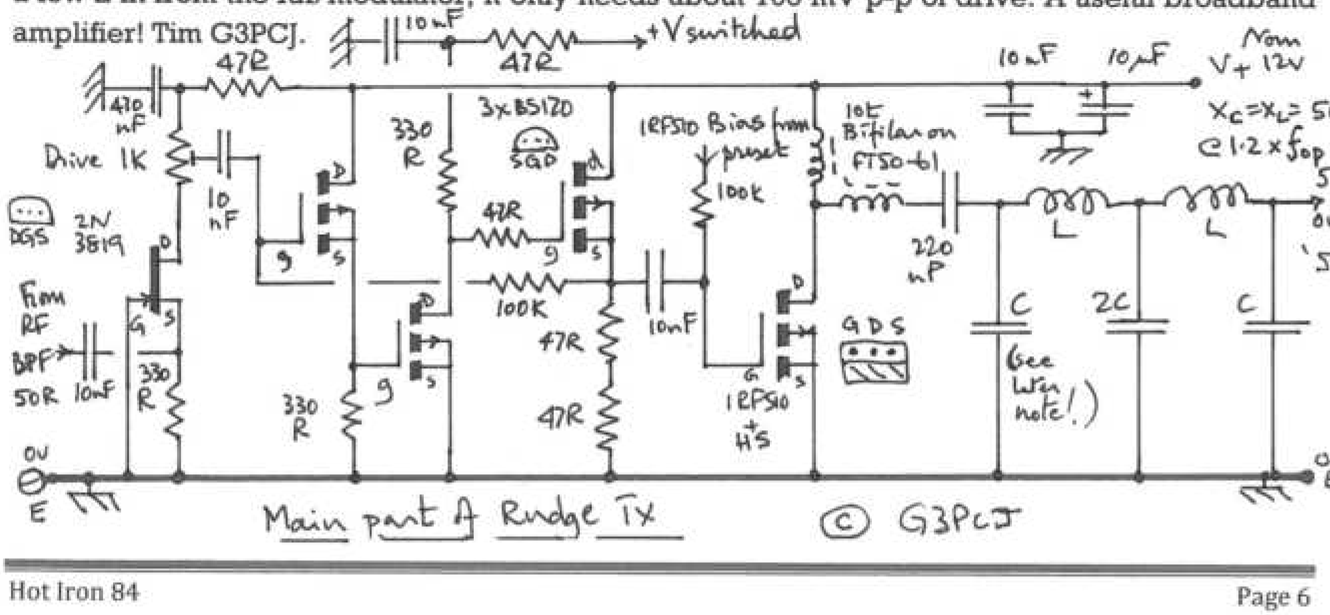
The Rode and Rudge

Steve Hartley has requested an easy build simple 20m superhet RX for his Buildathon events. My usual 6 MHz IF makes 20m not too difficult with an 8 MHz VFO; but 40m is hard because it needs either 1 or 13 MHz for the VFO. Thirteen is too high for good stability and 1 is too low for an easy VFO inductor! Hence we need another integer MHz intermediate frequency that can avoid these; using a 10 MHz IF needs 4, 3 and 5.5 MHz VFO for 20, 40 and 80m. These are the important bands and the lack of 30m can be tolerated when most interest is likely to be on phone. Richard Booth kindly made some suggestions for a four crystal IF filter which has been successfully tried by Philip Lock, so we have the makings of a new simple superhet RX.

While Steve's constructors might not get round to also tackling a TX on the same day, it would be nice to have a matching SSB TX provided it does not complicate the RX design. So I have suggested using relay switching of inputs/outputs of the two mixers, instead of the 4066 electronic switches that I use in other designs like Lydford and Minster. It is easy to add the tracks for these and include a shorting track across the normally closed contacts so that the RX would work without the relays being actually present. Those tracks would be cut when the relays are added as part of the TX construction stage! See this concept of the Rhode RX above!



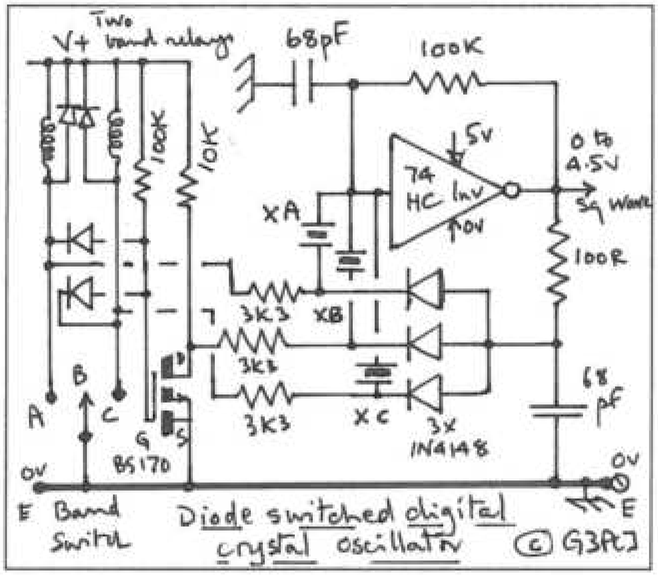
The Rudge TX PCB would have the speech amp, and all of the normal RF amp chain and transmit low pass filters (for any single band 20 – 80m), with its RF drive normally coming from the RX generating SSB on transmit. Interestingly, this only needs a 602 style mixer or modulator (as an alternative RF source) to make it into a simple double sideband suppressed carrier phone TX that might go with the Yeo or FiveFET simple RXs. Hence the need to keep the Rudge TX circuit simple to allow space for the optional 602 modulator. I had planned to use a high speed op-amp in the TX strip but three BS170 discretes both cost less and need less space! This TX amp is a development of my standard self biasing MOSFET pair that is so adaptable! By adding a buffer stage on its output it has good gain, a high Zin and a Low Zout. It easily drives the 150 pF capacitance of an IRF510 5W output stage on 20m; and when a grounded gate JFET is added for a low Z in from the RX/modulator, it only needs about 100 mV p-p of drive. A useful broadband amplifier! Tim G3PCJ.



The Marsh and Mells

Last time I floated some ideas for a new multi-band DC CW TCVR. The RX is now called the Marsh, and the matching TX is the Mells (photo on front page). The frequency scheme for the RX is a 2 MHz nominal VFO which is subtracted from band crystals of 5.5, 9, 12 and 16 for the 80 – 20m bands. The rig can be built for any three of these bands. The low VFO frequency gives excellent atbility. The RX has a low gain RF amp to prevent LO radiation and is flowed by a product detector using a pair of 74HC4066 switches to drive into a low Z audio amp, which is followed by conventional audio filters and output stage. Owing to the use of this strong type of mixer, it is expected that with just your good AMU, there is unlikely to be any sign of BCI – this saves the nasty complications of having to also switch a set of receiving bandpass filters. So band switching, by relays, only has to alter the inductor and capacitor combinations in the LO filters that follow the dual JFET LO mixer. After these filters the LO is squared up for driving the product detector and any associated transmitter.

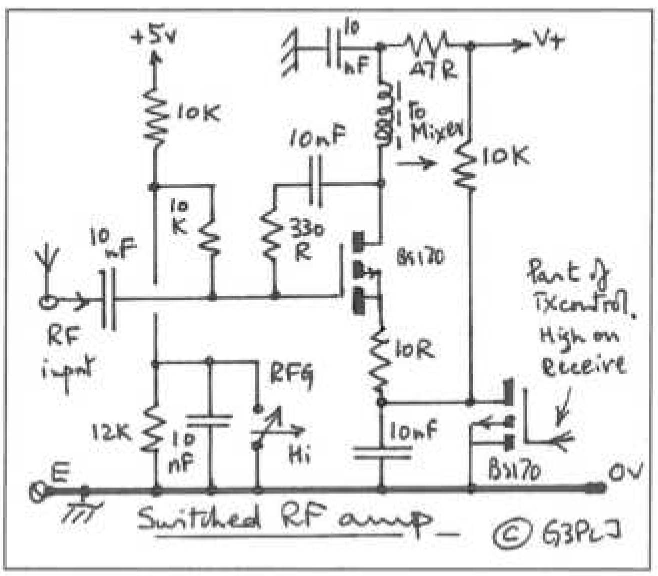
The Mells 1.5W CW TX is basically a crystal controlled TX but with the ability to be externally driven if a suitable LO source (like the Marsh) is available. Together they become a 3 band CW TCVR with full break in TR control. The Mells (with three crystals) might alternatively be used when paired with the three band Mark regen RX. The sketch right shows the method of switching crystals in the Mells' oscillator stage – it is slightly different to the normal method of diode crystal selection but is a more dependable circuit. The diodes associated with each crystal are turned on when the band relays (to select the relevant LPFs) are grounded so the extra BS170 detects the middle band when no relays are activated.



Diode switched digital crystal oscillator © G3PCJ

If necessary, the Mells can be used in single band form with one of the LPF relays instead acting as TR relay.

The Marsh does not need a TR relay because its RF amp can be switched off by taking the input BS170 MOSFET source to the supply voltage under control from the TX. The Marsh has a Fine/RIT control for selecting reception sideband and adjusting the beat note after the main tuning is adjusted to zero-beat the other station. On pressing the key, the Mells' controls automatically remove this small tuning offset to make it transmit on the other station's frequency. I would like an early builder or two for the Marsh/Mells combination – let me know if you are interested please. Tim G3PCJ



Switched RF amp © G3PCJ

Snippets

Linear experiments Paul Coddington has done a little more work trying out the VHF versions of the RD06 MOSFETs made by Mitsubishi. His previous info was with the HF versions. He appears to now have over 10W from the standard 10W Linear to over 30 MHz with about the same gain as at HF; however there are some uncertainties about the response of the harmonic filter(s) that he has been using – they may have had a corner frequency a bit too close to the 10m band edge! He plans more experiments when other matters allow more time! We await a report!

IRF510s and half wave filters The recent experiments with a new design of TX driver for the Rudge's IRF510 output stage, threw up a design point that I have overlooked - MOSFETs do have significant inter-electrode capacitances. The more powerful the device, the larger these are. For an IRF510, the usual concern is ability of the driver to move the 150 - 200 pF of the gate fast enough; I had forgotten the drain output capacitance which is typically about 100 pF when using a 12 volt supply! In a TX with a tuned output matching network, when tuning for maximum smoke, one automatically compensates for this effect – but not so with half wave filters. You need to reduce the first filter cap (nearest the IRF510) by about 100 pF if it is directly connected without any RF transformers for 1.5W out. With a 1:2 transformer for 5W out, the reduction required should be less but, experimentally, I still find that a first 20m filter cap of only 100 pF instead of the ideal 200 pF lifts the output appreciably (without worse harmonic output). It also calms the driver circuit greatly – less nasty squiggles! This could be changed on 20m Lydfords.

Windings in parallel Peter Thornton highlighted his bad experience years ago when paralleling two nominally same voltage windings on a mains transformer in order to extract more current than either winding could supply alone. During a soak test, the transformer became seriously hot **without** any load! It turns out that traditional transformers made with E and I laminations, seldom have identical output voltages from the same number of turns – this can lead to high circulating currents (and much heat) from even small differences in output voltage! Apparently the modern ones are often bifilar wound with much less variation between windings and can thus be paralleled! If in any doubt, test with a 60W bulb in series with mains input to prevent any damage from high circulating currents. The problem does not usually affect toroidal transformers.

***Mark** 3 band Regen* To fill a little space, this is what it looks like! It can be used with three band crystallised Mells TX!

Subscriptions!

It is that time of year again! Hot Iron is a quarterly newsletter for members of the Construction Club, published by Walford Electronics. This coming year, the fee is held at £8 for UK members and £10 for overseas. The year starts on Sept 1st 2014 but for anybody starting part way through the year, back issues will be sent as required. To keep it interesting, please let me have any questions, notes, ideas or suggestions for articles etc etc.. I need your contributions to make it interesting for everybody else!

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Autumn 2014 Issue 85

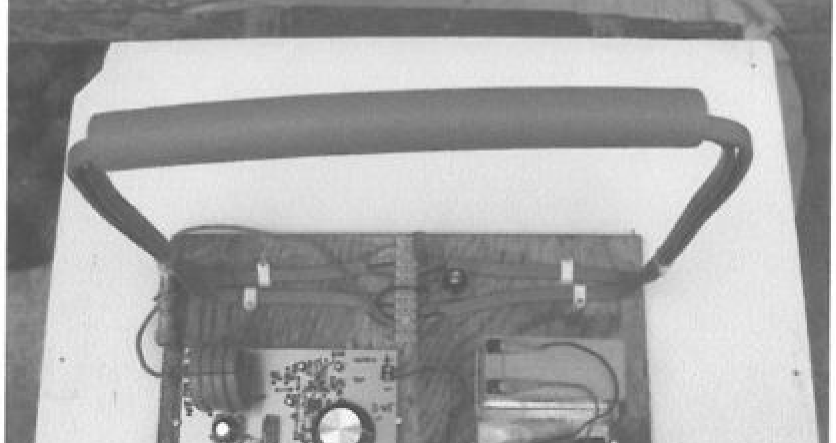
Editorial

Following on from Peter Cochrane's remarks about where amateur radio could head, the Chairman of the RSGB Board Graham Murchie GG4FSG has discussed how to get more (and younger) people into amateur radio and actively participating. He devoted two pages to the topic in the Aug 2014 Radcom to promote discussion and get people to send in ideas, which I did! I gather that I am not alone in suggesting encouragement of the building of radio projects. As ever, for youngsters and newcomers, price and convenience are the dominant factors. Hence my suggestion that the use of double sideband (with suppressed carrier) is the cheapest way to get on the air with voice, and a simple rig based on a SA602 mixer can be made to work both on reception and transmission. The Wick does exactly that and is consequently about the lowest cost method of getting on air. Using a ceramic resonator for the control of frequency (on 80 or 160m) provides a fair tuning range too, with little chance of straying outside the band!

Newcomers have little chance of making VHF gear work, whereas the MF bands are pretty straightforward. The main problem for these lower bands, is the size of normal aerials - but all is not lost! Magnetic loops can be made very effective and also quite simply constructed. So provided you don't expect to work DX, a simple low power rig plus loop is highly suitable for group projects where either across site, or across town contacts are desired/possible. I suggested that the RSGB should try to persuade Ofcom to allow fixed frequency very low power transmission under the control of suitably qualified teachers but I am told this is a no-no! By way of an example of what can be achieved, the photo below shows a demo set up that I made for the Yeovil QRP Convention this year; it is a COMPLETE 80m phone station – including rig, battery and loop aerial. I suggest that an RSGB badged project along these lines could go a long way to helping bring fresh people to the hobby! Tim G3PCJ

Contents Kit Developments, The High Ham, Roaring Mick update, MOSFETs & biasing, Wall warts, Supplies for 12v gear, RF Power measurement, Storage Batteries, Ring of Three amp, Nested Loop antennas.

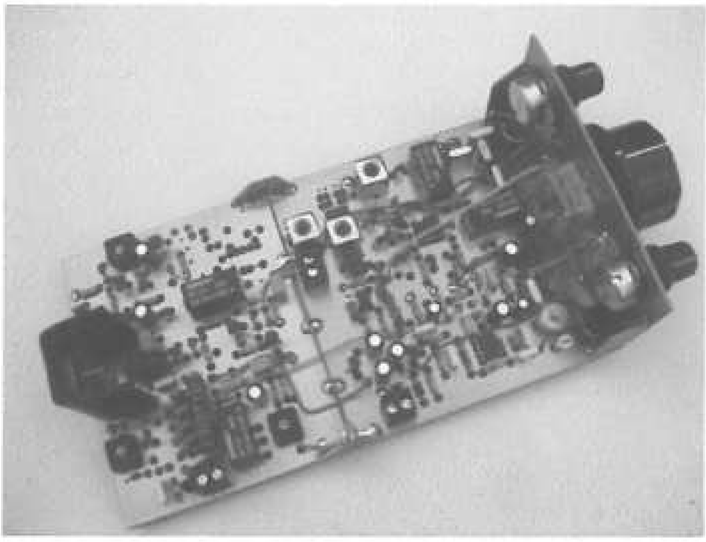
Hot Iron is published by Tim Walford G3PCJ of Walford Electronics for members of the Construction Club. It is a quarterly subscription newsletter that costs £8 per year. See the website http:// www.walfords.net



Kit Developments

Initial reports on the performance of the Marsh are encouraging. It and the Mells, which turns the Marsh into a three band full break-in CW TCVR, are available now.

I do now also have working the prototype Rode RX and its associated 5W Rudge TX. These are the SSB phone pair intended for Buildathon projects. See right. They use a simpler IF filter at 10 MHz and can do any single band of the 20, 40 and 80m group. Their novel aspect – relay switching of the RX IF strip for transmission – is working well. I am expecting Steve Hartley to be making one shortly.

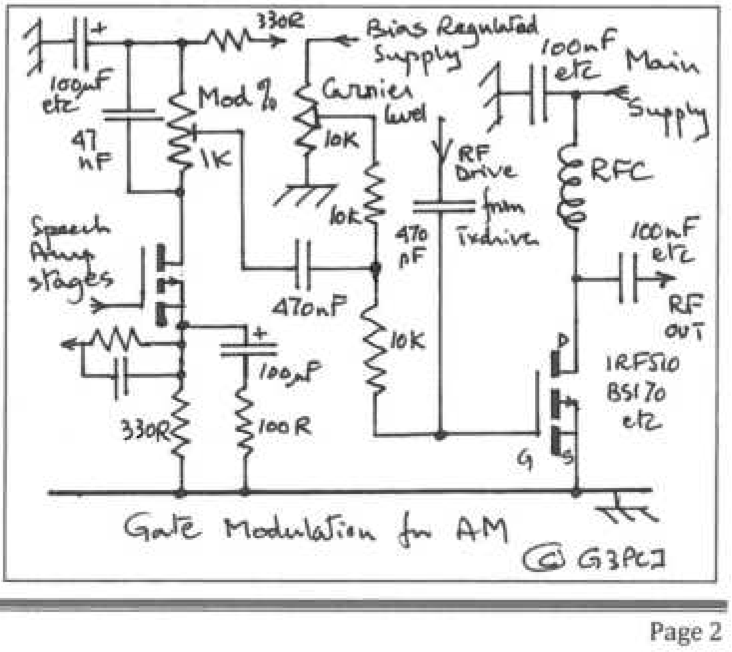


The High Ham

I have also laid out, but not yet built, the High Ham; it is a small TX and AM modulator. It is a bit of an experimenters kit! It has the digital oscillator, broadly as described in the last Hot Iron, with the ability to run with a ceramic resonator on its fundamental; or with a crystal on its overtone frequencies. In the desire to get onto 6m without a lot of hassle I have long been trying to avoid higher harmonics and so looked for a crystal that would get to 6m on its third harmonic. Luckily there is a 'standard' low cost one at 16777.2 KHz which gets us to 50.33 MHz; this will be much easier than using the fifth harmonic of 10.106 etc. I have ordered up a few of these crystals for experiments. For the output stage, which is digitally driven by three gates in parallel, I have given it the option of either an IRF510 with 1:2 transformer and potentially 5W out for the low bands, or a pair of BS170s for 1.5W on the higher bands to 6m.

The Cheltenham Club have expressed an interest in an Amplitude Modulated TX kit for a group project and so I have added that capability to the High Ham. The speech modulator is primarily a conventional pair of BS170s arranged as a feedback pair for biasing purposes; but to make the output levels into volts peak to peak of audio, I turned the normal source follower output stage into a common source amplifier with a gain of about 10. This is just the job for gate modulation of the output stage instead of the conventional AM arrangement of modulating the supply voltage. The very nature of AM requires the TX to run at one quarter of its peak RF output with no audio, or plain carrier; hence there is a fair dissipation all the time and the normal need for a watty modulator to drive the RF stage supply between 0 volts and twice the supply volts on audio peaks at full modulation.

Instead, with MOSFET RF output stages, you can apply the modulation to their gate with almost the same results. But because the gate is a high impedance spot, there is very little power required from the modulator, merely a few volts peak to peak to make the RF output go between zero and twice the carrier voltage level (and hence 4 times the power) as desired. This avoids power hungry modulators and audio transformers, which are like hens teeth nowadays!

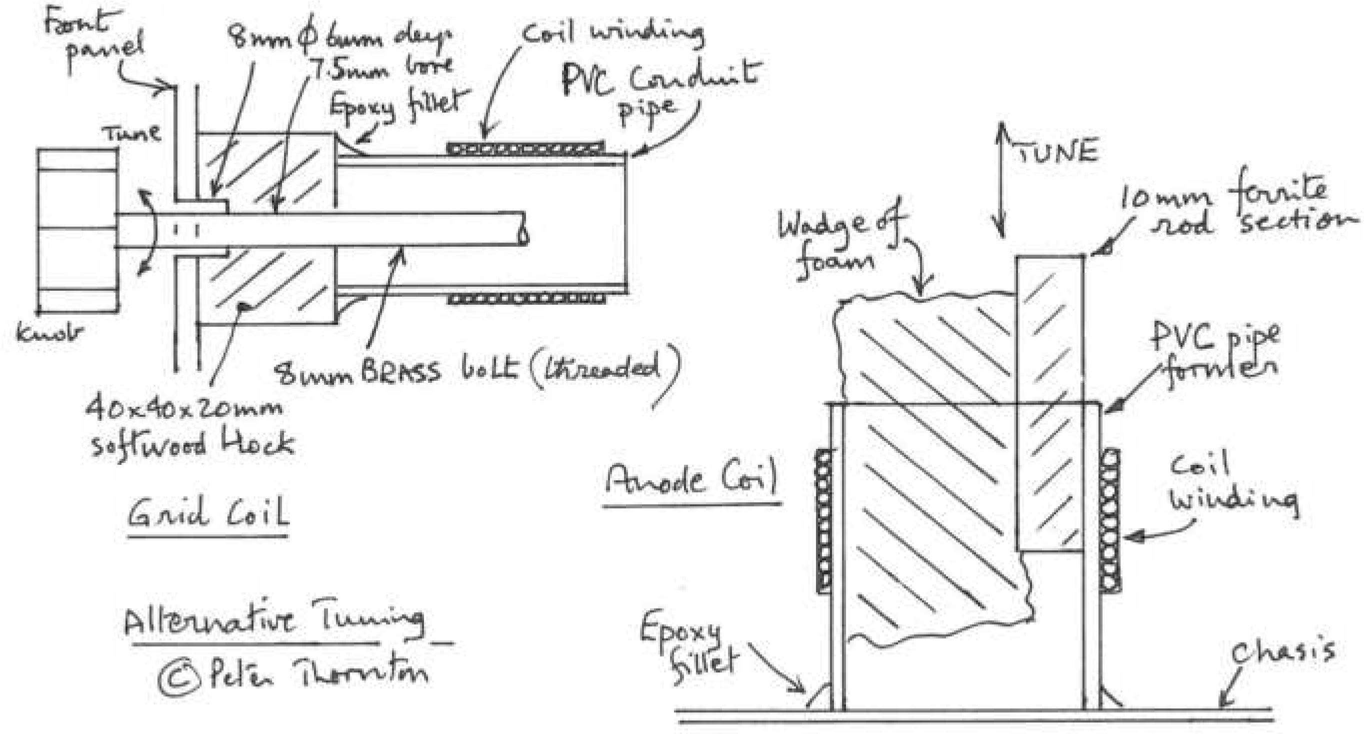


The Mark regen RX, which can demodulate AM, is the most suitable RX to go with the High Ham. G3PCJ

Roaring Mick Update - How to eliminate the variable capacitors – by Peter Thornton

The resonant frequency of a tuned circuit is given by the square root of inductance divided by capacitance; therefore if I eliminate varying the capacitance, the inductance is the only variable that can alter the resonant frequency. Historically, permeability tuning was much in favour being easier and cheaper than creating multi-section variable capacitors that tracked accurately. The manufacturers used iron / ferrite slugs to *increase* the inductance, with brass threaded inserts to *reduce* the inductance – thus each section of a multi-section tuner could be adjusted and trimmed to track exactly. I adopted the same principle with Mick: the half frequency grid coil had more turns than required, and an 8mm brass bolt effectively cancels turns to bring the inductance down. The anode coil uses a ferrite rod section, held in place by a foam plastic pad, to increase the inductance, thus tuning the anode circuit.

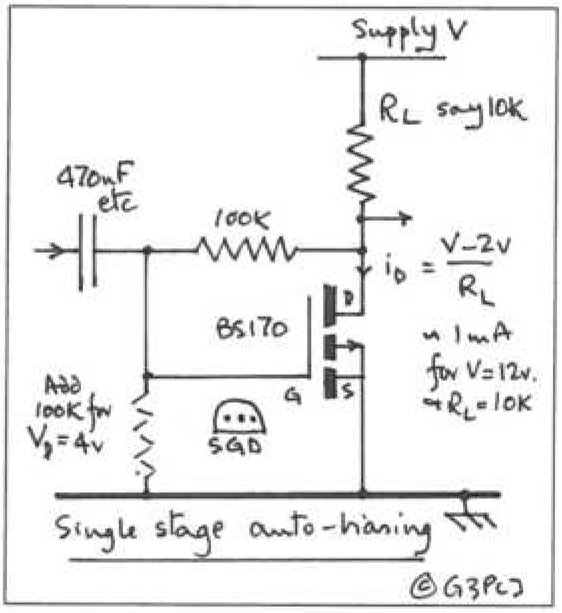
Initial trials have proved that expensive (and rare) variable capacitors are not necessary – permeability tuning is easy, repeatable and easily constructed without special tools or equipment. The anode coil tuner is self explanatory, the grid coil tuner is made by epoxy bonding a 40mm x 40mm x 20mm softwood block to the back of the front panel, and epoxy bonding the coil former to the block. A 7.5mm hole is drilled through, then the front panel and block are drilled 6mm deep with an 8mm drill to make a starter hole for the 8mm brass bolt. The bolt is lubricated with washing up liquid, and gently screwed into the 7.5mm through hole, using the 8mm starter hole as guide. This is done slowly, to avoid splitting the softwood block. This makes a smooth thread, which gives a micrometer action for the tuning. Initial trials using an ICOM 705 receiver show that the output frequency remained within 80Hz (after a 10 minute warm up, and the coil assembly enclosed in a simple pcb material earthed box) for over an hour. This is entirely acceptable for a one valve transmitter, with home-made tuning components!



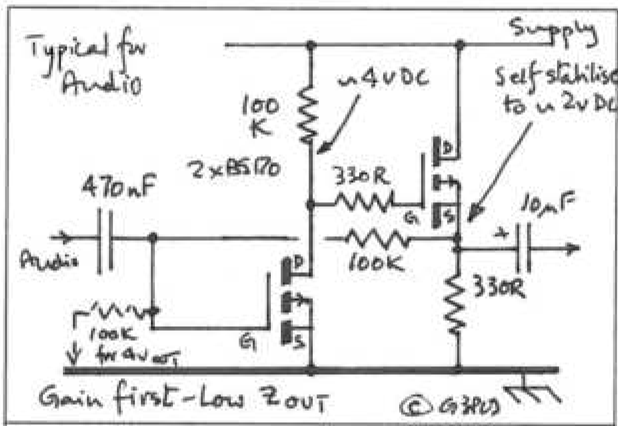
MOSFETs and biasing

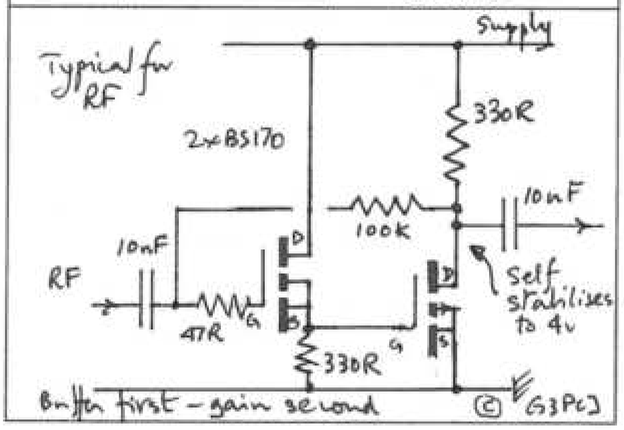
Those of you who have built my kits will know I am very fond of the small BS170 MSOFET. They cost pennies, can stand a drain voltage of up to 60v, max I_d of 800 mA (pulsed), dissipate up to 300 mW without a heatsink, have a R_{DSon} of less than 1.5R typically, forward transconductance of 320 mS, with potentially very high bandwidth (Ton/off of 10 nS) if you can overcome their gate to source capacitance which is typically 40 pF. They typically need about 2 to 2.5v of gate to source positive bias voltage to turn them on, which is what makes them so easy to self bias usefully! They are very versatile devices.

The gate bias current required is effectively zero with it looking like a capacitor, hence very high value resistors can be used to feed the desired voltage to the gate to make it conduct. The simplest arrangement for a single device is to connect the gate via say 100K to the drain and it will self bias with a drain voltage of near 2 volts; this leads to a drain (and source) current determined by the supply voltage less the 2v of bias, divided by the drain load resistor. For high gain, high output impedance audio applications the drain load can also be up to 100K. With this bias arrangement, the drain can only swing negative by 2 volts (but much more positive) so the peak to peak output voltage for most analogue signals cannot exceed 4 volts p-p. If more output is needed, then a gate bias divider can be used – 2 x 100K sets the drain volts at about 4v so it gives 8v p-p max output. A typical circuit is shown right.



The next stage of complexity is to add a source follower buffer stage and arrange that the two are self biasing by connecting them together in a DC feedback loop rather like the arrangements used for op-amps. The extra stage can be placed before or after the main voltage gain stage depending on whether high input impedance is desired or whether you need to get the output impedance down. See right. Placing the buffer first has most use in RF circuits where the high gate capacitance of the gain stage would be a problem without the buffer; in low frequency circuits as described in the first box, that capacitance is not a problem. Gain first/buffer second, and hence low output impedance, is a good speech amp scheme and both stages can be made to voltage amplify as in the High Ham – see earlier note in this issue.

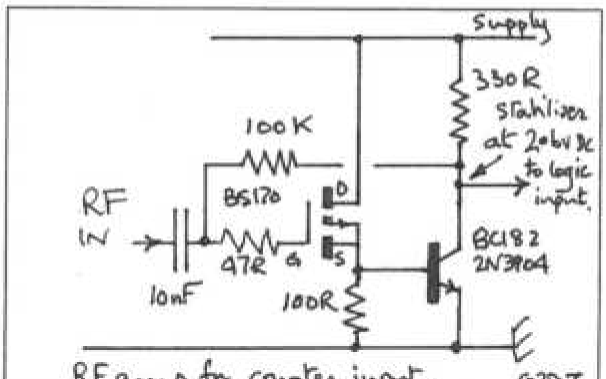




Continued over…..

MOSFETs and Biasing Contd

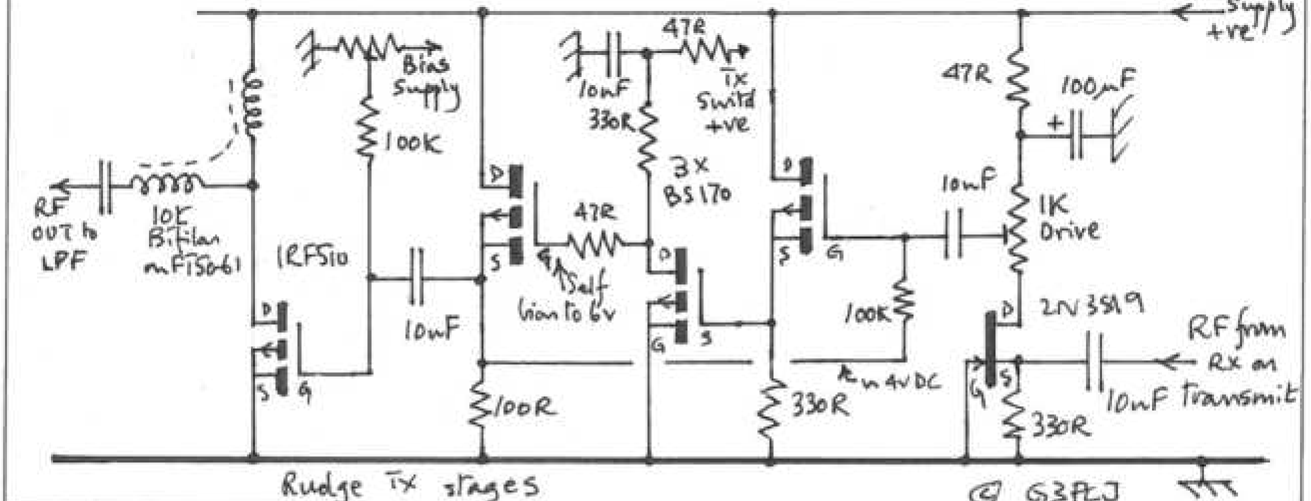
An interesting derivative of this two device circuit is to have one of them as a bipolar device instead of two MOSFETs. This makes their combined bias voltages (2 + 0.6) close to 2.5v which is of course the halfway threshold of digital circuits run on a 5v supply. Hence a pair like this makes a good high frequency amplifier feeding into a digital squarer stage such as is wanted at the input to a digital counter! See right!



RF amp for counter input.

I have failed to explain the presence (in these buffer stage circuits above) of the low value resistors in series with the gates, typically 47R,or more for audio applications! Due to the inherent capacity between gate and source of a MOSFET, any additional capacity from the load across the source to ground turns this circuit into the well known Colpitts oscillator configuration! Given their high gain and high speed, they will oscillate! Years ago I had an audio filter using a source follower that did not work as intended – it was actually oscillating at a few hundred MHz! So if in any doubt, always add a gate stopper resistor to a source follower. The corner frequency of the stopper and gate capacitance must be above max signal frequency.

The final elaboration is to add another source follower so that the three stages together have high input impedance, high gain and low output impedance. This scheme can then work much like an operational amplifier where the circuit gain and response are determined by the feedback elements. This is the scheme used in the Rudge transmitter where the feedback is really only for DC purposes and the gain is the maximum that the gain stage will provide. This can be high, by using a high drain load resistor (eg for audio), provided that the capacity of the following stage does not reduce the bandwidth below that desired. But for RF purposes, much lower drain load resistors are needed. In many of my superhet designs, the RF transmit signals are generated in low level RX stages so that after their RF bandpass filtering, the signal level is about 100 mV p-p with nominal 50R output impedance. This is well suited to feeding into a grounded gate JFET stage (which is self biasing unlike the MOSFET) with a Drive RF gain preset as its drain load. As that has an output impedance is about 1K, the total RF TX amplifier benefits from the third MOSFET buffer stage. With an input of 100 mV p-p, the four devices easily generate 5v p-p for driving the high gate capacity of an IRF510 TX output power stage. G3PCJ



Rudge TX stages

Wall Warts

Wall warts is the American name for the combined plug and power supply that is often supplied to power consumer appliances. These units are often to be seen at low prices at rallies and I expect that many a ham shack has a box full of them! They appear to come in four classes:-

- Switched mode PSU. As I have no experience of this type, it will not be discussed further.
- Cheap & cheerful. These consist of a transformer, rectifier and capacitor.
- Sophisticated. These are similar to the cheap and cheerful but they also include a three terminal regulator and maybe marked as being regulated.
- Fake. These are labelled as being regulated but are in fact cheap and cheerful. IF you open them up, they contain a PCB to take a regulator which has not actually been fitted. They maybe production rejects or a variety that has not gone through approval and is hence fraudulently marketed.

All of the above can be used in the ham shack. The first thing to do is to check the polarity of the output plug – most have the inner as the positive but not all. You need also to obtain the correct socket as there are many different diameters.

An easy way to check whether the output is regulated is to measure the off-load output voltage. If it is about 40% higher than what is claimed, then it is not regulated. If you have a scope, it is also worth looking at the output smoothing especially when loaded to the rated output. Anything with more than 20 mV or so of ripple at 50 or 100 Hz is probably un-regulated.

Now let us look at some uses. Some of my test gear requires 5 volts and this is provided by a three terminal regulator unit within the test gear. These can be powered by any of the above wall warts provided their voltage is high enough. The usual 5 volt regulator needs a minimum input of 7 volts and can withstand up to 20 volts or more depending on load current and hence power to be dissipated. If the wall wart provides the desired voltage, adequate current, and appropriate regulation then it can be used without any further ado. I happily run a communications receiver in such a way but a couple of extra capacitors were needed across the supply to reduce noise on the supply line.

Another thing that must be considered is the current that you wish to draw. I have no idea how these units are rated; for continuous or intermittent use? In practice this has not been a problem for me as none of my test equipment has needed anything approaching the rated current. As a guide line, I derate them by about 50% but the judgement is yours. Perhaps a reader may be able to comment.

Some wall warts look as though they could easily power a QRP station. Ultimately, how you use them is limited by your imagination.

Supplies for nominal 12v gear

Much amateur radio equipment runs off nominal 12v DC supplies but what does this mean? Many would say that the gear expects 13.8v which is the normal float charge voltage of a lead acid battery. Beware that car 12v systems can often range from below 10 to nearer 18v! Most equipment will often work from about 11 volts up to 15v before things go pop but do be careful with unregulated plain transformer, rectifier and large smoothing cap supplies. Their off load voltage can rise by 40% as Gerald mentions above. If the equipment has an internal 12 v regulator it is likely to need an absolute minimum of 14v and about 15v is more practical to allow for lead volt-drop; if derived from an unregulated source that input could rise to 21v!

In kits that need a regulated internal line, I often use 8 volt Low Drop Out (LDO) regulators that require a supply with as little as half a volt above the output. Provide the circuits supplied from the incoming main supply can stand it, the incoming supply range can then include 9 volt batteries up to the higher figures found in cars. But do beware of transients (low and high) when starting the engine! Best turn the radio off first! Do check the polarity too! G3PCJ

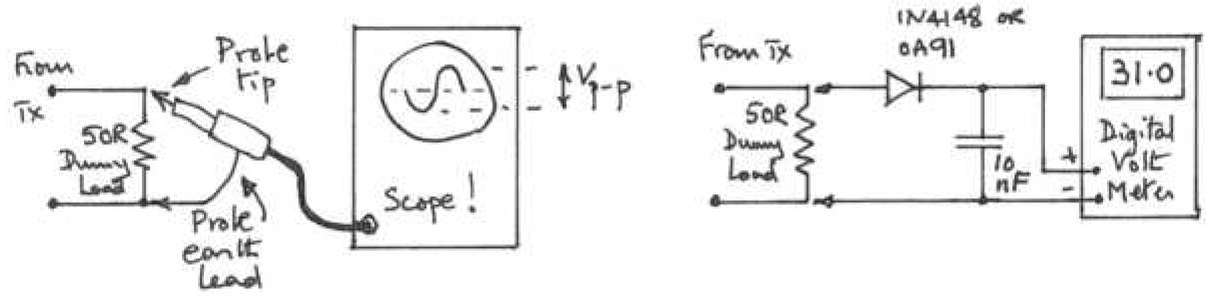
RF Power Measurement by Philip Lock

Many cheaper SWR/Power instruments are not very accurate when measuring low power. Here are two ways of measuring RF power, without the use of a power meter. If you have an Oscilloscope which is accurate at the frequency you wish to measure the power at, then connect the output of your transmitter across a 50 ohm resistor, and also the Y input of the scope – see below. The peak to peak voltage is read and then converted to RMS by dividing it by 2.828. Then multiplying it by itself, and then dividing it by the value of the load resistor.

Example - if the peak to peak reading on the scope is 63.2 volts. Then 63.2 divided by 2.828 = 22.348 times itself = 499.433 divided by 50 = 9.988, which is the power in watts.

If you don't have a scope, it can be done with a diode, 10 nF cap and a DVM or sensitive voltmeter. See circuit below. This measures the peak voltage to which must be added the voltage drop in the diode, and then converted to RMS by dividing it by 1.414. Then multiply by itself, and divide by the value of the load resistor.

Example - if the voltage reading on the DVM is 31.0 volts plus 0.6 volts for the drop in the diode if it is a silicon diode like a 1N4148 , or 0.3 volts if it Germanium diode like a OA91. Then 31.6 divided by 1.414 = 22.348 times itself = 499.433 divided by 50 = 9.988, which is the power in watts.



Power Measurement with Scope OR with Digital Voltmeter

©Philip Lock

Storage Batteries

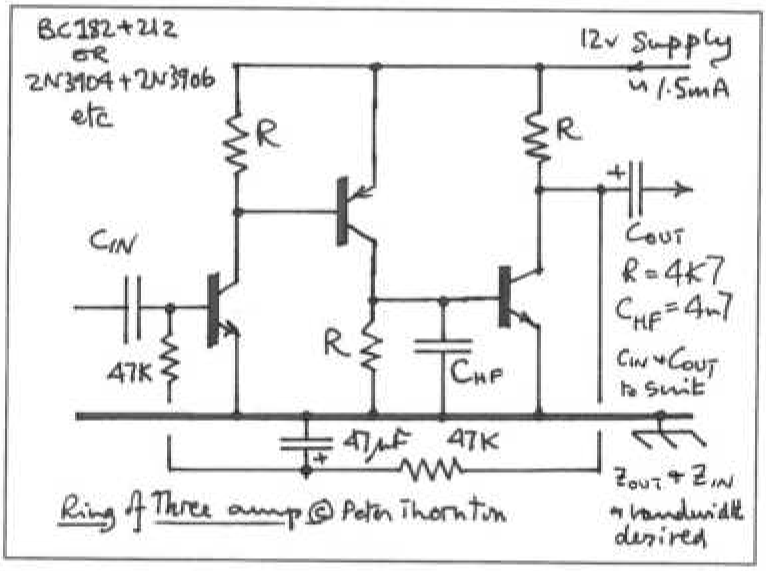
I read that a firm is developing a battery and inverter that will store the energy from a typical 100W solar PV panel of about 1.5 sq m during the day for off grid applications. The inverter has a power rating of about 4 kW (at 240v nominal) so that it could power the vast majority of domestic loads likely to be found in remoter situations. Is this a solar panel plus controller, large 12v battery and big ordinary static inverter? Useful piece of kit!

A second note points out the huge variations in solar PV generated electricity that the national grid has to cope with during the day, almost going from zero to a few hundred MW and back again in minutes! A team from Sheffield University is trialling a very large Lithium battery with bi-directional inverter/charger connected to the grid. Power handling ability is 2 MW, the battery is 800v with a storage capacity of about 15 MWHr & they are connected to the local 11 kV network. They intend to explore how these might operate at the sub-station level to even out grid demand which cannot be easily met from fossil fuel & nuclear generators that cannot be ramped up/down quickly. The alternative of pumped water storage needs much space! G3PCJ

Ring of three amp   By Peter Thornton.

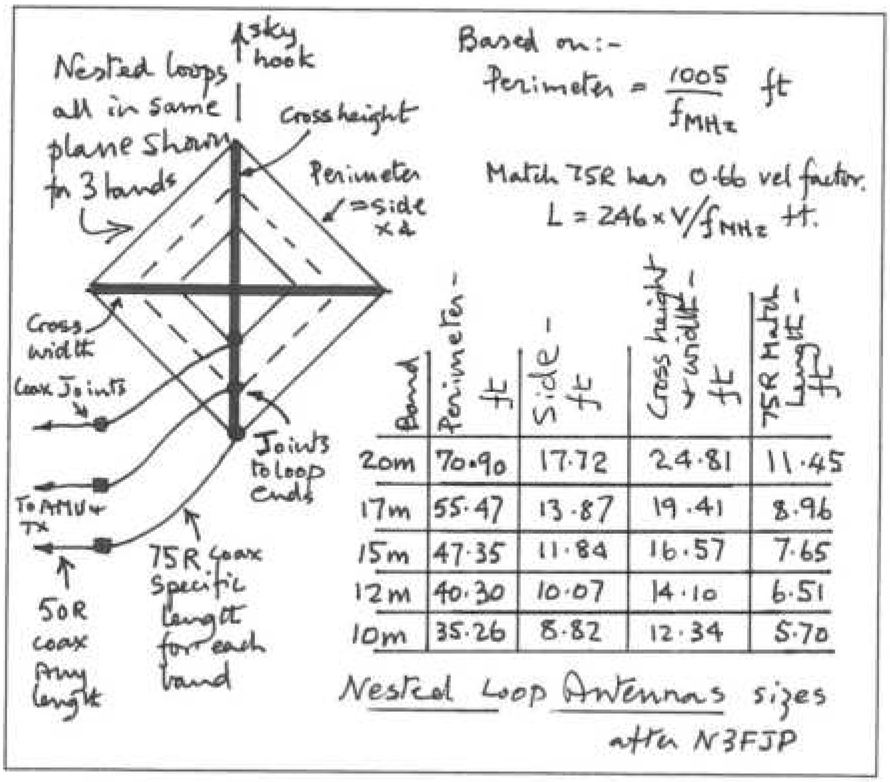
Much is made nowadays about the easy biasing power that MOSFETs allow: but complementary bipolar transistors can offer substantially simpler circuits if complementary devices are used. The direct coupling produces high gain, dc stability with minimal current consumption and low component count. Try that with MOSFETs....! Here is an amplifier which is very high gain (90dB), can run from 6 - 24v dc supply and is unconditionally dc stable. It consumes 1.5mA from a 12v supply with components as shown, and can use virtually any silicon bipolar complementary devices, but I'd recommend low noise audio types as the gain is so high. The gain can be engineered to any value required by adding an input feed in resistor, the gain then being the two 47k feedback resistors divided by the feed on resistor – as per normal op-amp and twin transistor buffer amplifiers.

Practical uses include the audio section of direct conversion receivers, the audio amplifier for a true TRF receiver and many other applications. You can engineer the frequency response easily with input capacitor and the third transistor's base to ground shunt capacitor; or devise (like op-amp filters) various networks to go in the feedback path. With the values shown, the amplifier will have a bandwidth of roughly 20Hz to 20kHz (depending on source and load impedances).



Nested Loop Antennas

Charles Wilson sends along a ARRL note by N3FJP about nested multi-band rectangular loop antennas mounted on a single rotatable pole. Each has its own 50R any length feed line which connects to a 75R matching section just before the loop, so that band selection is done in the shack. If you make it for all five bands (have as many as you wish), it is large & the windage forces will be large so a stout frame is required – that is the hard bit! Ideally you hang it from some suitable sky-hook! G3PCJ



Band	Perimeter - ft	Side - ft	Cross height + width - ft	75R Match length - ft
20m	70.90	17.72	24.81	11.45
17m	55.47	13.87	19.41	8.96
15m	47.35	11.84	16.57	7.65
12m	40.30	10.07	14.10	6.51
10m	35.26	8.82	12.34	5.70

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Winter 2014 Issue 86

Editorial

Further to my last Editorial about encouraging youngsters into the hobby, my thoughts have progressed a fair way! In discussions with Steve Hartley G0FUW, who is a RSGB Board member with a special interest in the topic, I am edging towards the notion that AM reception and later transmission maybe, are the way to go. Not too sure yet about what frequency to use but there is much to be said for using 40m or 160m. The former has the advantage that there is usually quite a lot of amateur CW/SSB activity but unfortunately the standard 7159 KHz crystals that used to be available are now extinct unless ordered in thousands. 160m does have 1834 KHz as a standard crystal which is still available, but it is often used for CW; there are AM nets on 160m and it might just be possible to do a receiver with the high frequency part of the MW and 160m in a single band. 80m also has active AM nets on 3615 KHz which can be done with a 3.58 MHz ceramic resonator but that might be less acceptable to OFCOM if any special permits were required. AM would allow the RX to be simplified, so reducing cost by omitting the regen stage of a rig like the FiveFET but that would eliminate the possibility of receiving CW or SSB, which is an important part of the introduction to amateur radio. As part of this exercise, I have developed the Forton AM TX that can do fractions of a Watt on a 9v supply (see photo below) – it is crystal controlled but can actually do any band 20 – 80m.

I don't now see aerials as the problems that I used in this application! A few metres of throw out wire will bring in the powerful AM broadcast stations on MW and 40m, and would do the same for a nearby low power transmitter using another short wire aerial, such as 'across a school playing field' etc on 160m. Give them both decent external aerials, when their builders are hooked, and the distances possible will leap upwards! There are many things to consider but a very worthwhile objective. Tim G3PCJ

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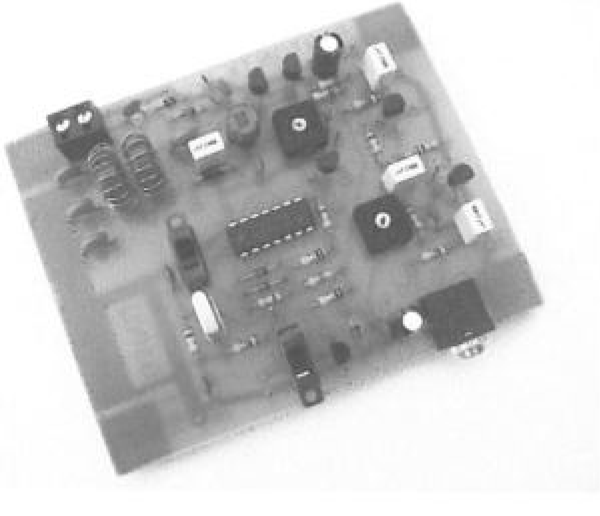


Hot Iron is published by Tim Walford G3PCJ of Walford Electronics for members of the Construction Club. It is a quarterly subscription newsletter that costs £8 per year. See the website http:// www.walfords.net

Kit Developments

After much experiment and the building a new prototype called the Star, I regret to say that the idea of using the RF and AF amplifiers for both reception and transmission in a single 80m low cost rig proved just too unreliable. End of the Wick idea!

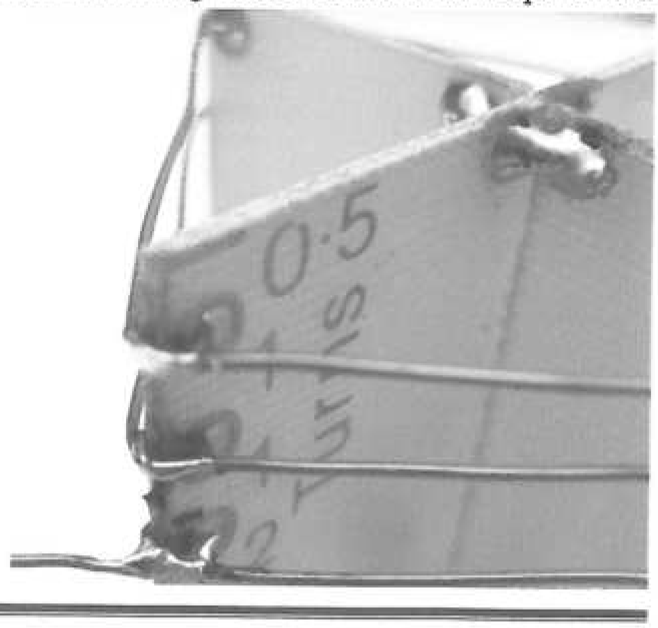
On a more positive note the new simple superhet phone Rode RX and Rudge TX are working well. Some early High Ham 5W AM transmitters (photo) are being built by the Cheltenham Club; this design can also do CW and has the ability to get on 6m at lower power with an overtone oscillator.

The Forton

This is a derivative of the High Ham described last time. Originally intended primarily for the bands 20 to 80m, with 'crystal' control but no trimmers for ceramic resonators so that it cannot be made (unintentionally of course) to go out of the band which is possible with some 2 MHz and 3.58 MHz ceramic resonators! It has AM as the primary mode but can also do CW. It includes TR control fro either the Yeo with a TR relay mounted on the Yeo, or without a relay for the FiveFET – the latter has had some very minor track modifications to provide the required interface connections but the actual RX circuit is unchanged. The Forton has reverse supply protection and will work with a supply from 9 to 15v but would normally be used with the PP3 battery of the FiveFET. It has a Net switch which turns on just its oscillator stage for netting of RX To the TX frequency. It also has a Transmit switch which is an alternative to the microphones PTT switch – I find the new CB style mics are more expensive than plain hand held 'ordinary' mics, but the switches on these are not able to act as a PTT switch, hence the need for an additional switch to control the rig on the PCB. Such ordinary mics often have ¼ in plugs and are supplied with a mono adapter that would short across any third ring contact of the common 3.5 mm variety, which I usually use for the PTT circuit!

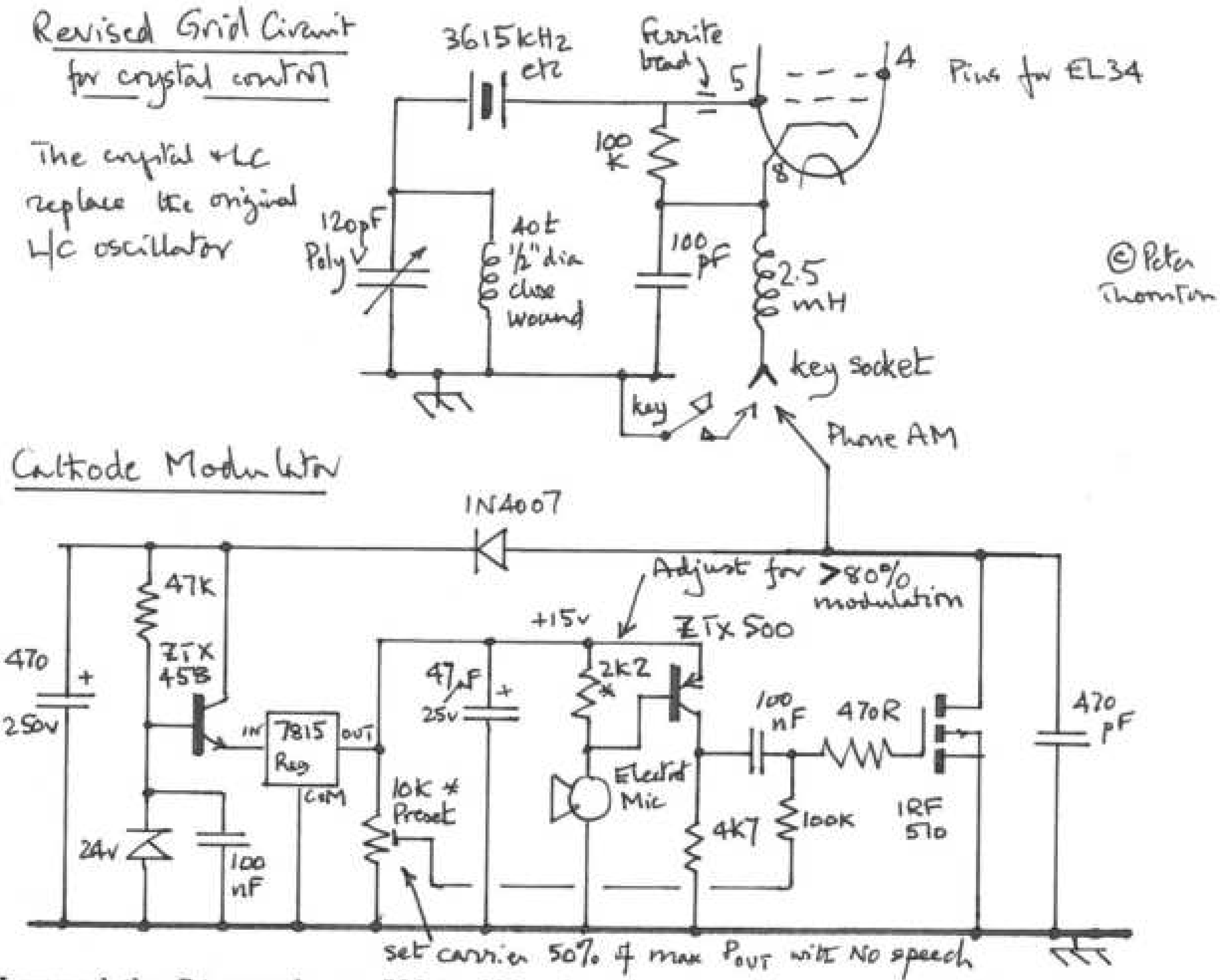
The new Mk 5A Antenna Matching Unit

Finding an alternative to the flexible multi-way PCB strap that I used to use for the coil in the AMU has been a challenge! My last design involved winding about 40 turns with taps onto a length of PVC waste pipe – this was quite challenging and took me several attempts before I had a half reasonable one. Much head scratching has come up with a far easier to make design based on a **X** form of PCB material former that can be packed flat for the post bag easily! The former also has holes along one edge to allow a small loop to be made for each tap; this allows the winding to be completed in stages between the taps without excessive wire lengths. The former material is joined at the middle of the cross and after the first turn has been applied, the arms then become quite rigid! Much better! G3PCJ



Mick Modulator – Simplest ever phone modulator – by Peter Thornton

This approach uses the original anode tuning of a fixed tuning capacitor resonated by a variable inductance. Amplitude modulation is produced by controlling the RF output from the valve's cathode instead of the conventional high power audio amplifier manipulating the main HT supply. The modulator circuit below is simply plugged into the normal key socket and does not even need its own supply! This is a case where semiconductors do work to advantage with valves! I elected to go for crystal control on 80m so bought a 3615 and 3625 KHz crystal from the VMARS suppliers; this needed minor alterations of the grid circuit, so while about it, I added L and C to give a small pulling range.

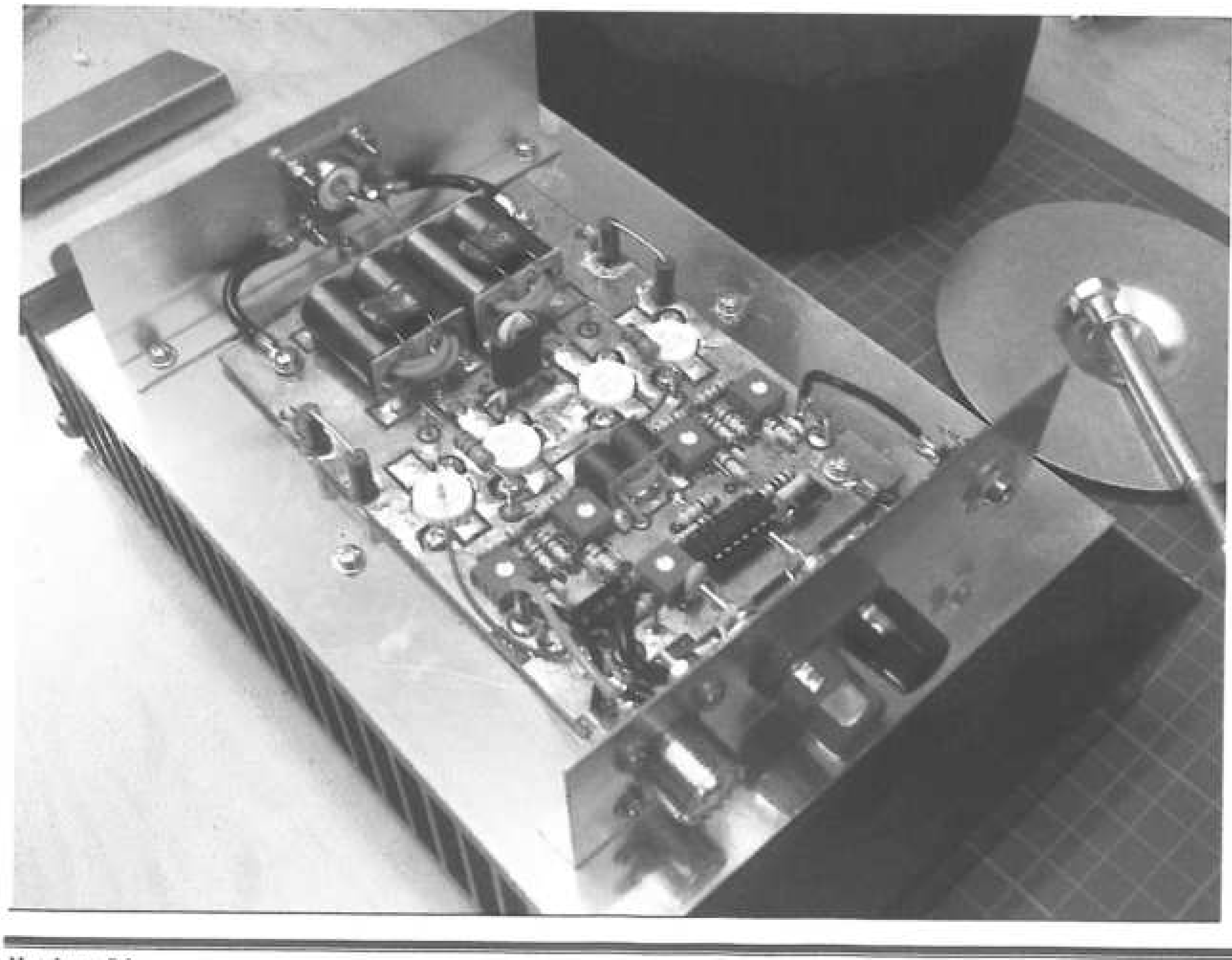


I upped the B+ supply on AM to 630v dc using a mains voltage doubler. The anode current max was around 80mA (max 100mA) so the dc input was about 50w, halve that = 20w in the carrier, 10+w in the sidebands, assuming efficiency is reasonable. The mic circuit capacitors provide good modulation with tight sidebands - a few hundred pF c-b on the ZTX500 clips the higher frequencies if the mic is better quality. You need to tune the anode up a bit quickly or the EL34 will bake bread! The peak AM output is just under the maximum possible with CW. The IRF 510 needs a heat sink - it's a linear regulator and has a few watts to shift.

Valve circuits like this are incredibly tolerant of abuse and "bung anything in" design - the circuits are simple, and to make sure nothing explodes on first power up, I connect B+ via a 40w mains light bulb. They can be very frustrating when they won't go - there's so little to go wrong! It's an old wife's tale that valve TX's blow crystals - just keep the grid/cathode resistor under 270k to keep the crystal's applied voltage down and make certain the cathode choke is a good one!

600 Watt Linear

Dan White and Steve Davies have been busy over the last year building some serious amplifiers! They found some Helge Granburg EB140 amplifiers on the web and set about incorporating them into a fully filtered and controlled multi-band outfit. Sadly Hot Iron is not large enough to be able to do justice to their project and their excellent write-up – if anybody wants to see the full note, I can forward it down the wire. Helge Granburg worked for Motorola for many years and produced several legendary designs of broadband high power semiconductor amplifiers, latterly using Motorola's watty MRF series of MOSFETs. This unit is one of them. The MOSFETs are the four white circular devices across the middle of the board, arranged in a parallel-push pull format; each device having its own preset to adjust its bias current. The challenge with these devices is to arrange the input and output RF transformers so that they overcome the high inter-electrode (not that they are valves!) capacitances. These RF transformers are actually assembled from multiple ferrite toroids on brass tubing to reduce the RF impedance of the primary 'wires'. Producing 600W with a 40v supply implies supply currents in the region of 30A with 50% efficiency – it is probably a bit better than that, but the connections have to be meaty and there is much heat to be dissipated! Dan found that good grounding and heat management was the key to solving most of their technical problems! The heatsink (under the devices) for the main amplifier is actually several times the volume of the amplifier circuit board! The complete unit has multiple inputs and outputs for various input power levels, with extensive switching of many matching indicators and a microprocessor to ensure that any untoward conditions result in immediate shut down! Needless to say, the design has very effective output harmonic filters for each band and extensive PSU arrangements! G3PCJ



From the Pesky Parrett to the Rode & Rudge by Steve Hartley G0FUW

Back in 2010 the Bath Buildathon crew decided to use a 20m version of Tim's Tone receiver for the annual Buildathon in January 2011. The receiver build went really well and everyone ended up with a working 20m superhet receiver. I tried adding a companion transmitter (the Parrett) but having been designed for 80/40m, it did not really have enough 'umph' for 20m and struggled to produce an SSB output above the QRPp level.

Tim did some reworking of the circuit and we managed to get it up to about 1W but the project became known as the 'pesky Parrett' and this radio began to gather dust. Then in issue 84 of Hot Iron I read of Tim's work developing the Rode and the Rudge as replacements for the Tone/Parrett combination. I tried hacking my Parrett to include the Rudge drive/PA circuit and I ended up with a good 3W output and after a weekend of popping on and off the bands I had 12 countries worked with just a city centre dipole; happy days!

Tim then provided the first of the Rode and Rudge kits for us to try. My 40m version went together a treat with a little over 4W output and probably the most stable free-running VFO I have ever built. Dan, M0TGN, built an 80m version of the Rode receiver and Mike, G3VTO, built the 20m version, both reporting good results. It looks like Tim has cracked it with a QRP SSB transceiver for less than £90.

We are using the Rode for the 2015 Bath Buildathon on Saturday 10th of January so there should be many more in use soon. (Get in touch with Steve if any of you wish to partake in his excellent Buildathon guided construction project this coming January – G3PCJ.)

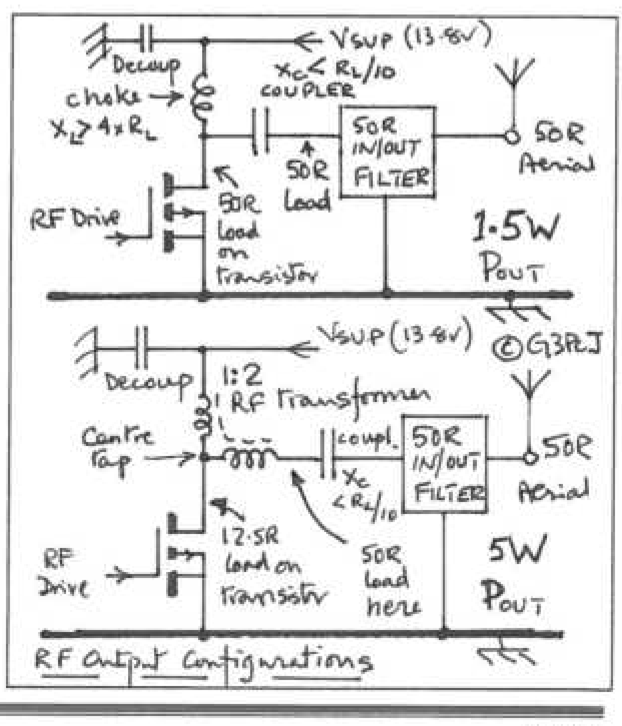
RF Ouput stage power

Often builders ask me if changing the RF output device of some transmitter to a higher power version will increase the RF output. The short answer is that generally it does NOT! It can sometimes make a very small improvement but this is a second order effect, and it can also increase the rig's reliability because the more powerful device will generally run at a slightly lower temperature. The reason that it does NOT materially affect the maximum RF output, is because that is determined primarily by the supply voltage and the load impedance presented to the output device. Steve Hartley, in a comment on some earlier article, reminds me that the power dissipated in a load resistor is given by these three formulas:-

$P = (V_{RMS})^2/R_L = (V_{pk})^2/2R_L = (V_{p\text{-}p})^2/4R_L$ This is because $V_{p\text{-}p} = 2V_p$ and $V_p = \text{Sqrt2} \times V_{RMS}$

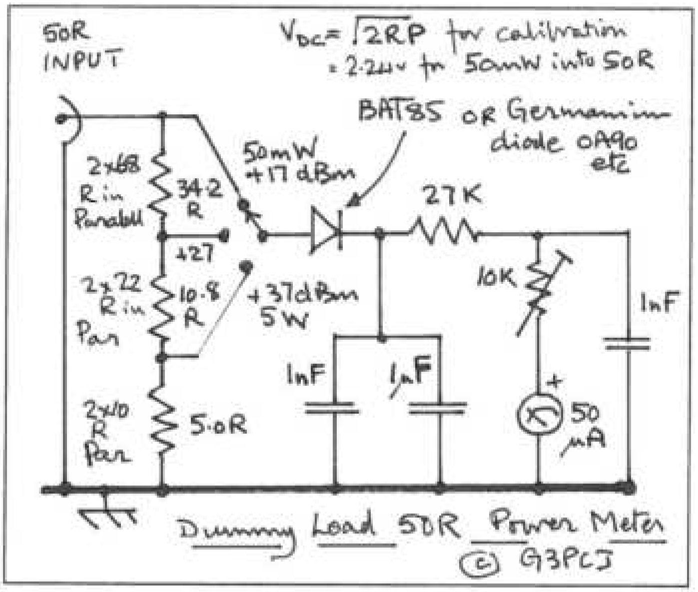
For a simple output stage like that shown right, the maximum peak output voltage is equal to the supply voltage and the load impedance is that of the aerial – usually 50R; hence irrespective of the device – bipolar or MOSFET – the maximum output is $(V_{sup})^2/100$; for the common 13.8v supply this comes to about 1.5W every time!!

If you want more out, you have to alter the load (or matching from aerial) to the RF device; the easiest way is to add a 1:2 RF transformer which transforms the load from the aerial to 12.5R presented to the device. Do the maths and this produces 5W as the maximum RF output that the stage can produce! Actual output in both cases is determined by the drive to the device. G3PCJ



Measuring RF output power

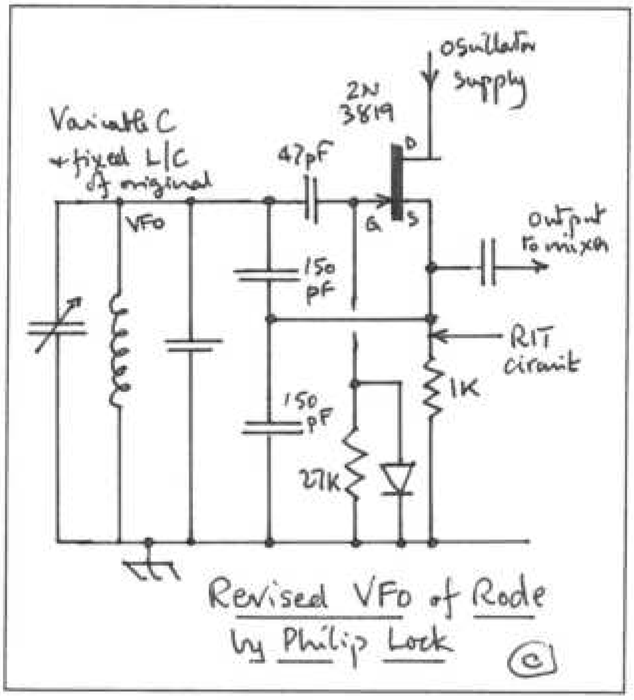
I hardly dare repeat this circuit right since I have put it in Hot Iron before! Its such a simple and convenient circuit that it makes a very easily made and useful piece of test gear. It is a PEAK reading RF voltmeter and 50R dummy load which you calibrate in readings of power – hence it has a square law indication for actual power in milli-Watts which makes it nominally linear in dB terms! It works right down to DC so that it can be calibrated by you with your DC voltmeter! The RF is applied to a 50R attenuator which is arranged for a 0, 10 or 20 dB (power) reduction in the reading. Calibrate it on the most sensitive range with a DC voltage from some adjustable source (that can produce at least 50 mA) when producing 2.24v for full scale; this corresponds to 50 mW or 17 dBm (i.e. +17 dB relative to 1 mW into 50R). Use the maths of the previous note! It can then read up to 5W.



Experience with the Rode

Philip Lock has had an early Rode which he built for 40m – all was well except that he occasionally had a bit of BCI from the adjacent 39m BC band at night. He tried reducing the value of the RF input filter top coupling capacitor from the suggested effective value of 3p4 to 2p2. The values in the kit are compromise of parts for the multiple bands and 40m is often tricky for BCI, so I am not surprised that Philip found that reducing the value to 2p2 did make a small improvement. This helps by reducing the bandwidth of the RF filter, so the out of (desired) band attenuation is higher.

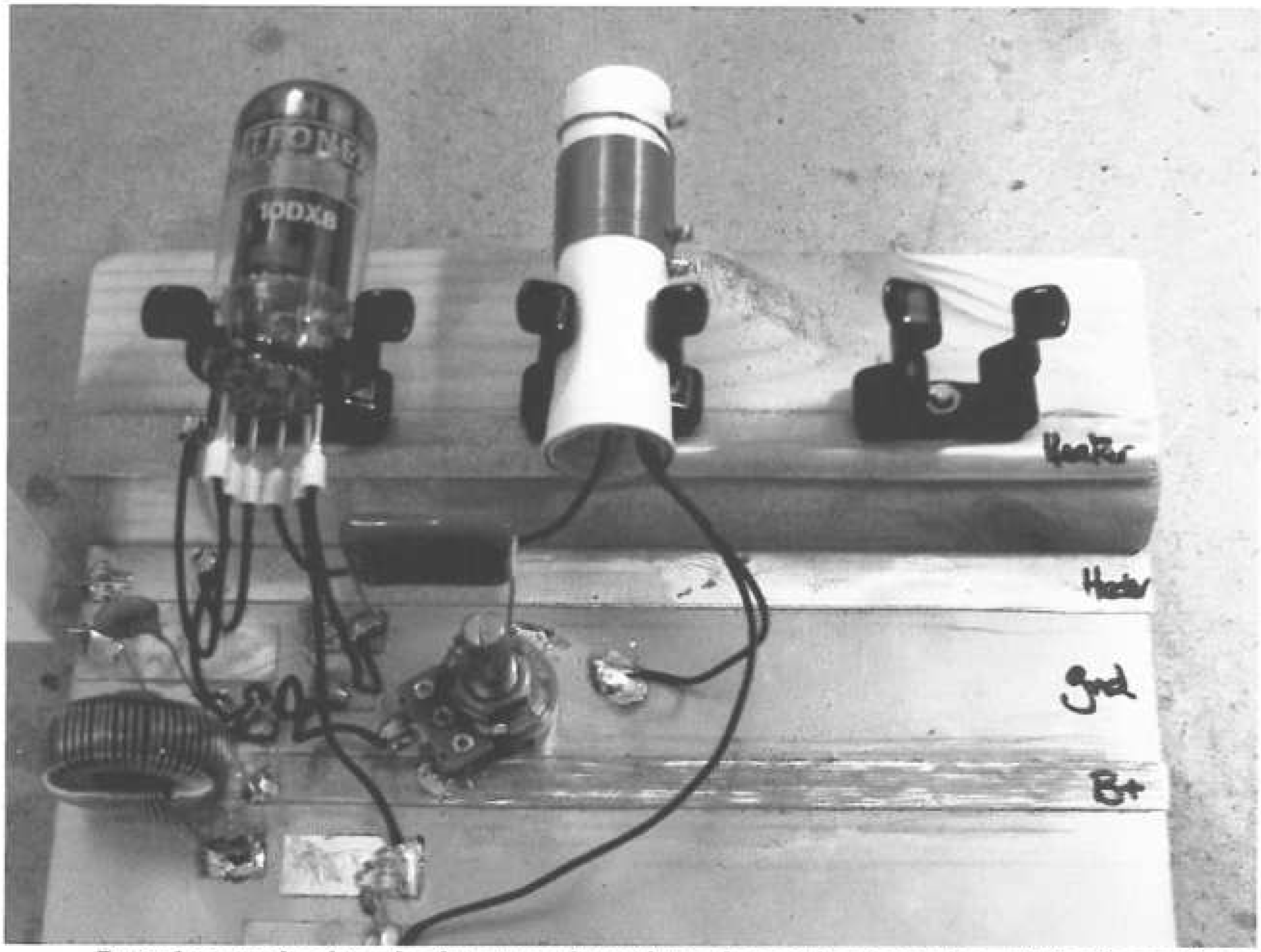
Unfortunately this did not entirely cure the problem! Further investigation led to alterations of the VFO Colpitts capacitor to provide a 'cleaner' output to the first mixer. I sketch right his revised circuit. It has the advantage of reducing the influence of the 2N3819 JFET on the resonant circuit because of the smaller coupling capacitor; he also reduced the JFET gate resistor to reduce the gain of the stage so that it only just oscillated. This cured the BCI!



I don't propose to alter the kit design because it has to work for all its possible bands and hence a wide range of VFO frequencies – I suspect this shows that reducing the LO drive to a 602 mixer also reduces its tendency to be overloaded by BCI. (Steve G0FUW's 40m Rode did not suffer this problem!) G3PCJ

Bread-boarding valve projects

Peter G6GNR sent this photo of some project - it appeals to me for its elegance & originality!



Peter has stuck a length of rectangular softwood near the rear edge of his piece of base copper clad laminate. He has screwed 'Terry' clips to the wood to hold the valve in place with an isolated copper strip under it for the heater supply. The valve overhangs the wood for better cooling! He has also used a Terry clip to hold his inductor in place, which looks as though it is wound on a length of plastic conduit pipe! Connections to the valve pins are by bootlace ferrules crimped onto wires and then slid on the valve pins – the size of ferrule being determined by the size of the pins of your valves. For these B9A valves, he used Rapid Electronics part no 33-1280 ferrules, for octal valves you will need larger ones. Do not worry if you have not got the correct crimping tool – just use the 'wire-cutting jaws' of ordinary pliers squeezed sufficiently to nip but not cut the wire and ferrule in two! Other insulated PCB strips can be used (stuck down) for the main HT supply which is labelled B+ in the photo; smaller isolated off cuts can be used instead of conventional tag boards for the other inter-component connections. As in transistorised bread-boarding, all the earthy connections are soldered directly to the main ground plane on base copper sided plain PCB. One could easily mount a vertical piece of PCB material along one side for the front panel controls – hold it in place with PCB triangular corner braces, soldered to the ground plane and back of the front panel; or use another rectangular piece of wood. Do the wiring tidily and it looks like a professional prototype! (I hope this photo from Peter copies well enough in black and white!) G3PCJ

Snippets

Extremely High Power RF amps You might think 600W peak power is enough but Pete Horrowitz reports in the May QEX on experiments he did with an IGBT AUIRG4045D made by International Rectifier. Its intended for low frequency power control applications in heating systems etc but he found that it had respectable performance on 20m! With 300v on the drain, he observed peak output powers up to 3.35 kW – in short bursts because of lack a large enough heat sink - this is from a D Pak device - about the same size as an ordinary TO220 device!

Paralleling of transformer windings I recall trying to parallel two windings of (apparently) equal voltage from a conventional (E & I laminations) transformer years ago. I got the phasing right by connecting the windings in series then testing the output voltage on no load. One way round = no volts (anti-phase); other way = double volts (in phase), so found the "start" and "finish" of each winding. Then I paralleled them, to get the sum of the winding's current capability, at the voltage of a single winding. BUT.... the transformer got extremely hot on no load. Then somebody explained that just a few mV difference in the winding voltages makes a very high circulating current in the paralleling connection. Modern transformers are (usually, but not always...) bifilar wound so similar windings have virtually identical outputs, so CAN be paralleled; but it always pays to check first by making the correct parallel connection then powering up the primary via a series 20W light bulb and give it a soak test. Any problems and the light bulb limits the current and no damage done. Toroidal transformer windings of equal voltage ratings are perfectly ok to parallel, because of the bifilar winding from the split ring shuttle winding method. G6GNR

Sprat DVD Graham Firth G3MFJ of the GQRP Club has kindly sent along their latest CD which contains all the issues 1 to 160 on it. It is an excellent reference work as Sprat is always full of fascinating ideas and circuits etc. All members of my Construction Club should have this - if you are not already a member of the GQRP Club you should be - its incredibly good value for money! Contact Graham, who looks after their Store at g3mfj@gqrp.com

Contactless Wireless Charging Linear Technology is developing a charger that does not require any complex information feedback path across the gap between transmitter and receiver even when the receiving device has been fully topped up, so they are much simpler devices. As is usual, such chargers depend on resonant loops for both transmitter and receiver with power being transmitted by inductive coupling, in this case at 120 KHz. The new scheme has a transmitter with just sufficient power for the worst case gap and power/time allowed for charging. The clever bit is how to prevent overcharging! This device does this by automatically de-tuning the receiving loop, hence receiving less power, when the job is done!

Happy Christmas

and all the best for

the New Year! Tim

"JOURNAL OF THE CONSTRUCTORS CLUB"

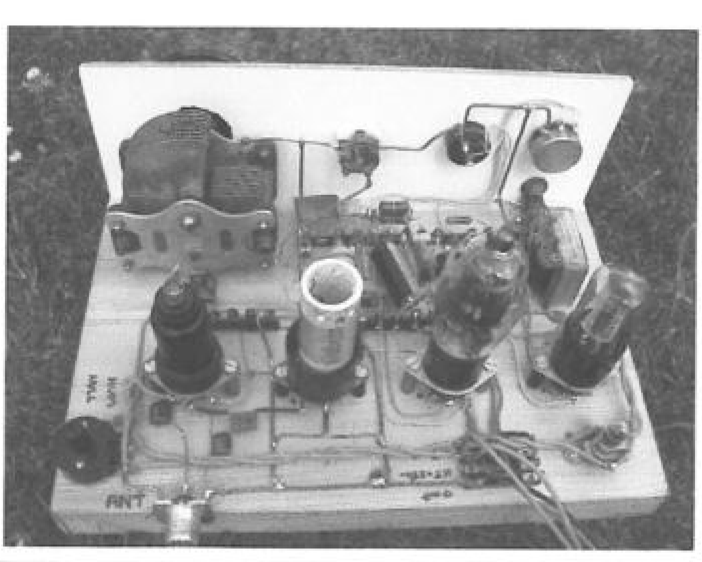
Hot Iron

Spring 2015 Issue 87

Editorial

Is the world really only 'digital'?! Of course its not but my eye was caught by an article in the Times entitled 'It's a litmus test – humans need to be hands-on'. This was actually about a serious proposal that examinations in school science subjects, which normally have practical experiments as part of their course, should be done by the candidate only via a computer screen – ie there would not actually be any practical examination, only questions (and suggestions) as to what would have happened if the experiment was being done for real! This is another example of where computing techniques are swamping our modern lives – nothing wrong with that for most people who are only using these gadgets; but for those of us in situations where some understanding of the underlying technology is required, it is often very much the case that the fundamental laws of that science are glossed over. The more that we get away from practical matters that are best explored in some sort of 'laboratory', the less the understanding of what is actually happening. Years ago when I was interviewing new highly qualified graduates for jobs in electronic engineering, it was striking how few had any concept of the effect of adding capacitance across a high impedance circuit – this was something I learnt on the 'bench' (and in my own radio den!) in a very practical and analogue manner. It was not something that I learnt solely from either reading a book or doing an exercise on a screen - we need to remember that the real world is actually analogue!

This leads directly into how we encourage more youngsters into our hobby. Some would say give them a PC with a dongle, or a Software Defined Receiver, straight away because this will attract their interest. I suggest that if somebody is to get the best out of such gadgets, they must understand a bit about fundamentals of radio techniques; amateur radio is a technical (not just a 'users') hobby so we must actively encourage an understanding of the real physical analogue processes that are involved. For this reason very simple receivers and transmitters need to be built and tried out by our 'new entrants', with them enjoying the success of using something they built, long before they are introduced to the wonders of the latest SDR piece of software. Examination theory and practical aspects need to be matched! Tim G3PCJ



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Kit Developments

More head scratching with Steve Hartley has led to minor improvements to the FiveFET to make it able to do the LF bands (as well as the medium wave) more easily. It can now do any one of the bands 20 to 160m just by adding extra resonating capacitors for 80/160m with the number of turns on the toroid adjusted to suit each band. This makes it a suitable companion for the new Fulford AM TX specifically which is specifically designed for new entrants. The **Fulford** uses a crystal or ceramic resonator to produce AM speech on 80 or 160m and will use the FiveFet's 9 volt battery. I am suggesting 160m AM (with initially throw out aerials) is the best approach to get youngsters interested – I hope with the help of the RSGB.

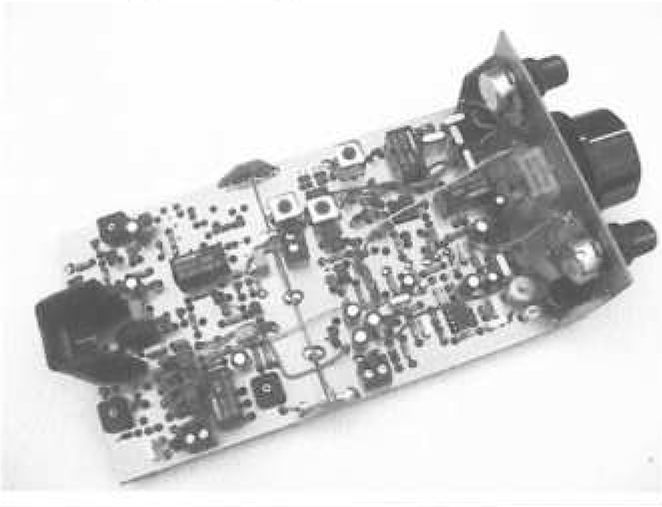
The **Low Ham** is a new 5W peak stand alone transmitter for CW **AND** AM on any band 20 to 160m. It uses a VFO in the range 5 – 6.2 MHz mixed with a 9 MHz crystal (and dividers) for any one of these bands – this approach gives good stability and freedom from chirp etc. This makes it suitable for brand X receivers as well as the Yeo for CW, and the Mark for AM speech. Currently the Mark is limited to the 20 – 80m bands, but I am contemplating an LF version that would do 40, 80 and 160m – a couple of early versions are being tried out.

Bath Buildathon

Steve Hartley reports that 'Eleven builders attended the 8th Bath Buildathon and built the Rode Superhet receiver kit from Walford Electronics. Six chose to build for 40m and 5 for 20m. Not everyone finished their kit on the day but comments received suggest everyone enjoyed the event and were inspired to do more radio construction in future. The receivers that were finished were pulling in European SSB signals loud and clear by the end of the day. The Bath Buildathon Crew are providing after event support to see the remaining receivers through to conclusion. Eight builders took away matching Rudge transmitter kits to turn their receivers into 5W SSB transceivers.'

Steve is kindly providing extensive follow up support for those who did not quite finish on the day. Subsequent reports suggest that nearly all of the uncompleted receivers are now working and that two of the Rudge transmitters are also up and running.

Comment by G3PCJ – Steve and his team of helpers do a fantastic job of assisting his builders during what often appears to be a quite challenging first ever electronic building project! Those of you who have had my kits will know that I insist of building the projects in stages, and then doing tests after each stage. Steve's approach goes even further by issuing the parts for each stage in separate envelopes which helps to reduce the risk of mistaken parts, and he often provides a photograph of the PCB for each completed stage! It is a mammoth effort to create this level of 'advice' and his candidates are very lucky.



The Rode is a phone superhet receiver, using a 10 MHz IF so that it can do any single band of 20, 40 or 80m. The receiver has relay TR switches which enable it to act as the single sideband generator when it is coupled up to the Rudge transmitter (right). The TX has an output stage which will produce 5W on a nominal 12 volt supply. Tim

Matching P-N junctions - by Peter Thornton

When building a diode balanced modulator, it's advised that the diodes be "matched", i.e. selected to be near as possible identical, electrically - by using a multimeter on "ohms" and choosing two diodes with equal or very similar "resistance" readings. But, as the old song says, "it ain't necessarily so"! Whilst multimeters will find two diodes of equal forward characteristics, they test at the current the multimeter uses for ohms ranges, and this more often than not isn't the current you use in your designs. My multimeter forces a current of 1mA, and measures the resultant volt drop, so a typical silicon diode, 1N4148, for instance, reads around 0.6 volts. Now imagine these diodes are to be used as the front end mixer in a receiver, driven by the usual buffer amplifier: The diode current might well be very different than 1mA!

Or, perhaps, the mixer is to be used in a transceiver, doing double duty as part of both the TX and Rx. The diodes may well have very different drive currents; from the local oscillator and buffer for Rx, and the audio buffer and microphone for TX duty. Two very different conditions!

Thinking of two diodes leads nicely to measuring transistor junctions, perhaps for checking functionality. The diodes inside the transistor cannot be differentiated - a multimeter can't easily identify collector and emitter, they both read identically at typical meter test currents.

Manufacturers go to great lengths to ensure matched diodes are identical over many decades of current - pico-amps to amps in some instances, measuring the forward voltage drop of the pair as the current is ramped up. It was in such a test set I noticed that extremely low currents, applied to bipolar transistor junctions, I could identify the collector and emitter. The emitter is substantially heavier doped than the collector; thus the forward voltage, base to emitter, is significantly lower than base to collector, and low currents will identify this - typically under 10uA. Your meter will need an input impedance of 10M or more to see these effects.

A test set up for our purposes uses very subtle and esoteric test gear: a 3.3M ohm resistor and a 9 volt battery! Connect the resistor in series with the battery positive (or PSU) and apply the other end of the resistor to the base, found by multimeter ohms testing, (assuming NPN; reverse the polarity for PNP). With a clip lead, connect alternately to each "unknown" leads of the transistor, and measure the voltage, base to lead 1, base to lead 2. The lowest noted voltage is the emitter.

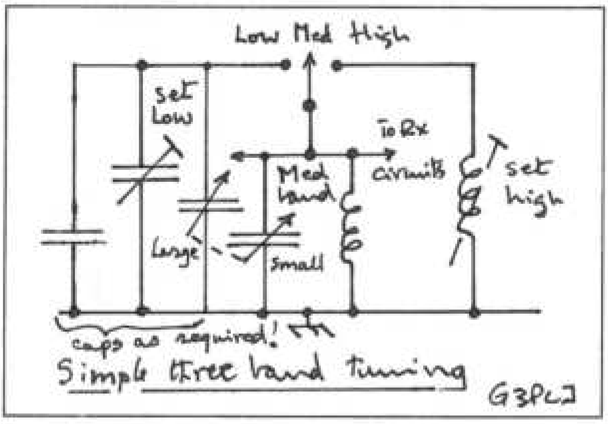
To match two diodes, temporarily connect the anodes, and apply the positive via the test resistor to the junction, and the clip lead alternately to the diode cathodes, as above. 3.3M, 1M, 100k, 10k and 1k test resistors will give 4½ decades of current, plenty adequate for amateur purposes, and measure the voltage across each diode.

This test will yield matched pairs of diodes, and carrier suppression probably won't be an issue in simple symmetrical mixers. You'll be able to see the doping structure inside transistors too. Some high voltage devices (BU208's and 1N4007 for instance) will give much higher junction voltage readings because of the P-I-N structures used to achieve high breakdown ratings.

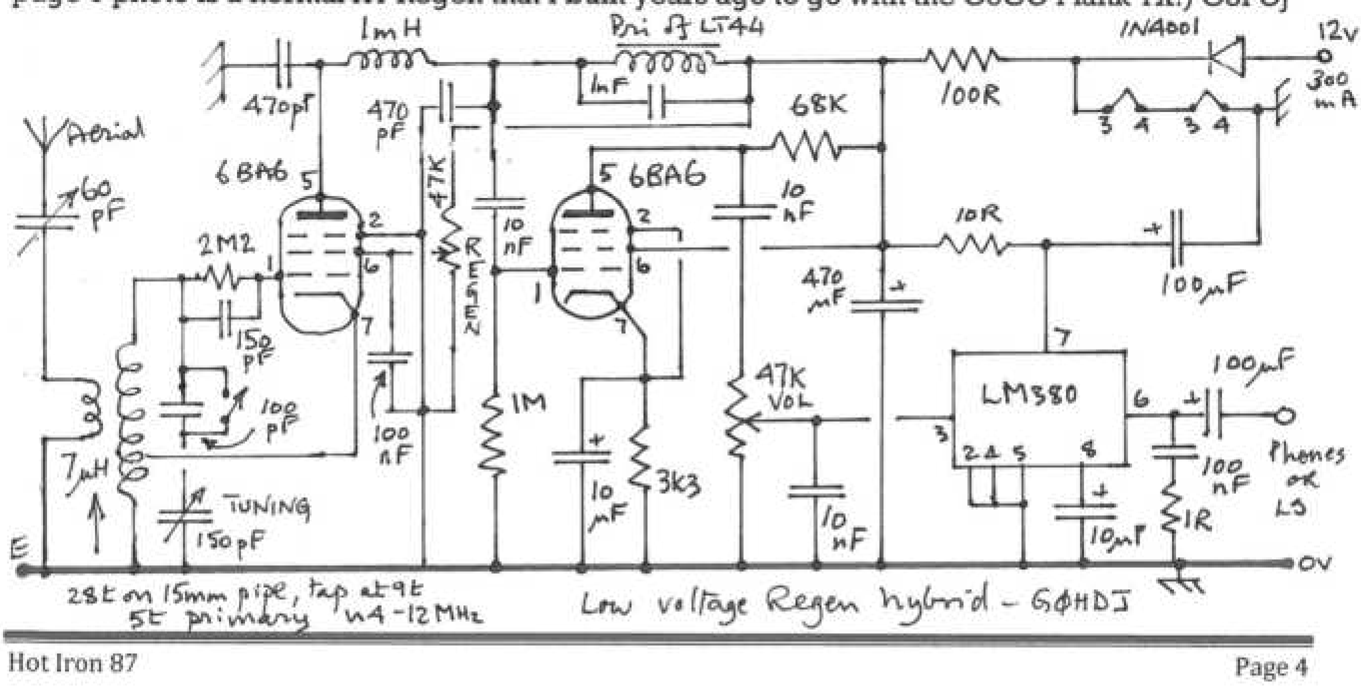
What a simple set up like this can't measure is the device capacitance, as we are using DC test currents. Matching junctions over many decades, DC and AC, is why matched diodes, transistors and SBL-1 mixers cost £££'s, not pennies!

Low voltage valved Regen TRF

This note follows a trawl through my raw material file for something slightly different! Its based on a circuit that Craig Douglas G0HDJ sent me a year or so ago. I love the simplicity of the Regenerative Tuned Radio Frequency (Regen TRF) concept where a single tuned circuit provides all the RF selectivity of the receiver! Absolutely great for multi-band projects – forget all those boring oscillators and mixing schemes with multiple crystals and band pass filters to get rid of all the unwanted mixer products! This particular design is single band; but a single pole centre off switch can add two extra bands very easily (see right). With the switch one way, a lower frequency band can be added by switching extra capacity in parallel; with the switch the other way, it adds inductance in parallel for a higher frequency band. In practice, the extra bands are usually limited to the adjacent amateur bands but it is so simple to do! The original LC values determine the central band frequency. The 'extra' capacitor and inductor should be adjustable so that they can be set for the two extra bands.



The design that Craig forwarded has a switched capacitor in series with the tuning capacitor – this is not part of a band changing scheme but is a method of reducing the variable capacitance so that the tuning rate is lower, making it much easier to tune – especially when there is no slow motion drive fitted! It uses the 6BA6 valve for the regen stage and the first audio – these just happen to have a viable performance with a 12 volt HT supply but every few volts of extra supply helps, so I would skip the supply protective diode! The classic problem of how to get a valved amplifier to drive a low impedance loud speaker (without an output audio transformer) is solved in this case by using a LM380 chip – some would say that's cheating! The other nasty components are the two chokes – the 1 mH RF choke is a quite large value for home winding, and the other one (regen stage audio load) is even worse! LT44 transformers are now a bit like hen's teeth! It is used instead of an inductance of a few Henries! Great for those who have them still in their junk boxes! The 'iron' needed for valve projects is their main drawback! (The page 1 photo is a normal HT Regen that I built years ago to go with the G3GC Plank TX!) G3PCJ



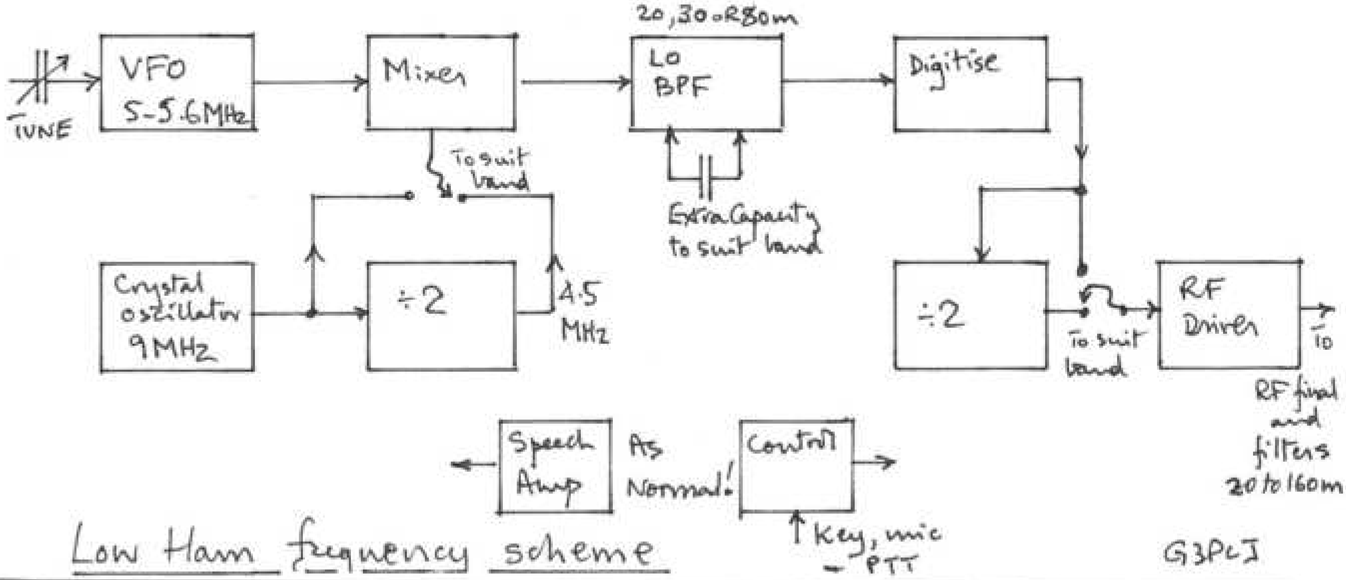
Low Ham *Frequency Scheme*

This single band rig is intended to be a companion CW transmitter for the Yeo 20 to 80m DC RX, and for those wanting Amplitude Modulated phone down to 160m. Its needs VFO operation, instead of being rock-bound! So the aim is a design for any band 20 to 160m with the minimum of extra parts for any particular band. 5W peak RF output seems reasonable, so that it will also do AM with a carrier power of 1.25 W peaking up to 5W on speech peaks.

With no need for linear transmitter stages, because CW and AM can be achieved by digital drive to the RF output stage (with following low pass filters), digital techniques can be used – in particular division. To avoid chirping on CW, the VFO must NOT be on the same frequency as the RF output – because it is almost impossible to keep the output RF away from a VFO on the same frequency: this is what causes the small changes in frequency when the TX is activated. Hence we have to use doubling, dividing or a crystal mixing scheme. 14 MHz is also too high for good VFO stability so the crystal mixing approach looks attractive.

Various crystal mixing schemes could be used to give several pairs of bands, but the classic 9 plus or minus 5-5.5 MHz has many advantages – this gives 14 and 3.5 MHz directly depending on whether the mixer adds or subtracts. The desired mixer output can be chosen by adding capacitance to a TOKO 3334 used in its output bandpass filter; so that only one set of mixer filter inductors are needed! The LO signal is then digitised so the mixer output becomes a square wave for driving the RF output stage. Enter the possibility of then also using digital division. The 74HC74 chip contains two D flip-flops that's can each be used to divide by two. The first divider would allow the 20 or 80m filter output to then become 40 or 160m. 30m can be done, without a material change in the VFO range, by using the other divider on the 9 MHz crystal prior to adding in the mixer. The block diagram is like this - G3PCJ

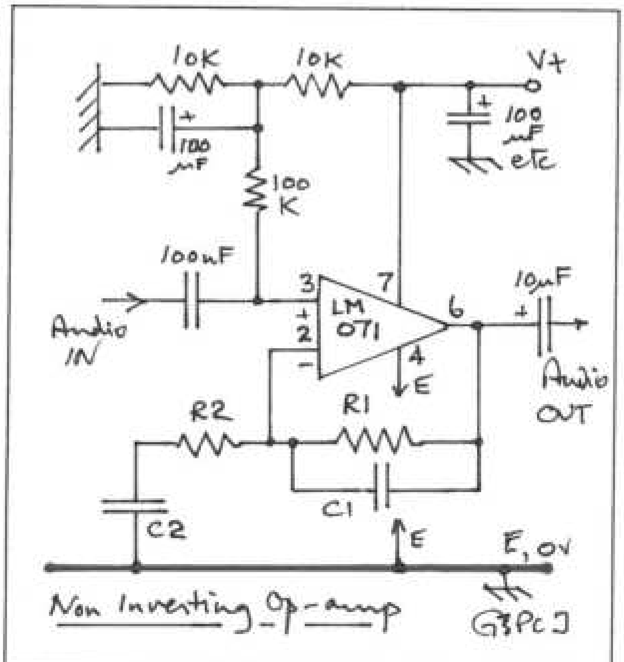
Band	VFO MHz	Xtal MHz	Xtal Div	Mix Sum	LO Out	Output Div
20	5	9	No	Add	14	No = 14
30	5.6	9	Yes = 4.5	Add	10.1	No =10.1
40	5	9	No	Add	14	Yes = 7
80	5.5	9	No	Sub	3.5	No = 3.5
160	5.5	9	No	Sub	3.5	Yes = 1.75



Op-amp Configurations

These very common and useful amplifiers can be used for many tasks - most often as low frequency amplifiers. With modern FET based devices like the TL071 (single) or TL072 (dual) or TL074 (quad) series, which have negligible input bias currents, one can ignore unequal resistance in the bias current path; for older ones like the 741 and its derivatives, the input bias current path resistances should be similar. The standard chips are TL08X but they cost the same as the generally better low noise ones, TL07X as above, so it is best to use these!

To allow the largest output amplitude possible, it is normal to bias the device's output to the middle of the supply so that the signal can swing an equal amount in either direction. This is done by connecting the positive input (ie the one that makes the output go positive when a positive change is made to that input) to a mid supply DC voltage – this can be derived from a well decoupled high impedance resistive divider. The TL07X series supply can be to 30v.



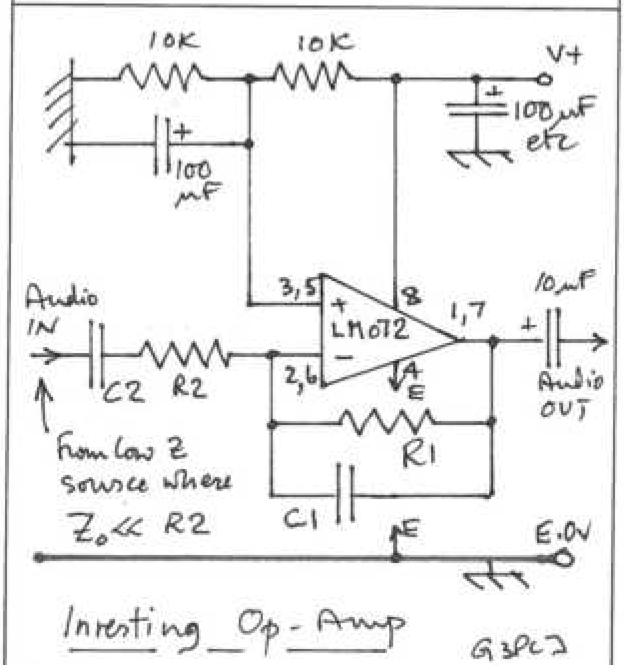
The two most common circuits are the non-inverting amplifier and the similar inverting version. In the former (see box right), the signal is applied to the op-amp positive input by superimposing it on the bias voltage. Gain is determined mainly by the ratio of the resistors connected to the negative input – the capacitors associated with them normally determine the upper and lower bandwidth:-

$$G_v = 1 + \frac{R1}{R2} \qquad f_{-3High} = \frac{1}{2\pi C1 R1}$$

For $R1=0$, $G_v = +1$ ie. buffer

$$f_{-3Low} = \frac{1}{2\pi C2 R2}$$

The output (with low impedance) is in phase with the input. Note that in the extreme (and very useful) case of the feedback resistor R1 being zero, the voltage gain is +1 meaning that it is a plain buffer circuit, with a low impedance output allowing the input to be from a high Z source.



In the inverting version, the signal is applied to the negative input. Bias is fed to the positive input. Gain is slightly lower (G3PCJ):-

$$G_v = \frac{R1}{R2} \qquad f_{-3High} = \frac{1}{2\pi R1C1}$$

$$f_{-3Low} = \frac{1}{2\pi R2C2}$$

SDR with the Realtek RTL2832 by Paul Tuton

It has taken me over a year of occasional fiddling when time has permitted to obtain a reasonable performance on the HF bands with this Software Defined Radio. It's not as simple as it might first appear! There is plenty of technical detail on the Internet - perhaps too much – and some of it is conflicting, so I offer these notes as a 'getting started' guide. Nothing more!

Hardware - the standard RTL2832 USB 'dongle' (from ebay/China ~£6) provides reception from VHF to over 1GHz. The lower limit is about 30 MHz but is just useable on 27MHz. Ignore the remote controller if sent but the small antenna is useful, also its cable can be cut to provide the right connector for the dongle.

Software - Three prominent applications are SDR#, HDSDR and SDR Console – all free off the Internet but do need a decent PC – I use Windows 7 on mine. Beware - these are all capable applications but because they are not produced to exacting commercial standards, they are intolerant of random button clicking, plugging dongles in/out for comparison etc. So try to be careful, especially when you first start otherwise you will probably have software crashes.

SDR# is the easiest to get working and is less sensitive to abuse. The installation routine is unconventional but it works. Pay attention to 'Zadig' which installs the correct drivers for this task. If your interest is VHF, then life is easy and it's the best way to start. Once SDR# is installed and is 'seeing' your dongle, select Wideband FM, tune to a local VHF broadcast station and it should work. You can also try near 433MHz – lots of bleeps, data etc from domestic WX station senders and the like operating in the un-licensed device band.

HF reception - When I started, the accepted way to receive HF was to place an 'up-converter' between the antenna and the dongle input. Search 'Ham it Up' (~£35). It's a broadband mixer with a 125MHz oscillator so by tuning SDR# between 126MHz to 155MHz you cover 1 to 30MHz. However, this starts to get complicated with more bits and pieces hung together with a mixture of incompatible connectors and patch leads. I found it hard work and the 125MHz oscillator was not as stable as I hoped. It did produce a reasonable HF RX but with many spurious signals.

So here is another lesson. Extreme band pass filtering at the antenna is essential. Without it, when using a typical 100 foot doublet with average AMU, you'll certainly hear a lot, but all at once! On 40 – 160m, I've had good results with a high-Q loop providing the necessary filtering.

Direct sampling - The RTL2832 VHF internal tuner/converter can be bypassed so that HF signals are routed directly to the A-D converter, which is called 'Direct Sampling'. This needs hardware mods on a microscopic scale, but ready modified versions are now available – see photo. For VHF, it operates as a standard dongle, but HF it has the hardware mods already done. When using SDR# or HDSDR, you have the option to configure the RTL2832 for Direct Sampling (Q Branch) and if you forget to do this, you will hear nothing. When switching back to VHF, you must disable Direct Sampling. (Note that SDR Console does not presently have the Direct Sampling option for the RTL2832 so only VHF use is possible.)

My experience with the 'RTL-SDR UV/HF' receiver has been very promising. It is a substantial improvement on the up-convertor approach. Just keep in mind that you need tight band pass filtering on the antenna input. (See Mar 15 Radcom review of Elad FDM-DUO TCVR for an explanation of what a modern very capable SDR rig can do now – G3PCJ)

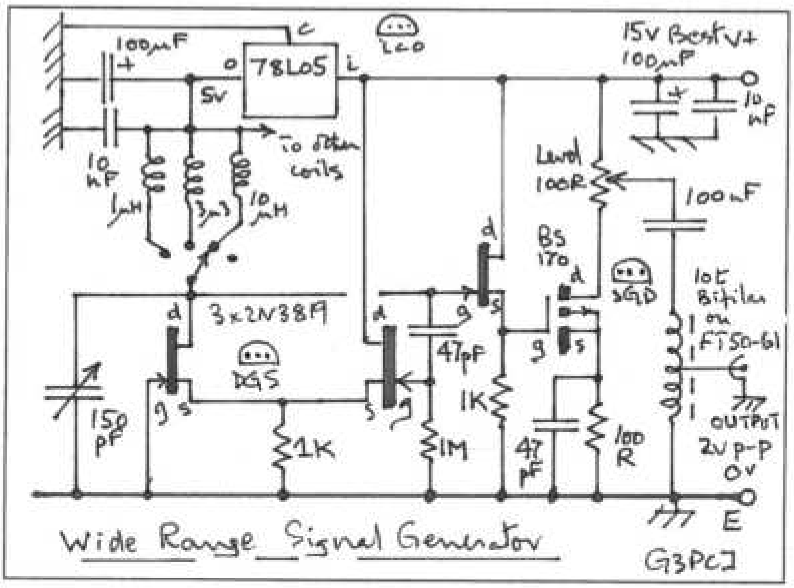
Snippets

Crystals in valved oscillators Following on from Peter T's note about using modern small crystals, Gerald Stancey mentions that the WS76 set was issued with pairs of FT243 crystals in case of damage during use! He warns that HC49 types need care when used in 6V6 Tuned Anode Tuned Grid oscillators. He has successfully 'loaded' 3579 KHz HC49s with solder down to 3575 KHz.

Solar powered aircraft Solar Impulse 2 hopes to complete a world circuit powered by 17,248 solar cells with 23% efficiency – these drive four 13.5kW brushless motors with gearing & 2 bladed propellers running at 525 RPM, and also charge a 260 Wh/kg lithium battery weighing 633 Kg (one quarter of aircraft weight) enabling climbing by day to 8,500m altitude, and slow descent by night on the battery to 1500m. Speed is in range 20 – 49 Knots. Wingspan is 72m.

Radar technology in cars The advantage of radar is that it can provide fast and clear cut measurement of velocity and proximity of multiple objects under any weather conditions. Cost is coming down and increased help to avoid accidents is a high priority. Four bands at 24 GHz are currently used but from 2022 the band 77 – 81 GHz will have to be used. Signal bandwidth determines range resolution with 4 GHz being desired. Complex transmit waveforms are used with Linear Frequency Modulated Continuous-Wave in 'chirped' pulses, to extract speed and distances to multiple objects. Inevitably, the very high data flow from the receiver is processed by means of I and Q channels in a powerful dedicated processor. If the RF is below about 67 GHz, direct sampling can be used but for the higher bands heterodyne converters have to be used to lower the data stream to an IF that can be sampled directly.

Simple Sig Gen I often need a wide frequency range generator that does not need high stability. The circuit right is a derivative of my Dipper and is very forgiving of resonator L and C values. I have eight coils in 1, 3.3, 10, 33..... uH sequence which gives approx 33 MHz to 200 KHz. The BS170 buffer amp stage with 2:1 transformer gives a low output impedance and about 2 volts p-p. It will work on a 12v supply but 15v gives better waveshapes. G3PCJ



31st Yeovil ARC QRP Convention

This takes place, as in recent years, at The Digby Hall in Sherborne on April 12 2015, with the doors opening at 0930. Admission is £3. There will be traders (including Walford Electronics), bring and buy, Club stalls, and RSGB, RAFARS and RASRS will also be present. If any Construction Club member plans to collect a kit, please give me advance warning! There will be two talks – 'A remarkable HF propagation path' by Rob G3MYM, and 'What's new in SDR?' by Jim Gailer G3RTD.

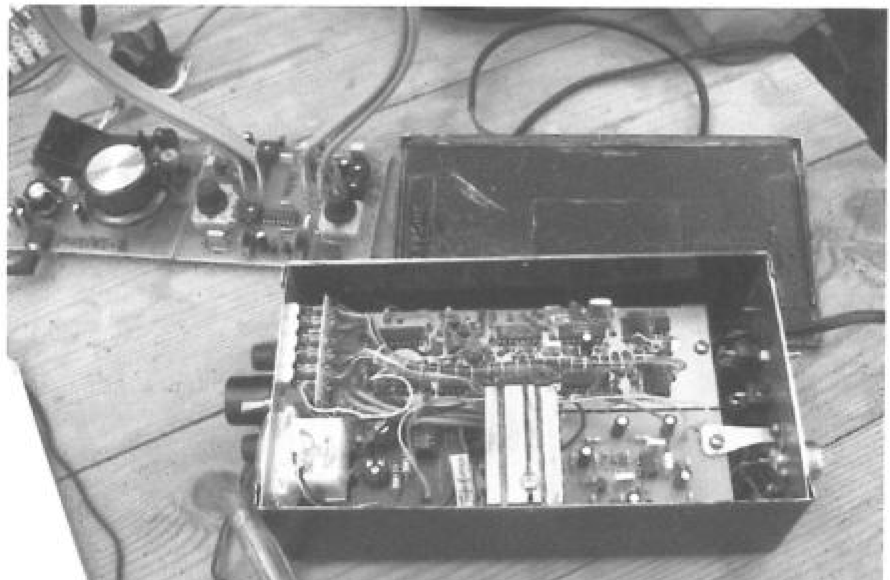
"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Summer 2015 Issue 88

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!

Hot Iron is published by Tim Walford G3PCJ of Walford Electronics for members of the Construction Club. It is a quarterly subscription newsletter that costs £8 per year but this is the last paper one! See the website http:// www.walfords.net for the latest news on how to receive it.

Kit Developments

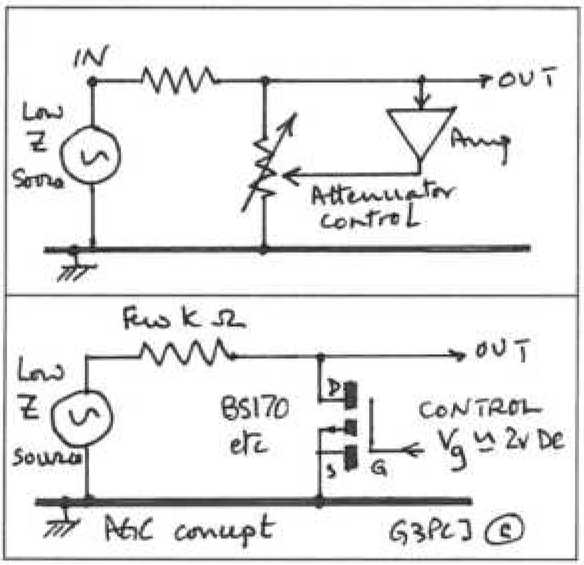
I did begin work on a new 'any band to 20m' Local oscillator kit and associated DC RX with planned DSB phone transmitter - to be named after the Lambrook villages. I built the LO unit and the receiver but concluded that it was a bit too complex for the intended market segment! It is now in the pile of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

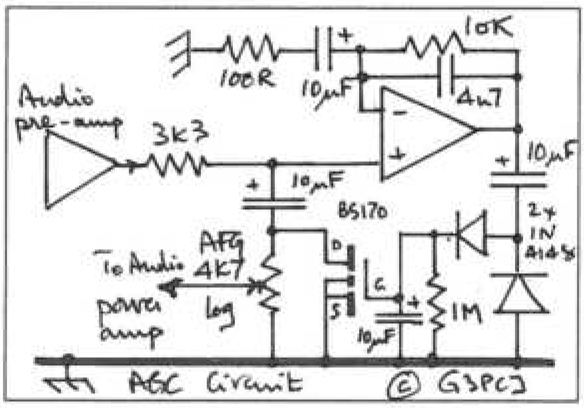
On another front, I had envisaged that the Low Ham design would be suited to the Yeo and Mark simpler receivers but have belatedly realised the TX complexity would be too high for these simple RXs; the plan now is to do a new 1 or 3 frequency crystalised 1.5W CW TX for them called the Isle – this is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

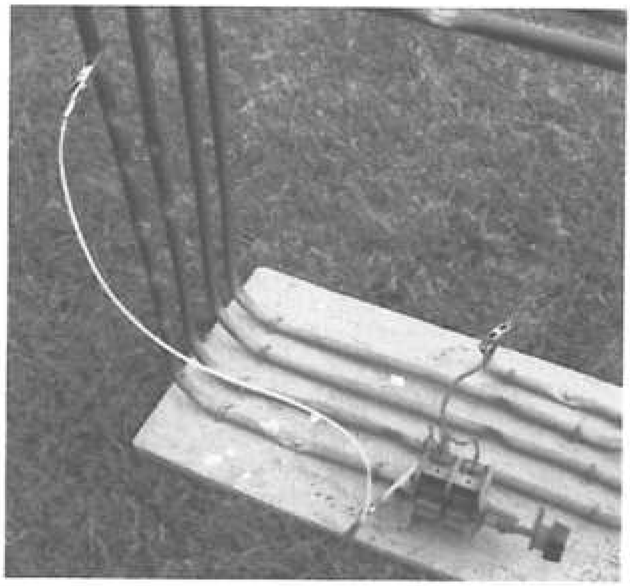
Most circuits will have several parts that connect direct to 0 volts, these can be added by soldering the earth side (eg of electrolytic capacitors whose polarity must be correct) direct to the ground plane. Do all these next working methodically from input across the circuit towards the output. In addition 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.

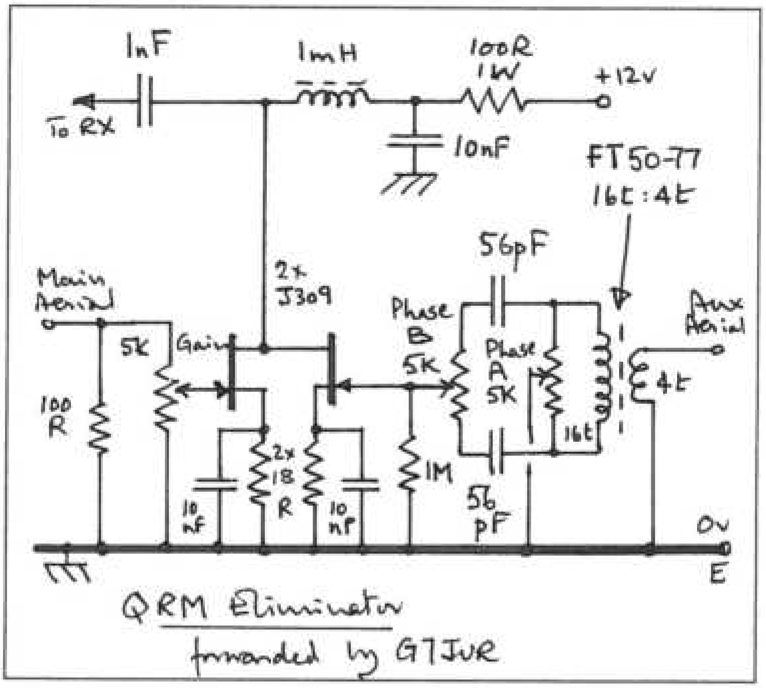
How does one feed RF to loop aerials? Purists wishing to retain the loop's symmetry will use a small coupling loop connected directly to the transmitter's 50R output. These small loops are usually about one tenth of the area of the main loop. The techniques for adjusting the size and location of such 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?

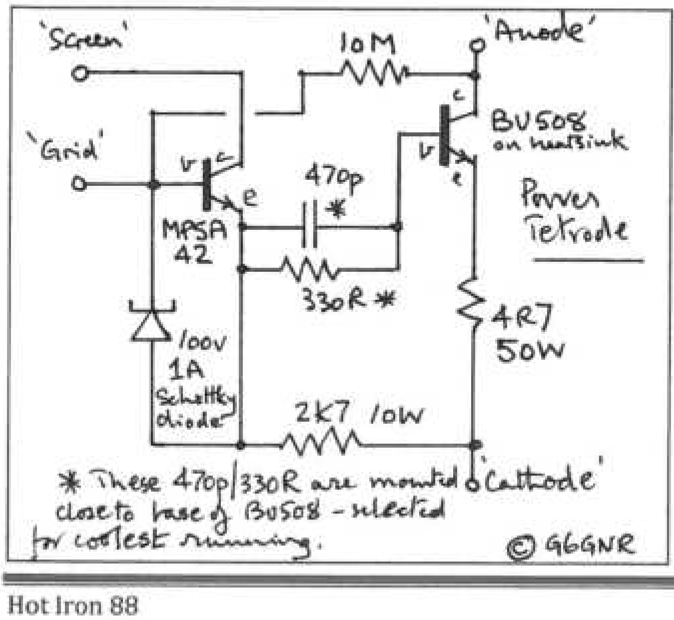
I was recently repairing an industrial RF generator, used for induction welding service. The power tetrode at the heart of it had given years of valiant service, but cathodes don't last forever, and a replacement to fit the socket, housing and equipment was unobtainable. The original tetrode *could* 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.

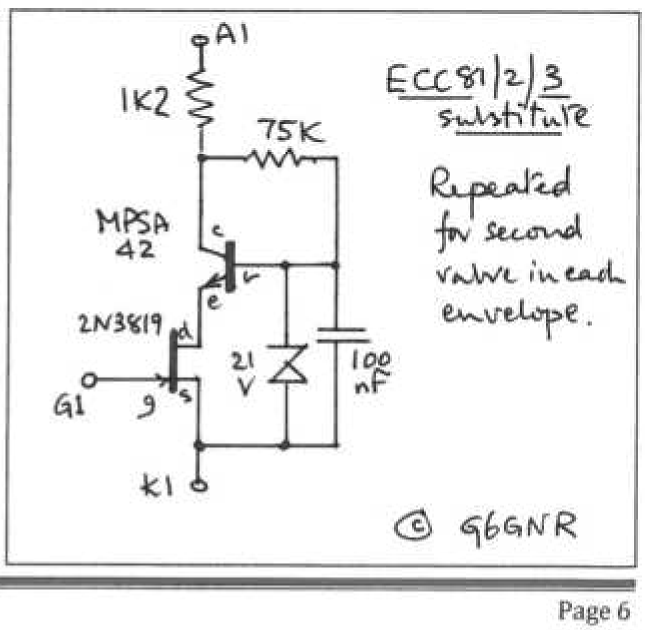
This dredged up memories of replacing valves with solid state devices. This tetrode was a big glass enveloped job, fan cooled, with an open circuit filament. The screen grid bias was used to control output of +200v to +350v DC. TV line output NPN transistors sprang to mind: cheap and available, and a 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

"JOURNAL OF THE CONSTRUCTORS CLUB"

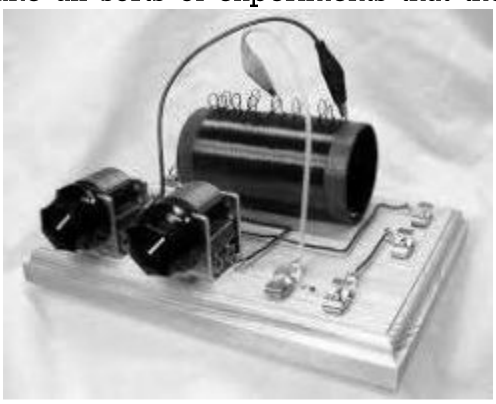
Hot Iron

Autumn 2015 Issue E89

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

Contents

Kit developments, RF output chokes, QRO & MOSFET drivers, Snippets, Valve HT supply, Valve RX ideas, FET mixers!

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

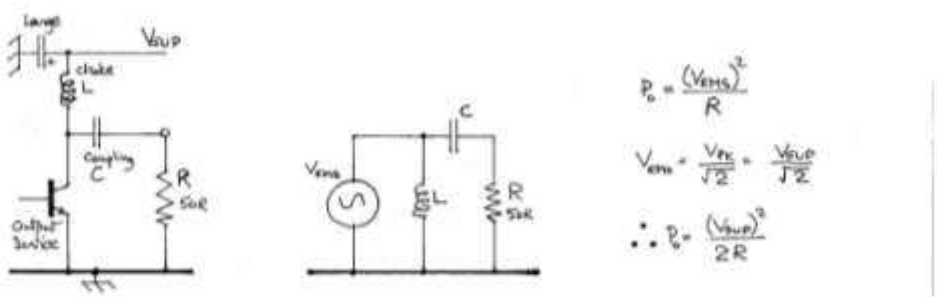
Nothing to do with radio but a picture is always welcome – so knowing that at least one of our members is a keen steam railway enthusiast – this is a recent picture of an ex South African Beyer-Garrett loco on the 2 ft Welsh West Highland Railway!

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.

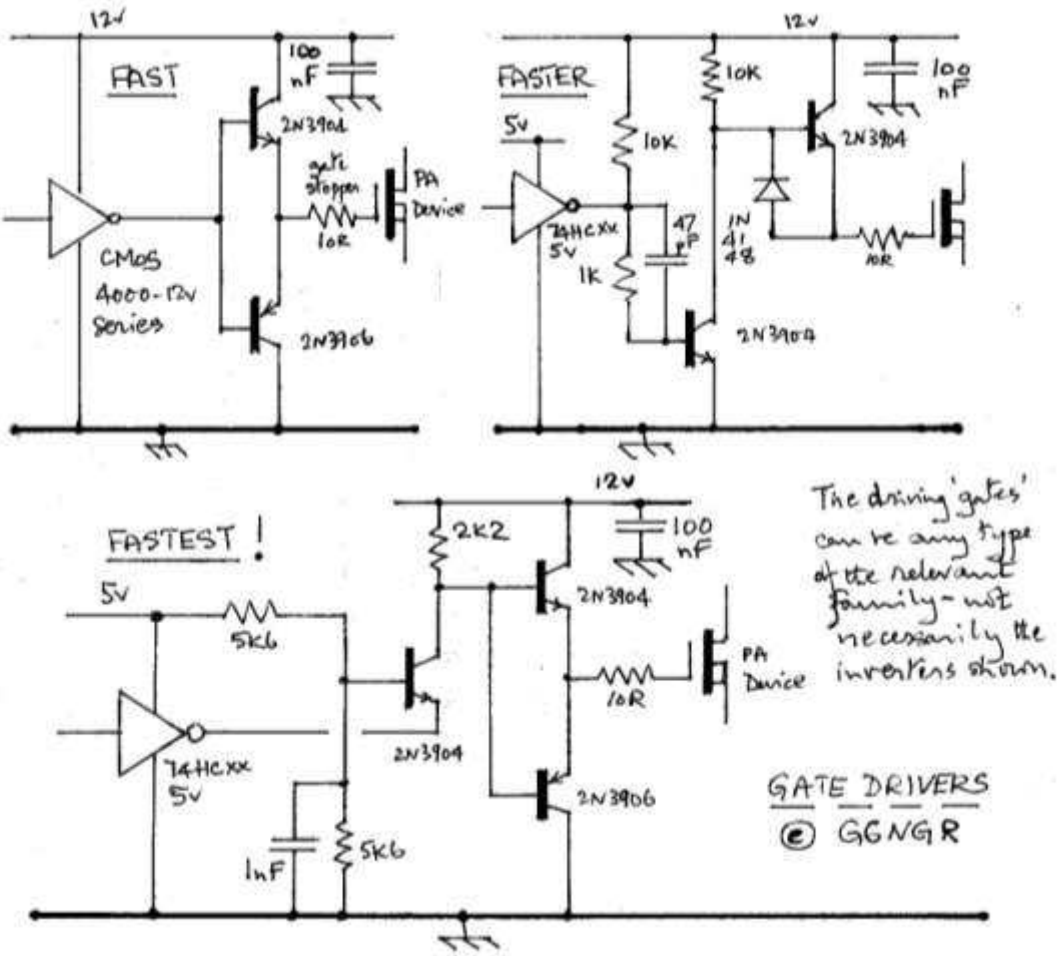
So what is the drawback of these MOSFETs? The answer is their high gate input capacitance – this can range into a few nanoFarads for the meatier devices, which makes them challenging to drive at higher frequencies. Often these MOSFETs are fundamentally high speed devices in all other respects, so if 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

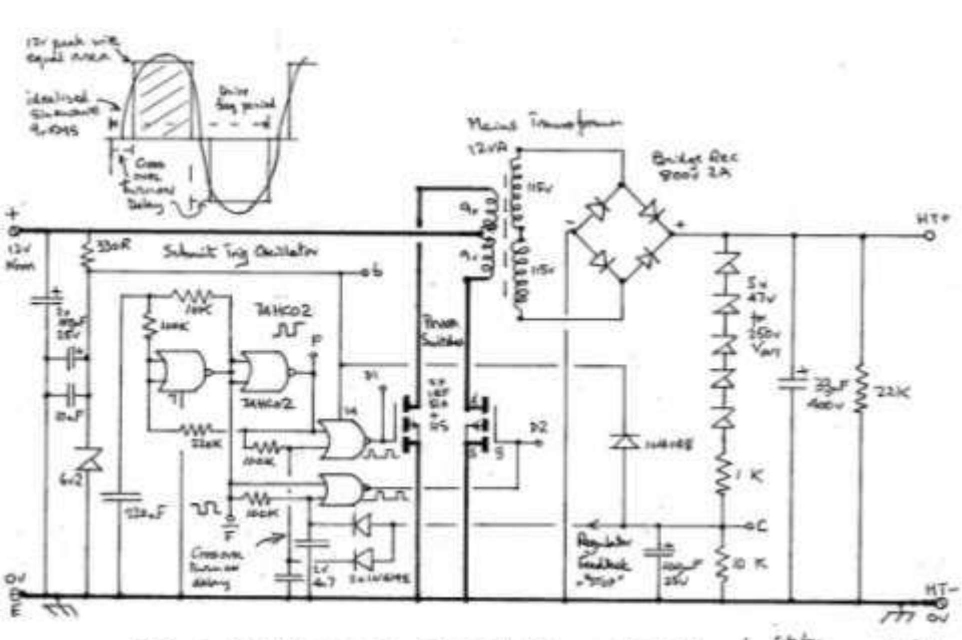
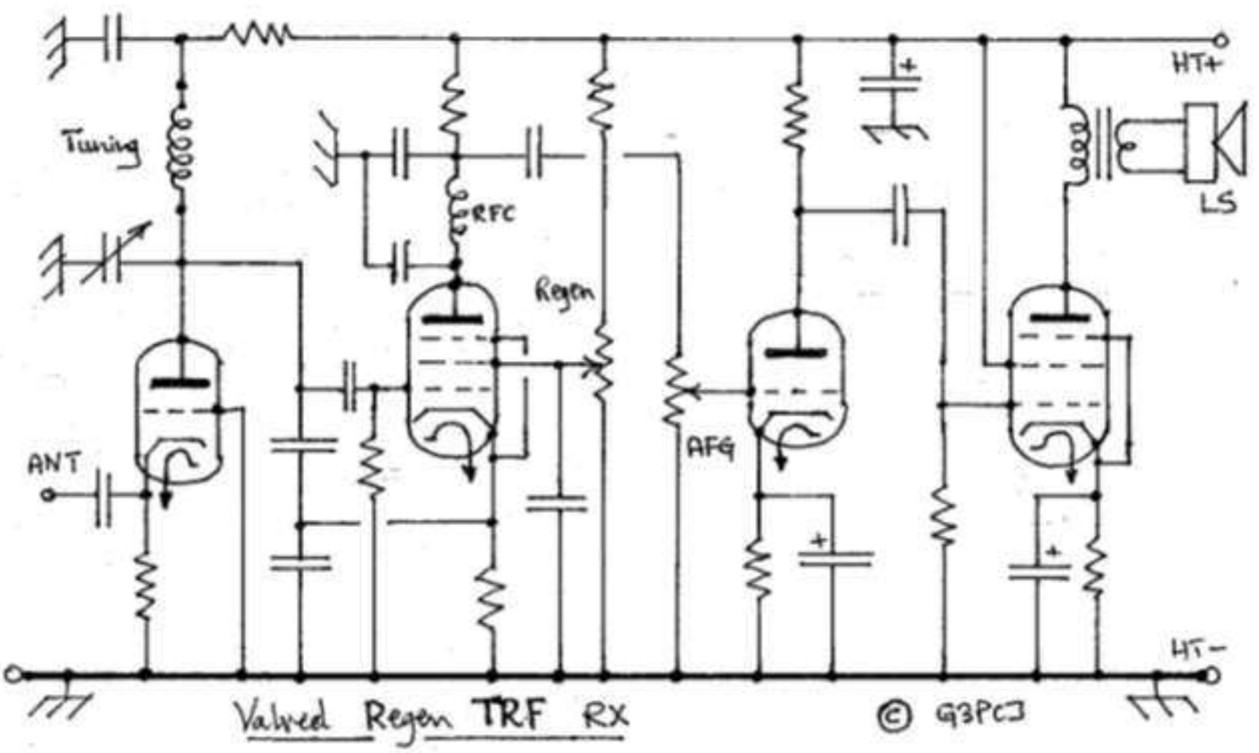


FIG : CIRCUIT OF HT PSU - Take Care - High Voltages!

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.

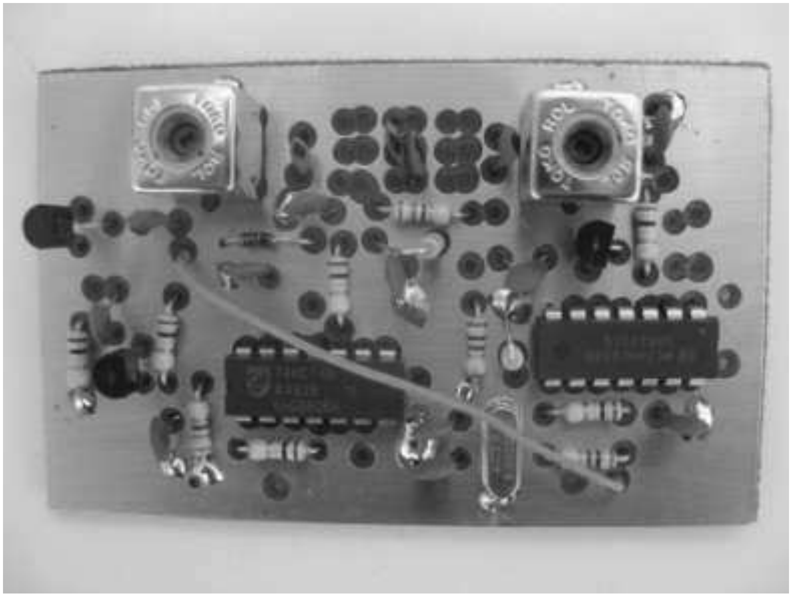
So what form of receiver should it be? It could be a superhet but that is really rather too complex! A Regen TRF is much more in keeping. Assuming that 12 volts is the main supply for the HT generator, this can also be used for the heaters - either with nominal 12v heater valves or for two 6.3v ones 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



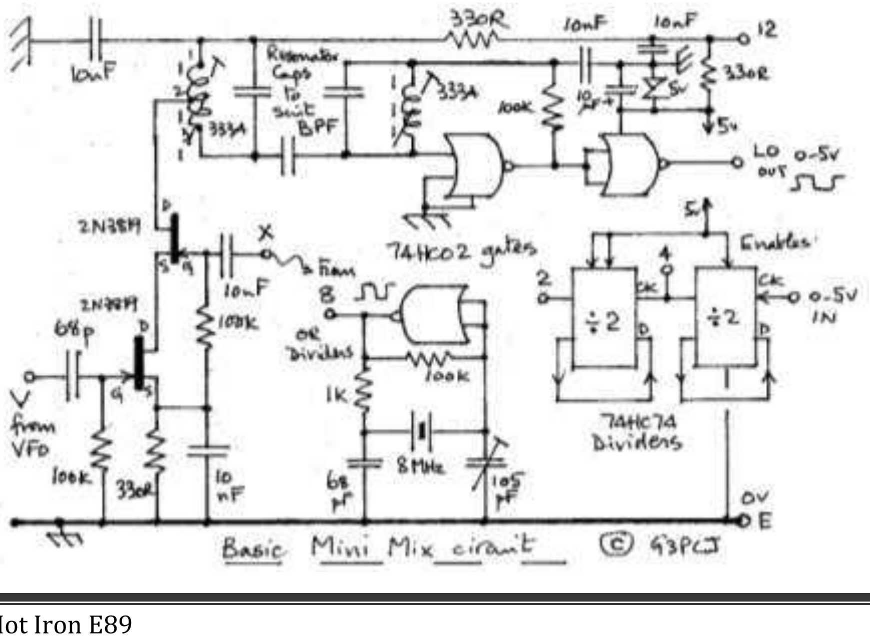
FET Mixers

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



"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Winter 2015 Issue E90

Editorial

Welcome to a whole host of new 'members' of The Construction Club (readers of Hot Iron) following the publicity given to Hot Iron by Bill Meara and his Solder Smoke musings. I just hope that together we can find enough good quality material to keep you all interested! That is why I say to all who have recently joined, if you can contribute an article, or even just suggest a topic that you would like given an airing, then please do not hesitate to let me know. Don't be worried about editorial style or any of that sort of detail because such trivia is easily overcome! Given that it is now over 20 years ago that I did the first one, some topics will definitely need covering again – so please tell me what you would like to read about.

Many of our newer readers are in North America and I am aware that the style of radio experimentation over there has a slightly different emphasis compared to Europe. In Europe, the price of kits, or parts for a project, have a very strong influence on decisions about what to 'build' – I suspect less so in North America where there is often more interest in good performance even if the cost increases appreciably. I am not sure of the reason for this, but it is possibly due to the lower cost of parts and there being more sales outlets for them. In putting together my kit designs, I have always tried to ensure that no one unduly expensive item dominate the cost of all the rest; so for example, I have shied away from expensive ready made IF filters, costing tens of £s over here, for use in simple circuits where the performance of the rest of the circuit does not match that of the expensive filter. This leads to a design objective of getting the best all-round performance that can be achieved for a given kit outlay – this is not designing for minimum cost always, but is about trying to balance the various aspects that go to make up the overall cost. One aspect that has always felt poor value for money in most (but certainly not all) situations to me, is the additional cost of smart enclosures - printed circuit board material can, with a little ingenuity, be used to fabricate all sorts of mechanical styles or even enclosures – its easily worked or joined with simple tools, and can be altered as and when a project develops further. I fully accept that if you are intending to use the gadget in difficult physical conditions, due to temperature, dirt or shock etc, then a case is essential but for most bench uses, they are a hindrance – especially when fault finding! I also tend to design in (too much?) 'adaptability' in the hope that builders will experiment themselves, and hence gain a better understanding of how it works! Tim G3PCJ

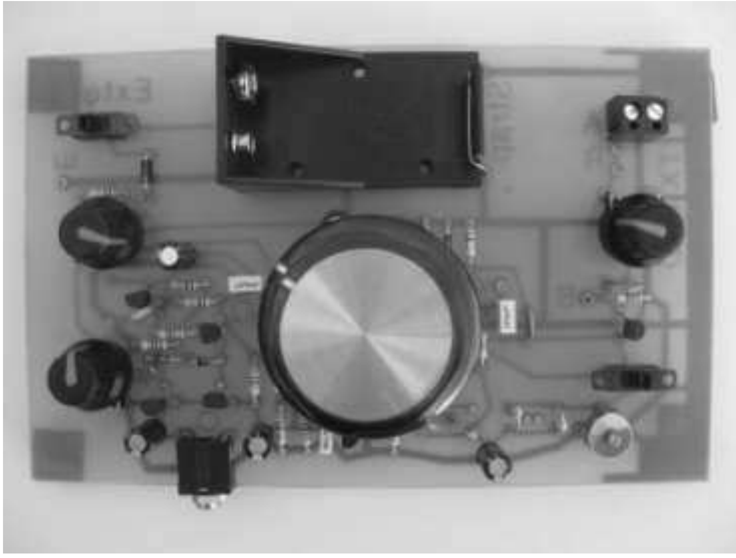
Christmas is imminent, so I wish you a Merry Christmas & happy New Year!

Contents Kit developments, Regen Extra, Aerial Locations, Analysis of the crystal detector, Derek Alexander G4GVM, Long wire AMU etc, Snippets – 602 levels, collecting parts, data storage.

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

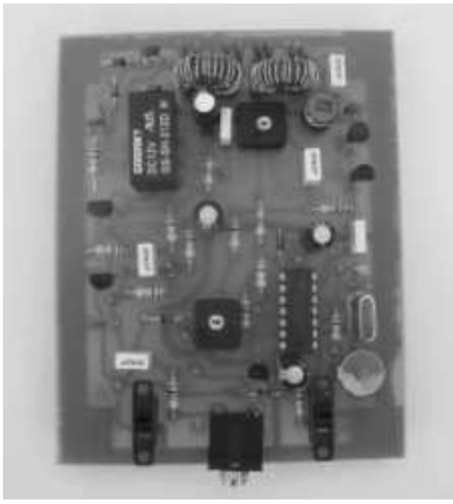
Kit Developments

Where to start?! I have spent quite a while working up a paper on what we, as a hobby, ought to do to encourage newcomers when building their first radio project – needless to say, I consider that it should be an 'analogue' item as most radio fundamentals are analogue in nature. This led to a revamp of the FiveFET design – much along the lines suggested by Ian G3ULO later in this note. I laid out the PCB, wrote the first draft of the instructions and made the prototype of what has become the Rumwell two band Regen TRF receiver. The photo alongside is of that version; but using it soon showed it was too sensitive to hand capacitance effects, because the tuning parts are in the bottom right corner just underneath one's right hand! Steve G0FUV also suggested that it would be easier to build if some of the parts on the left side (the audio amplifier) could be spread over to the right hand side.



In short, it needed a complete physical re-arrangement but with the same circuit. I ended up swapping the band switch (bottom right of the photo) with the RF gain pot immediately above it and a general move of parts from left to right. I have re-written the text and will be adding it to my website soon. The Rumwell RX is now a two band Regen TRF – each band has the option of series or parallel connection of their inductors. This gives the choice of the high frequency end of what we call the medium wave in Europe (about 780 KH to 1.5 MHz) or 160m for the LF band, with either 40 or 80m possible for the other HF band. It has an RF gain pot, together with Coarse and Fine Regen controls on the left side and can drive the 15R audio load of modern stereo phones or a small loud speaker. It can copy AM, CW or SSB/DSB.

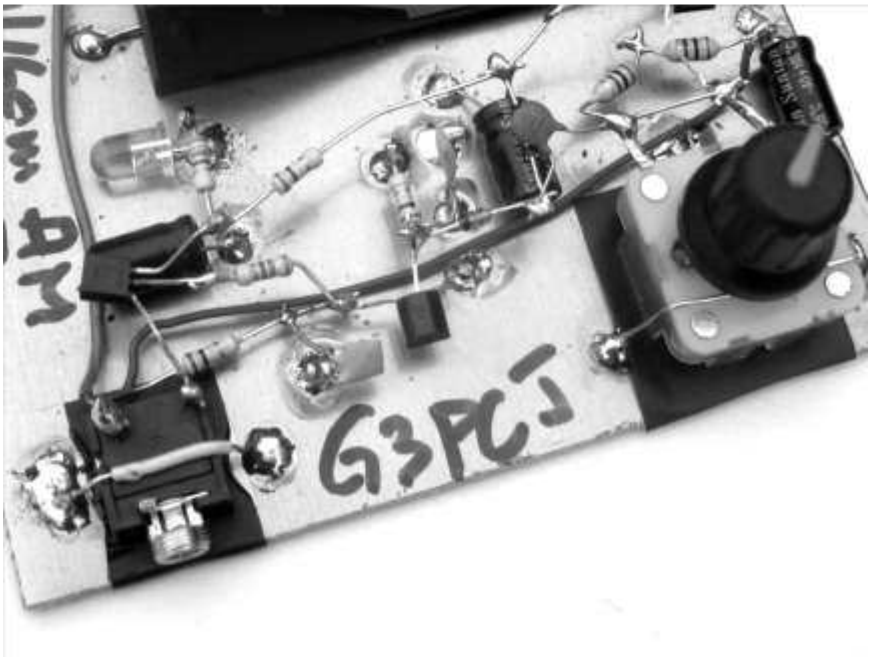
The matching simple AM transmitter is the Rimpton which would normally be mounted immediately to the right. To keep it simple for newcomers, this is normally crystal controlled but it has the option of using a ceramic resonator (adjustable with a trimmer) for 80 and 160m. It has a peak output of 1.5W on a 12 volt supply so can run an AM carrier of about 0.35W. It uses a pair of low cost MOSFETs in the final, without the hassle of a modulation transformer, with a twin pi harmonic filter that can be built for 40, 80 or 160m. The design is a derivative of earlier projects so is fundamentally proven; the prototype is built (photo right) but not fully written up. Working with short throw out aerials, these two kits are just the sort of projects for Scouts or Cadet groups, where a licensed amateur is to hand to help and supervise operation by unlicensed hopefuls, making their first contacts across playing fields etc!



I have also spent quite a while considering even simpler RX projects – the photo on the top of the next page might become such a kit - more details next time!

I am sorry I cannot tell you more about it yet, but it does demonstrate a perfectly viable building technique for one off projects!

Meanwhile some of the other more complex kits under development have had to take second place. Doing the design and laying out a PCB is the easy bit – writing the instructions, testing and then polishing them is what takes the time! G3PCJ



REGEN EXTRA by Ian Spencer DJ0HF/G3ULO

I suppose in these days of large scale integrated circuits and SDR we should ask ourselves why we would want to build a receiver who's circuit was basically invented way back in the 1920's and 1930's. Well for me when I switch on an SDR I know how complicated it actually is and expect it to perform but when I switch on a Regen using just 1 valve or a couple of transistors then I feel that's it's a minor miracle when it works. I built my first Regen in 1962 so more than 50 years ago and am still building them because when a good Regen is operated properly not only is it very sensitive but also pretty selective. I never cease to get a thrill when that single valve or couple of transistors allows me to listen to signals coming from the other side of the world and listen to not only AM but also SSB and CW over a wide frequency range with no problems of IF image etc. Just amazing.

All Regens have at least two controls and some perhaps three. Something to tune to the required frequency with a Regeneration control to get that all important performance and in the luxury version an AF gain control for the volume from the loudspeaker or headphones.

But that said the simple Regen is very touchy to adjust and not easy to get working at optimal efficiency, so that simplicity has a price and I was wondering if it could be improved without adding significantly to the complexity. In reality, moving just one component and adding two others can work wonders.

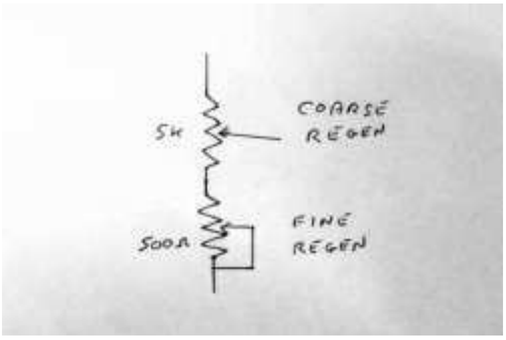
The three main problems seem to me to be that the tuning capacitor or varactor diode covers quite a wide frequency range so tuning in a signal perfectly isn't easy, especially when that signal is amateur band SSB which requires very exact tuning.

The Regen control is very sensitive, a few degrees too far and the set is oscillating, a few degrees back and the receiver loses sensitivity. A tricky adjustment.

And the last problem is the volume control if the set has one. Now the standard thinking is to put an AF volume control into most sets just before the final AF amplifier so that you can adjust the volume of audio but this is in my opinion the wrong place for the volume control. The reason being that Regen receivers work best with weak signals and very strong signals can easily cause overloading of the Regen detector leading to distortion and pulling of the oscillator frequency. This is especially evident where strong SSB is being received.

To get perfect audio from SSB the oscillation of the Regen has to be just strong enough to replace the missing carrier signal. Too much oscillation and it swamps the audio, too little and it sounds like an over modulated, distorted AM signal. Now if you put a 1k to 5K pot (it's not critical) between the antenna and ground and take the input to the receiver from the slider then you can vary the strength of any signal from zero to maximum and by turning back the pot on strong signals this not only makes life easier for the Regen detector but also automatically lowers the volume in the headphones or loudspeaker. In my opinion a much better solution. So just moving 1 pot from the AF section to the RF input can make a vast improvement in the quality of reception.

To get greater control of the regeneration just requires an extra fine adjustment potentiometer, so if the main Regen is a 5K variable resistor then adding a 500 ohm or 1K variable in series with it gives a very effective fine control. For the cost of one potentiometer you get effectively a 10:1 reduction drive (see photo 1). You set the fine control to mid position, tune to the place on the band where you want to listen and then advance the course Regen pot until oscillation just starts. Now you can back off the fine Regen pot for maximum sensitivity and selectivity on AM signals and advance the fine control a bit to get the set oscillating for perfect CW and SSB reception and the adjustment is so much smoother than with the coarse regeneration adjustment. But remember the old saying you can't make a silk purse out of a sows ear. If you advance the Regen control and it starts to oscillate but when you back it off it continues to oscillate then you've got that sows ear and the fine Regen control isn't going to help. Entering and exiting oscillation should in any well built Regen be nice and smooth.



And finally to get that perfect frequency control if the tuning is done with a capacitor then just fit a small perhaps 10pf variable capacitor in parallel or if your Regen uses varactor tuning then as for the Regen Pot a small value pot in series allows very smooth and accurate fine adjustment of frequency making those SSB signals much easier to tune in, almost like having that expensive reduction drive. Maybe better as you can still use the main tuning control to quickly make large frequency changes.

If you've never done it before try these changes to your Regen and see just how much easier the handling of your receiver becomes. Never mind the SDR's, feel that Regen performance.

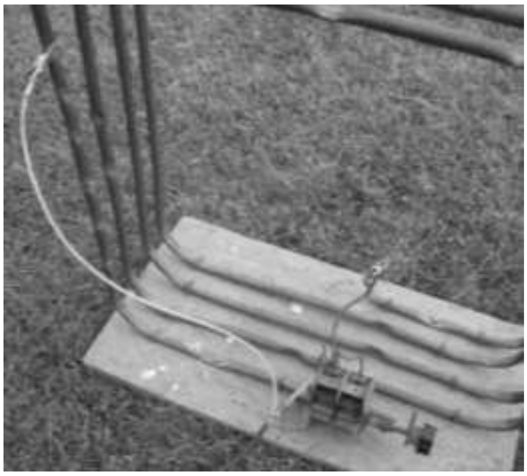
Here is my Regen derived from the Walford Electronics FiveFET. On the front panel you can see the main tuning control with to the left the fine tuning and to the right a band switch for 80/60/40/30/20 Metres. On either side of the headphone socket are the fine and course Regen controls; to the right is the RF gain control.

Aerial locations

This is not a speciality of mine but my good friend Eric G3GC, who died many years ago, drummed into me that one should get as much wire out as you can, up high, and ideally in a balanced configuration! Sounds easy like that but for people with small, or even no garden at all, it's a bit challenging. On the farm I am spoilt for space out in the fields but surprisingly, finding a suitable aerial location is not that easy, due to the proximity of other buildings near to the house and my electronics bench. One should try and avoid long feeder runs if possible.

The first thing is to try and get the radiating elements, usually wire for HF aerials, in the 'open' – this is a vague term but really it means getting them (especially that part of the wire carrying a high current) away from other conducting materials – such as the house power, or 'comms' wiring, metal water pipes, or even bulk conductors such as earth! Another hidden nuisance is metallic foil on the black of some modern plaster boards, whose purpose is to prevent it burning! If mobile coverage is appreciably better outside the building than inside it, then don't put your aerial inside it! Reinforced concrete structures (especially flats) can be difficult due to the structural steelwork. Many people are forced to consider their attic spaces, but these are best avoided if possible because the external roof material is a conductor when it is raining! And that is apart from any wiring or pipes that are conveniently hidden overhead! So get the wire out in the garden if you can. Run it from the eaves guttering, or even the chimney if you can do that safely, away from the house to some convenient sky hook at the far end of the garden. If there are not any trees then run to the tallest pole you can manage, with a supporting stay(s) to keep it upright. It is advisable to keep the aerial wire out of reach of humans (young or old) so that any high voltages are avoided – for high power work, it is wise to use egg type insulators but modern 'poly' rope is a reasonable short term (insulating) expedient, until it perishes in the ultra violet light after a few years!.

Feeding RF into such a wire is not always easy because it is often 'end fed' and that tends to be a high impedance point with consequent high voltages – with a good antenna matching unit this need not be a problem - but what completes the RF current path on the earthy side of the tuning unit? Where is the RF earth? And I don't mean the mains power safety electrical earth! While that safety earth should be connected to real ground somewhere, it can be quite a long way off (many wavelengths) and is definitely NOT recommended as an RF earth. In fact one should NEVER connect your RF earth (which might be metalwork in the real ground) direct to the main safety earth, especially if you have PME (protective multiple earthing) just in case that goes wrong and all the 50/60 Hz mains return current (maybe 100 Amps or more) tries to zim down your thin RF earth wire – not good! So how should you obtain an RF earth? Ideally, by a thick wire to lots of well bonded metalwork buried in the ground over an extended wet area! That maybe impractical if you live in a flat several floors up so the next best thing is to provide the missing half of the ideally balanced aerial in the form of a counterpoise; this needs to be a quarter wave long at the operating frequency. If that is difficult then consider a magnetic loop aerial, it wont be as good as a large outside aerial but they do allow you to get on air - even with a thing like my 'radiator' on the right, complete with its own gamma match!! G3PCJ



Analysis of the Crystal set's Detector

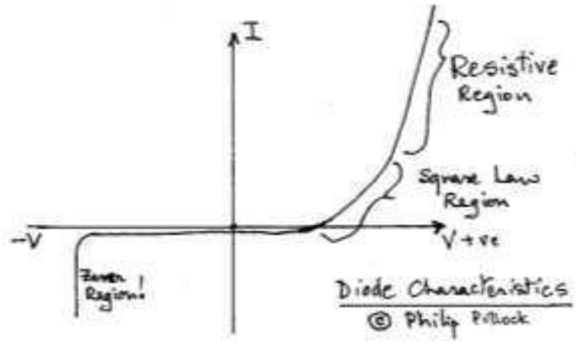
It is said that, "You don't understand something until you try to teach it". I have recently come to appreciate the truth of this as I teach a course at the South Dublin Radio Club.

Nothing shakes one's confidence more than examining the fundamentals of a subject. How much of my knowledge is incorrect 'Ham Lore' or glossed over principles taught to me at University? Explaining the fundamentals, raises the question, "do I really understand it myself?" Lets take the crystal set for example, as I heard on Solder Smoke of the Michigan Mite," There's a lot of electronics going on there". The tuned circuit was easy enough to explain, as was the crystal ear piece. But the detector or demodulator - or is it a rectifier? That, gave me problems.

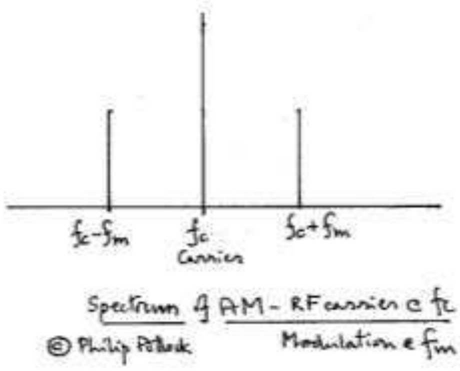
Read the simplified explanations and one could think that there is a carrier wave whose amplitude varies with the modulating waveform. This is then rectified by a diode and the radio frequency component is filtered off, leaving the audio. Much is made of selecting the appropriate CR time constant for best output as it follows the modulating waveform. Other sources such as The ARRL Handbook, most emphatically state that the audio is demodulated from the carrier using the diode as a demodulating mixer. The audio being one of the mixer products. (ARRL Handbook 2013 10.9) That a diode demodulates an AM signal by allowing it's carrier to multiply with it's side bands may jar those long accustomed to seeing diode detection ascribed merely to "rectification".

What should I tell my students? To decide, it was back to the fundamentals. The diode detector is so called because it was used to detect the presence of a signal. It can work in two ways: as a frequency translator for low voltage levels as in the diode modulator. Here the transfer characteristic of the diode is like a square law device. For large signals the transfer curve becomes resistive and the diode behaves as a rectifier.

Here is a diode transfer characteristic. Here we can see the two regions of operation - Square Law and Resistive. For the small signal, multiplication occurs due to the square law diode transfer properties and the modulating signal is converted back down to audio frequencies. The two input frequencies are the carrier which multiplies with each side band frequency to produce the modulating audio as one of the products. The audio can be filtered out from the other products which are usually outside the range of hearing anyway.



Here is an AM signal with one audio frequency.



What is going on? The square law device has this characteristic:

$V_{out} = kv_1 + k_2v^2 + k_3v^3 + k_nv^n$

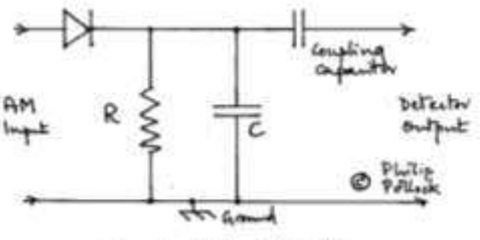
The k is a constant & depends on the diode curve's shape. For $V_{in} = V_c(1 + m \sin \omega_M t) \sin^2 \omega_C t$ where m is the modulating index, ω_C the carrier and ω_M the modulating frequency. Apply it to the diode and the k_2v^2 term produces:

$k_2V_C^2 \div (2m^2\sin^2\omega_M t)$ which gives us the modulating signal.

The other terms give us other frequencies which can be filtered out.

As a rectifier: In this case the diode rectifies the signal when it is large and the voltage across the capacitor follows the shape of the envelope waveform. The shape is the waveform of the modulation and therefore the detector output is the modulating signal. Some use the description envelope detector for this detector.

I find this simple explanation hard to understand. If we are talking of a carrier with one audio tone, I can understand how a capacitor will charge up to the peak value of the tone amplitude. Many different amplitudes as found in a voice signal does not make sense. All information should be lost in the integration process occurring in the capacitor. A combined voltage pulse should be the output. The usual text book explanation of the envelope / rectifier demodulator confuses me.



Simple diode detector

So back to the mathematics! The rectified diode output developed across the resistor should be half sine waves of the carrier and the side-bands. Fourier Analysis of a half sine wave gives a series of:

$v = 1/\pi + ½ \sin \omega_C t - 2/ \pi (1/3 \cos 2\omega_C + 1/15 \cos 4\omega_C t$ _+.etc.)

Multiplying the signal to the diode by $V_{in} = V_c(1 + m \sin \omega_M t) \sin^2 \omega_C t$ by the series gives these terms:

$V_{OUT} = V_C / \pi + V_M m \sin \omega_M t / \pi$ + etc.

I am happy with V_C / π which corresponds to the rectified carrier, a DC voltage, and $V_M m \sin \omega_M t / \pi$ which gives the modulation, free from it's carrier.

I have describe both methods. Both occur depending on the applied signal levels. I am not happy with loose talk regarding AM. I think it creates much confusion; there are internet forums with arguments over which way a diode receiver works. All the controversy seems to derive from a lack of mathematical understanding and loose terminology. The carrier frequency carries nothing. Each side-band frequency is a modulated carrier frequency. Not everyone can do the maths but they can understand that the diode rectifier demodulator works as a consequence of rectification and multiplication of a signal's Fourier components. A simplified explanation causes confusion.

Note from G3PCJ! I include this thought provoking note above from Phillip to see what any Members think is happening. I must admit to finding it a little hard to use this analysis when designing a crystal detector. I apply the principle that the detector's CR time constant must be long compared to the period of the RF carrier frequency and short compared to that of the upper modulation frequency. Apart from ensuring the detector has enough forward bias to be operating in at least the square law region, I am not sure what else you should do! Comments or suggestions please!

Derek Alexander G4GVM

Bob Bowden G3IXZ tells me of the sad death on 22nd November of an important person in the history of my kit business. Derek was a great QRP devotee and Chairman of the Yeovil Amateur Radio Club during the formative years of the 1980s when it became a centre of excellence in this branch of our hobby. Together we designed the Yeovil transceiver, as a derivative of an earlier 80m phone superhet TCVR called Tiny Tim. The Yeovil was a great success and was an important early project in my kit business; Derek regularly used his Yeovil until quite recently. On moving to Hereford about 22 years ago, he joined the Hereford ARS and greatly boosted the construction activity by designing a simple direct conversion QRP CW transceiver, many of which were constructed by club members at the time. I think I am right in saying this became known as the Fox Mk 3. His enthusiasm never waned and he was still designing and building innovative items right up to the end.

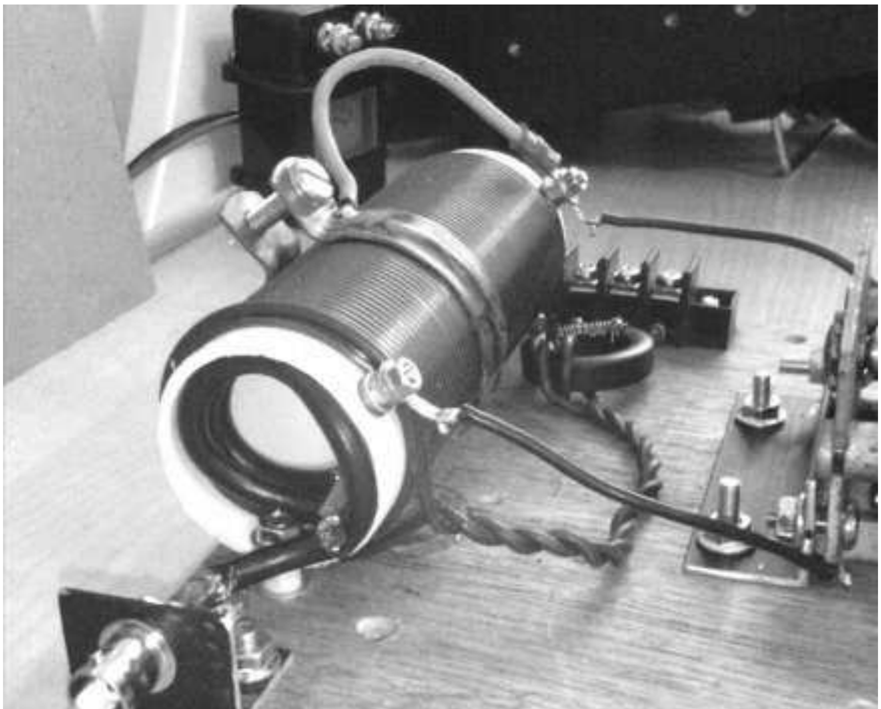
He will be greatly missed by all who knew him, Tim G3PCJ

Les Moxon, Random Wires, Counterpoises... by Peter Thornton

An all band HF antenna that fits an awkward and pinched space - my back garden - is a W3EDP, but couldn't get RF "up the spout" on all HF bands despite all the usual tweaks. Time for another look at my "Bible": Les Moxon's (G6XN) "HF Antennas for all Locations". Les reckons an end fed wire is a Zepp fed, scant half doublet - with all the usual problems, and plenty!

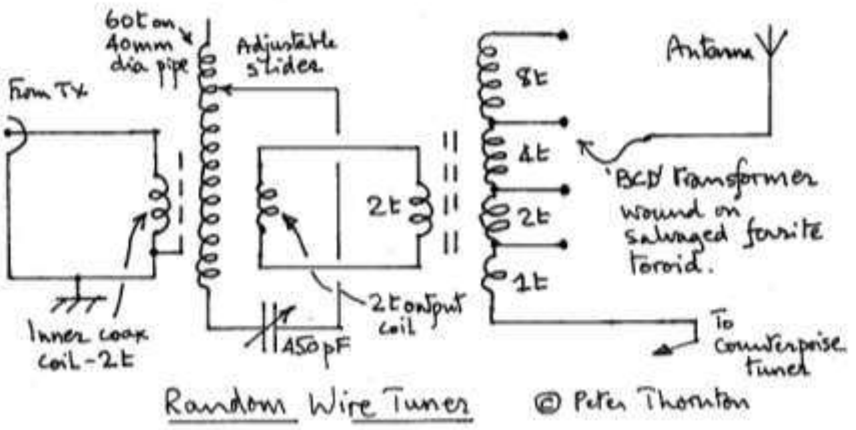
Les shows some ways to feed random wires; I added Faraday screens and an output isolating transformer. The 'EDP's counterpoise, usually 17' long, I found better at 9m, chucked wherever the cat allowed, and tuned this as per Les' advice. The counterpoise tuner is 2m away from the ATU; I found close together wasn't as effective - the wire between them playing a part. Individual circumstances being so variable, you'll need to try a few options to get the counterpoise series resonant. MFJ make "artificial earths", and this is what you're after with a counterpoise.

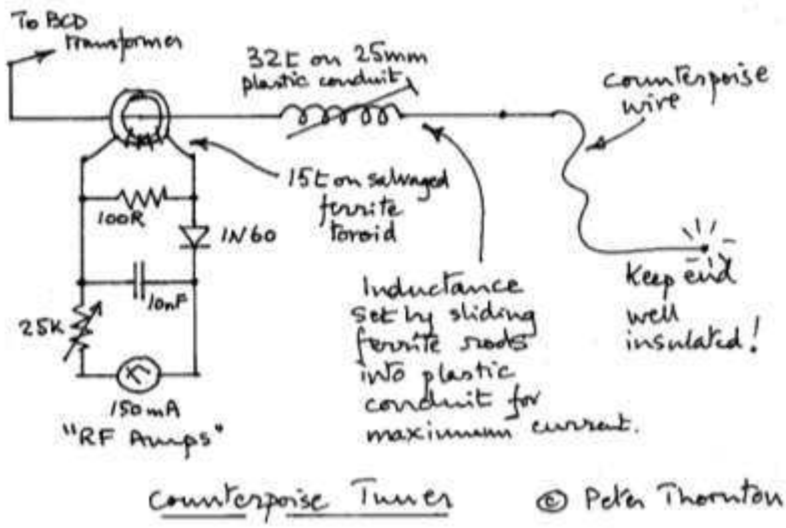
I have a penchant for salvaging ferrites from scrap switch mode power supplies; and here's where I used a few. I've found suitable ferrite rings quickly and easily, these ferrites are chunky rascals, easily able to handle my QRP 5 watts. The 2 turn driver coil fits *inside* the resonator coil, made from co-ax with the core soldered to the screen through a hole in the sheath for a Faraday shield. Directly above the driver coil, on the *outside* of the resonator coil, is the 2 turn output coil: this is Faraday screened from the driver coil by the close wound resonator coil. The output coil link feeds the BCD transformer which allows a choice of ratios to get the best match. The resonator coil has a sliding copper collar, made from a 54mm copper pipe "U" clip, bent into a circle to clamp around the resonator coil. I soldered the shorting wire to the collar as the clamp screw can't be used for connection - it can't be too tight or you can't slide the collar along the coil. I removed enough enamel from each turn of the resonator coil for the collar to contact wherever it was set - about 1/5th of each turn. With 60 turns on 40mm waste pipe I can tune and match 0.9MHz to 30MHz.



The BCD transformer gives a wide range of load impedances. The multiple isolation and screening eliminate stray RF, and the tuned counterpoise, though an extra "faff", gives far better results; what's more I can see the results in the RF ammeter - very useful, in circuit permanently and no lossy SWR meter. I run AM on a local net (3615kHz & 7158kHz) and the results are much improved; the tuner runs with "room to spare" Top Band to 10m, so I can experiment on any HF band, without risking the transmitter P.A.

Counterpoise tuner on left and main AMU on right in photo above.





Snippets

602 Input levels Philip Lock reports further on experiments to improve the Minster TCVR LO mixing (when adding band cards) by altering the SA602 mixer input levels to reduce unwelcome mixer products that caused birdies. He found that the screened PCB interconnecting leads were best grounded at both ends, especially the coax for the point 7 connection. He also removed R211, and replaced C208A and B to 140 pF, and changed R210 to 5K6. After this the signal on pin 6 of IC210 was about 250 mV p-p and triangular. He would have preferred a sine wave input to the LO mixer (to reduce the harmonic content) but this is not easy to achieve without considerable complications in a multi-band rig!

Valve HT supply I have laid out the PCB for the circuit (to obtain 250v DC from a nominal 12v DC input), that I outlined in the last Hot Iron. It is not yet tried out but if anybody is particular interested, let me know and I will get on with it!

Collecting parts One member, new to electronic construction, asks what ‘parts’ he should obtain to support his future electronic projects. Most of us who have been dabbling for years instinctively know what might be useful, and hence buy it when we see it for sale cheaply! It is difficult to make a definitive list but I would always include almost any small or medium sized hand tools, perhaps next followed by items of simpler test equipment such as multi-meters, digital counters, signal generators, or even oscilloscopes. Obtain these and you will not need much else! After that the more obscure/expensive parts are worth bagging when the opportunity arises. I would put single or multi gang air spaced variable capacitors top of the list, especially those with slow motion drives! After that mains transformers with low voltage secondaries that might be suitable for power supplies (with care), and even rarer items such as IF filters with CW or phone bandwidths, based on commonly used actual Intermediate Frequencies. Most other parts are now so cheap that, when you have not got what you need, you should order 100 of them – often the delivery costs alone will make that sensible!! G3PCJ

Data storage etc

There has been a lot written recently about scammers obtaining personal records in order to perform identity theft etc. So I now explain my approach! Generally, I do not keep records of any Hot Iron reader’s personal information apart from your name and e address – because I am not usually told it! I do keep the addresses of most people ordering kits, but when I get that data from Paypal etc, they are usually kept here in paper form. I am never told credit or debit card numbers because I have no need for it, nor any means of using that information! The name and address information that I do store electronically (in an Outlook address book) is not encrypted and I try to avoid that information being available to other readers when sending Hot Iron out. However, if anybody is unhappy about your information being vulnerable to hacking, then please let me know and I will delete your data. Tim G3PCJ

Finally Happy Christmas to you all and may your electronic experiments all work first time next year!

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Spring 2016 Issue E91

Editorial

At last the days are getting longer and there is less temptation to spend time huddled over some inside project because the weather is poor or it is dark outside! As a farmer, we also tend to notice that our grass is beginning to grow again – both in the field and on our lawn – in fact it has hardly stopped growing this winter and I ought to be getting the mower out right now! All of which suggests its time to be thinking about outside radio projects – most probably something to do with aerials!

For many years I have had a half wave dipole for 160m centre fed by open wire line but one support was carried away by the wind this winter, so I have been temporally using a different half wave dipole for near 7 MHz inside the roof, fed by what the telephone fitters in the UK call 'drop wire', this is a high tensile copper pair in a figure of 8 plastic coating which is a fair match to the low impedance centre of a dipole. While not the best of aerials, it does have the benefit that if a new receiver can hear the atmospheric static using this dipole, then the RX does have enough sensitivity and there is no need for anything better – a lower noise front end with a bit more gain will still only hear the band noise even with a better aerial! About the only case for improving the sensitivity is for applications where a 'normal' full size aerial cannot be accommodated thus requiring a smaller aerial that would normally also hear less noise! (If space is really tight, I prefer a magnetic loop – these can be quite simple malleable copper tubes in either single or multi-turn form, or even multi conductor mains fixed installation cables (only suitable for the LF bands due to high capacity between cores) – feeding the loop RF can also use a gamma match tap part way round, instead of the fiddly small feed loops that are often suggested for the feed mechanism! No need for AMU either!)

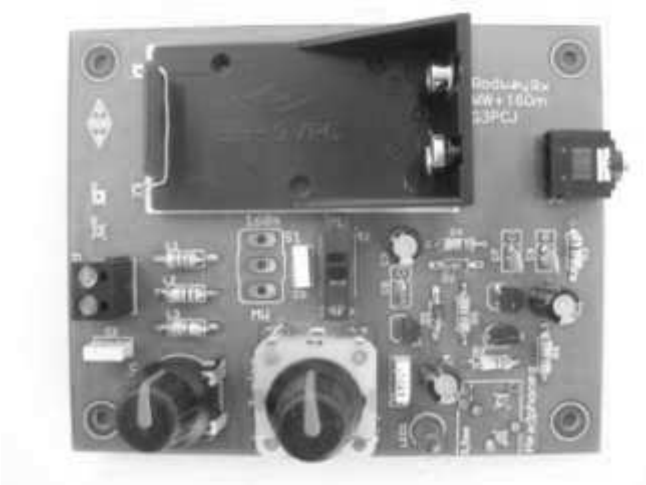
But back to my downed external dipole! For various reasons, I am not allowed to replace it and must erect something in an alternative location with a span of up to about 100 ft (30m) but it has to be end (or near end) fed! I want multi-band operation so contemplate an open wire end fed Zepp of 66 ft but my 'electronic theory' really does not like that single unconnected feed wire where the other side of the feeder joins the half wave! Where does the RF 'in that open circuit' go?! I would much prefer a balanced scheme and I have the feeling that the open wire feeder of a traditional Zepp contributes very little – I fancy you might just as well run the single aerial conductor all the way to a capable Aerial Matching Unit that tune out any reactance and can be mounted near the operating position, with a decent RF earth spike/mat or multiple counterpoises!

I am sure that amongst us, we have a reader with more relevant knowledge on this subject than me, so please come forward and tell us what I should erect! Tim G3PCJ

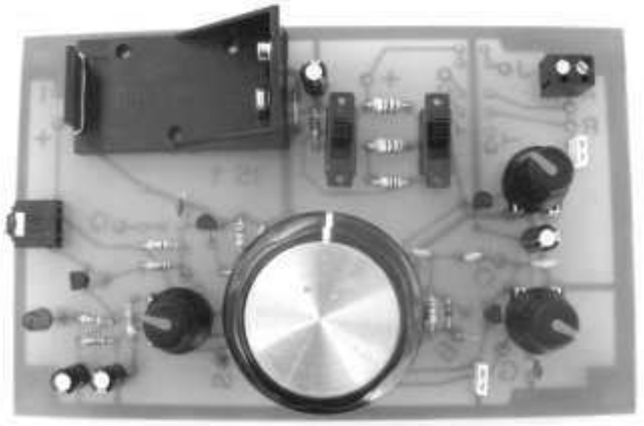
Contents

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

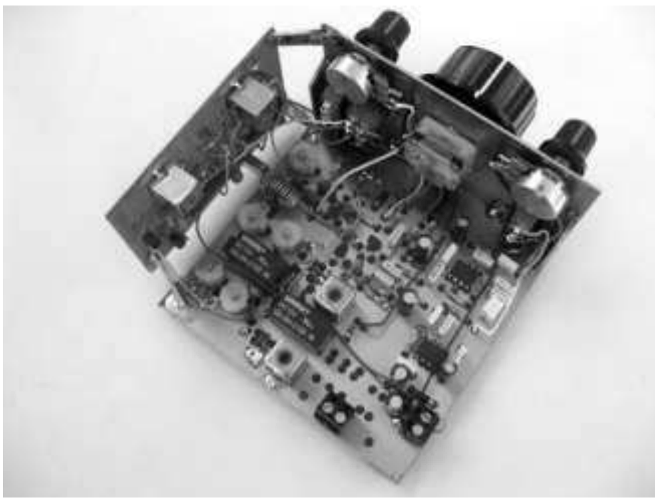


It has been another busy few months; not long after I had completed the design of the Rumwell, I realised that it was not simple enough for complete newcomers – the hand wired crude prototype seen in the last issue has since become the Rodway after discussions with Steve Hartley G0FUV and the RSGB about projects for schools. It uses a PCB laid out by the RSGB (on right) with three BS170 transistors in a plain TRF arrangement. It has two bands – the HF end of the Medium Wave band with its powerful broadcasting stations for an early build and easy 'success', and also 160m for an intro to amateur radio. I am expecting to be able to offer the RSGB version for sale soon.



I have begun work on the Redlynch RX (early version right) which is a derivative of the Rodway but with a Regen stage added (another BS170) so that it is able to copy CW and SSB as well as AM. It is intended as a broader introduction to amateur activity so it has all four bands 40, 80, 160 and Medium wave! It too uses a 9 volt PP3 battery and modern 32R phones but is laid out on a 100 x 160 mm PCB for plenty of space. This can also be used with the AM phone Rimpton TX (see last Hot Iron) which can do any one of 40, 80 or 160m with a peak Pout of 1.5W AM, or also on CW!

The last project nearing completion is the Mk 2 version of the Yeo DC receiver. This starts life as an 'any single band' of the 20 - 80m group but has the ability to add two bands to make it into a 20, 40 and 80m RX. This is aimed at use with the Mk 2 Mini mix kit with its 3 band LO outputs, where the Yeo's VFO is altered to run at 5 MHz to mix with the 9 MHz crystal for 14 MHz and divided down lower bands (on right). It has audio output for a low Z speaker or phones with a switched humped low pass filter for CW centred on 725 Hz. The Fine tuning control can be 'centred' automatically by the Isle transmitter when used for CW. This early model has the Mini mix kit attached by PCB strips on the side. G3PCJ



Out of the Dark Ages by Pete Juliano N6QW - radioguy@hotmail.com

Yes, we are talking about *The Dark Ages* or it would seem so, if someone were to suggest using Dual Gate MOSFETs in a new radio design. Hello, Dark Ages when one thinks about that undoubtedly right at this moment, there is a 10 year old school boy (or girl) that received a $5 Raspberry Pi Zero as a Christmas present.

With that device and using only two capacitors and one single coil, that youngster has fashioned a fully functional SDR transceiver. It was a simple matter using Python to create, in software, two Hilbert transforms, add in an image cancelling summer, create a couple of digital filters for SSB and CW, and finally add in a couple of IQ detectors. Oh lest we forget the waterfall display that uses parts from a defunct cell phone. Along the way he or she added an S Meter and fast attack AGC circuit. The really sad part for me was all that was done during a 15 minute school recess break. The $5 SDR transceiver is alive and walks amongst us! In today's radios there are few wires and it is mostly software wherein radios from the Dark Ages –it was all wires and discrete components!

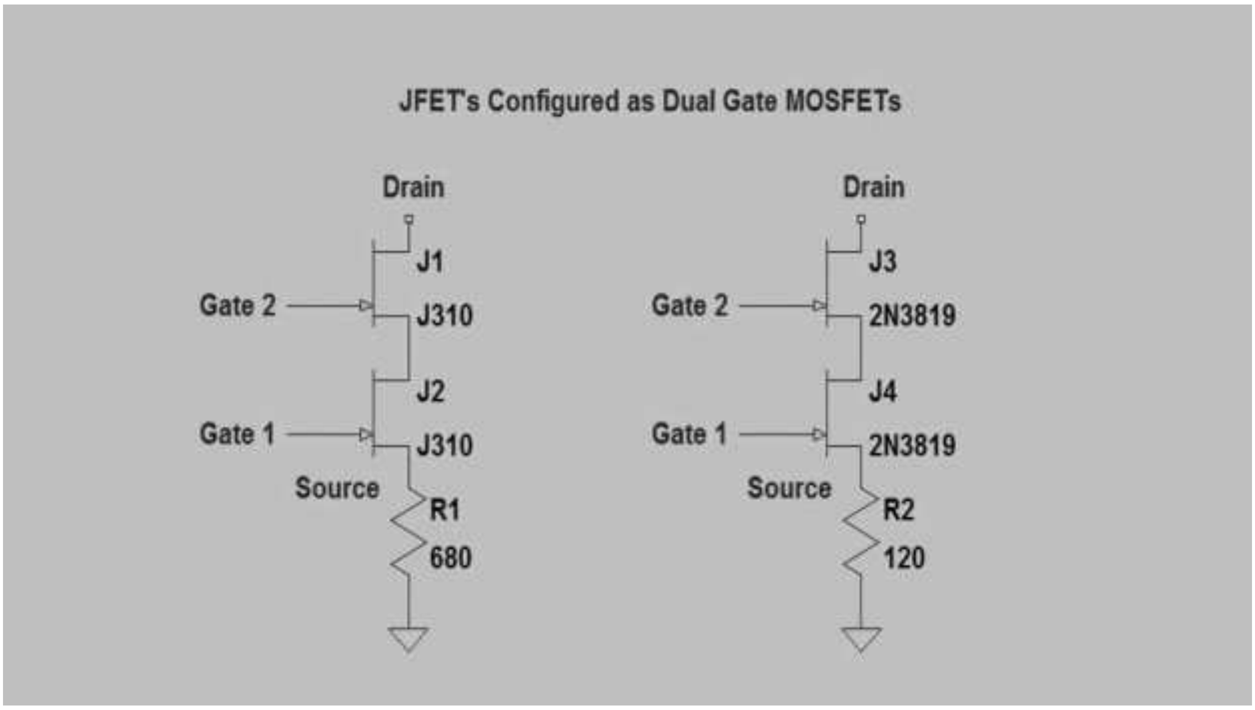
One problem today in using Dual Gate MOSFET's in our projects is that the old standard "leaded devices" such as the RCA 40673 Dual Gate MOSFET are nearly un-obtainable or cost an arm or leg, if you are lucky enough to find one. Virtually every ham radio project in the 1970's and early 1980's started with an RCA 40673. Who can forget Hanchett's 40673 VFO that graced the pages of QST which became the standard for VFO's? Or consider the project books from ARRL authored by Doug DeMaw or Wes Hayward that had a DGM in literally every circuit.

Today there are many Dual Gate MOSFETs (DGM) now available in the Surface Mount packaging at a fairly low cost. One good example is the NXP Phillips BF991 that costs roughly around 50 cents in single lots. This DGM is good to 200 MHz and can operate easily on 13.8 VDC. Of course surface mount for many homebrewer's is like climbing Mount Everest in Bermuda shorts and flip flops (a standard California Uniform of the Day). Hang on for in a short while we have a solution for you.

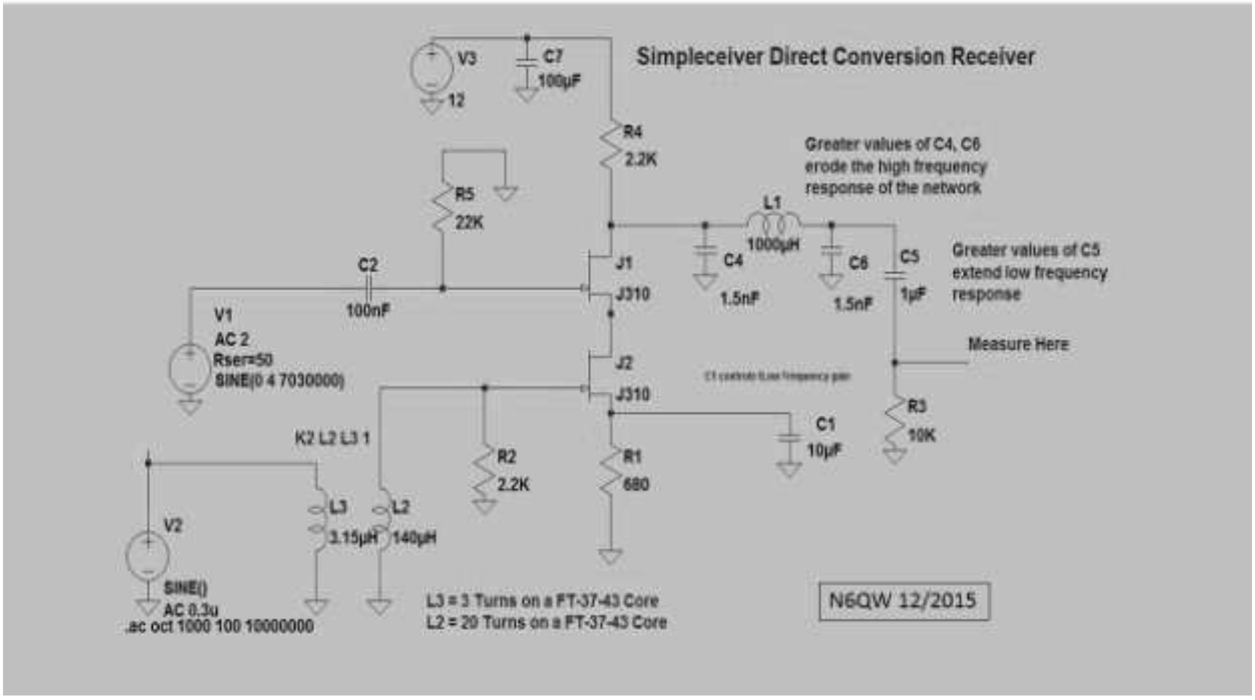
I am often asked why do you like Dual Gate MOSFETs and before I can answer, I usually hear "well you know they are subject to overload and they have noise figure problems and on and on". My answer is that DGM's can be configured as an Oscillator, Mixer, Amplifier, or even as a Product Detector. In fact they can be "gain controlled" by either manually or automatically changing the voltage on Gate #2 – we are talking AGC here! So there are many positive aspects for using such devices.

Now the solution –why not scratch build a Dual Gate MOSFET from commonly available leaded parts. If we were to connect two JFETS such as the 2N3819 or the J310 in the cascode configuration – instant Dual Gate MOSFET. Essentially cascode has the Source of one JFET connected to the Drain of the second device. Shown below are two popular JFETS that have been employed in our projects. But note that the Source resistors are different based on the individual differences of the devices. The J310's require a higher Bias level.

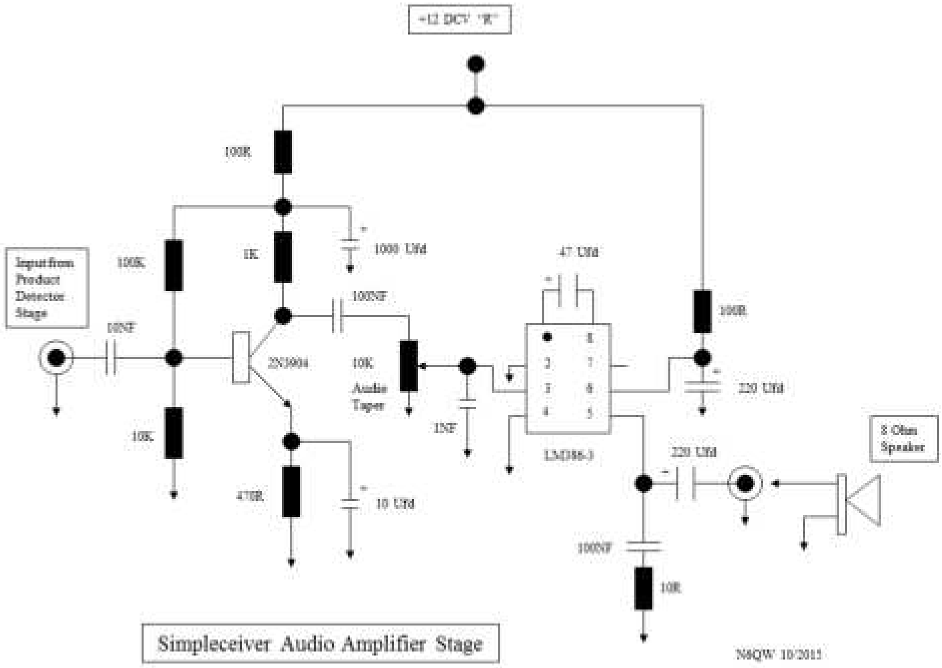
The bonus -- you get the benefit of Gate #2 such as in the case of a Direct Conversion Receiver, where the LO is injected into Gate 2 and the antenna with suitable matching is applied to Gate #1. In the case where the pair is used as a Product Detector then the BFO is injected into Gate #2 and the signal from the IF, with appropriate matching is fed to Gate #1. You get the idea.



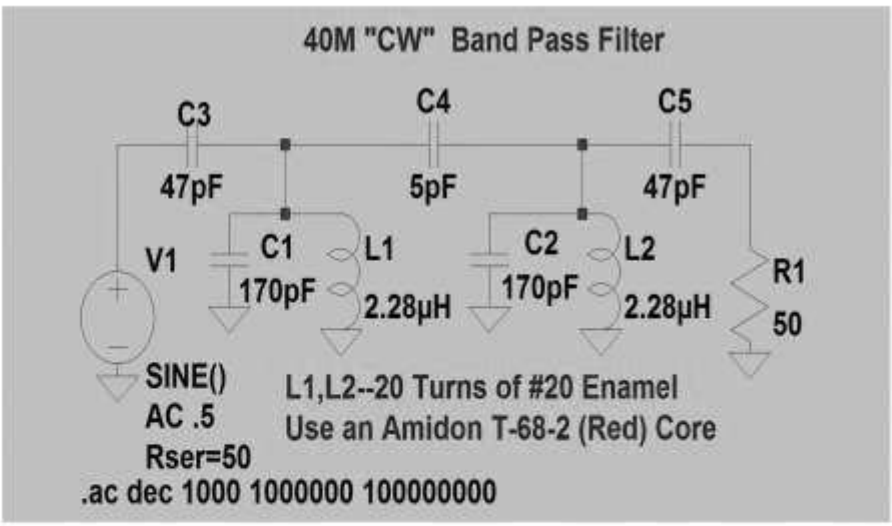
Here is a design for a Simple Direct Conversion Receiver element using either the J310's or the 2N3819's. The design below is direct from the LT Spice Simulation which I encourage the readers to use for evaluation purposes. You will see about a 20 dB gain over the audio spectrum. The LO has about 2 Volts Peak to Peak (10 dBm) and the Zin is 50 Ohms. For the 2N3819 the only change needed is the Source resistor is 120 Ohms versus the 680.



This Direct Conversion receiver is followed by audio amp employing a 2N3904 driving an LM-386-3 as shown below. I have built discrete component audio amplifiers but I consider that approach pre-dark ages.



Ahead of the DCR module would be the Band Pass Filter that has been peaked up for 40M CW. This is the LT Spice Simulation and R1 is not used in the physical build.



It may be necessary to add a bit of RF amplification ahead of the Band Pass Filter and the Internet abounds with many circuits. I say this because one builder was using a rain gutter for an antenna, only he didn't realize the gutters were plastic material and so he only had about 10 feet of wire for the antenna. The RF amp helped out – a lot.

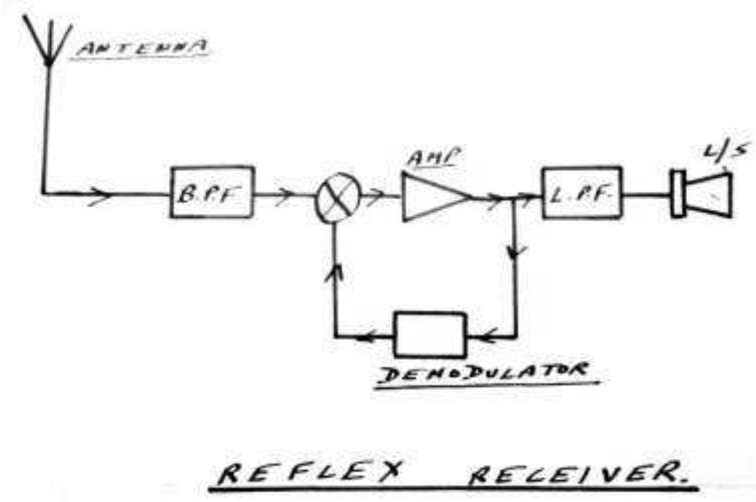
So OK no one asked why the young lad or young lady needed the two caps and the coil for the Pi Zero? [Drum roll please!] For the young of today, it is the "cool factor" – you have to have something that you can point to and say "Isn't that cool?" Dark Ages also has a further definition: anyone who watched the moon landings in 1969, as an adult, (like me) is from the Dark Ages.

73's Pete N6QW (Request by G3PCJ – would that 10 yr old please come forward and offer me a short layman's guide for Hot Iron on the Hilbert transform?)

REFLEX RADIO RECEIVERS by Keith Woodward G6AAZ

My earliest memory of homebrew construction was to build a Reflex (or Reflectional) radio receiver from a design in "Radio Constructor". Some 50 years later having built many of Tim's kits the thought occurred to me as to why are such receivers are not as popular as other designs (i.e. Crystal, TRF, Regenerative, DC or Superhet)? Then I realised that I did not know how a Reflex receiver worked so I found out and hence this article.

The Reflex receiver dates back to 1917 and it works on the principle of using the same amplifier for both the radio (R.F.) and audio (A.F.) signals. The R.F. from the antenna and tuned circuit passes through Band Pass Filter (which act together in a similar way to a T.R.F. circuit) before passing through the amplifier. The signal is then routed through a High Pass Filter before going to a demodulator which extracts the A.F. signal form the R.F. carrier. Next A.F. signal passes through the same amplifier before passing through a L.P.F. before reaching either an earphone or loudspeaker. The design uses the "superposition principle" i.e. if the amplifier is linear then 2 signals of different frequencies passing through it can be separated at the output using suitable filters.



The main design objective was to reduce the number of active devices at a time when they were very expensive. To put it another way the Reflex receiver uses half the number of active devices when compared to other receivers of its era. In the 1920's it was used in inexpensive vacuum tube radios and in the 1930's in simple portable vacuum tube radios. However the design was vulnerable parasitic oscillation if the design of the amplifier was either not linear or was operated outside its linear range.

So the challenge is, can anyone design a reliable receiver for amateur radio purposes working on the reflex principle. Any body wish to offer a design?

Comment by G3PCJ The reason that nobody uses this approach, in modern 'commercial' designs, are the obvious ones that Keith mentions! He alludes to the compromises that have to be made in order to make a viable design; the consequence is that probably some aspect of performance is not as good as if that functional block had been designed just for a single purpose! The other important difference is that years ago valves were very expensive compared to the other parts and hence there was a very strong incentive to make them 'work' as much as possible – transistors are now so cheap that they can be thrown in almost without consideration of their cost! BS170 MOSFETs in quantity are just a few pence each but it is the mechanical items that are now unduly expensive – e.g. tuning capacitors and knobs – I cant immediately think how to get multiple uses out of them?!

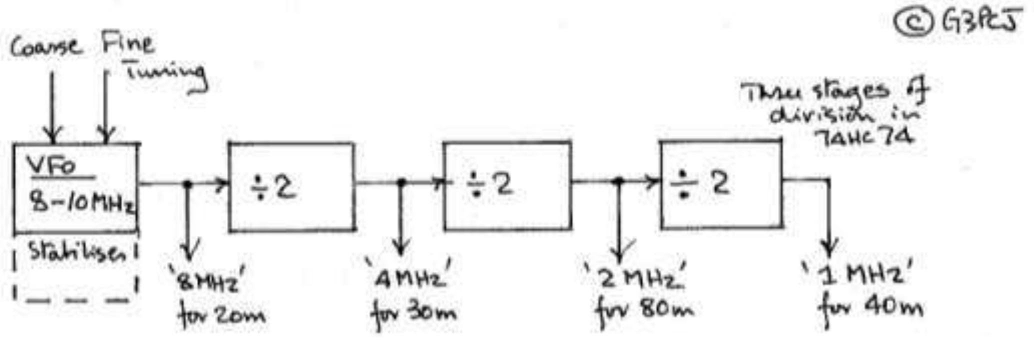
Local Oscillator Schemes for Superhets

I am always doodling over alternative 'analogue' (not DDS!) frequency schemes for new rig possibilities – here is another! I have used an Intermediate Frequency of 6 MHz very successfully in many rigs and see few reasons to depart from that! It makes sideband switching, and simple frequency counter designs, much easier! The bands of most interest are those in the group 20 to 80m because some, or all of them, are what most customers usually desire.

The table below shows the local oscillator (LO) frequencies that could be used for additive or subtractive mixing in the superhet's first mixer, based on a 6 MHz IF:-

Band	**Freq range MHz**	**Additive Mix LO range MHz for 6 MHz IF**	**Subtractive Mix LO range MHz for 6 MHz IF**	**VFO division factor**	**VFO range MHz**
20m	14.0 - 14.35	20 – 20.35	8.0 – 8.35	1	8.0 – 8.35
30m	10.1 – 10.15	16.1 – 16.15	4.1 – 4.15	2	8.2 – 8.30
40m	7.0 – 7.2	13.0 – 13.2	1.0 – 1.2	8	8.0 – 9.6
80m	3.5 – 3.8+	9.5 – 9.8+	2.5 – 2.2 - Backwards	4	10 – 8.8

It is obvious that the LOs of the subtractive mix are all harmonically related or very nearly so - hence digital division becomes an interesting possibility! With the VFO running near 8 MHz, three stages of division by two can provide the LO for any or all the desired bands!



Harmonic Related VFO for 6 MHz IF Superhet

There are some drawbacks – firstly, the VFO has to tune from 8 to 9.6 MHz to cover all of 40m (or to 10 MHz for the US 75m band) – this is a bit large for comfort - but its not impossible if one uses a combination of Coarse and Fine (or band set and band spread) controls. The other aspect is that the tuning rate of both controls will vary from band to band – this might be a little disturbing at first but the simplicity of digital division, which avoids the need for crystal mixing and LO band pass filters, is a huge cost, complexity and reduced risk benefit. CIO sideband switching is needed but is not difficult! Stability of an 8 to 10 MHz oscillator might be questioned but if it were stabilised with a Huff and Puff scheme (see next page!) that should not present a problem either. If the superhet is also to do CW, then provided this is done by the injection of a keyed 750 Hz tone, then the LO frequency does not have to change between reception and transmission in order to get both stations on the same frequency! G3PCJ

The Big Bad Wolf (drift)*....* by Peter Thornton

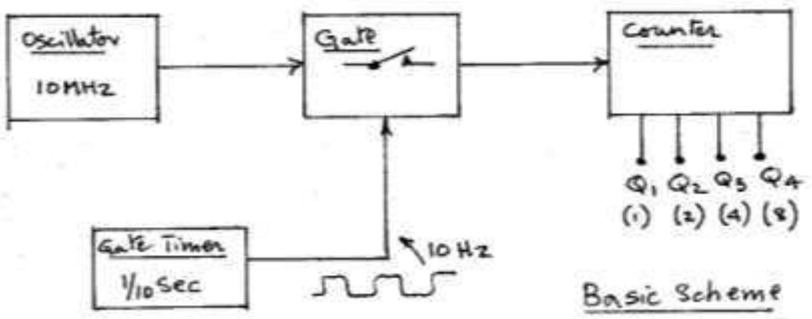
In L/C oscillators the wolf is *drift*. You can use whatever configuration you want, L/C oscillators will drift with temperature, time, power supply variation, orientation (with regard to other components) and a dozen other effects that make an L/C oscillator not an easy choice, despite the great advantage of simplicity plus few components. You *can* eliminate drift to a certain extent; add positive and negative temperature co-efficient capacitors for instance, use a Clapp or Vackar configuration (though for my money you have to try very hard to beat a Butler, either fundamental or overtone), or you can use an *oscillator stabiliser*.

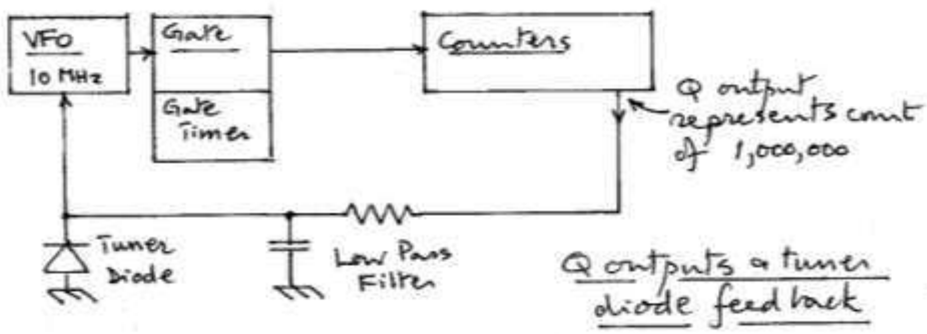
Commonly known as "Huff & Puff" stabilisers, these add-on digital systems give an L/C oscillator the stability of a synthesizer; they tune in a series of frequency steps, the step size determined by the timing of the digital system. Huff & Puff stabilisers were first outlined in the 1969 by Peter Martin, G3PDM, and implemented practically by Klaas Spaargaren PA0KSB in 1973, as reported by Pat Hawker G3VA in his "Technical Topics". The principle is this: count the oscillator cycles (cycles per second = frequency = Hertz) for an accurately defined time; check if the count is more or less than the desired frequency; apply a "correction" to the oscillator. Thus, the oscillator frequency is controlled and defined by the accuracy of the count time - in commercial frequency counters, this is called the "gate" time. Here's an illustration. Our variable frequency oscillator is of reasonable construction and design, and is running at 10MHz. The gate time is set to 1/10th of a second, so the counter will accumulate a count of 1,000,000 in 1/10th of a second, as in top diagram on next page. I have only shown a single counter chip for convenience (many more can be strung together for bigger counts) and illustrated the gate as a switch. Reset lines, power, etc. are not shown for clarity.

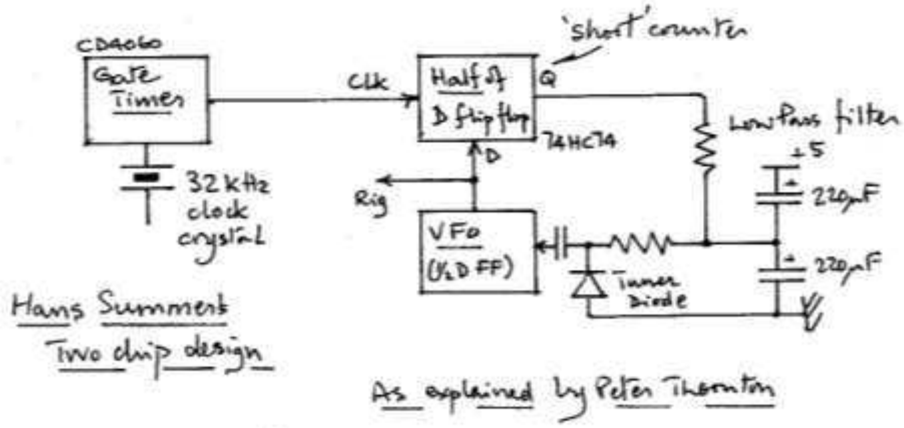
Now consider the VFO drifts LOW - in $1/10^{th}$ of a second, the count might only be 999,900; if the VFO drifts HIGH; the count might be 1,000,100. Part of the capacitance in our L/C VFO is the tuner diode, if the VFO drifts LOW, we need to increase the bias on the tuner diode; if the VFO drifts HIGH, we need to decrease the bias on the tuner diode. If we observe a "Q" output (in second diagram,) that represents the "1,000,000 stage", and that Q is logic "0" after $1/10^{th}$ of a second we know the count is LOW; then if the "Q" is logic "1" the count is HIGH. The "Q" output, representing a count of 1,000,000, is inverted, and then used to adjust the bias on the tuner diode, the counter will correct the drift of the VFO, to maintain the count to be *exactly* 1,000,000. That's Huff-N-Puff, as in middle diagram! You can scale the frequency, gate timing and Q output to suit any frequency.

It would appear that you would need strings of decade counters to accumulate the numbers, and special gate timing for the scheme to be successful; but in reality you can simplify the whole thing to a couple of logic chips! You don't actually need all the in between stages of the 'measuring' counter & instead use just a short version consisting of a single flip-flop. The simplest design I've ever used is in the bottom diagram, which is from Hans Summer's design at www.hanssummers.com in the "Other Radio Topics" section. The gate timing is done with a 32kHz watch crystal plus a CD4060 chip, the Huff-N-Puff "counting" is done by one half of a 74HC74 dual D flip-flop. Hans uses the other half of the dual D flip-flop as an inverter for the VFO oscillator! You can easily adapt Hans' design to suit; 74HC logic is fine to 50MHz, and if you really want to push the limits, Potato Semiconductor (yes, check them on the internet!) make 74HC pin compatible logic chips that run to 1GHz.

HUFF-N-PUFF!


Oscillator
10MHz
Gate
Counter
Q_1 Q_2 Q_3 Q_4
(1) (2) (4) (8)
Gate Timer
1/10 Sec
10 Hz
Basic Scheme


VFO
10 MHz
Gate
Gate Timer
Counters
Q output represents count of 1,000,000
Tuner Diode
Low Pass Filter
Q outputs a tuner diode feedback


CD4060
Gate Timer
32 kHz clock crystal
Clk
Half of D flip flop
Q
D
74HC74
'short' counter
Low Pass filter
+5
220μF
220μF
Rig
VFO
(½ D FF)
Tuner Diode
Hans Summers
Two chip design
As explained by Peter Thornton

Gaining the confidence to home-brew - by Dick N4HAY

I have been a committed QRPer for many years and over this time I have built and operated a number of QRP kits. My biggest and most complex kit was the Elecraft K2. Much as I love to operate these rigs I have always had a yearning to really understand and participate in 'The Radio Art'. How does that radio really work? I wanted to be a radio design engineer from a very early age. So much so, that I attended university and obtained an electrical and electronic engineering degree. However this led me down a professional career path far removed from my starting goal. Life has a tendency to get in the way, of course. In my early years I never did get to really understand how radio worked - certainly not a practical, deep and real understanding. So how might one go about acquiring this knowledge?

For me it was not until 3 years ago when I was working in South Africa that I really started to make meaningful progress towards my original goal. I was travelling a lot in my job. These long flights gave me the opportunity to study the classic QRP books. After absorbing Doug De Maw's books (W1FB), I started to study Experimental Methods for RF Design, EMRFD. A brilliant book authored by Wes Hayward W7ZOI, Rick Campbell KK7B and Bob Larkin W7PUA. Unlike many other radio texts I had studied, I found, to my surprise, that I could easily understand the clear descriptions and concepts laid out in this book. At the same time I was given an oscilloscope, a function generator, a frequency counter and a variable voltage power supply by my friend Monk ZS4SF. I set up this equipment in my tiny shack and immediately started exploring the concepts and circuits laid out in these books. I became obsessed with measuring components and trying to understand exactly what their characteristics were. I started with simple resistor, capacitor and inductor combinations. First I would perform some simple calculations in order to be able to predict the circuit behaviour. I kept it simple initially, by experimenting with audio frequencies and components. For example, one of my earlier experiments was to calculate and then measure, the time constant of a resistor-capacitor low pass filter network. I designed an experiment using the function generator to generate the signal input to the circuit while observing the output waveform on the oscilloscope. I discovered, to my amazement, that the measured result indeed agreed with my calculated result. Through these simple experiments I gradually built up confidence in myself, my instruments and how to interpret the results. I then tried to understand what was causing the variances between the predicted results and the measured results. This thought process led me to the next level of understanding and further experimenting. All the while I was becoming better at using my calculator and at manipulating large and small numbers and the use of long forgotten engineering notations. I gained an appreciation for the decibel system and a practical feel for the logarithmic nature of the analogue world we live in. Today thinking in dB's and dBm's comes completely naturally to me.

After becoming familiar with resistors, capacitors and inductors I began to be able to identify such elements as resonant circuits and filters while studying schematics. I was now able to identify their resonant frequencies and 3dB roll-off points based purely on looking at their values. 40 meter band tuned-circuit values became familiar as did other band and audio circuit component values.

One of my favourite sources of information is the RF workbench series written by VE7BPO (now archived on his blog http://qrp-popcorn.blogspot.ca/p/blog-page_9.html). VE7BPO taught me the importance of the 50 Ohm RF work bench. This series led me to build a Return Loss Bridge, an RF Power Meter, an RF Signal Source and to acquire a set of fixed and switched attenuators. With these tools I was able to explore, measure and gain confidence in understanding subjects such as matching, gain, loss and distortion.

I have spent hours reading and re-reading Chapter 2 of EMRFD and then setting up simple single- transistor circuits such as the common emitter and emitter follower topologies. By varying the bias conditions, source and terminating impedances I have gained insights into the art and science of amplifier design and the inevitable trade-offs required. Each time I perform a measurement I learn something new. Upon rereading the relevant paragraphs in EMRFD I gain new insights.

I have also discovered the power of writing up my lab book and blog (ZS6RSH.blogspot.com) before, during and after the experiment. This forces a certain discipline and helps me to understand more clearly what I am striving to accomplish, what is being observed in the measurement results and what the next step should be.

In conclusion, looking back over the past three years at the wonderful road I have travelled and will continue to travel, I would suggest that the combination of studying, predicting a circuit behaviour, building the simple circuit, and measuring and comparing the result is a great path leading towards establishing a level of confidence and understanding in homebrew QRP radio design that will lead to an ability to design one's own circuits. A worthy goal indeed! This picture is where it all happens at N4HAY!

Snippets

Analysis of the diode detector I wondered in the last Hot Iron if anybody would care to comment on the mathematical analysis by Phillip Pollock of the simple diode detector; I did get only one comment – from a member who said he was thinking about it – but I have not heard anything further! I understand that he is using an ancient slide rule to help compute his answers!

Thank you

This is a convenient space to fit in a very big thank you to all the contributors to this issue of Hot Iron. Three are new authors for this journal and I very much appreciate the time put in by them (and also my regulars) to create material that I can insert straight away with very little editing. It has been particularly helpful this month as I have had to be away for long breaks in the Isle of Wight and hence out of touch. Much appreciated – thank you!

New Material

If any reader can write me any sort of radio related article please do let me know. Almost any radio topic is of interest to us all so please do not hold back. Similarly, if you have any question or topic that you think needs a bit of an airing, please tell me because others are likely to share your interest. Don't worry about diagrams, I can deal with them! Tim G3PCJ

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Summer 2016 Issue E92

Editorial

The grass is at least growing now and the cattle are out with the better weather. Time for some antenna work outside soon! To my surprise, nobody has commented (to me at least!) on my quip in the last editorial, that maybe an open-wire fed half wave antenna in the classic Zepp configuration, is not really a 'good' system. Even though the open wire feeder can withstand the resulting poor-match and high voltages, it just does not feel right for one side of the feeder to be unconnected to anything where it meets the half-wave antenna connected to the other feeder wire! I suspect that the performance of the same total length long wire antenna, working with a good RF earth and a capable Antenna Matching Unit, will be comparable. Come on one of you antenna experimenters – explain to me why I am wrong!

Through the good offices of the Radio Society of Great Britain (RSGB), we recently managed to get about 200 simple Rodway radio receiver projects into English schools where the mid-teen pupils were able to build the sets and have an introduction to amateur radio. This exercise was funded by the Radio Communications Forum with much hard work by Steve Hartley G0FUW and the staff of the RSGB. I was tasked with the circuit design – see later for some aspects of that! (The last Hot Iron had a photograph of an early Rodway.) The receiver uses the plain Tuned Radio Frequency approach with just three BS170 MOSFET transistors. It has two bands – the high frequency end of the Medium Wave for the powerful broadcast stations, that should be easily received, and 160m for demonstrating amateur radio techniques. In a few modern school buildings, there was a slight problem with the reinforced concrete construction acting as a Faraday cage barrier for the broadcast signals, but they were at least able to hear a nearby 160m phone transmitter operating into a dummy load instead. The RSGB had the PCBs made and gathered together all the parts for the kits. The excellent kit instructions, which had an introduction section about radio techniques and early radio history, were put together by Steve G0FUW and his Bath Buildathon team. I was particularly pleased to have been involved in the project because I feel very strongly that introducing analogue radio concepts to school children is an essential first step - long before they might get into radio processes executed in the digital domain. Radio communication is fundamentally analogue and they can easily do experiments in the school lab in support such electronic construction activities – not so easy with digital micro-processors! So they should start with the ANALOGUE concepts and techniques, and then most certainly should progress to digital methods if they are interested. The project is more fully written up in the May 2016 issue of Radcom.

Tim G3PCJ

Contents Kit developments, Redlynch circuits – RF amp, Fine tuning and Bias schemes, More LO schemes for superhets, Variable capacitors and all that, avoiding heavy iron in valve circuits, Snippets – reclaimed components, and my Thanks.

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

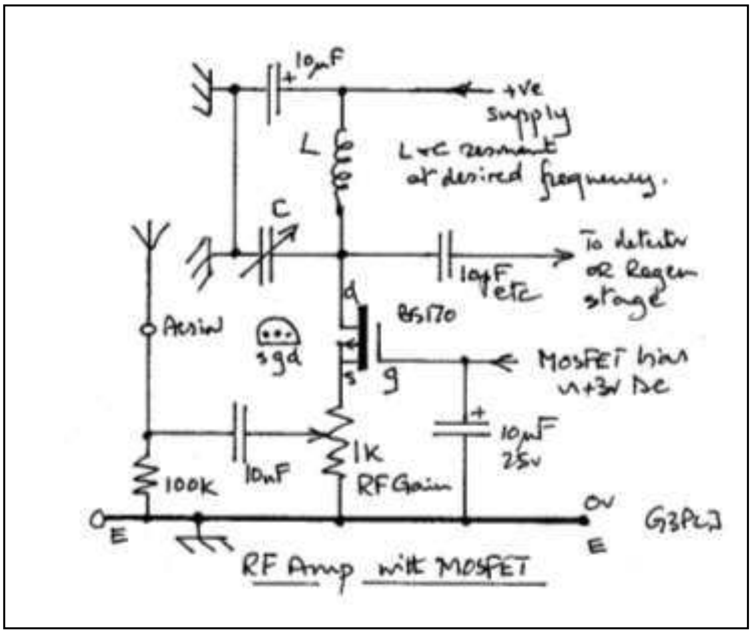
Kit Developments

In the last Hot Iron I mentioned the Redlynch derivative of the Rodway. The former is now available – see website www.walfords.net ; it is a Regen TRF with four bands giving coverage of 40, 80, 160 and MW bands, with much of the in-between frequencies as well owing to the simple tuning schemes. It is intended as an introduction to amateur radio for individuals and radio Clubs.

There is much interest among CW operators about how well simple Regen TRF receivers can perform. With this market in mind, I have laid out the PCB for a further derivative called the Cale (another small river in Somerset) for CW work on the 20, 30 and 40m bands. It intended to be the companion RX for the simple 3 band crystal controlled Isle CW transmitter. It is in the small upright format like the Yeo pictured right – which is now also available. I will be making the Cale prototype soon.

RedlynchCircuits

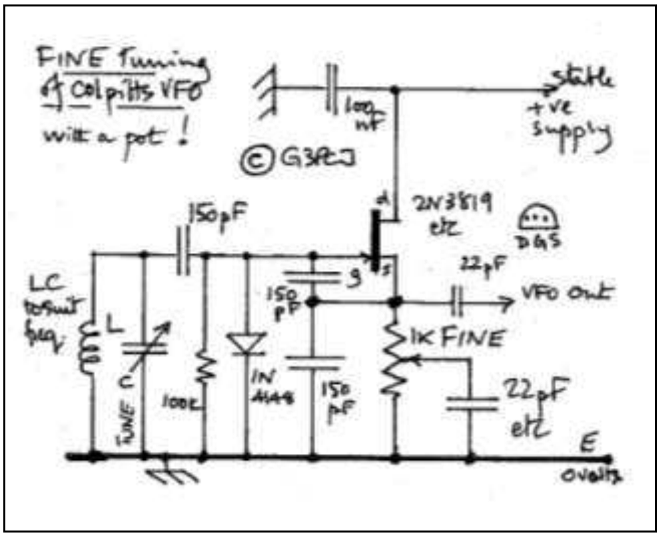
The desire to use a single type of active device in these simple lower cost circuits – preferably a MOSFET – has led to several interesting ideas:-



RF Amplifier

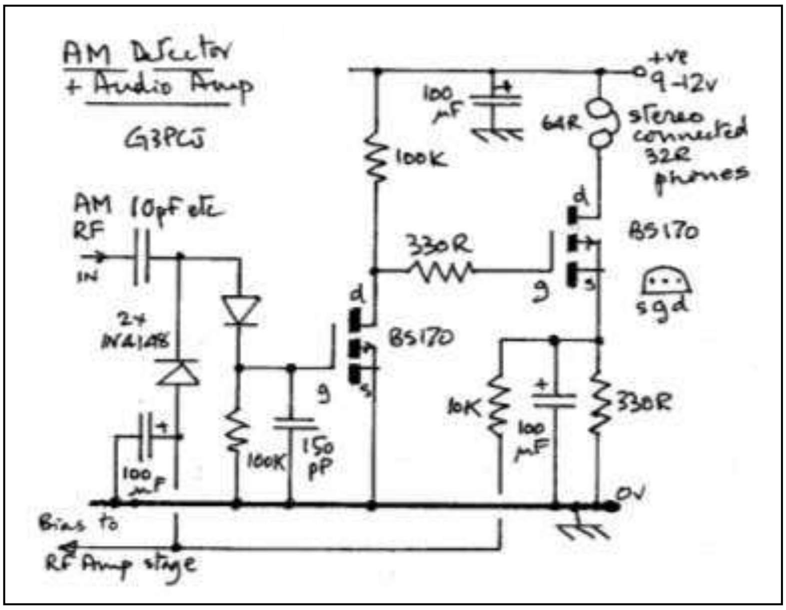
Youngsters especially - but many older people also - don't like winding inductors or toroids; so in these simple designs, the tuning inductors had to be ready wound and without any small or low impedance primary windings that are classically used for the 50 Ohm aerial input! Enter FETs with their high dynamic drain impedance that would not cause any problems for succeeding stages – especially if that stage is regenerative for high Q and good selectivity! An RF amp will also reduce aerial radiation if a following Regen stage is actually oscillating. Thus a parallel resonant tuned circuit can form the drain load of the FET. If the FET works in the grounded gate mode, feeding the signal into the source (with its low impedance), it will have a reasonable match for a 50R aerial feeder. This makes for a very easy input stage and can easily incorporate an RF gain control as shown above. A MOSFET can be used in this role where low cost is essential but is a bit more prone to unwelcome high voltage static on the aerial lead (hence back to back input diodes or a discharge resistor). A junction FET is more robust, and its capacitances are less variable, so is better where performance is more important.

Fine Tuning



Air variable capacitors and slow motion reduction gears are now lovely items of the past! Coarse and Fine tuning controls are the next best alternative but even small variable capacitors are impossibly expensive! One approach is to use some form of varactor diode whose capacitance changes with applied voltage derived from a Fine tuning potentiometer. Often these diodes are connected across the Colpitts capacitors of the rig's variable frequency oscillator. If you connect a small capacitor across the lower Colpitts capacitor it will shift the frequency down but if instead it connects to the lower end of the Colpitts stage source resistor it will have no effect! What control can do this? A potentiometer! So replace the source resistor with a pot whose slider has the small capacitor to ground! The relationship between slider position and capacitance change may not be linear (nor well defined), but the end conditions are well defined and it is low cost! The incremental frequency range of the control is adjusted just by just changing the slider capacitor.

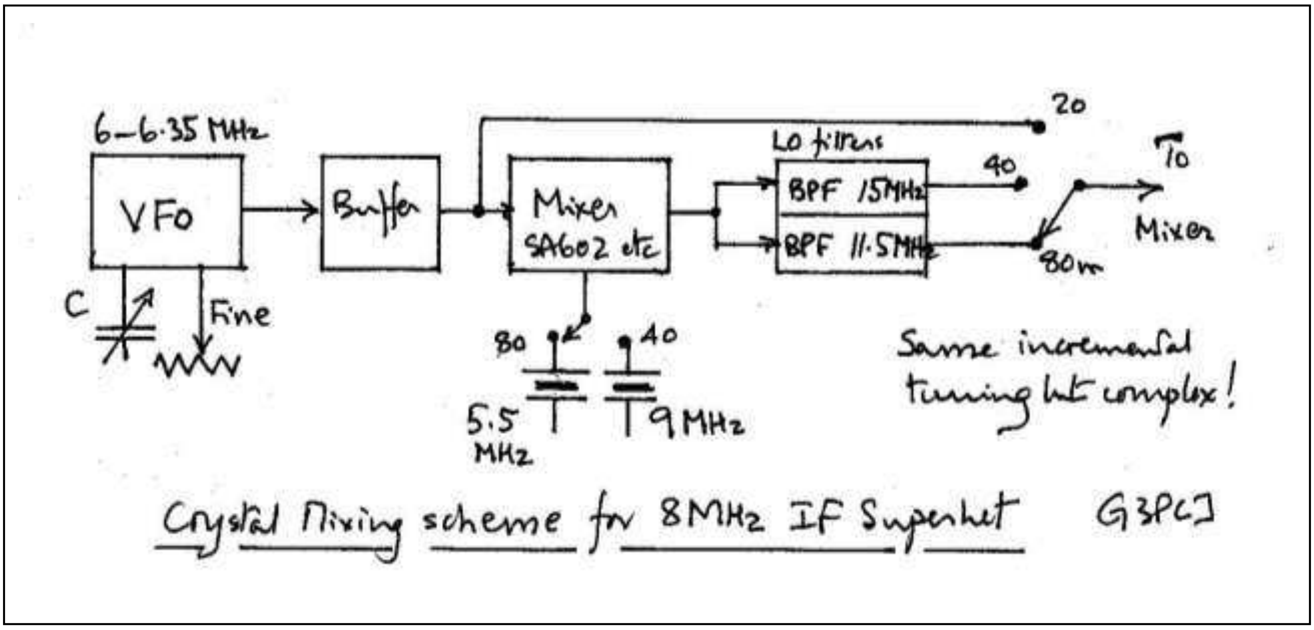
Biasing



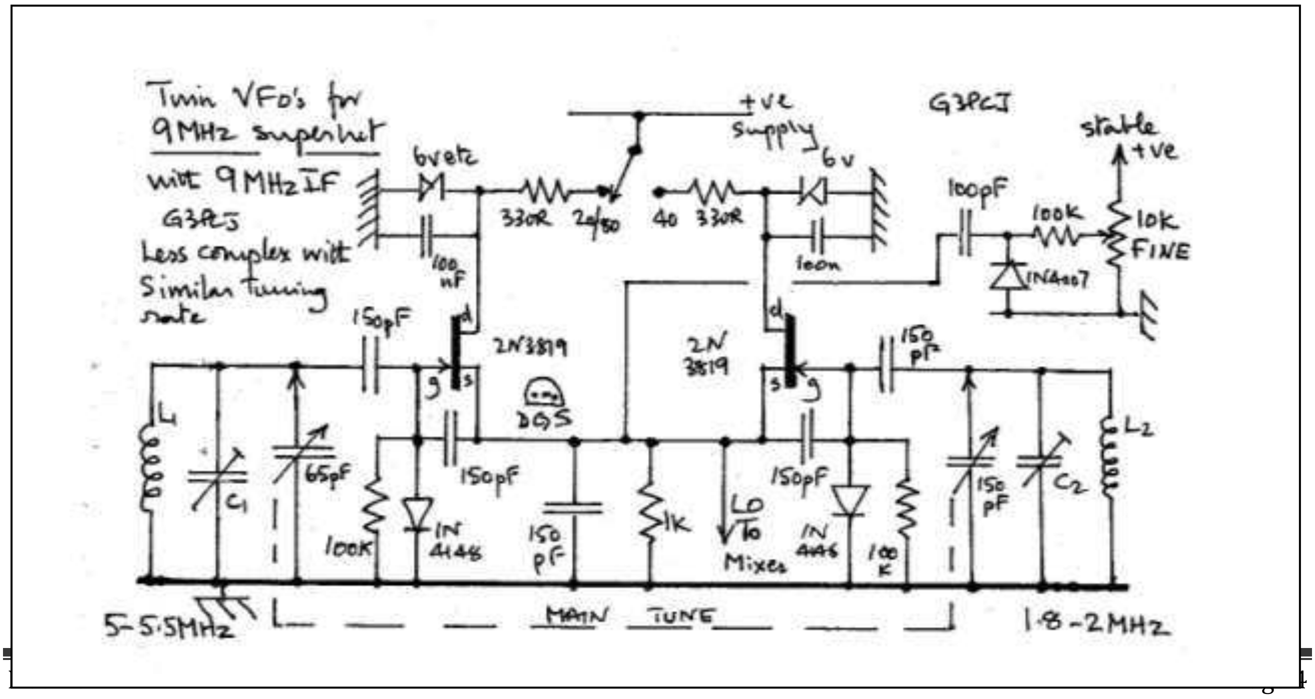
These simple TRF receivers need an amplitude detector instead of the product detector more commonly found in DC RXs. An amplitude detector is a rectifier by another name. Historically germanium diodes would have been used but they are like hens teeth now so we have to use silicon ones – they are fine for low signal work provided they have some form of forward bias. This is easily arranged if two diodes are used and they can directly feed the high input impedance first stage of a MOSFET audio amplifier. The design above has a second MOSFET output stage for driving series connected modern 32R phones. So with the feedback arrangement shown, the output stage source voltage settles at just over three volts - made up from the two volts needed to turn on the first audio MOSFET plus two diode drops. The diodes are only passing a very low current so together have about a volt across them. To boost the builder's electronic construction confidence, the source 'resistor' can incorporate a LED but it is not an essential part of the loop design – it is the diode drops and MOSFET gate turn on voltage that control the DC conditions. This bias arrangement is fairly 'stiff' because the MOSFET has very high DC gain and so can be used conveniently to bias the receiver's RF amp stage if that is also a MOSFET! G3PCJ

More Local Oscillator Schemes for Superhets!

I outlined an approach for a multi-band superhet with an IF of 6 MHz in the last Hot Iron but it did have at least one major drawback – the tuning rate was significantly different for all bands! Although a user could quickly get used to the rate for any particular band, it is not good for a top end rig - so think again! The scheme below is better but does have the drawback of needing 'tender' and complex extra bandpass filters etc – it still uses the crystal mixing approach, to avoid chirp/FMing and give stability on the higher bands:-



I think this could be improved for a three band rig doing 20, 40 and 80m by changing to a 9 MHz IF with a VFO at 5 – 5.5 MHz (in the classic 'image' scheme) for 20 and 80m. This needs to work on both sidebands but that is relatively easy! How do 40m? Use another complete VFO working 1.8 – 2 MHz! This is less complex than another set of filters and crystal mixing so is a good solution for the Somerton RX and Dorchester TX to replace the Minster & Lydford. G3PCJ



Variable Capacitors and all that… by Peter Thornton G6NGR

Many folk in the electronics World think the tiny bit of silicon inside is the "clever bit". Well, a "pie without a crust is no pie", and most people don't see the "crust" on a device! I'm talking about the "encapsulation" - the covering that keeps fingers off the silicon, be it plastic, or the metal cans of yore. The encapsulation is as important as the silicon: without both, that's no pie!

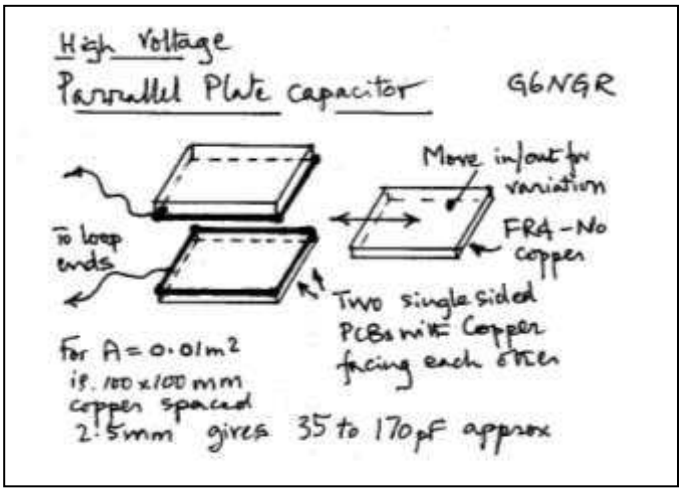
I used to maintain machinery at Ferranti Electronics and one of the jobs was to repair a pellet heater machine, this heated the plastic pellet of moulding material that was injection moulded around the silicon devices. The plastic pellets had to be stored at 2C to prevent deterioration; not good for pressing through the channels of a moulding tool with tiny galleries and runnels - so the plastic pellet had to be heated up to 110C immediately prior to being forced into the mould tool. A pellet that was cold would result in a split inject barrel (and me in the gaffer's office).

How to heat up a plastic pellet quickly enough for production? An oven was too slow; and unused pellets would be ruined, it is a thermo-setting plastic and once it starts polymerising, it quickly becomes an un-meltable lump! The answer was RF power - lots of it. As the cold pellet dropped into the inject barrel, a coil around the barrel was energised with 15kW at 80MHz. The pellets became the dielectric in a capacitor: every dielectric has losses - no dielectric is perfect, the current leads the applied voltage by just under the "perfect" 90 degrees. That few degrees off 90 represents the losses, and they appear as.... heat. Thus - one hot pellet, heating as it drops through the injection barrel into the mould tool, immediately prior to moulding. Perfect!

Which leads nicely to a problem I had at my house recently. New neighbours installed a plethora of electronic gizmo's. Reception of amateur signals was impossible: on HF, I'm S9 noise top to bottom! I decided to try a loop antenna, and yes, on 15-12-10m a loop helps, I can turn it to reduce the noise on RX. The design is from W9SCH, the "Rockloop". Make it with the thickest copper you can get your hands on, to keep those losses low. A Rockloop design is at: http://www.qsl.net/dl1gsj/html/rockloop.html and many more are on the Internet.

How about transmitting? Loops for a TX need a **very** good variable capacitor for high power: some loop designs demand split stators, others vacuum variables. Neither available here! Answer: use dielectrics. I set up two pieces of 2.5mm thick single sided FR4 copper clad board (copper facing copper) with insulators spacing them 2.5mm apart. The formula: Capacitance in pF = E x 8.85 x A/D (where E = Relative Permittivity of the insulator, A = plate area in m^2, D= spacing in m) and that's my variable capacitor. "How do you vary the capacitor?"

Easy. Slide a piece of plain (no copper) FR4 material in the gap - it has relative permittivity (E) of ~5 (air is 1) so the inserted dielectric, as in the formula, varies the capacitance. It's fully insulated, so it's safe to touch, has no "earthy hand" issues and FR4 is one of the lowest loss dielectrics available to amateurs. A few HV capacitors add some shunt pFs to the "variable" pFs to set the band. You can use any insulator to adjust: I happened to have FR4 to hand. Good luck!



Some common materials' Dielectric constants

The actual value will be somewhere between the "low" and "high" values below.

Material	E value (low)	E value (high)
Air (clean & dry)	1	1
Epoxy Resin	3.3	3.5
Formica laminate	3.6	6.6
FR4 PCB material, no copper	4.8	5.3
Glass	3.8	14.5
Mica sheet, no internal voids	3	9
Neoprene Rubber	4.1	6.7
Nylon	3.4	22.4
Paper	1.5	3.3
Plexiglass (USA) / Perspex (UK)	2.6	3.6
Polycarbonate (Plas-Glas)	2.9	3.2
Porcelain	5	6.5
Slate	7	7.1
Styrofoam	1.05	1.1
Teflon	2.1	2.1
Vinyl	2.5	8
Wood, dry and split-free	1.4	2.95
Water, de-ionised 18M-ohm	34	80

The breakdown strength, kV / mm varies greatly with moisture and atmospheric pressure; but some materials are relatively un-affected by moisture and pressure. FR4 PCB material is the best choice overall in this regard - proven by its use as the material of choice for best quality PCBs.

The Dielectric strength of FR4 is given as 20MV/ m which corresponds to 200kV / cm: whereas clean dry air has a breakdown of ~30kV / cm, and is an industry accepted value. Unfortunately you can't scale this relationship down much below mm's - the geometry of the gap plays a much more important part as the dimensions shrink. Eventually as you shrink the scale you end up studying Paschen curves, gas dynamics and Quantum effects.

Suffice to say, two capacitor plates separated by 2.5mm of plain FR4, will - *if kept clean, dry, and dust free* – will withstand 20kV (peak) forever and a day; and has done so in many a Glasman, Brandenburg and Wallis HV power supply.

Avoiding Heavy Iron in Valve Circuits by Robert - DL3RR

Transformers for valve circuits are unquestionably the most expensive part. Sadly, gone are the days of picking up heavy iron for reasonable prices at the surplus stores. A few years ago, I was looking at ways to experiment with valves relatively cheaply and what was possible in order to eliminate the need for expensive transformers. Tim's comments in Hot Iron E89 persuaded me to put pen to paper.

Mains Transformer

At this point, I should make clear that the mains transformer should **never** be left out. I realise this is common sense, but nevertheless there are various circuits available on the Internet which connect HT straight to the mains. This is extremely dangerous! Admittedly some appliances "back in the old days" did this, but it is unacceptable in this day and age.

Tim's circuit in Hot Iron for generating HT is extremely elegant. As an alternative, I have reverse fed a small mains step down transformer. A 230v:16v transformer can be fed with 12v and this will generate a high enough HT voltage to adequately run (at least) a small regenerative receiver. It needs to be borne in mind that the transformer core is not optimised for this and core losses will be higher than in the "correct" direction but it will work. However, don't make the mistake of thinking that you can try and drive the secondary above 230v – even with a transformer of suitable power rating! The core will saturate and the transformer will burn out. Of course, I found this out in a weak moment when the result of common sense breakdown filled the workshop with smoke!

Low HT Voltages

It is possible to use small-signal valves at surprisingly low HT voltages. When I was doing my degree, voltages of above 30v were frowned upon (looking back, and remembering "us lot" - for good reason!) I got around this by building a headphone amplifier with an "HT" voltage of 30v. The output stage was MOSFET based to reduce the output impedance of the valve stage, but it still had a valve as the amplification stage. Of course, you are clearly not going to be able to run a power pentode at this sort of voltage, but it is surprisingly effective if high power isn't needed.

Such a low HT voltage is going to have the valve working way outside of its linear region, but by carefully choosing the valve we can, to a greater or lesser degree, get around this problem. An ECC88, for example, is a very good bet, as are space charge valves which were designed to run on low HT – but these are getting hard to obtain.

Output Transformers

Output transformers are often the most expensive – even more so than mains transformers for the simple reason that they are not mass produced any more and demand is small.

In my search for an alternative, my first choice was a 100v public address line transformer. These are designed to transform the high impedance output of a public address amplifier down to the 4, 8 or 16 ohm needed for a speaker. I had some success with this method, and it is certainly significantly cheaper than using a true valve output transformer, as these transformers can be bought for a few pounds. They obviously won't be Hi-Fi quality – but in amateur radio applications this isn't a problem.

I also experimented with valve stages to get the output impedance down. A cathode follower output stage was designed on paper using a 6AS7. This valve was originally designed as a series stabiliser for power supplies, and has a very low anode resistance and amplification factor and thus a high transconductance. As the output impedance of the cathode follower is given by the approximate relationship:

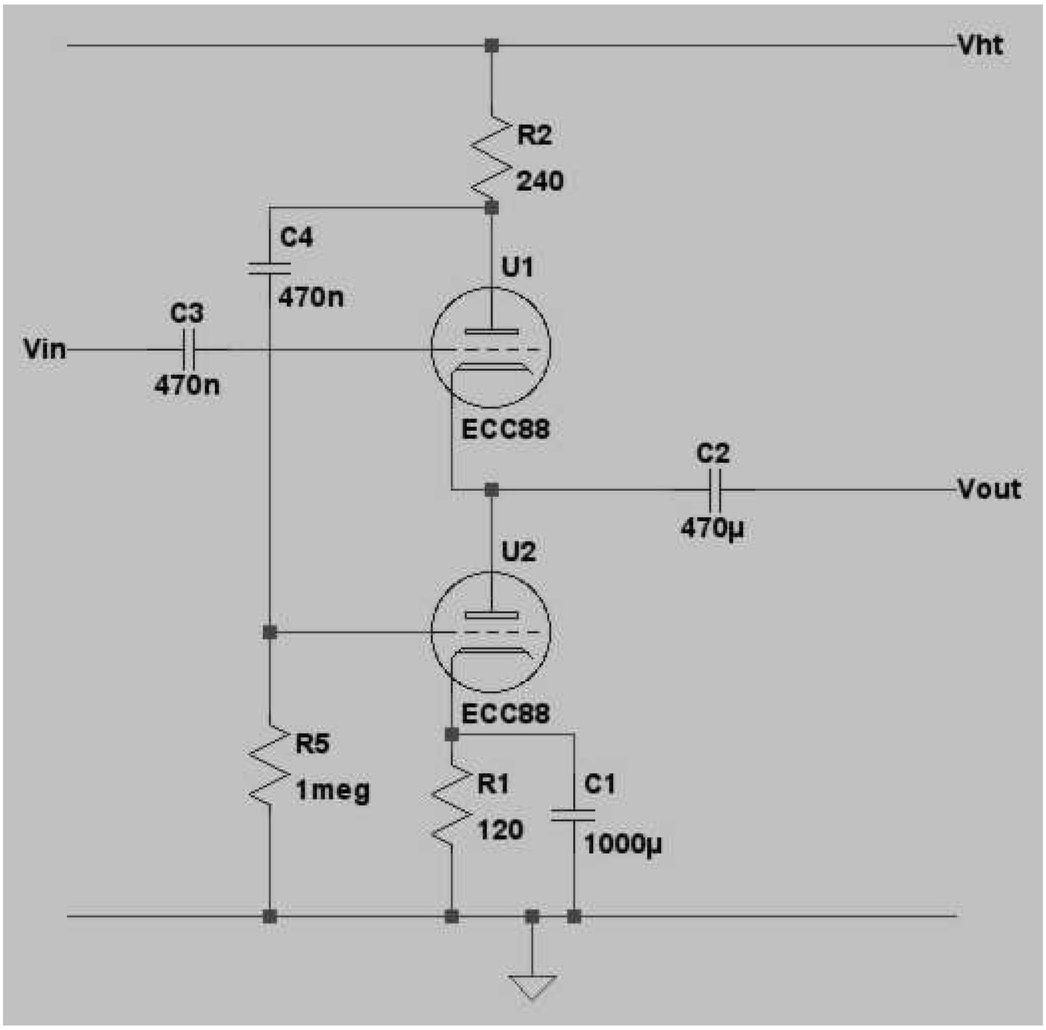
$$Zo = \frac{1}{gm}$$

For the 6AS7 we get approximately:

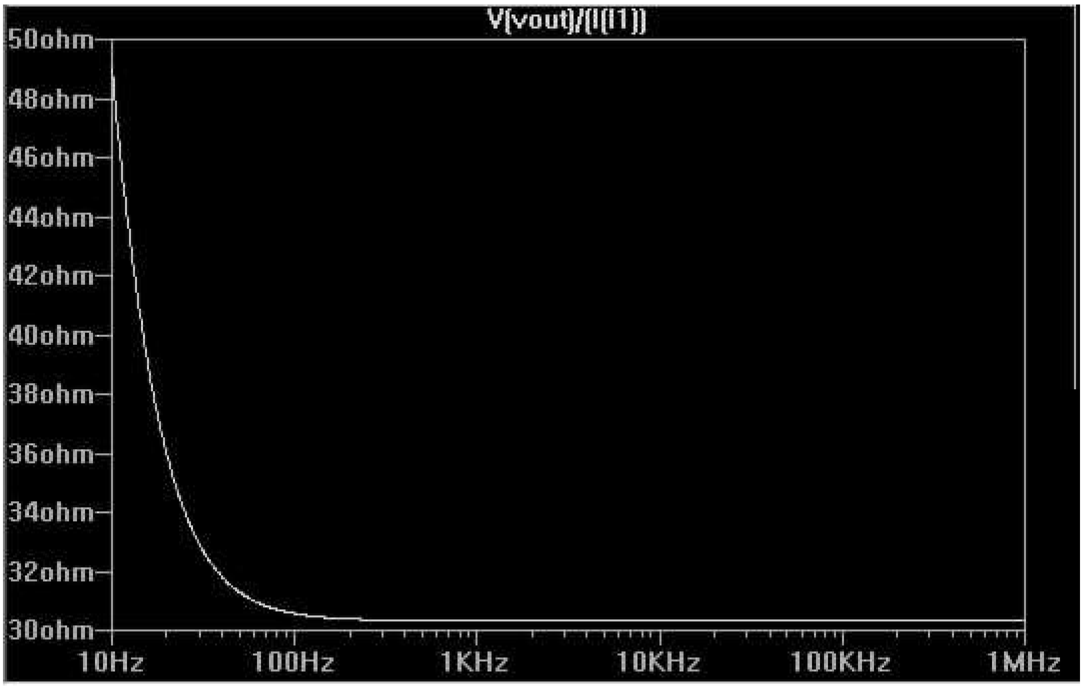
$$Zo = \frac{1}{7 \times 10^{-3}} = 142\Omega$$

Although this value of output impedance is much lower, it still not ideal for low impedance headphones; and no use at all for a speaker. Plus, coupled with the 6AS7 needing a heater current of 2.5A the costs we save with the output transformer will need to be invested in the mains transformer!

What turned out to be useful was a topology known as the White Cathode Follower, which I believe was originally patented for driving 75Ω transmission lines. Here, the trade-off is the need for two valves, but as a small double triode will suffice this isn't too much of a problem. The White Cathode Follower is essentially a cascode amplifier which uses feedback to reduce the output impedance. One valve is used as the amplifier, and the second as a regulator. The circuit diagram is shown below:



As can be seen from the AC analysis plot below, the output impedance of this circuit is extremely low – certainly low enough to drive a pair of headphones and probably even a small speaker (although I haven't tried this). The only thing to bear in mind here is that the capacitor C2 should be a good quality device rated to at least 1.5 times the HT voltage (220 volts in this example). If the device were to fail short circuit, then a significant portion of the HT voltage would appear on the headphones.



Summary

To cut a long story short, there are various ways of getting around using heavy iron – some of which are more useful than others. Like many things in life, it is a trade off. You cannot expect miracles but there are various ways to avoid having to spend big money on large transformers. I welcome comments and suggestions, and can be contacted at robert@dl3rr.net.

Comment by G3PCJ – Most interesting Robert – thank you! I think there is a similar semi-conductor equivalent of your White Cathode follower concept. I know that you were aiming to use an all valve method but when doodling audio output circuits (for 32R phones) recently, I wanted to do it all with a single type of active device to reduce the part picking time when making up kits! I concluded this could be done with an emitter or source follower in the upper 'leg' (as above) and some sort of common emitter (or source) stage in the lower leg. Lack of time prevented me thinking out how to control the gain of the lower leg to make them balance but the White follower is the valve equivalent! Hopefully some Hot Iron reader will be able to tell me its name so I can look it all up on the web from somebody who has solved it already!

Snippets

Beware the Chinese are reclaiming components!! I am sure that most of you at sometime or another have been tempted by the cheap Radio related items that have become available from China. Most of these items can be had on EBay for very cheap prices and some are genuine bargains. I have bought many of these items and have never had any problems other than the wait! I have on a number of occasions, purchased BaoFeng Hand Held radio's and for the money, you cannot go wrong. A few years ago a dual band hand held would have cost over £300 but now we can buy them for as little as £20! The same goes for kits and very cheap test equipment kits can be bought for a fraction of their real value…But.. Now it would appear that the Chinese have gone into the reclaim market!! For those who don't understand how this works, you build a circuit, it works and then after a few years you salvage parts from it to build a new circuit hence the term 'reclaim' and trust me, it is big business in the UK, in particular house building materials, as some of this material can be used again and save fortunes on new items. Well the Chinese are reclaiming electronic components as well and selling them as new!!! I have just taken delivery of a 45Watt Linear kit that was ordered from Banggood and it contains a reclaimed 2SC1971. However it is stated in the advert that this component is used!! I have also bought some of these 50R 100W resistors that keep popping up on eBay cheap,

The idea was to make a 200W dummy load with 4 of them in a series parallel configuration for less than £10!! I ordered two lots from different sellers and they both came in and to my amazement, both lots are also second hand and have been cut out of equipment…you can tell this by the fact that they have very short leads and have screw marks on there mounting tabs. They all are made by Florida RF and are all in pretty cellophane bags but sadly second hand. They all test ok but as these are advertised as new, it does make you wonder. The moral of the story is simple you get what you pay for……… (It is also true of kits too! G3PCJ)

Ray Koster G7BHQ

Here are a couple of photos of various projects. Sig Gen with counter and a 'FiveFET bling' – both by Giles G0AJC

Thanks and New Material!

I am delighted to welcome two new contributors this time – it makes it so much more interesting to have a variety of styles – circuits, construction or the English – thank you all! If any reader can write me any sort of radio related article please do let me know. Almost any radio topic is of interest to us all so please do not hold back. Similarly, if you have any question or topic that you think needs a bit of an airing, please tell me because others are likely to share your interest. Don't worry about diagrams, I can do them! Tim G3PCJ

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Autumn 2016 Issue E93

Editorial

September 1st marks the start of another year for Hot Iron! Twenty something years of radio related pen pushing! This is undoubtedly very much easier now than it was back in the 1980s or even earlier. But the bigger change I think is how much easier it is to now build electronic circuits than it was in the pioneering days of electronics. In the first half of the twentieth century, probably as much effort had to be put into making the mechanical structure of a receiver (or transmitter) as was expended on the circuit construction. I well recall one of my earliest projects – it was to build a DC multi-meter! I still have the case I made for it - after saving my teenage pocket money, & obtaining the prized sensitive milli-ammeter – probably from some ex-Government surplus store! I dare not show you a photograph of it since it has had several subsequent uses (lastly for an absorption wave-meter) & now looks rather sad! I spent many evenings drawing it out, scribing the aluminium sheet, finally cutting and bending it into some sort of nearly rectangular enclosure! Then the fiddle of getting BA sized small nuts and bolts tightened in impossible corners and hoping that all the sides would remain at right angles to each other!

Nowadays we look on line and order a relatively cheap metal or plastic box that comes with grooves for a PCB and a tight fitting weatherproof lid, if wanted! It's so much easier now. It's the same with the actual circuit elements. Gone are the days of trying to cut out the large holes for octal valve holders without the special tool for that! Drilling multiple small holes around the periphery and then filing them smooth always left metal swarf in places that were hard to clean! Then came the task of mounting the air variable tuning capacitor which often needed an external slow motion drive with the complication of organising a tuning scale pointer mounted on the capacitor shaft which was not always readily accessible! I fancy that twisted pair heater wiring was supposed to be neatly installed next! Most of the small fixed capacitors and solid carbon resistors had to be mounted on tag strips with multiple wires, covered in insulating sleeving, making the connections to the valves. What a fiddle compared to stuffing parts into a through hole printed circuit board! Who says that building electronics is difficult nowadays? Even the enclosures can be made quite easily out of PCB material if you wish with only the services of the kitchen table and a soldering iron (almost!). I will admit that using modern surface mount techniques is another matter though! Aren't we lucky – there is no excuse for not having a go if you are interested in radio related electronics – it is easier to make a 'project' now than it has ever been!! Tim G3PCJ

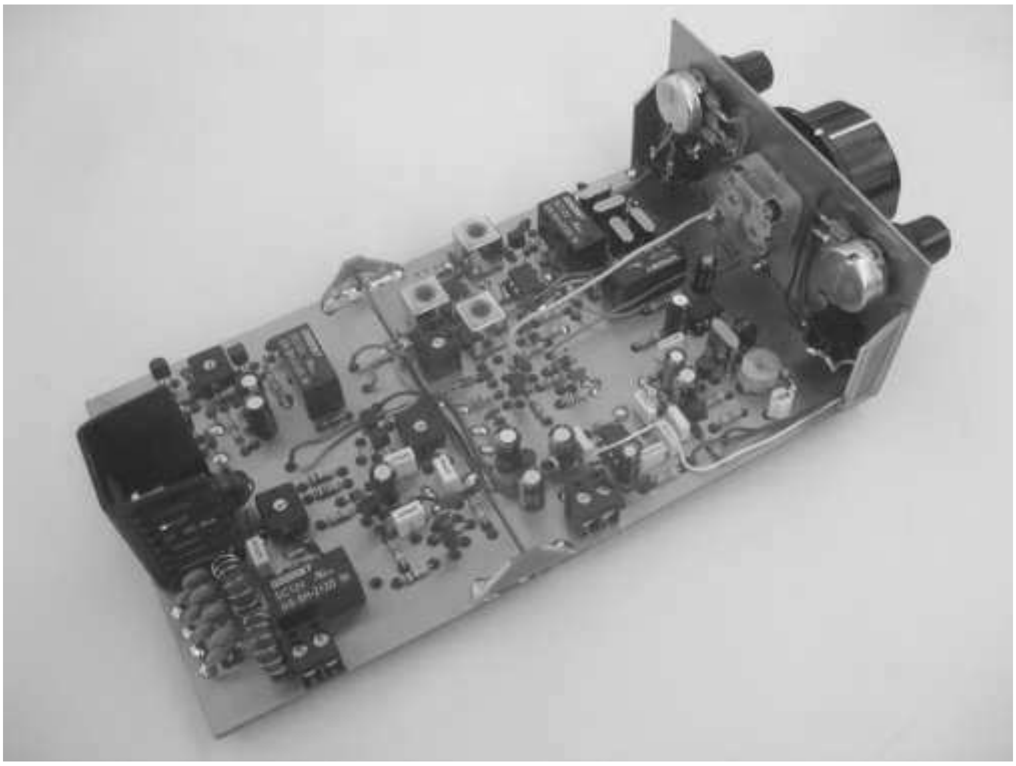
Contents

Kit developments - Halse and Hatch SSB TCVR, The Rockwell and derivatives, The Weston; Noise and Kits with a Difference; SA602 as an RF amp; Multi-band VFO: Somerton RS and its 100 KHz references; Experiments on 136 and 475 KHz.

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

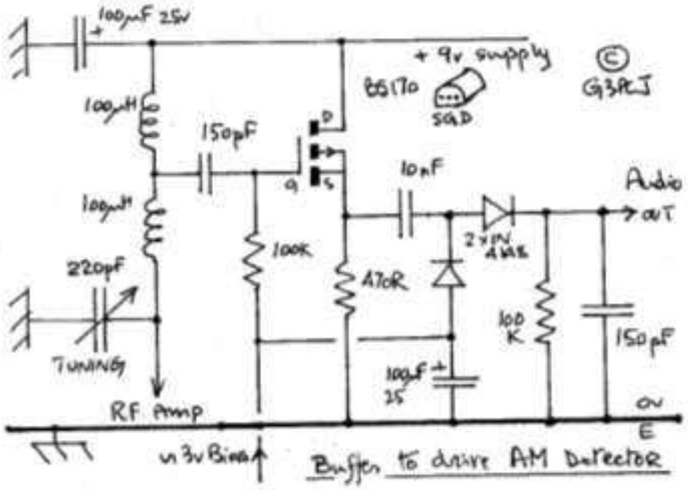
Much of the last three months has been devoted to proving the new **Halse and Hatch** project – together they form a single band single sideband 5 Watt phone transceiver for any one of the 20, 40 or 80m bands. They are derived from the earlier Rode and Rudge but with more emphasis on ease of construction. The TCVR below is built for 20m. They use a 9 MHz IF with four crystals in a ladder filter. For 20 and 80m, the VFO runs at near 5 MHz in the classic arrangement; but for 40m the VFO is altered to run near 2 MHz. The transmitter works by using the receiver IF stages working backwards to generate low level SSB, which is actually ejected out of the RX aerial terminal! Not having done much for Practical Wireless in recent years, I have written them up for PW in two articles, the first of which will appear at about the same time as this Hot Iron goes out. Readers of PW can enjoy a special discount, which I am very happy to also extend to readers of Hot Iron – please enter the code HIH&H when ordering using the Paypal button on my website ordering page – www.walfords.net – the discounted prices are £45 for the RX alone, or £77 for both RX and TX. £6 is automatically added for packing, UK first class post and Paypal fees. For overseas airmail orders, please add £2 to the price for Europe, or £5 for the rest of the world – I am sorry that's so expensive!



The Rockwell

This is a Regen TRF derived from the Redlynch but with a less complicated circuit, which is aimed at radio clubs where groups of builders are being introduced to electronics. As before, it has ready wound inductors so that its starts life receiving the powerful Medium Wave broadcast from about 1.5 MHz down. Then extra toroid inductors can be added; with adjustments to the main tuning capacitor options, so that it can tune sections that include the 40 or 80m amateur bands as well as their nearby broadcast bands. I am about to build the first one. (I suspect that being somewhat cheaper than the Cale would have been, this is also more appealing for this group of builders. The Weston, mentioned below, is also likely to sell better than the 3 band Cale Regen, so that is on hold for the present.)

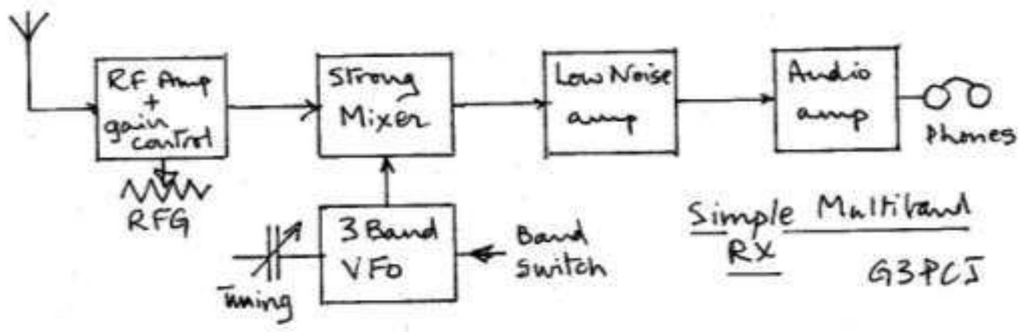
I also mentioned last time that ferro-concrete buildings can act as Faraday cages making it hard for short aerials to obtain enough signal for simple TRF type receivers; one approach to cure this is to add more gain – either in the Radio Frequency or audio stages. Steve G0FUV has done an interesting comparison between several versions of simple TRFs, including the ZN414 style projects and their recent derivatives; this suggested that more gain at RF was best to avoid an excessive amount of audio gain that might be unstable.



The early Rodways used very light coupling (ie very small capacitor) between the RF tuned circuit and the diode detector so this was an obvious place to insert a buffer stage to increase the RF effective gain. The resulting part circuit is shown right. The buffer is connected at a convenient tap (mid point of the two fixed inductors) on the tuned circuit to reduce stray capacitance on the high impedance end of it; this has the beneficial result of a single tuning range now being able to get down to 160m (for AM demonstrations with a local TX) as well as covering the main frequencies of the Medium Wave band. The 3 volt bias for the extra BS170 buffer stage comes from the audio stages.

The Weston

This design does not yet exist so I am floating possibilities - hoping for some comments! I am struck by the cost and complexity of incorporating RF filters in simple multiband RXs; I ponder if a DC RX with a strong mixer but without any RF filters can be the basis of a simple multi-band DC RX, with only appropriate changes to the VFO for the different bands. I have in mind a design that would do 3 bands - 20m, 40m, and 80m. Strong out of band BC signals might be a problem so an RF gain control is needed; an external tuneable trap circuit might also be required but a simple T match AMU might be more useful if a TX is ever to be added. Probably arranged in flat physical format to reduce cost and maybe with an integral PP3 9v battery? Target customers are those wanting initial experience of more than a single amateur band. The block diagram is something like this:-



Noise, Kits with a difference - *Some thoughts by Nat Waals*

Noise!

I am drowned in RF interference noise at my home; all HF bands, MW / LF, 6m too: a broad S9 "mush" from no particular direction drowns out amateur signals. I suspect the sources of this rising tide of bilge is cheap Far Eastern LED light bulbs, and ubiquitous "wall-warts" powering Far East consumer goods. A lash-up "noise cancelling" circuit, using a sense aerial and phasing makes some difference, but nowhere near enough to allow amateur signals to be received as they were a few years ago. Tuned loop aerials are a bit better for receiving - but who has space (and an accommodating XYL) to have large rotating loop aerials in a house?

Mobile 'phones must have encountered this problem - they operate 800MHz and up, where the interference is nowhere near as bad, this "mush" being worse below 70MHz. Mobile 'phone receivers use "differential" amplifiers that cancel common-mode noise; phone reception is superb, all considered, but that's more to do with the digital quadrature AM modulation with Hamming code error correction, rather than a noise cancelling circuit. No help for us amateurs!

During WW2, the faint and tenuous signals from European Resistance group "Parasets" were routinely received; but in far lower background noise circumstances. Even without zillions of LED light bulbs spewing out interference, radio engineers of the 1940's had to use special methods - "diversity" reception - involving receiving stations spaced miles apart, with land lines combining the received audio via phasing networks (of which the British Post Office engineers were masters). No solutions there for amateurs!

TV transmissions, now digital, and amateur digital methods (WSPR, HELL, WOLF and the like), point the way. They establish precision timing or synchronisation to establish low error rates beneath a sea of noise. If the receiver can be synchronised to the transmitter, the only noise that will make it through the receiver is that in identical phase to the desired signal. After all, that's the method modern PAL (Phase Alternate Line) colour TV uses: the phase of the colour burst is corrected every alternate line, it's almost phase coherent. If you want to see the effect of no phase correction, watch an American NTSC colour broadcast: "Never The Same Colour". It's an "open loop" system, no synchronisation, errors cumulative.

Look at amateur radio methods predominant today, and their synchronisation (or lack of it).

SSB: no synchronisation possible. Workable, but woefully lacking. No workable improvements can be made; the carrier is suppressed as well as the opposite sideband, so no phase reference can be re-created at the receiver.

CW: synchronisation not possible, the carrier disappears between each character, and the timing is anything but accurate. A fast PLL could capture the carrier and lock, but, to date no PLL or Bayesian Statistical device has ever decoded CW accurately in such diverse backgrounds as the human ear can manage.

FM: yes, good for local contacts on any band, but don't expect miracles. Some good work has been done on 1.8 - 2.0 MHz recently, but NBFM for DX isn't an option as "capture effect" shuts out a DX signal when a local opens up "full blast".

Which leaves..... not a lot. Until you realise the trouble isn't in the receiver alone; it's in the transmitter, too. If, at the receiver, we had a synchronising signal as well as sidebands, then yes, we could synchronise receivers to transmitters, and the noise problem all but disappears. Don't believe me? Take a look at WSPR QSL reports. Fine for slow data, what about speech?

There is a way. A DSB signal can have the carrier re-created by a DeCostas loop coherent demodulator. Coherent "I/Q" binaural, DSB has a full 6dB advantage over SSB (source: Amateur Radio Techniques, page 117, Table 4, Pat Hawker, G3VA) under the same destructive noise and interference conditions. However... a DeCostas loop is definitely not an amateur option: it is a complex and tricky beast, especially since the magnificent NE561 PLL is no longer made.

Recent work by Jim Kearman, KR1S, with a true synchrodyne receiver (phase locked local oscillator) has shown good results. Following a design by G.W. Short in the 1970's Jim built a silicon equivalent, and found it to be a very different receiver than he expected. The design was for full carrier AM broadcasts, but the design he suggests would easily adapt to an SA612 mixer which wouldn't need full AM carrier - a tiny fraction of the carrier would be enough to phase lock the local oscillator and render coherent detection of the sidebands. Jim's proposals are well within the capabilities of most home brewing amateurs; as is a DSB transmitter with a tiny percentage of carrier being transmitted to synchronise the receiver. The "AM Window" web page has examples of how to generate AM with zero to full carrier using an SA612. It is not for no reason that Commercial aviation use synchronous AM for aircraft communications!

Kits with a difference

Those familiar with industrial electronics will know 19" rack modules well. Euro card frames are similar. The idea is a box in which standard sized PCB's fit into guides, the power and I/O connectors being wired across the back of the box, so updated or revised PCB's can be plugged in, with minimal disruption.

Why aren't radio kits designed this way? Not to fit into racks, but as modules on standard sized PCB's, that all fit together. Think of a block diagram! If the blocks were made as modules, that all fitted together, then multiple choices of each block could be offered, the price of each reflecting the signal handling capabilities, complexity and so on. You could buy a basic option; then build up your radio gear as time and money allows.

This isn't so far fetched as it sounds. In the silicon chip manufacturing and PCB assembling industries, the machines all have standard interfaces: you can plumb together any machine to any other, and they "talk" to each other. This is "SMEMA" - Standard Mechanical / Electrical Machine Automation, and if it can connect machines as diverse as found in a PCB assembly line or wafer fab then surely it could be done for a radio design? Yes, it would cost; but kit designers could use surface mount automatic assembly methods - at a fraction of the price of through hole PCB assemblies - and kit builders could work on a modular level, rather than component level. Much more sophisticated circuits could be made available for lower cost in smaller footprints, surely a step forward in custom built "home brew" radio? Fault finding would become easier too.

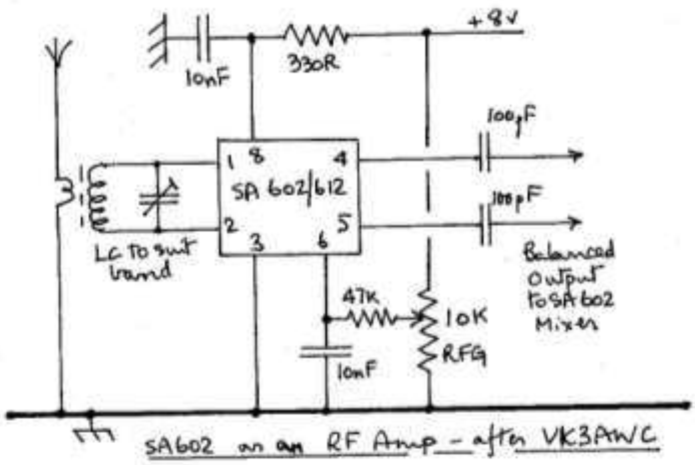
This now leads to another scenario: modules could be directly compared to each other - "plug-n-play". Different kit maker's products could be compared; as new upgrades appear, new devices become available, low cost upgrades become simple. Radio equipment could be assembled by simple inter-wiring - bringing "home brew" amateur radio to those with arthritis, poor eyesight or disabilities that prevent assembling a PCB from scratch.

The hard bit would be establishing a common bus and interface specification; but if it can be done in as diverse a regime as PCB manufacturing and wafer fabrication, then surely it can be done with a radio transmitter or receiver? Maybe needs a co-operative effort with other kit designers sharing the costs?

(I wonder if the limited size of the kit market makes this idea financially viable? G3PCJ)

Unusual use for a SA602 – as an RF amp!

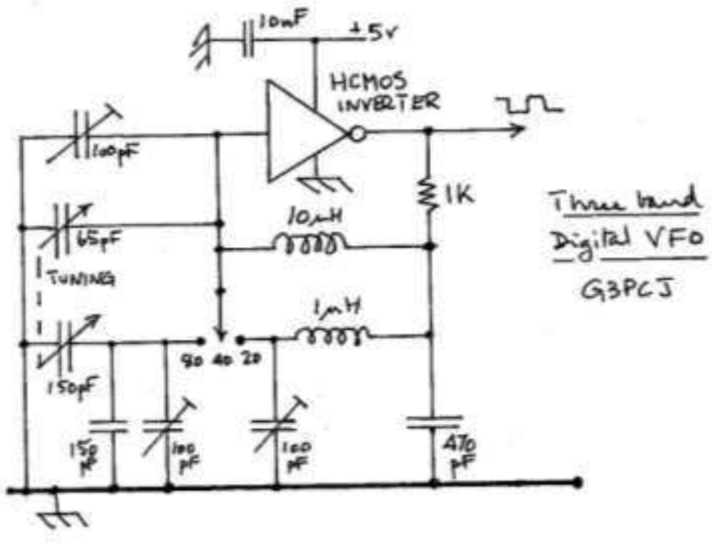
Somebody sent me this suggestion many months back but unfortunately I cannot trace who it was! The idea is thought to have come originally from VK3AWC but has been promulgated by G3ULO/DJ0HF. He wanted an RF amplifier with balanced input and output ports to help remove common mode interference in a simple DC receiver.



The internal Gilbert Cell structure in the mixer portion (of an SA602) is fully balanced and is directly driven by an oscillator stage whose base and emitter are brought out to external pins to allow for alternative oscillator configurations. Adjust the bias on this oscillator stage via the base pin 6 (even when not oscillating) and you directly control the gain of the balanced stages of the what was the mixer but which are now acting as a plain RF amp! All you need is a simple pot between the supplies feeding pin 6! I have not tried this myself but I am confident it works, and can also be used with single ended inputs and outputs if you wish - just RF decouple the unused input and ignore the unwanted output! G3PCJ

Snippet

Multi-band VFO Here is the germ of an idea for a very simple three band VFO! Not tried yet but should be viable. The digital inverter gate is biased into its linear region by the DC feedback through the inductors so that it can oscillate. Exact values for all the tuning capacitors are not given since that rather depends on the tuning range desired for each band. The direct output of the gate can be used to drive the other inverters in a hex CMOS gate which can then feed some sort of switching mixer.



Somerton RS and its 100 KHz references!

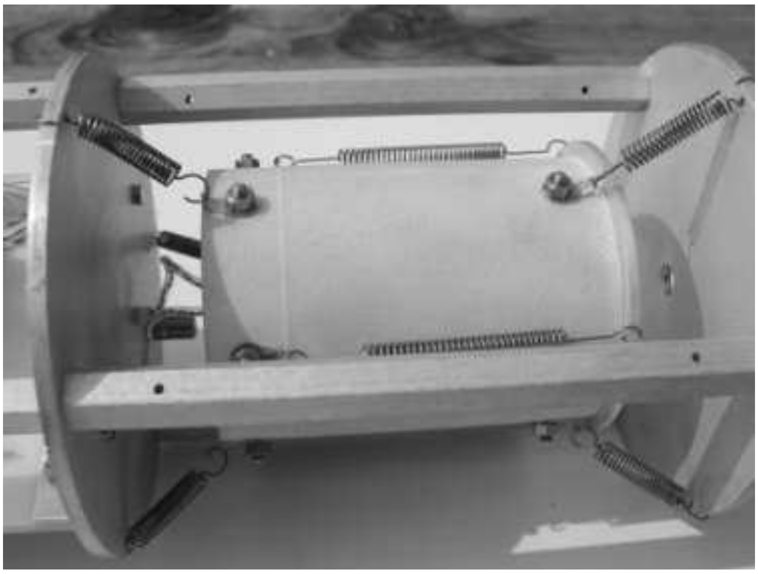
I happen to live about 2 miles from what was Somerton Radio Station. It opened in 1927 as one of the main HF receiving 'Beam' stations conceived by Marconi to conduct international Government and commercial traffic on the 'short waves' instead of the alternatives of under-sea cable, or by radio on low frequencies. The associated principle transmitting station was at Dorchester on the southern coast of England – they had to be separated by about 20 miles to avoid overloading of the receivers when the transmitters were active. The buildings are still unused!

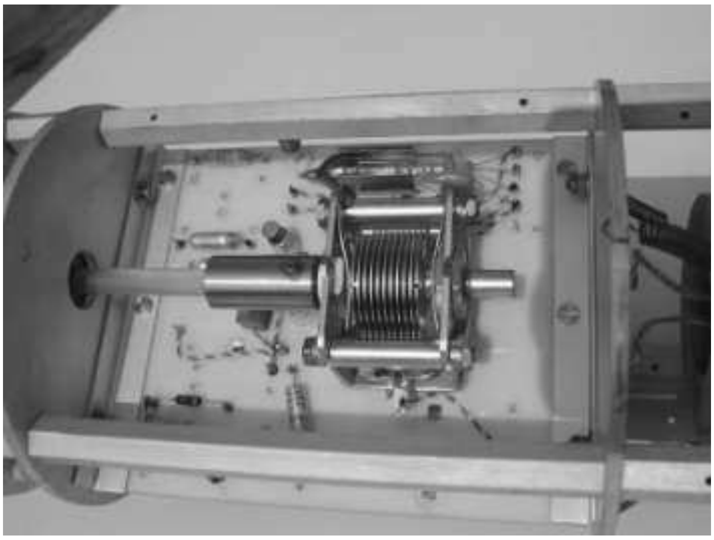
Unfortunately there is not much information about the design of the early receivers but their sensitivity was very low! Hence the need for huge vertical Franklin aerial arrays consisting of curtains of multiple dipoles, with curtain reflectors to make them fire the right way round the world; both hung from 300 feet tall lattice masts with a very characteristic T shaped structure at the top. The receivers were connected by private lines direct to the main operating positions in Electra House in London where the messages were distributed. By the 1940s there were many such arrays for multiple directions to similar RX and TX stations, with each route often having a choice of two or three working frequencies to cater for HF propagation variations by day and night. The aerial farm occupied over 400 acres with a mass of low loss open wire feeders that criss-crossed the site on telegraph poles! Later when the business was taken over by the Post Office after WW2, the receivers were updated and smaller horizontal rhombic aerials were installed. These could receive from either end by choosing the 'active' antenna line in the antenna switch room, which ran at low impedance after step down transformers from the high impedance open wire lines. Although the principle traffic remained CW in one form or another, in later years there was also telephony, with ship to shore and aeronautical activity. Eventually closure became inevitable as the traffic migrated to satellites; the final day of operation in 2000 was a huge cross band event between Somerton RS and radio amateurs all around the world.

Not long after closure, I happened to be driving past and saw the standby generator being loaded onto a low loader truck. I went back and got my camera but it was too late – most of the equipment had already gone for scrap. I did manage to rescue some wiremen's tools and a variety of insulators (right). Shortly afterwards, one of the retired staff suggested the scrap men would have missed the 100 KHz reference oscillators that were housed in 30 foot deep tubes! Their role was to keep the RXs accurately on tune to within about 1 Hz. A look under the three suspicious drain inspection covers outside the back door revealed cut off cables with an oscillator dangling on the end of each of them!

The oscillator units, complete with guide wheels to steady them in their tubes (right), proved to be hermetically sealed units with no obvious means of disassembly. Given that I had three, I felt justified in taking an angle grinder to one in order to be able to examine the circuits inside and determine the connections. (I had already decided to donate one to the Cable and Wireless Museum at Porthcurno which would leave the third for some other museum.)

What emerged was a most unusual structure to my eyes – the crystal was mounted in a sprung mounted enclosure with heavy thermal insulation. This is obviously to add to the temperature stability provided by being down 30 foot deep tubes. The associated circuits were built with pin and wired boards & discrete Rs and Cs, using germanium transistors, and a lovely 'gold' plated air variable tuning capacitor which could be driven remotely by a stepper motor. It was too good an opportunity to leave it untried! I applied a slowly increasing supply voltage to what was obviously the power line and it sprang into life at 5 volts with 100 KHz – and for certain with better accuracy than anything that I could muster! In use, the frequencies from the three units were compared, and the odd one out discarded when necessary!

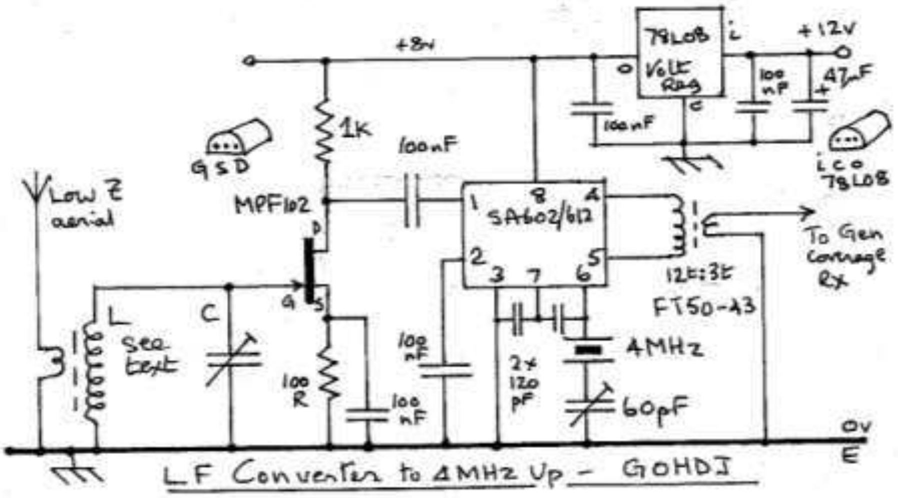




The real mystery is why the crystal is mounted in an assembly which is so obviously prone to vibration – we do occasionally get very weak earthquakes here! I am still looking for a good Museum to display third unit if anybody has a suggestion! Tim G3PCJ

LF Receivers

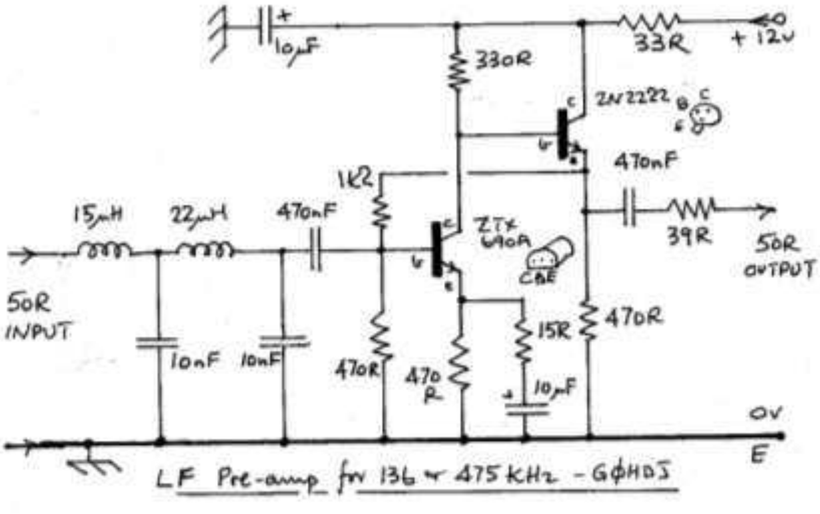
Craig G0HDJ has sent me some notes on his receiver experiments for the LF bands 136 and 475 KHz. He is reluctant to stay up all night to see what can be heard but has heard very few signals that can be definitely attributed to amateur activity. He has tried the Drew Diamond RX for 475 KHz band which worked well (after finding the missing links that led to initial silence!) but it is limited to only a single band. Craig instead preferred the converter approach using a SA602 mixer, with 4 MHz crystal, feeding into his general coverage RX. Circuit below:-



This scheme has the advantage that any of the LF bands can be used with a suitable RF filter on the front end! I have intentionally left the LC values off because I don't have them to hand but its not difficult to get something to resonate on any of those bands from 160m downwards; the low impedance aerial input winding should have about one fifteenth of the turns on the main resonant winding. The bands will translated from about 4.136 MHz up to nearly 6 MHz for 160m.

Craig has also found that an RF amp is a useful adjunct. He has tried two circuits, one with a JFET amp followed by a buffer, the other with a bipolar amp and buffer output. The bipolar version shown below, it has a broadband input RF filter which cuts off signals above about 550 KHz so is no good for 160m! I suspect that less exotic transistors like BC108, BC182 or 2N3904s could be used instead of the ones indicated. The arrangement has allowed him to hear signals on 136, 472 KHz as well as the aircraft non-directional beacons on 343 (Westlands in Yeovil), 380/415 (Bristol), 388.5 KHz (Cardiff), as well as broadcast stations on 162, 183, 198, 225, 234, 252 KHz and others!

Enough from me for this issue of Hot Iron – please keep your contributions & questions etc coming! Tim Walford G3PCJ



"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Winter 2016 Issue E94

Editorial

A nasty damp grey day here after a wonderful dry Autumn with magnificent leaf colours in all our trees – given the large number of you readers in North America, I can comment that the scene in the North West states (famous to us in Europe for your Fall colours) must have been spectacular if you have had similar conditions. This change in our weather makes me look at the list of inside electronic things that I need to tidy up and progress, of which creating a new 'top of my range' rig has to be pretty near the top of my job sheet!

I have note books filling up with block diagram ideas, circuit scribbles for various potential functional blocks and then the awful estimates of what the resulting rig's might cost be. This price estimation process is fraught with risk but it is noticeable that sale price is a much more important consideration in Europe than it is in North America where 'performance' has a much higher priority. I find the second hand market for black box rigs creates a price zone which it is advisable to not approach when contemplating a top end design! My latest doodles get pretty near this zone when you add in the potential extras of frequency readouts and antenna matching units, after you have given the rig at least 5W output of CW or SSB with AGC and CW receiving filters etc - even on a single band; add in one or two extra bands and it becomes unattractive except to those who wish to build their own gear almost irrespective of cost, and who are then able to say that they have built it on air, with all the pride that gives. I am currently looking at how to utilise my range of RF accessories and filters to make a simpler single band rig into a multi-band one – it is certainly worth exploring more!

Meanwhile, later in this issue you will find diagrams and photos of the first block of the **Weston** project. I have long felt that good projects can be made without an etched/drilled PCB and so I will be describing how to create this receiver over three issues of Hot Iron. This is not an original idea of mine but arose from suggestions of at least two regular contributors to HI – thank you! The intention is to end up (after three issues) with a mid complexity single band superhet RX. I will provide full circuit details which I hope will allow potential builders to also use whatever similar or commonly available parts they can obtain locally. I am also contemplating whether it might be feasible to carry on and make it into a transceiver but at the moment I do not wish to add any complexity to the RX that might make the TX ultimately easier.

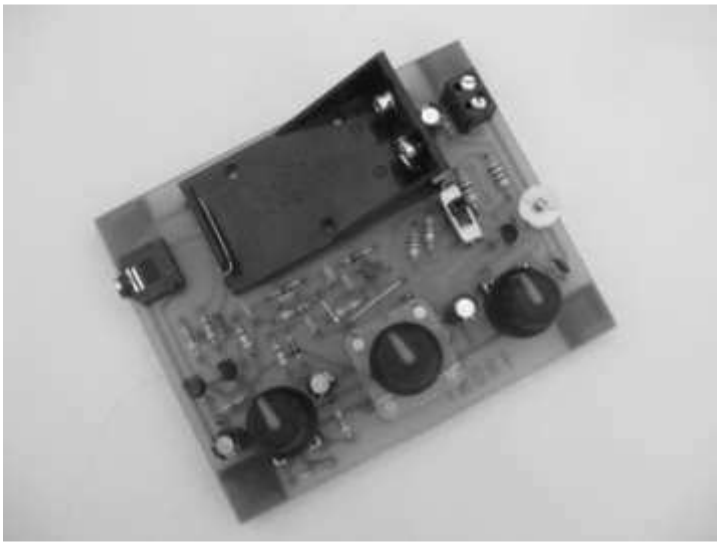
Tim G3PCJ

Contents

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

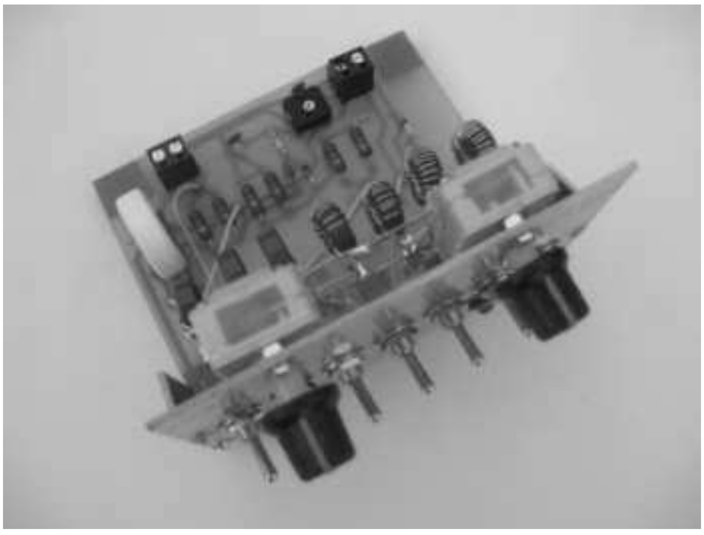
Kit Developments

With articles about the **Halse and Hatch** in Practical Wireless, I have been busy sending out kits for them – so far with surprisingly little comment on how builders are getting on – this is either because all is fine or builders have given up in disgust! I hope & pray it is the former!



The **Rockwell** (right) has been altered in the light of most helpful comments by two particular builders who felt there was room for development of the rig itself and of the instructions. A little bit of head scratching by me on the build sequence, and the addition of a trimmer, now makes it much more adaptable for either general coverage of much of the HF spectrum, or for particular amateur bands. To remind readers, it has two switch selectable bands with two values of the ready wound inductors that can each be wired in series or parallel for coverage between 20m down to the low frequency end of the Medium wave near 750 KHz. The latter gives an early confidence boost to novice builders who can easily receive the AM broadcast stations before attempting the more challenging CW or even SSB reception! Because the Regen stage uses the Colpitts configuration, there is an existing chain of fixed capacitors across which the variable tuning capacitor can be connected so as to reduce the tuning range on a chosen band to make tuning adjustments easier - the extra trimmer sets the mid band frequency.

The other revised project is the **Mk 6 AMU** shown below. This retains the same fundamental matching bridge and T match circuits as in earlier versions, but now has what I think is an easier form of 'variable inductor' for people to build. (It also fits into padded bags for carriage more easily!) The 'inductor' is changed to a series of switch selected toroids, wired in series with inductors that increase in a binary progression – this gives up to a total of 20 μH in about 0.1 μH increments. In reality, for any particular band, only two or three adjacent inductors are actually required because the T match circuit is so versatile. With both sections of the two PolyVaricon capacitors, the circuit will match loads of about 25 R to 2500R over the range 2 to 30 MHz with either balanced or unbalanced feed line. The switch selectable resistive matching bridge allows a safe tune up irrespective of the actual line impedance. It drives a LED which you extinguish for AMU tuning, but when you bypass the bridge, the LED responds in response to RF output voltage. The design can feed a conventional moving coil meter if desired. Power is limited to about 20W due to the PolyVs and bridge resistors. Out soon. G3PCJ



Crowbars & Light Bulbs - simple protection circuits – Peter Thornton

These circuits are common in Industrial Electronics Maintenance workshops, where electrical and electronic faults have to be found quickly! In amateur radio shacks, these circuits are just as useful, and prevent disaster without blowing fuses. Fig. 1 below shows a crowbar circuit. This is designed to blow the fuse if - for any reason - the power supply delivers a higher voltage than the equipment being powered can tolerate. It has a subtle addition: a tungsten filament lamp in parallel with the fuse provides features not normally associated with common designs.

Initially, if you're powering up for the first time suspect equipment (or you don't trust your power supply regulator), remove the fuse F1. Install an incandescent bulb into the L1 position, of equal rating to the power supply output voltage and of sufficient wattage to power the equipment (21 watt / 12v. car stop lamps are useful). Connect up the equipment, and power up. If any shorts or similar destructive faults exist, the light bulb limits the current available to the load, and stops any disastrous burn-outs. An incandescent filament light bulb has a unique feature: it's cold resistance is ~ 10 times LESS than its "hot" resistance. If the load is fault free, the lamp should (if you've fitted a sufficient wattage lamp) not visibly glow, but if the glass envelope feels slightly warm after a few minutes - the equipment running more or less as per normal. I have various 12v car lamps to hand, 2.2 to 48 watts at a nominal 12v rating (remember you can parallel lamps, and if you use lamp holders, you can simply slot in another lamp if you need to).

Assuming the equipment runs as expected, then the fuse F1 is fitted. The equipment is now powered directly from the power supply, and any failure in the power supply which would result in over-voltage being applied to the equipment is clamped by the zener diode and SCR. The 10K // 100nF eliminate any noise pick-up or brief transients. You can pick and mix the zeners to get the voltage you want, remembering to add the SCR gate-cathode volt drop of ~ 0.7v. A 15v zener gives a trip point of ~15.7v which mimics very closely the maximum charging voltage of an "aged" car battery in summer with no lights, air-con, or heated screens to drop the alternator output - hopefully your equipment designer took this into account!

Lamp L1 now has it's second role: if the voltage rises to the trip point, the fuse blows open, and L1 lights to tell you so. Now L1 shows it's third function: before you use the crowbar again, you should **CHECK IT ALWAYS TRIPS** at the over-voltage you want: but how do you do this without blasting lots of fuses? Easy! Remove F1. Turn the power supply down, connect a dummy load on the output (a 12v / 21 watt light bulb perhaps), and wind the power supply up **SLOWLY** whilst monitoring the output voltage - until the lamp L1 lights. Note that voltage; try a few times to be sure you have the exact voltage at triggering, and you have tested the trip without wasting fuses. Replace F1 and that's that.

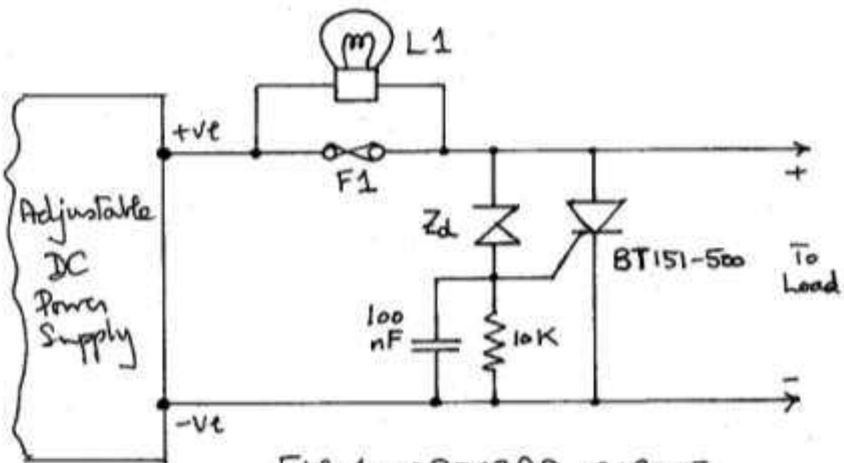


FIG 1 : CROWBAR CIRCUIT

Fig. 2 below is an AC version for mains powered equipment – this circuit has live mains parts that might harm you: you MUST follow the appropriate electrical codes that are applicable in your region for safety, and use due diligence in your construction. Use protective devices as appropriate - you have been warned!

This unit shuts off the output if over-loaded; L1 is a tell-tale lamp - it tells how the mains are supplying the load, the relay is arranged to drop out if the load draws excess current. When feeding a switched-mode power supply, you might need higher wattage lamps than expected at L1 to persuade the switch mode power supply to run - the start-up circuits like to see full mains at switch on in some designs.

The lamp L1 is in series with the live line of the incoming mains, and limits the current as in the crowbar circuit. In series with the lamp is a normally open relay contact, the relay coil being fed from the load side of L1. S1 bridges RLA/1 normally open contact: to start feeding the load, momentarily press S1: full line volts are fed to the load via L1. If the load doesn't take excess current RLA will latch in and power be fed continuously to the load. RLA coil should be rated at the line voltage of your supply, and must be an "AC" type of relay with a contact voltage and current rating suitable for the heaviest load likely to be encountered.

The relay forms an under-voltage trip latch: if the output voltage falls below the relay drop-out value, then RLA/1 contact opens, isolating the load. Why should the output voltage fall? Excess current, and the non-linear characteristic of L1, drops the voltage across RLA coil! With this circuit, over-current does not mean smoke: L1 limits the current and then RL1/A isolates the load. For those "awkward" loads - like high voltage power supplies that need to charge up empty smoothing capacitor banks - S1 can be judiciously kept engaged, the relay will pulse, L1 flash, and s-l-o-w-l-y fill up the load capacitance until the load is up and running and RLA locks in – but be careful in case something else nasty is going on! Any faults in the load that only appear when the voltage has risen to near maximum - like electrolytics that go "short" at near full applied voltage - will not cause blown fuses, and RLA safely drops out.

A selection of mains light bulbs, 15 to 150 watts prove useful: if the load won't start up, even after several relay pulses, try a higher wattage lamp. The unit can be conveniently built in a conduit knock-out box, with a short (fused) mains lead feeding the power, and a surface mount socket fitted to simply plug in the (now protected) load.

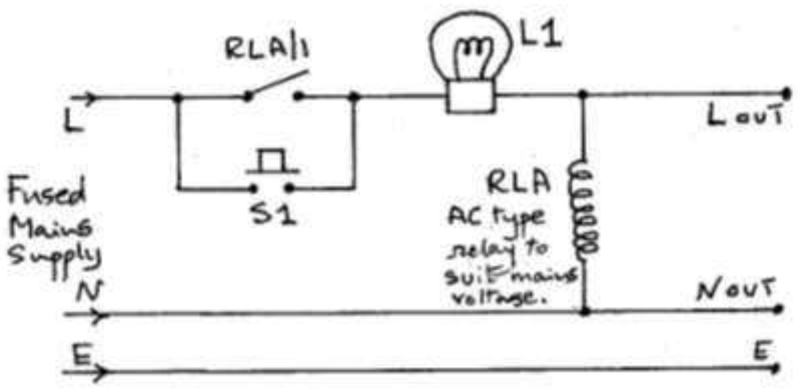
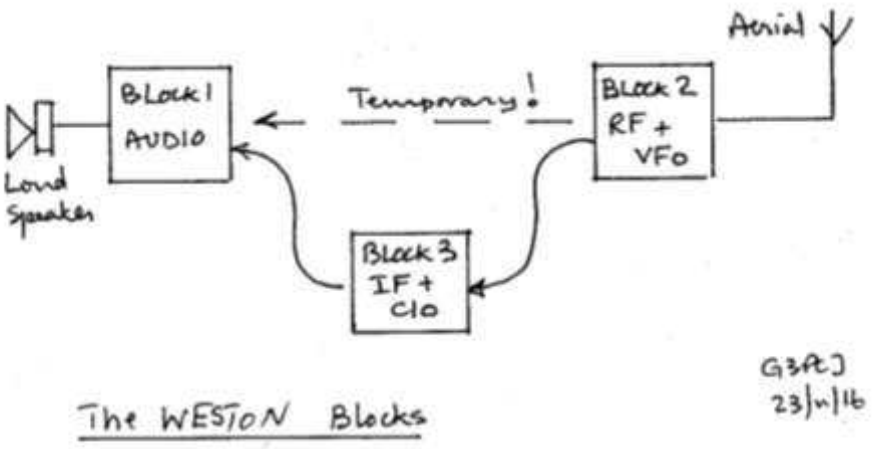


FIG 2: LIGHT BULB PROTECTION

The Weston Receiver

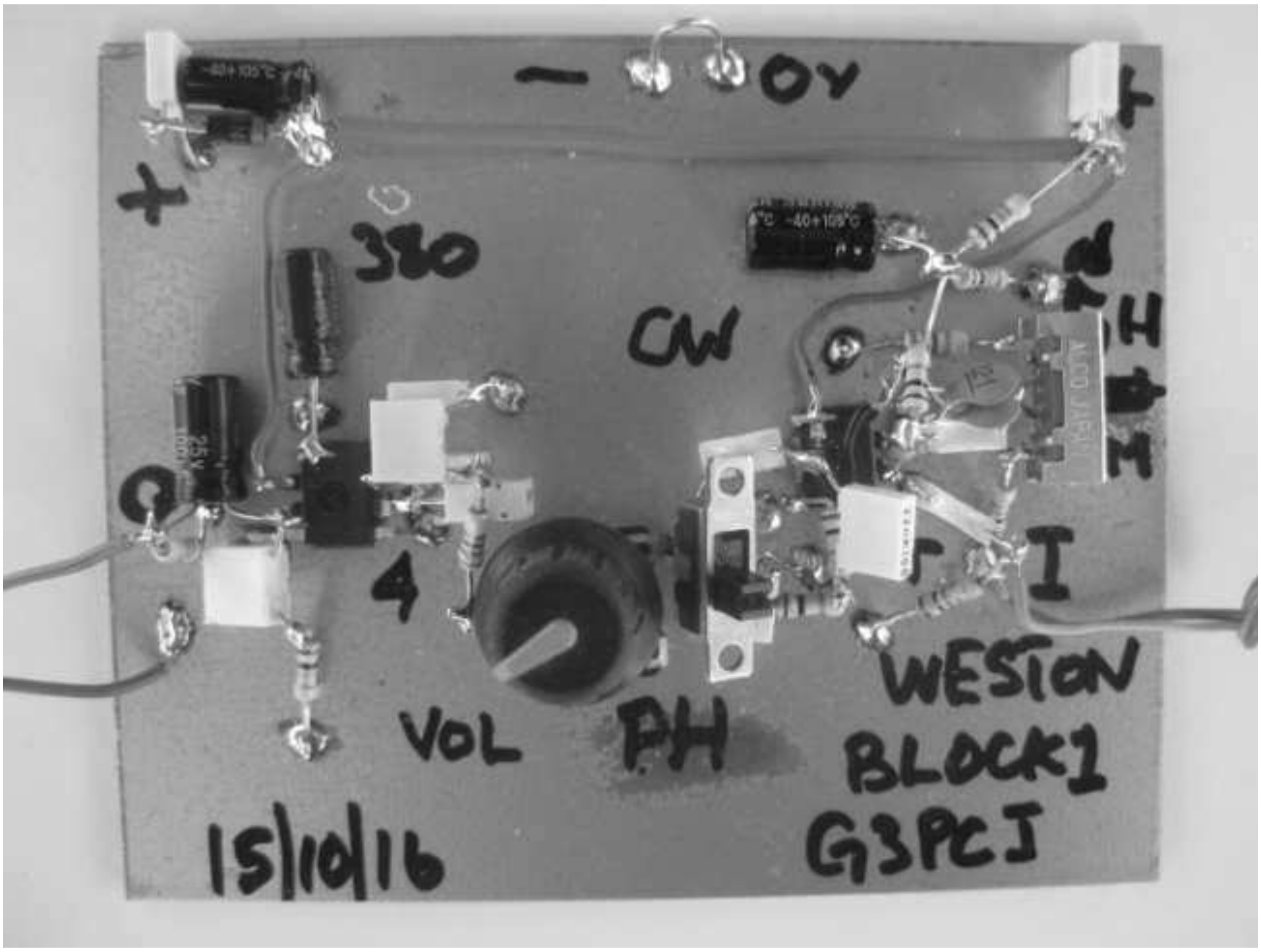
The ***concept*** of this rig is an easily built superhet receiver, for any band in the 20 – 80m group initially. I envisage three main Blocks which I will describe in this and the next two Hot Irons. I am NOT providing kits of parts and it does not depend upon an etched printed circuit board - you can do you own if you wish, or use ready made strip boards with lots of holes, but I have never been keen on them! Dead bug construction is an easy alternative as explained below! The general arrangement is shown in the diagram below. Block 1 is the audio stages, Block 2 will add RF filters, mixer and VFO so that it can become a direct conversion RX temporally! Block 3 will then add an IF strip, mixer and carrier insertion oscillator; the whole will then become a single band superhet after the VFO has been altered for the IF offset.



Dead Bug Construction!

A word first on this method of building circuits! It is excellent for RF work because of the continuous sheet copper ground plane and the short leads (if desired) for components which minimises stray capacitance. The technique has all earthy parts soldered direct to the ground plane wherever the layout suggests it is best or convenient! It also permits easy alterations when needed. With a little practice it becomes quite easy to do! I tend to start from the circuit diagram laid out for the best signal flow – in this case from right to left – and sometimes sketch out a physical layout for the main components - the ICs, TOKO inductors and other larger mechanical parts like tuning capacitors etc. If you are going to add controls and or input/output sockets, it is often best to do their physical arrangement first - you can easily solder smaller pieces of the sheet material to the front edge (with suitable braces) for a control panel with any sockets that you want. Not every Block will need a 'control panel' and you might choose to use smaller preset type controls mounted directly to their associated parts, as I did for Block 1. I find it best to then mount the ICs; upside down with the pin numbers written in the corners. Assuming you are using dual in line ICs, the earthy pins are first bent out sideways just beyond the plane of their body, so that these earthy pins lie down against the copper ground plane for easy soldering. The supply pin(s) is then decoupled with a 10 nF disc directly between that pin and the ground plane so that the IC is now also well anchored. Often it is best to next put in the supply components with a supply line to the various stages running along the top edge of the copper sheet where it will not be in the way of other parts. Any supply resistors run from this edge wire to the IC supply pin with its decoupling capacitor. A wire link can be used instead where there is not supply dropping resistor. The input circuitry can then be attached as convenient with any extra joints between components up in the air away from the ground plane or other junction points. If there are at least three leads (ideally spaced at 120 degree intervals!), then these joints will be pretty rigid in space!

Then add the output parts in the same manner. If required, you can usually add resistors of 1 M or higher as a sort of stand-off insulator – this approach is good in the higher frequency part of the project where circuit impedances tend to be much lower than 1 M, but be more careful in audio stages where impedances are often high – if the circuit already has 1 M resistors, its is best to avoid any extra 1M stand-offs in that part of it! Some photos follow of my Block 1 but yours does not have to be exactly the same. I am afraid that my photographic skills and kit are not really up to showing the detail properly. Try it & see how you get on – nothing is lost if you have to re-arrange the layout as long as you can still solder the components together!

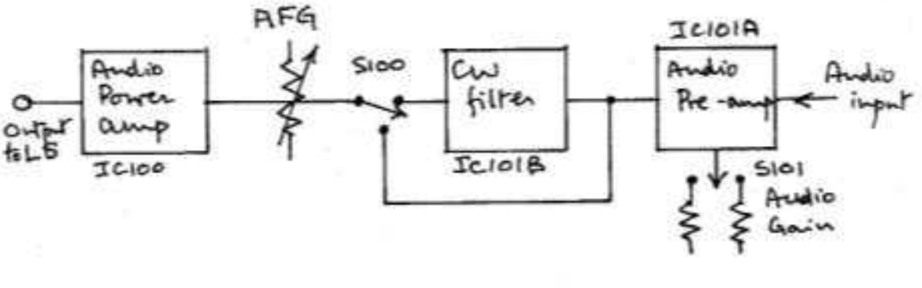


Above – Dead bug technique - Block 1

Left – Output stage IC100 close up

Block 1

These are the audio stages with parts numbered up from 100. The audio sections are shown alongside with the circuit on the next page. It has a gain adjustable op-amp voltage amplifier, with selectable audio filter for CW, followed by the AF gain control and the audio power amplifier. Given that physically, the RX is likely to have its output on the left for right handed tuning, the circuits etc have a signal flow of right to left for easy transfer to the physical realisation. Physically, I have made mine by 'dead bug' construction on a copper clad fibre glass sheet that acts as ground plane and an easy form of 0 volt line!



WESTON BLOCK 1 SECTIONS

As we progress, I hope to be able to suggest alternative parts for the semiconductor devices so builders can use whatever they can acquire or have to hand. The audio power stage needs to be able to drive modern 4R speakers so they can also easily also drive the higher impedance 32R type of phones; I prefer the LM380 which has a fixed voltage gain of x50 to the alternative LM386. Either the 8 pin or 14 pin 380s can be used. They can take a supply up to 22 volts! This part of the circuit has provision for muting and the feed in of CW sidetone when transmitting if wanted. The preferred AF gain control would have a logarithmic type of control law but a linear one is perfectly usable; the value can be whatever is to hand in range of 1K to 10K. It is preceded by a fundamentally high input impedance op-amp voltage amplifier, with a centre off switch in the feedback network that allows the gain to be set to x1, x33 or x100. You could use other resistor values for a x10 position but I was trying to minimise the number of different values in each block! The suggested op-amps are the low noise type with FET inputs to minimise any output voltage offset effects; the TL072 has two op-amps in one IC but you could use two of the single TL071s, or even omit one if you do not want the CW filter. Bipolar input op-amps like the 741 are not ideal (due to their finite input current) but might work if desperate! Without the two input capacitors C120/121, the input impedance is about 100K which is suitable for many general purposes like the simple receiver below. (R113 is an anchor with no effect due to its high value; C120 & 121 are needed for Block 2 to reduce its output audio bandwidth.) The second op-amp stage is a humped low pass Sallen and Key filter, designed as a CW filter whose response rolls off sharply above about 1 KHz; it has a slight peak at nominally at 723 Hz. Again, a low noise FET input type op-amp is preferred. The supply range can be up to 30 volts! In several cases, two components are suggested to avoid another value. The parts list is:-

Resistors	1R R101; 3K3 R100,102,111; 10K R107,108,112; 100K R104,105,109; 1M R113 AFG Pot R103 – 1K to 10K – desirable have log law with knob!
Capacitors	220 pF disc C111,116,117; 22 nF Polyester C100,106,107,108,112,114,119,120,121 ; 470 nF Polyester C103,105,109,110,118; 10 µF 25v electro C104 ; 100 µF 25v electro C101,102,115
Semicons	1N4007 D100; IC100 LM380-8; IC101 TL072
Hardware	Copper clad fibreglass board – min about 80 x 100 mm; S100 1P 2W switch; S101 1P 3W centre off switch; wire and solder as required etc

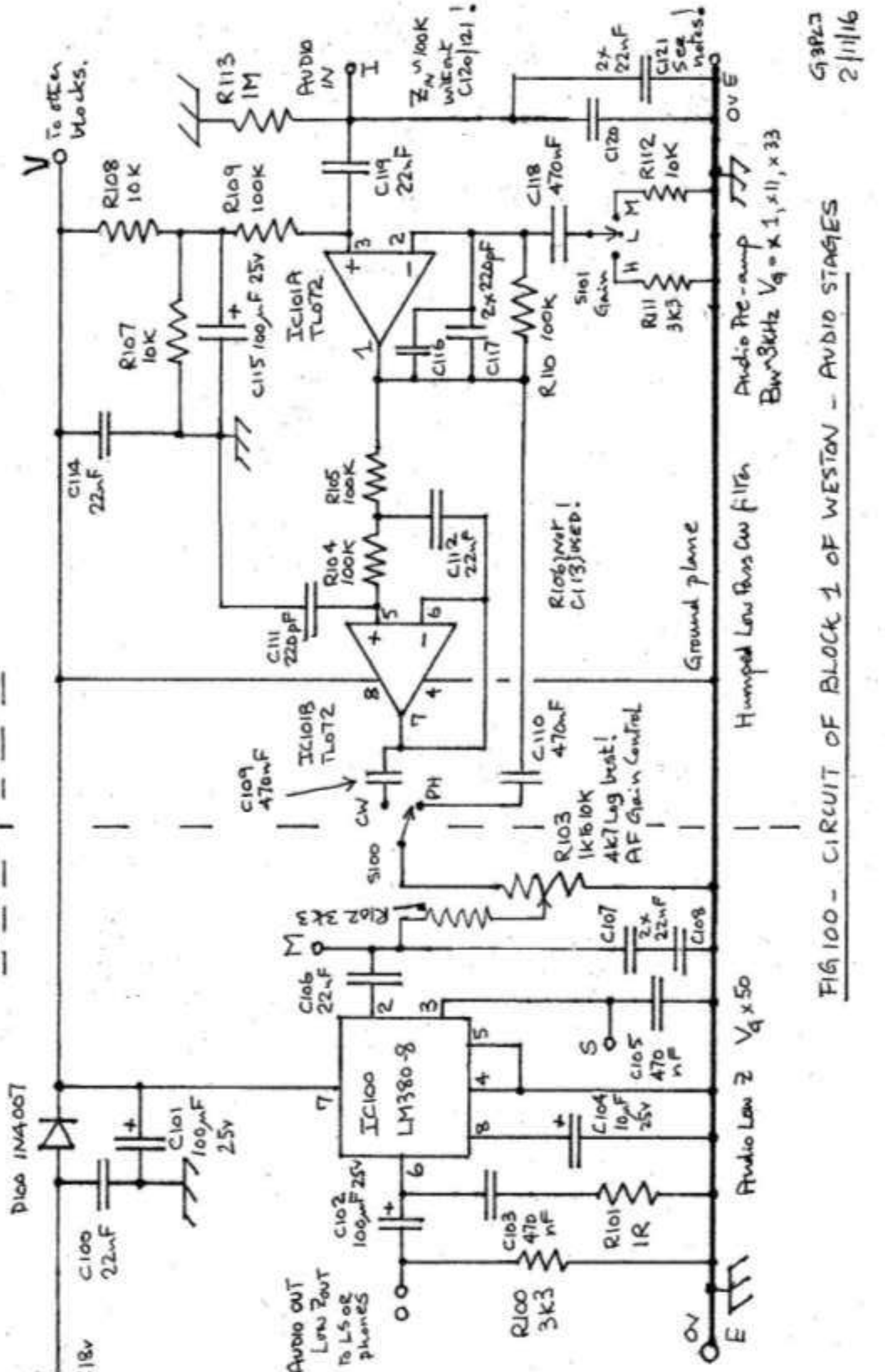


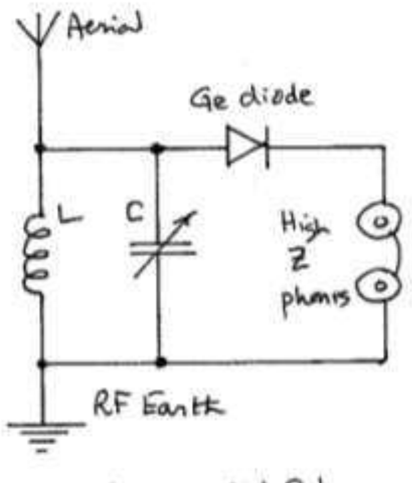
FIG 100 - CIRCUIT OF BLOCK 1 OF WESTON - AUDIO STAGES

Testing Weston Block 1

You can test the two sections separately after each is built. Power up the output stage and the DC voltage on chip output pin 6 should be close to half the supply voltage. If that is right, connect you loud speaker or phones and then perform the 'screw-driver hum test'; apply your finger to the shaft of a metallic screwdriver and dab it cautiously on the input pins – listen carefully and you might hear hum picked up by your body from nearby mains wiring, or possibly slight clicks as you make contact. Next power up the op-amps and check the DC output pin (1 & 7) voltages – again they should be half the supply voltage and you can repeat the screw driver hum test on their input but beware, the noises might be somewhat louder so be prepared for that! If you select the CW filter, the hum is likely to sound as though it is coming from a long large diameter pipe! A high gain audio amplifier like this is quite a useful item to have on your work bench for all sorts of monitoring jobs, or even as a speech amplifier for a transmitter. But what you really need to test it, is a crystal set to make it into a receiver - see below!

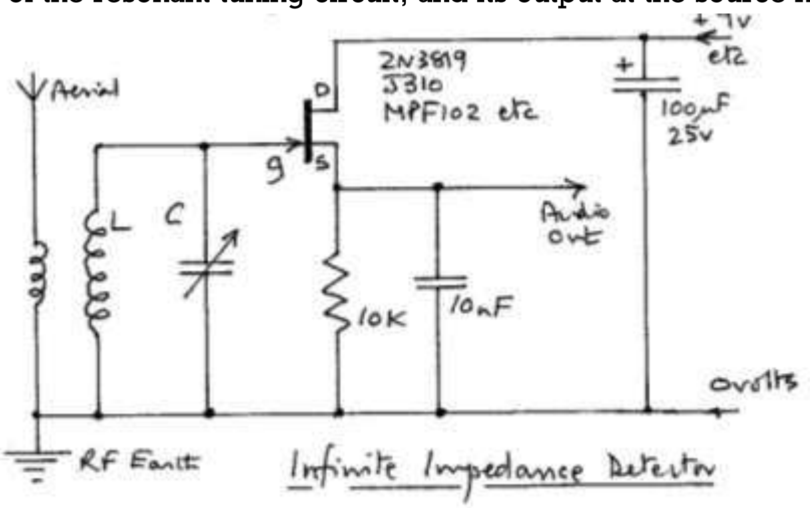
Modern alternative to the crystal set!

Years ago, building a crystal set for the AM broadcast stations was easy; you needed a germanium diode (or a galena crystal and cats whisker!), an inductor and variable tuning capacitor (see right) and not much else apart from the expensive high impedance phones and a large aerial! But nowadays high Z phones and germanium diodes are almost unobtainable, even if you have the L and C tuning parts. Silicon diodes like the 1N4148 can be used but you will need to apply a small forward voltage to overcome their 0.65v diode drop, otherwise you won't hear anything! Another challenge for very simple tuned circuits is how to preserve their selectivity. Loading of them by either the aerial or of the phones/detector can wreck selectivity easily! If it feeds modern 32R phones, the load impedance on the tuned circuit will be so low that there will be no tuning unless it is tapped right down the inductor which will then make it completely deaf again!



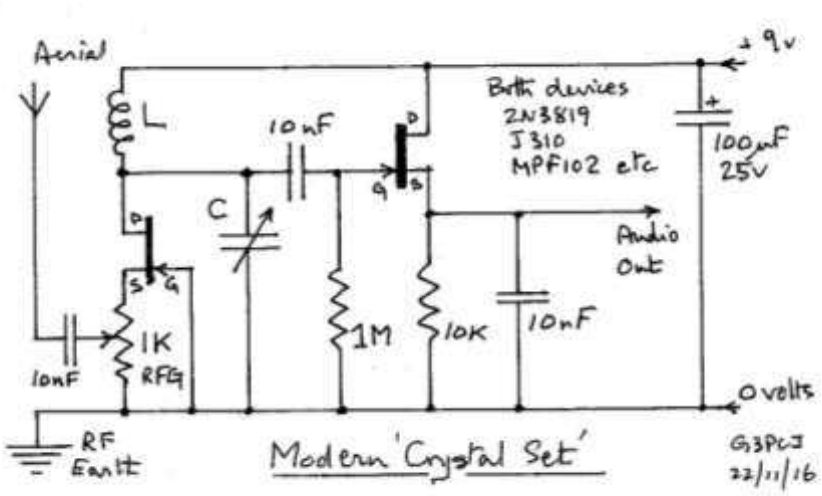
Conceptual Crystal Set

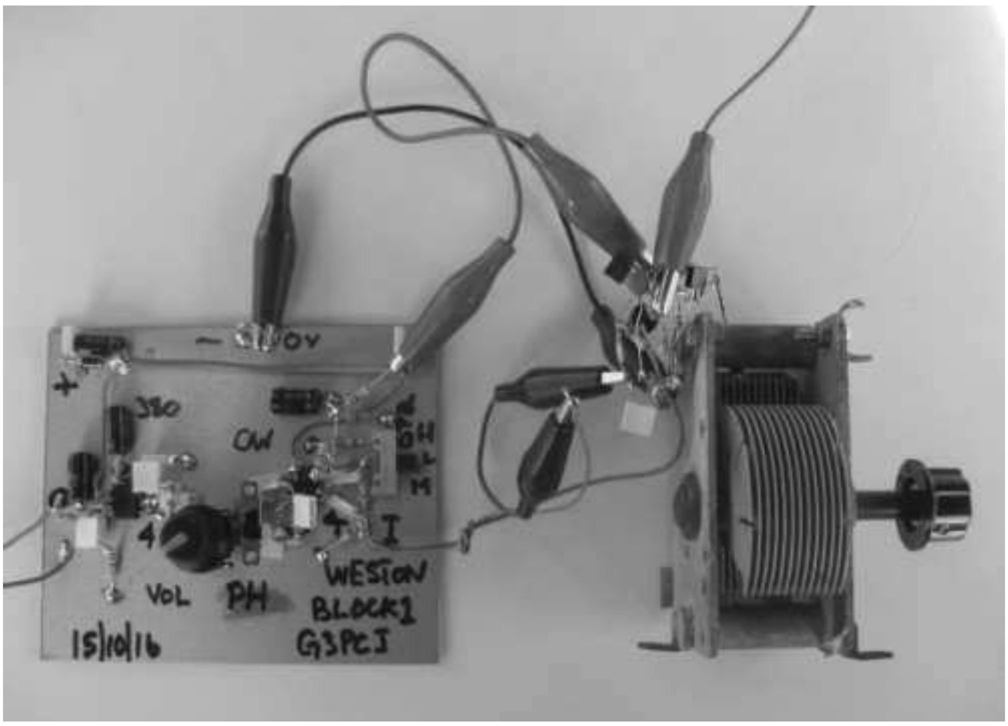
Sadly, I am afraid the answer is to use some modern semiconductor device(s) and a battery. A sensitive detector, which rectifies the incoming amplitude modulated RF voltage without loading the tuned circuit, is needed – a good solution is the 'infinite impedance detector' which uses a Junction Field Effect Transistor (JFET) acting like a perfect diode - this can be connected directly across the tuned circuit because its gate input impedance is way higher than that of the resonant tuning circuit, and its output at the source has a CR combination that passes just the desired audio at a moderate impedance; this can be fed directly into the high impedance audio input of the Weston's block 1 (without C120/121). The resulting crystal set type of receiver is shown alongside. This version still needs a tuning inductor with a separate primary winding for the aerial – but see over!



Infinite Impedance Detector

The above tuning inductor needs either a separate primary, or taps on the secondary so that the aerial, which might exhibit low impedance at the frequency of interest (or high capacity), does not load the tuned circuit and so destroy its Q and selectivity. Tapped inductors are not that hard to make but there is a transistor alternative! A second JFET RF amplifier stage is easily added and will preserve the high Q and selectivity. The simplest scheme is to use another JFET in the common gate configuration, with the aerial feeding into its source, and the LC tuned circuit as the drain load. Because the supply rail is heavily decoupled, it is at 0 volts in an RF sense so that any RF developed across the drain load inductor, can also appear at the input of the following infinite impedance detector provided it is AC coupled. A final wrinkle is to use the JFET source resistor as an RF gain control because sometimes a little less RF gain may avoid broadcast station interference (BCI): because this is feeding our high gain Block 1 audio amplifier (again without C120/121) we don't need to worry about a low RF input signal level – either intentionally to avoid BCI, or because the aerial is a bit short! The resulting circuit above can be built in ugly fashion in the air or on the frame of the air variable like mine below! Luckily there are still plenty of Amplitude Modulated broadcast stations in the European Medium Wave band at about 1 MHz so any combination of variable capacitor and inductor that resonates near 1 MHz will be fine. I happened to have a 500 pF variable to hand, which with a ready made 100 /uH bead inductor, serves well; you can alternatively pile wind about 50 turns of thin enamelled wire close together on a section of 40 mm plastic waste pipe for an alternative inductor.





Never throw away old burnt out mains transformers because their higher voltage windings are a source of such thin enamelled wire, and the secondary wire might be suitable for winding the amateur band RF filter toroids of a later Weston block!

Snippets

Higher power Linear Dan White has recently been experimenting to obtain more power out of one of my standard Linear RF amp kits that are intended to produce 10W (on 13.8v) with about 1.5W of drive up to about 15 MHz. His plan was to drive it with a Rimpton AM TX coupled to a Rockwell RX on 160m. The main changes were to alter the MOSFETs to IRF520s and the output transformer to 3+3:12 turns; he also beefed up some of the interconnections and gave the bias circuit a little thermal feedback from the much enlarged heatsinks. Bench testing produced over 50W on 160m dropping to 35W on 20m, both with near 10W of drive. More on this later I hope!

Gluing toroids It is happens occasionally that toroids get broken in transit as they can be brittle; one recent builder thought he would try 'super-gluing' the two T50-2 halves back together again as he was reluctant to wait for a replacement. The application was in a transmitter low pass harmonic filter and it worked perfectly. If it had been the inductor of a VFO, I think I would only do that as a temporary fix because I suspect it will alter their temp coefficient of inductance – either up or down might wreck the VFO's stability.

Russian Circuits One of our contributors has put together a compendium of over 100 circuits by Viktor Polyakov and others, for a whole mass of different applications. The Russians have proved to be very inventive over the years and some of these are fascinating. If you would like to receive the pdf file, send your request to the Equipment Engineering Co at equieng@hush.com

DSB/SSB bandwidth Mont Pierce inquires about the bandwidth differences between these two methods of phone transmission. Double sideband modulated RF, as it leaves the transmitter, does occupy double the bandwidth ie about 7 KHz and its nominal frequency is in the middle of this 7 KHz segment; single sideband occupies 3.5 KHz with the nominal frequency (where the carrier would have been) on one side of that section – the side depending on whether it is upper or lower sideband. (DSB is seldom offered in black box rigs, but the carrier can be either suppressed or actually present depending on the type of modulator - if the rig is producing conventional amplitude modulation, then the carrier is present with both sidebands and it occupies 7 KHz. I have used 3.5 KHz here as a typical audio bandwidth for these examples, but it can be down to nearer 2 KHz.) At the receiving station, a simple product detector will produce a 'valid/good' output if either or both sidebands were transmitted provided the receiver's local oscillator is set to where the carrier would have been if had it been transmitted; however if the receiver has narrow filtering ahead of this detector, and that filter is set to remove the wrong sideband then no signal is heard when tying to hear SSB. If it was actually SSB then the frequency is actually clear because nothing was transmitted and that channel (or gap in frequency) could be used by another TX/RX pair, but if it was Double sideband, then there would actually be a signal there if you changed to the other sideband.

That's enough from me. Happy Christmas and a prosperous and healthy New Year! Don't forget to let me have any contributions for Hot Iron! It would be lovely to have some pictures of your Weston projects for the next Hot Iron! Tim Walford G3PCJ

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Spring 2017 Issue E95

Editorial

Recent mails with a couple of good radio friends have suggested a bit of lateral thinking is needed to get new enthusiasts on the air using HF! I quote (almost verbatim) from one Club Chairman who highlighted the hurdles before his newer members like this – 'We have an issue in our Club. FT817 is now £500!!!! Members cannot all afford £500 to go onto HF. FM 2m handheld £25. But the local area in West Wales is coastal and hilly, so repeater access can be difficult. Many not have CW skills nor much interested in that mode. I got into Ham radio by listening to 'shortwave', principally Top Band on Sunday morning. So maybe AM is ideal ...'

This made me get out the doodling notebook! Undoubtedly, generating low or medium power Amplitude Modulated phone signals on HF is very much simpler than attempting Single Sideband phone, particularly if the RF final stage is a MOSFET that will allow modulation at its gate and so avoid a watty power audio modulator that would have been used in years gone by. The receiver might also be somewhat simpler because it only needs an amplitude detector. But after that, choices have to be made for the kit designer! Who are the target customers? Is the objective to interest new Club members who have probably never built a radio before, who might be started with across playing field, or town, contacts; or is it for more experienced builders who will want a small portable 'unit' perhaps with good sensitivity and selectivity for DX? If the desire is only short range AM without adjacent strong signals, then a very simple plain Tuned Radio Frequency receiver will do – this can be made quite easily with only four MOSFETs! As soon as you want more selectivity while retaining adjustable tuning, & extra sensitivity, then a classic superhet with amplitude detector has merit. If it has also to receive SSB or CW, then you need to add a Beat Frequency oscillator. A much simpler alternative is to make the plain TRF into a regenerative TRF which will boost the selectivity and sensitivity as well as allowing copy of SSB/CW. This can still be done with four MOSFETs! Phone transmission can then start with a 'crystal' controlled RF oscillator followed by an output stage using a MOSFET whose gate bias voltage is driven by a low power speech amplifier. If 9 volt battery operation is desired, one BS170 can produce ¾ of a Watt of peak RF output (implying 3/8 of a Watt carrier for AM). A genuine crystal will have very limited pulling range but luckily there are standard ceramic resonators that can be used for 80 and 160m so being 'rock' bound is not quite the drawback of years gone by! Then you also need to decide whether to have a single dense PCB for RX and TX or well spaced out 'seperates' for the less experienced! Do they need large aerials – no; loops and loaded whips can be good! See the Gurney Slade later!

For those 'rolling their own' rigs, I detail Block 2 of the **Weston** project later on; good to hear that some of you are using these ideas! I am indebted to my contributors and do encourage any of you to write in with a note or to suggest topics that need an airing! Tim G3PCJ

Contents

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

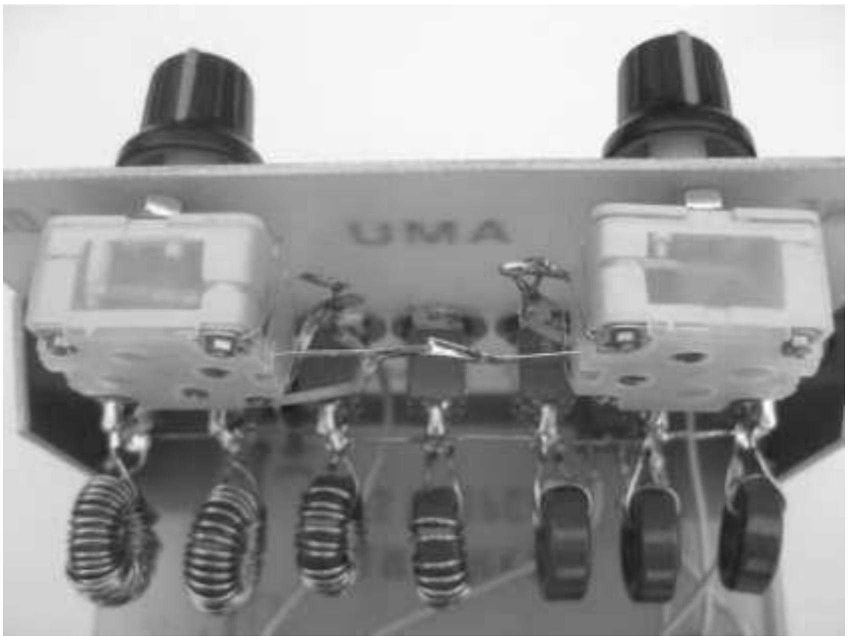
What with Christmas and my day job, not quite as much development work has been possible as I would wish! I have done a fair bit of doodling about AM on 160m arising from the discussion on the first page but nothing new to report on the kit front YET! Meanwhile I do offer the **Rockwell** Regen TRF which does two bands, each of which has a choice of series or parallel fitting of their inductors so allowing it to be built for any bands of MW, 160, 80 or 40m! For those wanting an AM transmitter, the **Rimpton** is a simple phone transmitter for any of 40, 80 or 160m bands using either a crystal, or a 3.69/2 MHz ceramic resonator for a small tuning range using the trimmer. It produces 1.5W peak (0.35W carrier) on nominal 12v supplies.

I have done a bit more on the Somerton and Dorchester top of the range rig to try and reduce its complexity/cost. This concentrated on starting with a single band 40m design to which could be added 20 and 80m, or possibly 30m. 80m is awkward if the IF is an integer number of MHz, using a crystal mixing LO approach because it will need a less common X500 KHz crystal. One way to avoid this is to divide the LO by 2 for all bands, which does have the added advantage that a more symmetrical drive might be possible to both sides of a first mixer using switching gates; the LO scheme does then get easier but it still needs a double tuned band pass filter in the LO chain for each of the bands with crystal mixing. Add in digital frequency display and it soon gets far too complex compared to a digitally driven VFO using DDS with its own readout! I am afraid this makes the original S and D project unviable for me. However….!

It eventually dawned on me that if the configuration is a changed to a double conversion superhet using crystal driven converters for the first mixer followed by a conventional superhet with 500 KHz of tuning, then one can avoid having LO band pass filters for each band which is a considerable saving. I intend to explore this approach a bit more.

On other fronts I have done a PCB for a more powerful linear RF amp with bigger heatsinks but have yet to build the prototype – I suspect the heatsinks may cost more than the electronic parts which seems illogical for simple extrusions with a few holes drilled in them!

The **Mk 6 AMU**, with the toroids for much easier inductor construction, is now available. Here is another view! The switches each give a binary increase in inductance – it's quite easy to adjust because usually only two adjacent switches will be needed, so you can quickly flick on just any one and then maybe add the one next door for a slightly better match!



Tim G3PCJ

A very simple modular receiver – Peter Thornton

Working in semi-conductor manufacturing I often had to build test equipment, and this was always "modular" design: GHz bandwidth oscilloscopes, spectrum analysers, signal generators and the like had to be used for many different jobs - not possible to buy one for each transistor type to be tested! This influenced me when putting together the simplest possible frequency stable receiver shown below – it's a set of modules to make a "Direct Conversion" receiver.

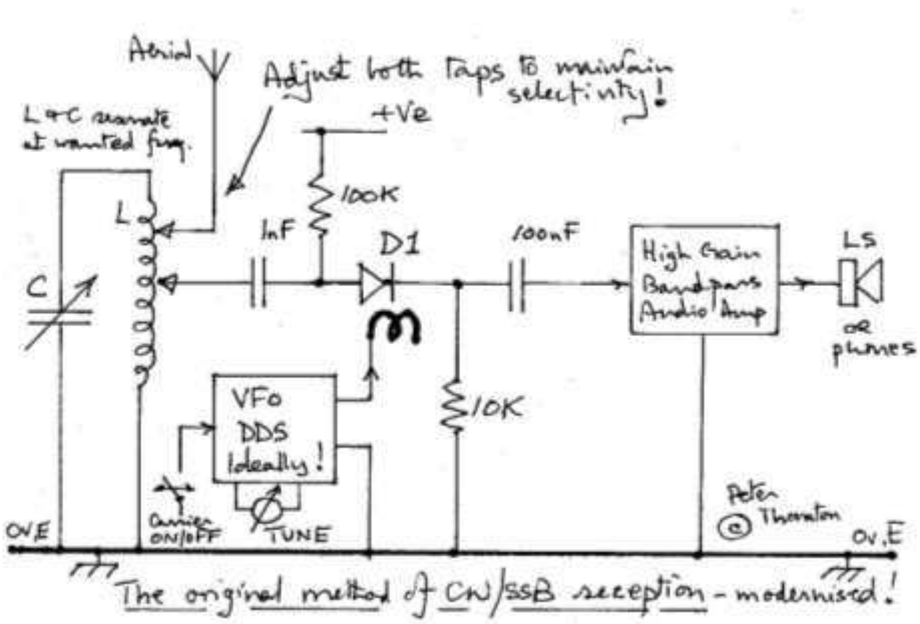
The first module, is the TRF module and detector. This has the tuned circuit for the desired reception frequency which also helps to eliminate broadcast breakthrough. I mounted the L and variable C in a PCB material screened box with a temporary lid. L & C are chosen to resonate to the desired listening frequency. The coil is provided with taps so that both the aerial, and the output to the diode detector, can be adjusted to prevent either of them excessively loading the tuned circuit and hence wrecking its Q or selectivity. Alternatively the aerial can be connected via another variable capacitor to reduce the loading on the resonant circuit. The detector is biased by the 100K resistor form any convenient well smoothed supply. I had three diodes to try: a plain 1N4148, a Schottky 1N5711, and a germanium 1N60. The whole section was built in a PCB material screened box

For the second module, I set up my bench audio amplifier, which has two (bridged tied) LM386's fed by a single stage bipolar transistor pre-amp, to give about 400Hz to 4kHz bandwidth with an overall gain of up to 70dB.

The third module is the VFO, which (in my case) is a DDS unit that is ultra-stable: any clean & stable VFO is suitable; as is a Variable Xtal Oscillator. The VFO signal is coupled to the detector diode by a turn of insulated wire near the diode, *not connected in any way*.

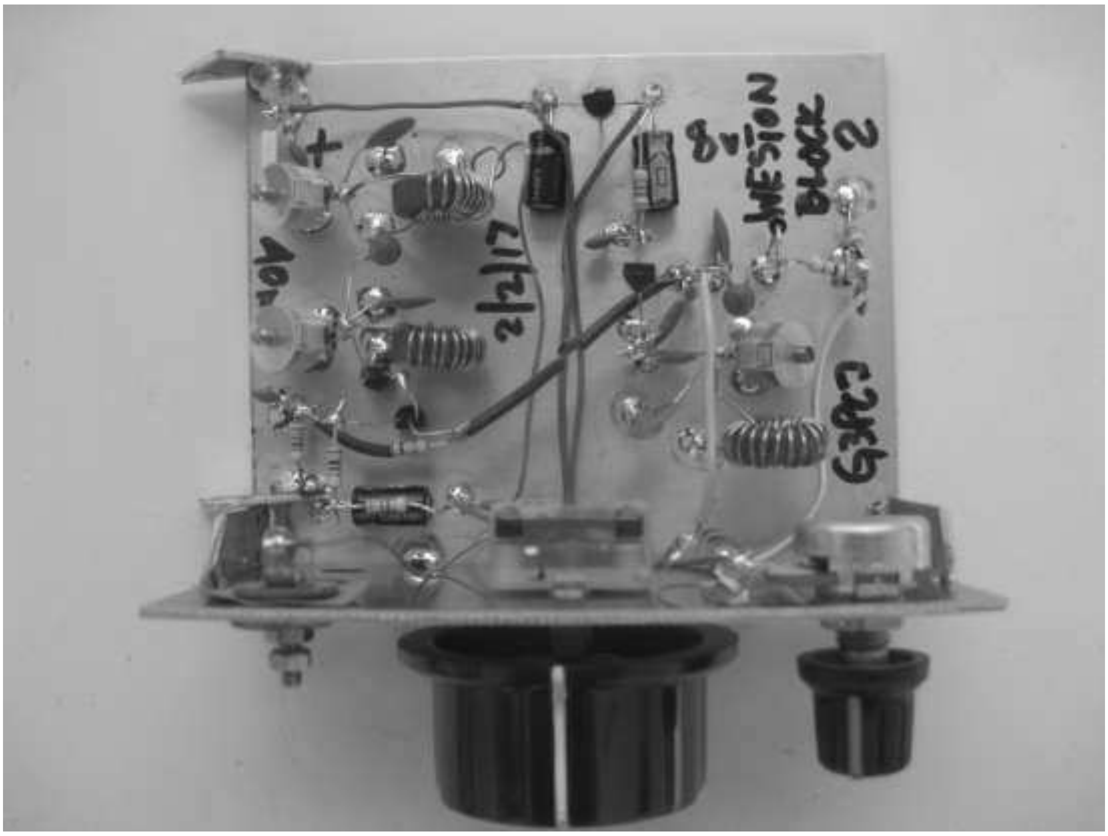
I tried all three diodes - the 1N4148 was noticeably the worst at any bias current. The 1N60 was good; but the 1N5711 had noticeably lower noise.

There you have it: a sort of amplified crystal set + VFO = Direct Conversion! Surprisingly sensitive, stable and drift free, it is just about as simple a receiver I can make. No doubt it could be improved with multi-diode mixers, filters, and so on: but it did what I wanted, no fuss, simple, adaptable for virtually any frequency. For HF use, the coil tap was best at ~ 10% up from ground, the low loading of the L/C circuit preserved its Q so eliminating the off-tune broadcast breakthrough. Broadcast short wave stations are a useful indicator of ionospheric conditions and they can be received by zero beating the VFO with their AM carrier.



The Weston Block 2

As explained last time, the aim of this project is to end up with a single band superhet built in easy stages with an interim version as a plain direct conversion receiver. Block 1 was the audio stages described last time. Block 2 adds the RF filters and a mixer (acting as a product detector), which is driven by a VFO operating at the desired band's frequency, for the DC RX. I have built mine for 40m as there is usually something to be heard at any time of the day! As before, my version is built in 'dead bug or ugly' construction style – its so easy and effective! Instead of it all being 'flat', I have added a small ready drilled PCB front panel (salvaged from some unsold kit) which will make operating the tuning controls rather easier. I might later change the AFG preset in Block 1 to a proper pot mounted on this panel after Block 3 (the IF strip) has been added. My Weston Block 2 below is a bit tidier than the other example of 'free construction' later!



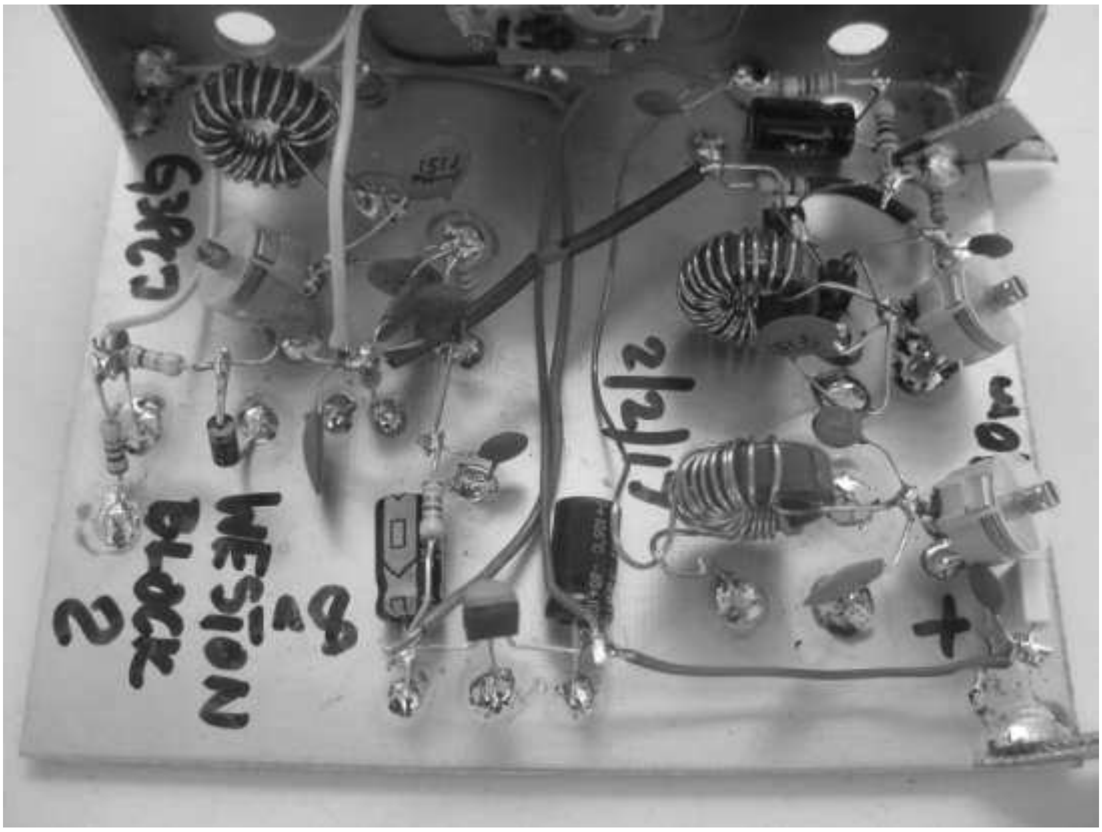
Block 2 circuits

The circuit (Fig. 200) of this block is shown on the next page. The weak signals from the aerial (in block 2A) are first passed through a double tuned parallel resonant top coupled filter whose task is to reject the undesired out of band signals. The first resonant circuit (L250 and C201/251) also acts as a step up transformer by matching the low impedance (typically 50 R) of the aerial feeder to the high impedance (several K) of the parallel tuned circuit. A turns ratio (between primary and secondary of L250) of 5 or 6:1 is a good starting point! The top coupling capacitor C252 is small – typically about one fifteenth (or less) of the main resonating capacitance (C201 plus C251) – make the coupler larger for a desired larger bandwidth, or smaller to reduce the coupling between the resonant circuits and hence a narrower band which might be needed where strong broadcast station signals are present not many kHz away - as on 40m! The second tuned circuit of L251 and C202/253 can directly feed the very high input impedance of the gate of the lower JFET transistor TR201 in the mixer. The other mixer JFET is driven by a large signal from the VFO.

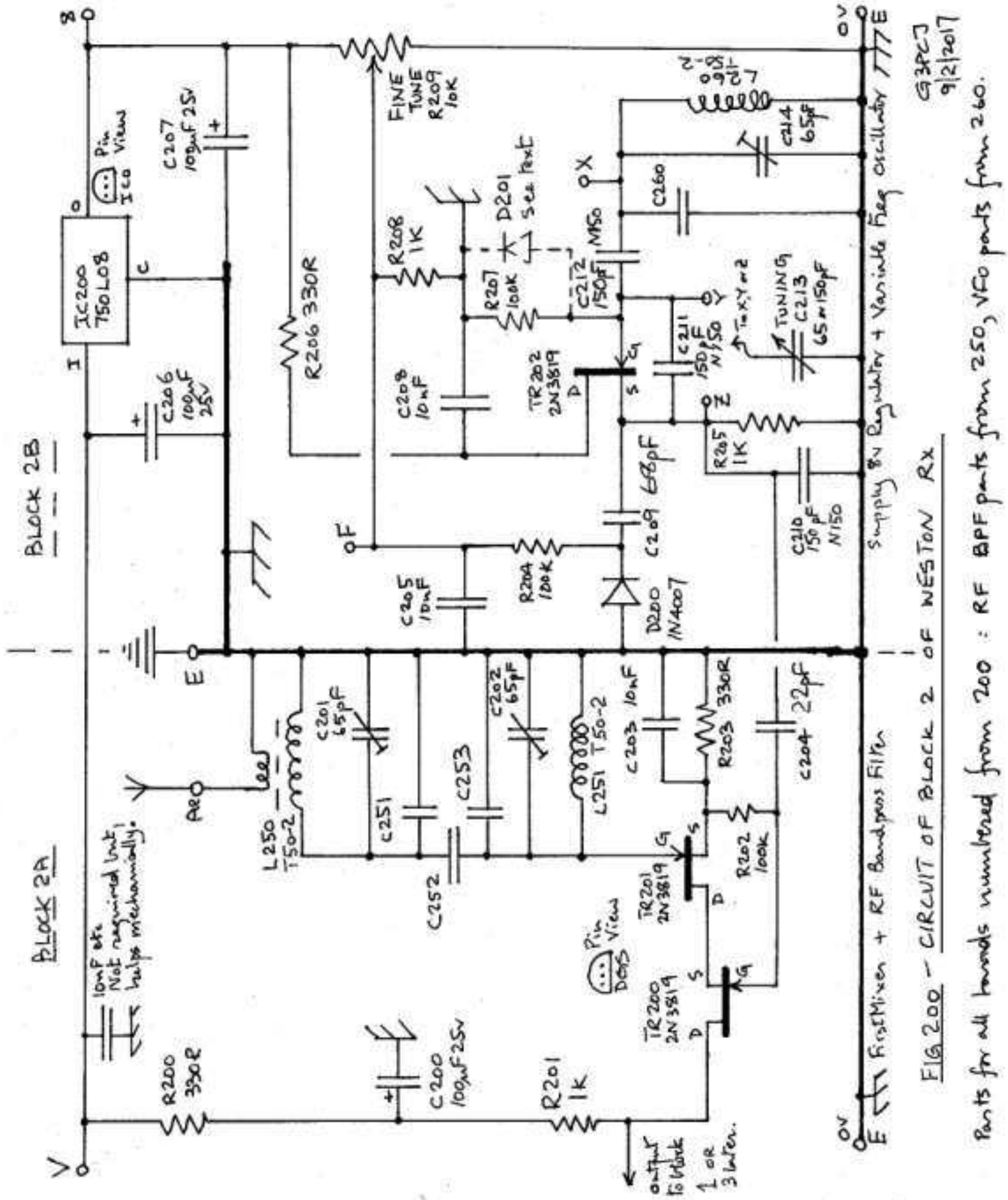
The output of the mixer is developed across the 1K drain load R201 with filtering by the previously omitted C120/121 of Block 1, which is now needed to limit the bandwidth to about 4 KHz. For my ears only one 22 nF was required at C120! I have drawn the circuit with 2N3819 JFETs but you can use other types such as J310 or 2N5459 but beware of their alternative pin-outs! Bear in mind that I have shown C251, 253 and 260 as single capacitors but for some bands they might need to be series or parallel combinations of a pair – see tables later.

In my model, block 2B uses a low drop out 8 volt regulator for IC200 which permits operation with down to a 9 volt supply. You can use the more common 78L08 regulator if you wish but this will need a minimum of 10 volts to the regulator! A stable voltage is particularly needed for the Fine tuning control voltage applied to D200 which is acting as a cheap varactor diode! R208 helps to linearise the action of the Fine control R209 that provides a few KHz of adjustment – this is needed because the main tuning of C213 is often too fierce without a slow motion drive. A Colpitts oscillator is used with N150 temp coefficient capacitors (at C210,211,212,260) for good stability and to provide several points X, Y or Z to which the tuning variable can be connected for alternative tuning ranges. Normally a diode would be fitted at D201 but is best left out here as the mixer TR200 needs a large drive from the VFO.

Resistors	330R R200, 203, 206;1K R201, 205, 208; 100K R202, 204, 207
	Fine Pot R209 – 10K – lin law with knob!
Capacitors	6p8 disc C252; 22 pF C204; 68 pF C209; 150 pF plain C251, 253;
	150 pF N150 C210, 211, 212, 260; 10nF C203, 205, 208;
	100 µF 25v electro C200, 206, 207
	65 pF yellow trimmer C201, 202, 214
	65/150 pF PolyVaricon tuning cap C213 plus hardware and large knob
Inductors	T50-2 Red toroid L250, 251, 260; 1m 24 gauge enam wire
Semicons	1N4007 D200; 2N3819 TR200, 201, 202; IC200 750L08
Hardware	Copper clad fibreglass board – min about 80 x 100 mm plus front panel to suit



Weston Block 2 circuit



Testing Weston Block 2

I suggest start by mounting your tuning capacitor; if you have an air variable of about 50 to 100 pF this will be better than a plastic PolyVaricon for C213 but even if your junk box is lacking the exact value, it does not matter too much because the Colpitts circuit has three points to which it can be connected, depending on the tuning swing that you want. You may also want to add a slow motion drive! (As a bit of general advice, buy any old air variables in reasonable condition whenever you see them at junk sales – new ones cost serious money!) Start building the circuit with the 8 volt regulator IC200, the decoupling capacitors C206/7 and the Fine tuning pot R209 which will discharge the circuit when switched off. Note that the low drop out type of regulator 750L08 does need a much larger capacitor on its output to prevent oscillation, so be generous with a 100 /uF! Check its output and then build/test the VFO section. Bear in mind you will want to alter the inductors and fixed tuning capacitors (L260, C260 most likely) when you change from DC RX to superhet with Block 3 next time, so give yourself a little more room for this part of the circuit. Start with the basic parts of the Colpitts VFO leaving out the Fine tuning parts R208, C205, R204, D200, C209 and the connection to the tuning capacitor. At this stage the VFO is to operate at the desired band frequency – the table below shows the values that I used for 40m with suggestions for the other HF bands.

	L260	C260	L251	C253	L250	C251	C252
	T50-2	pF	T50-2	pF	T50-2	pF	pF
40m	2 uH = 19t	150 single	20t	150 single	20 + 4t	150 single	6p8
20m	1 uH = 14t	75 =2x150S	15t	75 =2x150S	15 + 3T	75 = 2x150S	3p4 =2X6p8S
30m	1.7uH=16t	75 =2x150S	18t	75 =2x150S	18 + 3T	75 = 2x150S	3p4 =2X6p8S
80m	4uH = 30t	300=2x150P	32t	300=2x150P	32+6T	300=2x150P	13.6=2x6p8P

When winding the inductors, it is sensible to leave the ends long enough to add a turn on each just in case more inductance is actually needed – it can always be cut off when you know its not required! Start each winding by sliding the toroid to the middle of the core and then put on the rest of the first half of the turns required – bearing in mind that each time the wires goes through the middle it counts as one turn. Finish the winding off by using the other end to apply the other half of required number of turns. The turns should ideally occupy about ¾ of the circumference – spreading them out or bunching up as required. For the extra primary winding of L250, this can be wound over the earthy end of the larger secondary winding, with the two primary ends twisted together to identify them. If you do not understand the suggested combinations of single, or series/parallel of two capacitors for each of C251, 253 and 260, then ask me or any nearby more experienced person. The VFO inductor has slightly less turns to make up for the increased 'fixed' capacity in its part of the circuit compared to the simpler RF filter resonators.

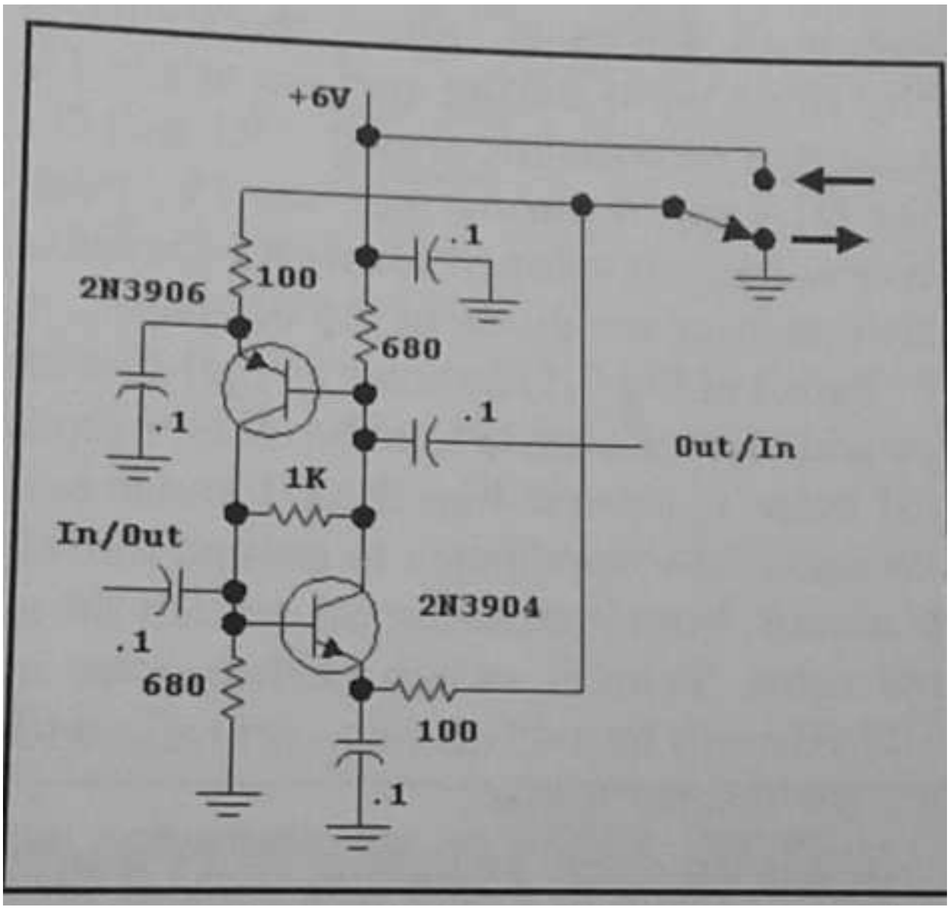
Once the VFO is assembled, you can use a counter connected via divide by 10 probe to point Z or listen for it on a nearby general coverage RX. You can also check it is actually oscillating by temporally grounding point X to stop the oscillator which should make the DC voltage across C208 change very slightly. There is a fixed minimum capacitance of 50 pF from the series value of C210/211/212 which must be added to say 30 pF (half value) from C214 to decide what is needed at C260 to make L260 resonate at band frequency. Use the trimmer C214 to bring the centre of the tuning range to your desired band centre. Once oscillating near band centre, try large or small sections of the tuning capacitor C213 connected to whichever of points X, Y or Z gives you the desired tuning range. X will have the largest swing and Z the least! You can then add the Fine tuning parts R208, C205, R204, D200, & C209. The role of R208 is to help improve the linearity of the Fine Tuning control.

After this, add the RF bandpass filter parts, with the same cautions about winding the toroids L250/251. You will find that when you install C204, the VFO frequency will go down slightly so use C214 to bring it back to band centre. There is nothing to adjust in the mixer, the only items to be adjusted are to bring L250/251 to resonance at band centre by tuning in some signal steady in amplitude and frequency, and then adjusting for maximum signal output from Block 1. See the earlier comments about fitting the Block 1 input filter capacitors C120/121.
As this is a DC RX, you will hear either sideband of signals; next time we change it to a superhet!

My favourite circuit by Pete Juliano N6QW

As I penned this article I almost felt like a school boy some 60 years ago, when a school assignment was to write about a favorite holiday, or a favorite summer vacation. Or like once where the subject I selected was My Favorite Girlfriend. That did not turn out well. But nowadays it is serious electronics projects.

I think we can all relate to a favorite circuit and the favoritism frequently is associated with the simple axiom – it works, it always works and it is my go to circuit. Lurking in our minds is that well if we only use this circuit, we will never learn anything new or we will never advance the state of the art! We have a great word on this side of the pond which I now will express "Baloney"! There are plenty of opportunities to add state of the art features to our rigs and thus the projects do not end up being cookie cutter. But at the heart of the issue is known performance and the favorite circuit acts as the anchor for the project. OK I gassed enough - here is my favorite circuit, which I first came upon in the publication ARRL's Experimental Methods in RF Design (EMRFD) by Hayward and others. Notably the circuit was designed on the other side of the pond by Plessey for use in back pack radios. This circuit is a bilateral amplifier stage that uses but a few parts (cheap parts to boot) and operates in two directions with a simple changing of how the circuit is powered. Put the voltage at one port and it amplifies left to right and reapplying the voltage at another port and the amplification is right to left. The stage gain is about 17 dB both ways.



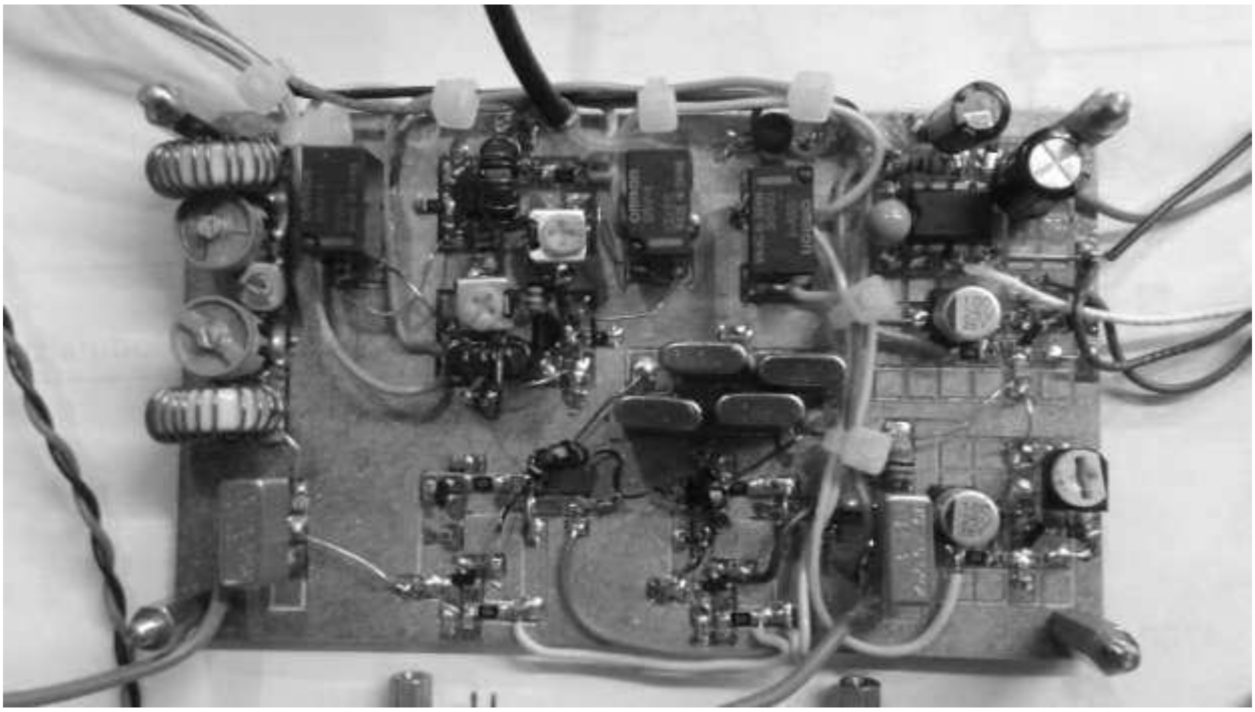
My favorite circuit has become a building block in most of my current crop of SSB transceiver projects. The circuit is basically a pair of complementary transistors that work only at one direction at a time. For those who have EMRFD it is Figure 6.110. This truly must be the worlds' best kept secret. The textual info in EMRFD says this is good through the HF range!

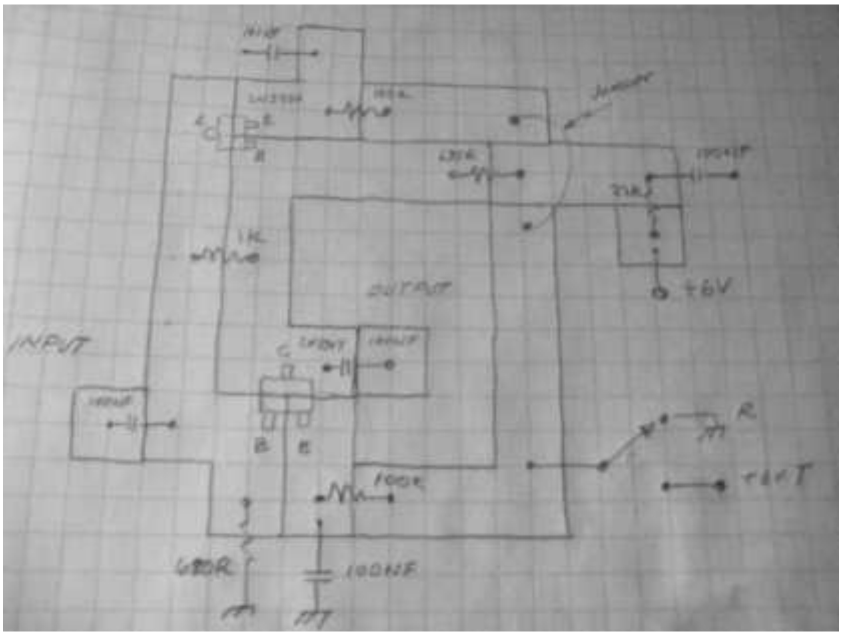
Imagine having one of these stages ahead of and following a crystal filter. Now you will need some matching so for a homebrew filter I match 50 to 200 Ohms and this is done with six bifilar turns which gives a 4:1 match. For a 500 Ohm filter (like the GQRP club filter) I use a single winding of 19 turns tapped at 6 turns (19^2 = 361 and 6^2 = 36, 361/36 = 10:1). Ahead of and following this stage are SBL-1's or TUF-1's which of course, are double balanced mixers (DBM).

The advantage of this architecture is that the 1st DBM takes the LO input so in effect becomes the Rx and Tx mixer stage. With the DBM on the back end it is the Product Detector on Receive and the Balanced Modulator on Transmit. At this DBM port we inject the BFO (Carrier Insertion Oscillator) signals. There is no RF switching of LO and BFO signals with this scheme!

So now think a bit how few components there are in this IF module which forms the heart of a SSB transceiver. Now you perhaps can see the why of my favorite circuit. I have built the circuit with leaded components as seen below in my shirt pocket 20M SSB transceiver (2" X 4" X 2"). Sitting right behind the amp board is a 4 pole 4.9152 MHz Crystal Filter. The signal direction change biasing is done with the small relay shown at the top corner. The two circuits are shielded. At either side are ADE-1L DBM's

I have also built this same circuit using surface mount parts which I found to be even cheaper than the leaded components but SMD is not every one's cup of tea. Here is the info for those with a stout heart (after drinking a lot of stout). This has a lot more circuitry on a board 3 X 5 inches; but shows the amplifiers, the crystal filter (a commercial unit from INRAD at 9.0 MHz), and the two TUF-1 DBM's. Also on board are the microphone amp, and audio amp, the band pass filter ahead of the 1st DBM and a two transistor bi-directional amp that has one leg for the Rx RF amp and the other leg as the Tx Pre-Driver stage.





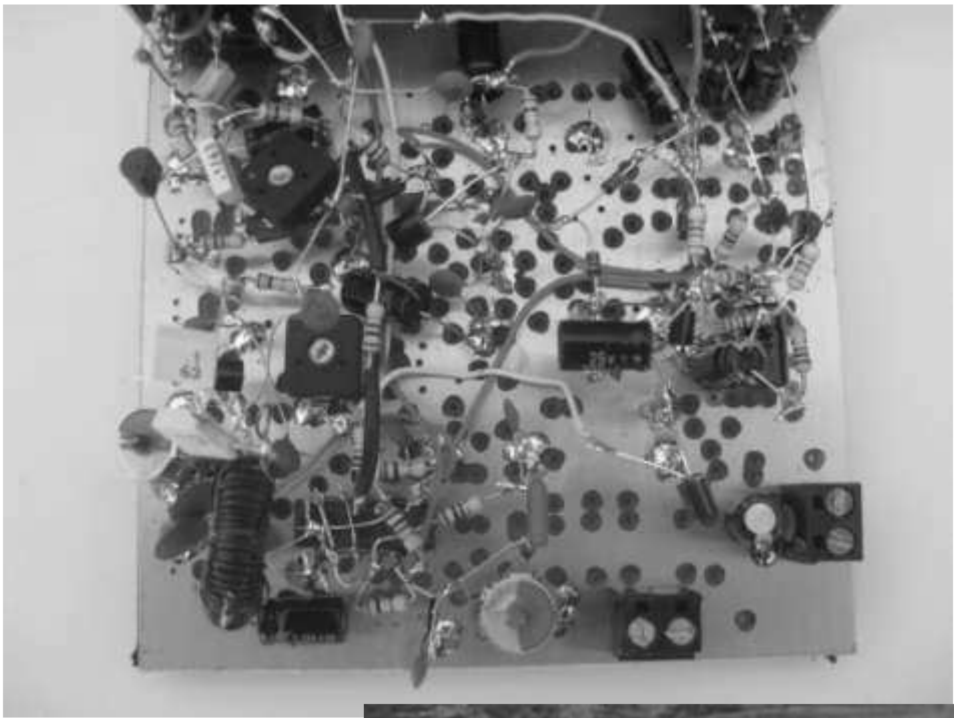
Below that is a sketch of how I initially laid out the amp using SMD parts using graph paper. This sketch was later translated to G Code using the free drawing package G Simple and then, using my CNC Mill, I made the board. No, everyone does not have a CNC mill in their garage; but the sketch above could be translated to a drawing for etching using the Chuck Adams, Muppet Board technique and you are there.

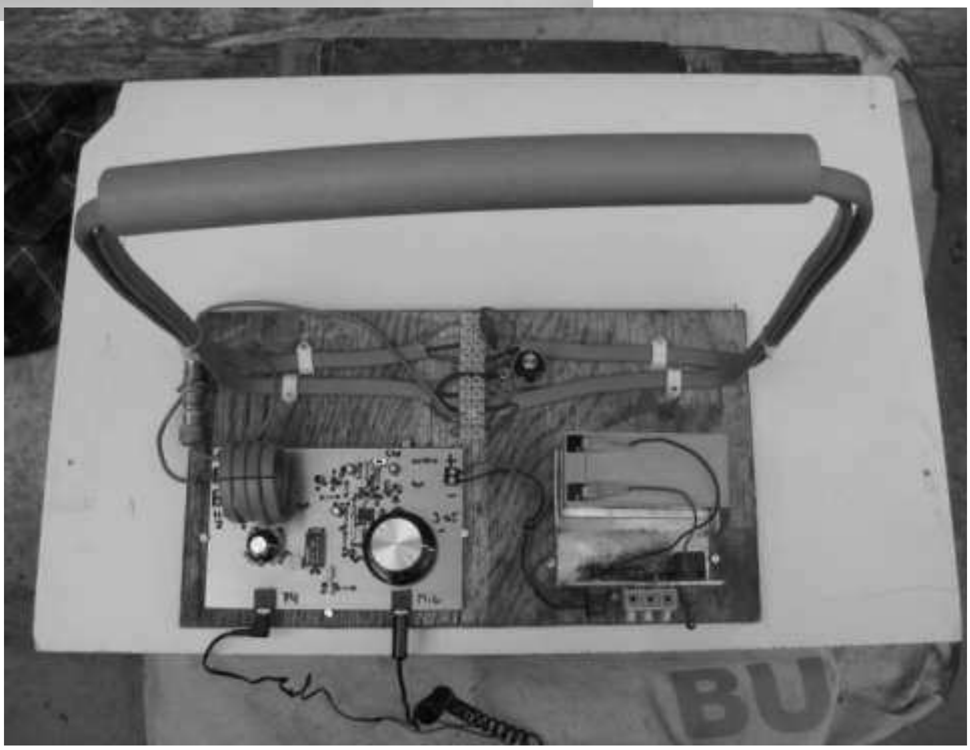
Quite honestly I believe the SMD version works a bit better as everything is tight! There are currently 10 transceivers I built using this circuit –so I guess it does qualify as "My Favorite Circuit"!

73's Pete, N6QW email: n6qwham@gmail.com

Snippets

Here is a shot of my latest 160m AM TCVR rig which I hope will become the Gurney Slade. It is not tidy and would not be any good for taking up a mountain but for development purposes, this style of construction on a copper ground plane is absolutely fine! This one looks a lot worse than it need because I used an old unsold PCB that had been drilled and countersunk – it might just as well have been a plain copper sheet. It is so easy to alter or add to the design, and with a little more care, can actually be made quite tidy and robust! It does not show up so well but the RF output tank in the bottom left corner has multiple taps for long or short top band aerials! This particular version also has an extra two audio output buffer stages in the top right, so that it can drive both sides of stereo phones when their common lead is actually earthed. The RX is mostly in the front right of the picture, with the transmitter RF oscillator and control chip near the trimmer at bottom left, and the speech amplifier in the top left.





Don't be put off the use of 160m because you lack garden space! It is surprising what you can do with a magnetic loop aerial with a single or multiple turns. More on this next time – the carrying handle shown right has up to 8 turns and is resonated (on 80m in this example) by a small variable just above the battery! G3PCJ

Keep the Hot Iron topic suggestions coming please!

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Summer 2017 Issue E96

Editorial

One of the challenges that is constantly in my kit designer's mind is 'how to produce a reasonably priced multiband HF phone transceiver'. I am very aware that once the cost of a kit begins to be near that of youngish second hand commercial equipment, then the market is confined to those who really enjoy building irrespective of cost – such customers are lovely to have but there are not enough of you! In reality, once that price threshold is approached, the demand almost dies out completely. Although the financial numbers are still large for new 'good value' multiband multi-mode rigs, their real term cost continues to decline as performance of computing machines increases, and those processors increasingly perform the fundamental signal processing within the rig in addition to all the extra frills that come with little extra cost. This makes it increasingly challenging for the more traditional analogue approach that is my natural inclination! I am pleased to report later in this issue on a small 'useful idea' in the hunt for good multi-band design concepts for the long planned Somerton and Dorchester TCVR.

But meanwhile, I and probably a good few of you, would like to better understand how modern computing machines perform the signal processing that is fundamental to a radio receiver or transmitter. I have been inquiring around, looking for somebody who could give us a good introduction to software defined radios (SDRs) without too much heavy mathematics. In the earlier SDRs, extensive use was made of the phasing approach (for sideband removal) combined with the direct conversion to audio baseband, followed by filtering executed by Fast Fourier Transforms in the processor; but now the performance of analogue to digital converters, and of digital processors, has advanced to the stage where the signal processing can be done at much higher frequencies – even at the HF of the band! This is much less easily understood and if any of you can write me an introduction to the subject, or know of somebody who might, then let me know please. I would like to broach this subject in the next year of Hot Iron!

Some of you have been following the evolution of the Weston design – in the last issue it got as far as a Direct Conversion *receiver* and later in this issue, I will detail the next stage which changes it to a superhet receiver. I have also done some doodling about the possibility of eventually adapting it into a phone *transceiver* – at first sight this does appear to be possible, but it will be quite complicated and will require several alteration/additions to the RX to make it possible; with about as much extra circuitry for the transmitter as there is in the whole of the RX. I do know of a few members who are actually building 'Westons' and it would be good to know if transmitting is also desired – so please let me know if you want to make yours transmit!

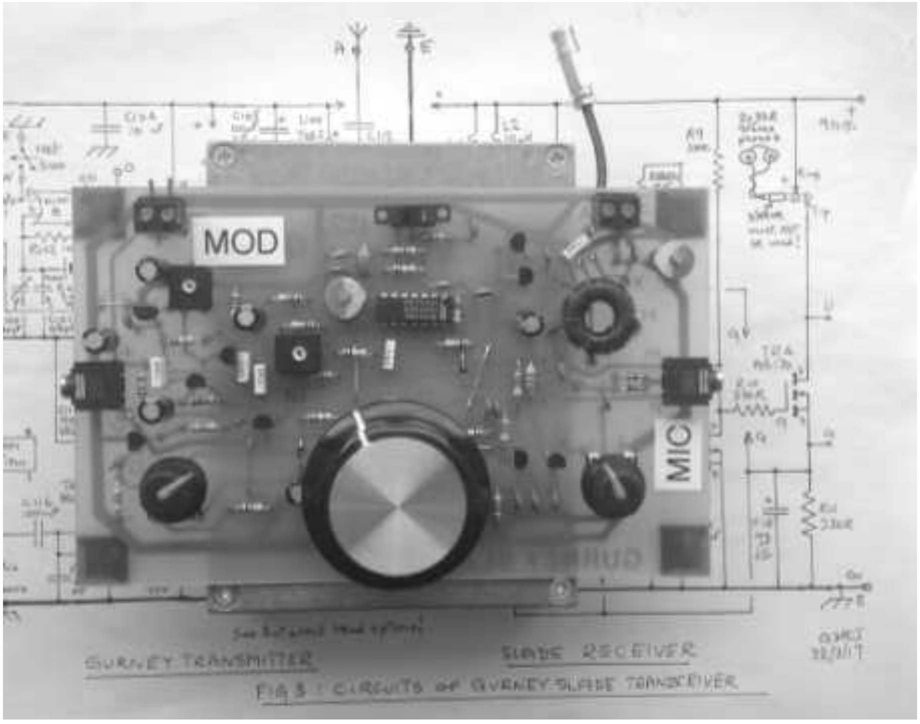
I am delighted to welcome a new contributor - Tony Fishpool with his favourite circuit. Peter Thornton poses a novel antenna idea for your constructive observations! Tim G3PCJ

Contents

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

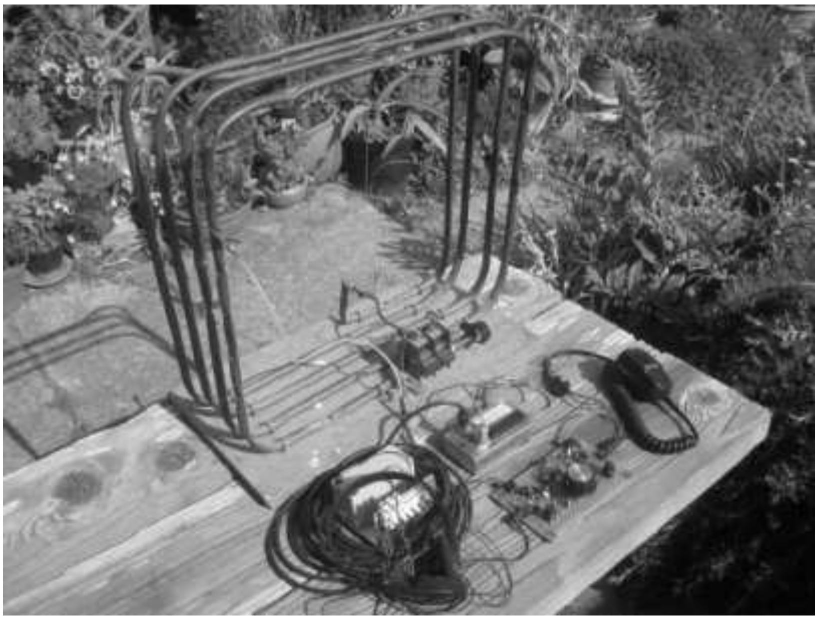
Kit Developments

I am pleased to report that the ‘respectable’ version of the Gurney Slade is now available instead of the bird’s nest shown last time! Several models are out and it is working well. To remind readers, it is aimed at new entrants (ideally in a Radio Club group) to the hobby wanting to get on air without having to win the lottery first! The RX has the ability to tune the high frequency end of the Medium Wave band for early confidence boosting; and to be then altered for either of the 80 or 160m amateur bands. Because the RX is a Regen TRF it can listen properly and easily to Amplitude Modulation (AM) as well as amateur CW or SSB. The model left was build by Matthew Twyman who first suggested this AM TCVR.



The associated transmitter produces phone AM on 80 or 160m and has a tuned output tank circuit with taps for connection to ‘long wire’ type aerials without the need for an AMU. The maximum output is about 0.75W on a 9 volt supply or 1.5W when using 12 volts – the corresponding carrier levels are 0.2 and 0.4W. AM has the distinct advantage of being cheap and the gear is easy to build and then set up; tuning is much less tender too than for either CW or SSB. The transmitter is ‘crystal controlled’ but there are suitable ceramic resonators that can be used both for both 80 and 160m which gives a few 10s of KHz tuning range, set by the trimmer in the top middle of the picture.

Just in case you all think that operation on 80 or 160m is impossible without huge antennas, the other photo right shows a /P operation from our garden to a friend who was the other side of the house (75 yds away with several very solid stone walls in between) and using a similar small multi-turn resonant loop and rig. Signals were very string (bordering on overload) so I am confident that across town contacts between Club members are quite viable.



Vertical Antennas & 'Top Hat' capacity loading – Peter Thornton

It's been long accepted that top loading a "short" vertical Marconi antenna set up above an earth plane really helps. The loading coil can be reduced, the radiation resistance rises, so losses are reduced - all in all, a healthy state of affairs. Fig. 1 below illustrates the common set up: a (usually tubular) metal mast is set up on an insulating base (praise be for glass pop bottles!); and an earth "mat" surrounds the base and a set of wire elements are fitted as a "top hat". All accepted stuff, nothing radical in this, surely?

As Fig. 1 shows, each of the "top hat" elements create capacitance to earth; the "top hat" capacitance being made as large as practicably possible by adding elements, as in antenna "roof" wire meshes, TEE style and "L" style multiple top wires and such like. The new LF amateur bands on 600m and 2200m have highlighted the need for top hat capacitive loading all the more - with added impetus for serial tuned counterpoises to reduce losses as far as practicable. Make no mistake though: creating top hat loading is a major problem. The extra weight, wind loading and sheer area required, let alone the extra insulators, spreaders, wire and booms make this approach hard work. Insulators, especially on the LF bands, suffer from corona discharge damage - "brushing" - where insulators leak RF to ground and eventually decompose or shatter. In a nutshell, top hat capacitance is a right royal pain to create and maintain!

How to do something better is a good question: top hats do work, its been proven time and time again, but perhaps thinking about electromagnetic fields in a different way suggests a new approach. It should be perfectly feasible electrically to create top hat advantages by using an annular ring of high voltage capacitors at the top of the mast, as (Fig. 2), all connected together and grounded via a "screened" cable inside the tubular mast. Thus we could put many nF's of capacitance - as opposed to a few hundred pF's - at the top of a mast and get all the benefits of top hat loading without all the engineering problems highlighted previously.

Now here's the crunch: you don't need screened cable to earth the common centre connection of the top hat loading capacitors. The RF is applied to the outer surface of the mast; the earth return is on the inner surface. Faraday screening practice tells us this is perfectly acceptable: proved by "plumber's nightmare" copper pipe RF feeders - they have cooling water running through the middle and hundreds of kW of RF on the outer surface, common in RF induction heating systems. Thus the capacitors' common centre connection is connected to the inner surface of the mast - no need for a wire all the way down the middle!

The key to the entire idea is that the RF travelling up the outer surface mast can't "see" the return RF current going down inside the mast - the "Plumber's Nightmare" principle - so the radiation from the outer surface current isn't cancelled by the RF current on the inside surface, travelling in the opposite direction.

This concept is a work in progress while I trawl around for a suitable pipe supplier - I would love have any comments from anybody who can contribute!

Prove me wrong please! Peter Thornton equieng@gmail.com

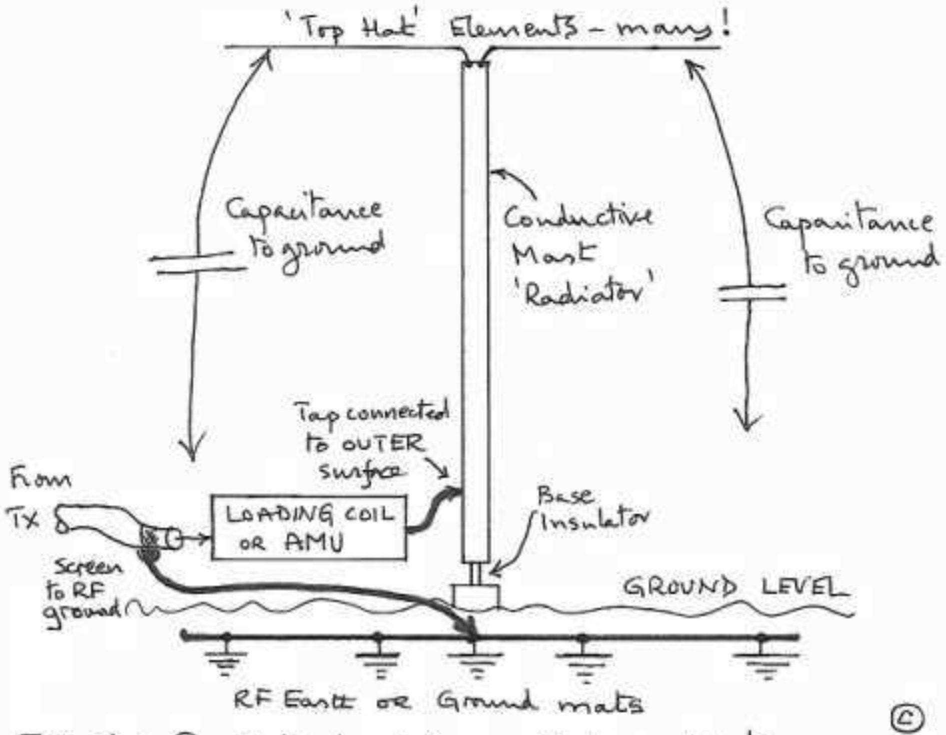


FIG 1: Top Hat Loaded vertical radiator

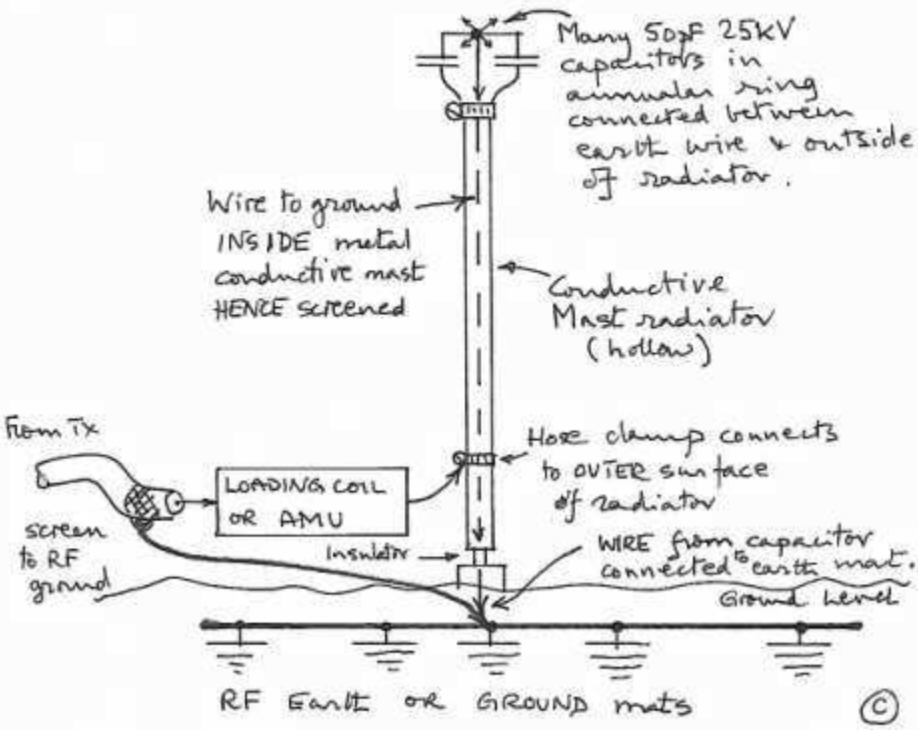
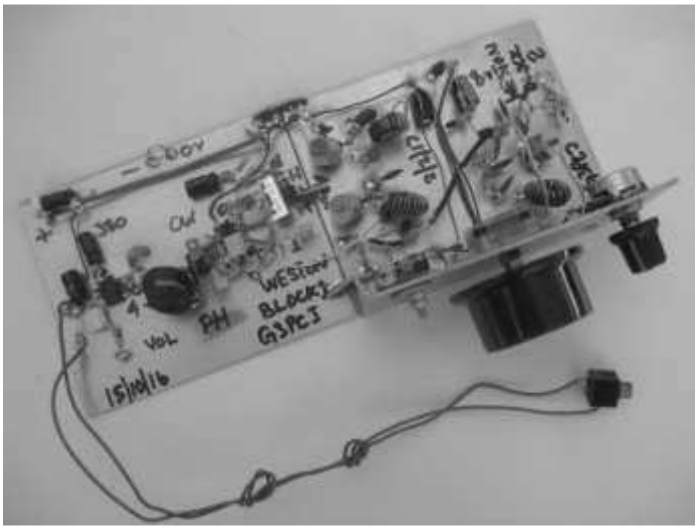


FIG 2: Discrete capacitor loading of vertical radiator

The Weston Block 3



For some reason I forgot to include a picture of Blocks 1 and 2 together (forming the DC RX version) last time – see right for what mine looked like at that stage! The next stage is to convert them to a superhet by adding an IF strip and product detector which will also require the VFO frequency to be altered for the IF and receiving band. The advantage of a filter type of superhet is that it removes the unwanted sideband, hence only half as many (and all ‘genuine’) signals. See the block diagram in the earlier E94 Hot Iron.

What Intermediate Frequency (IF) is best? For relatively simple single conversion designs like this, it is wise to consider an IF somewhere in the range about 4 to 15 MHz. I like to use an IF that is an integer number of MHz so that a digital frequency readout showing only the KHz numbers of the VFO frequency will be correct, and if wanted, the MHz display numbers can be hard wired on for the chosen band. There is a good range of low cost integer MHz computer type crystals from which you can build the actual IF filter using the ladder format. I suggest 9 MHz because a VFO tuning 5 - 5.5 MHz will then cover the 20 & 80m bands just by changing the input RF bandpass filter so that the first mixer adds or subtracts; for my 40m version, the VFO will need to tune 2 - 1.8 MHz for 7 – 7.2 MHz. You can also buy 9 MHz ready made filters.

Given this project is about building a working RX rather than one aiming for exceptional performance, I suggest an IF filter with four crystals will give adequate suppression of the unwanted sideband; its bandwidth needs to be about 2.5 KHz wide for phone signals but could be much narrower if wanted only for CW. Filter performance is highly dependent on crystal actual parameters so by all means start with my suggested values for the associated capacitors but be prepared to alter them if the filter is not working well! (Ladder filter theory is a bit beyond the scope of Hot Iron so if you wish to design your own consult the many on line excellent articles.) You will need a fifth crystal of nominally the same frequency to control the carrier insertion oscillator which will feed the product detector; this converts the IF signals back to audio. Traditionally you would use crystals cut for the nominal sideband frequency – offset about 1.5 KHz in either direction from the nominal IF value - so 8998.5 and 9001.5 KHz for mine – but usually it is possible to pull an IF crystal either way sufficiently; to go up needs only a trimmer in series with the crystal, and to go down needs some inductance (a few micro henries for L300) in parallel with the C300 trimmer that is itself in series with the X300 crystal. The suggested circuits for the IF filter and the Carrier Oscillator/product detector are shown on the next page. The oscillator is a standard crystal controlled Colpitts one using a 2N3819 JFET; the diode D300 which can be added at its base to limit the oscillation amplitude is best omitted so as to have a large drive to the JFET mixer.

The RF input filter stays unchanged but for my version the VFO needs a much larger inductor to get to near 2 MHz which is most easily done with a TOKO 3333. The table after the circuit shows the suggested inductor and capacitors for various bands etc.

Weston Block 3 Circuits

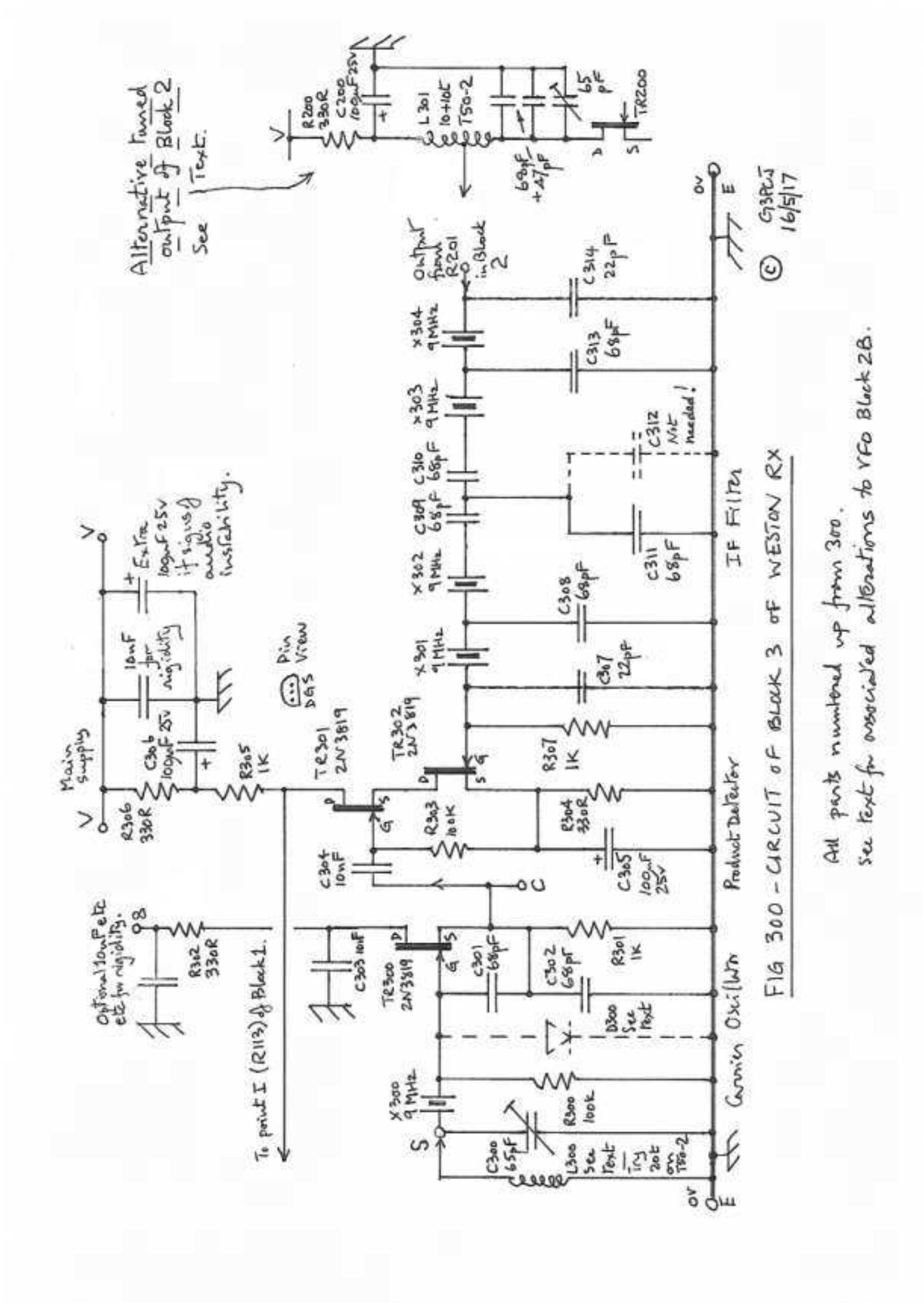


FIG 300 - CIRCUIT OF BLOCK 3 OF WESTON RX

The IF filter and CIO with product detector will easily fit on another half of a standard 100 x 160 mm PCB; you will need to separate Blocks 1 and 2 so as to insert the new IF strip between them electrically and I therefore suggest also physically! Again use copper clad board with dead bug style construction – adding anchoring supply filter capacitors to make the circuit mechanically rigid. This particular design of IF filter is intended to work with terminating impedances of near 1 K at both ends of the filter, so it can be driven directly from the old 1K load resistor of the original first mixer. At the filter output there is an extra 1K load resistor at the input of the product detector mixer TR302 which would otherwise be just the very high value of the JFET gate. The drain load R305 of the extra second mixer is the same impedance (1K) as in the earlier direct conversion mixer so there is no need to change the associated audio filtering capacitors in Block 1. The table below is for a 9 MHz IF but beware that if you choose instead to use an IF of 6 or 10 MHz because you happen to have lots of those crystals, then you will need to change the sideband oscillator frequency to retain the normally used sideband when the band is the other side of the IF! For 8999.5 KHz add about 20 turns on a T50-2 at L300. A high IF will keep the VFO lower for the higher frequency bands. See note 4 below about a tuned IF driver.

The table below gives suggestions for the alterations to the VFO resonators for the common bands. I have suggested ready made TOKO inductors because the values needed for some bands are large and beyond that sensibly put on T50-2 toroids. Apart from changing L260 you will need to change C260 for your band. There are too many options for me to define all values so do some experiments with your variable capacitor sizes and tuning connection across the Colpitts capacitors C210/211/212 so that you obtain the desired tuning range for your band. The Fine tuning circuits are still well worth retaining (unaltered).

Sideband and VFO for a 9 MHz Intermediate Frequency

Band	Normal Sideband CIO KHz	Sideband L300 Turns on T50-2	VFO MHz	Revised L260 Micro-henries	Tot nom Res Cap pF	Revised C260 See note!
20m	8998.5	3 /uH ~ 20 turns	5 – 5.35	5 uH - TOKO 3334	177	Try 68 pF
30m	Either for CW! Not needed		1.1 - 1.15	45 uH - TOKO 3333	465	Try 2x150 pF
40m	9001.5	Not needed	2.0 – 1.8	45 uH - TOKO 3333	140	None
80m	9001.5	Not needed	5.5 – 5.2	5 uh - TOKO 3334	167	Try 68 pF

Note 1. About 100 pF has been allowed for the series value of C210/211/212 plus part of trimmer C214 – there is also a wide increment available from the inductor L260's adjustment range. For my 40m version, using the 150 pF section of C213 connected to point Y gave 200 KHz range.
Note 2. I also added extra large decoupling capacitors on the main supply as there was some evidence of audio instability when the supply protection diode was in circuit!
Note 3. To avoid excessive hash from the first mixer, I found it best to limit the amplitude of the VFO oscillator by fitting a 1N4148 diode at D201.
Note 4. To increase the 'effective' RF gain, I found it best to alter the output of Block 2 to a tuned circuit as shown on top edge of circuit above. R201 replaced by centre tapped 20 turns on T50-2 toroid resonated by fixed 68pF + 47pF + 65pF trimmer.

Parts for Block 3 are:-

Resistors	330R R302, 304, 306; 1K R301, 305, 307; 100K R300
Capacitors	22 pF C307, 314; 68 pF C301, 302, 308, 309, 310, 311, 313;
	10nF C303, 304; 100 /uF 25v electro C305 (upped to 100 /uF), 306;
	65 pF yellow trimmer C300
	C312 not fitted. ?Extra 65 pF trimmer, 47 pF and 68 pF for L301?
Inductors	2 x T50-2 Red toroid L300, 301; 1m 24 gauge enam wire
	X300 – 304 5 x 9.0 MHz xtals HC49 style - low or full height
Semicons	2N3819 TR300, 301, 302;
Hardware	Copper clad fibreglass board – min about 80 x 100 mm

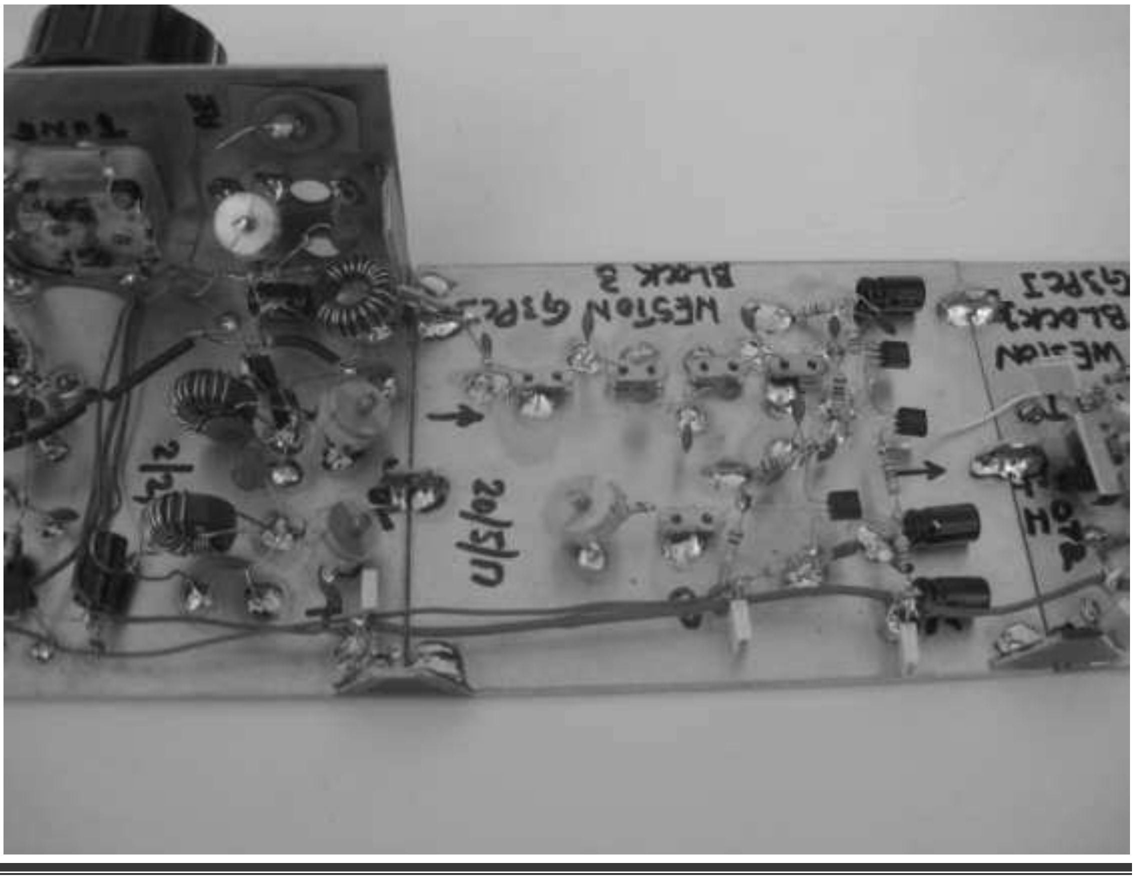
Testing Weston Block 3

I decided to keep my RX as a group of PCBs all in line so it was necessary to separate Blocks 1 and 2 and insert Block 3 between them. Connect the main positive supply for R306 and feed R302 from the regulated 8 volt supply in Block 2 that was used for the VFO. You can check that the new CIO is running with a counter or a general coverage RX tuned very close to your IF frequency; it is actually best to finally set C300 after the superhet is working, when you should adjust the trimmer C300 for the most natural sound of incoming signals – this will of course also need the VFO alterations to be working! If you cannot adjust C300 to obtain correct proper sounding audio, it is quite likely you have the carrier oscillator on the wrong sideband so try adding (or omitting L300) and then adjusting C300 for the best audio quality.

The IF filter is straightforward, and should not need adjustment if all the capacitors match the characteristics of the crystals – keep fingers crossed! It is sensible to arrange the filter crystals broadly in a line so as to increase the separation between input and output and hence reduce the chance of strong signals bypassing the filter. There are mixed opinions on how best to mount the crystals but I prefer to mount them rigidly by spot soldering the metallic case to the sheet copper ground plane – this is best done with a 25W soldering iron to quickly heat the crystal can to sufficient temperature. Keep all the leads in the filter short.

The VFO inductor should be changed to the suggested TOKO type and again it will need mounting rigidly by soldering the can tab to the ground plane with a 25W iron. C260 will need altering for the desired VFO range. Given that you now have an adjustable inductor as well as the trimmer C214 to set the **high frequency end** of the **VFO range** (with the minimum setting for your tuning capacitor), there is less need for C260 to be a specific value. Do be careful when adjusting the core of TOKO type inductors as they are brittle - you need a small non metallic screwdriver – an old credit card cut down to a screwdriver point works quite well. Measure the new VFO frequency by a counter attached via a divide by 10 probe onto point Z of Block 2 or listen for it on a nearby general coverage RX. Once the VFO is about right you should begin to hear signals on your chosen band without having to re-adjust the RF band pass filter in Block 2.
This is what my Block 3 looks like (with altered Block 2 output) when it is mounted with Blocks 1 and 2. The tuned output of Block 2 alternative circuit shown above gives a useful increase in gain so that band noise can now be easily heard with a modest aerial!

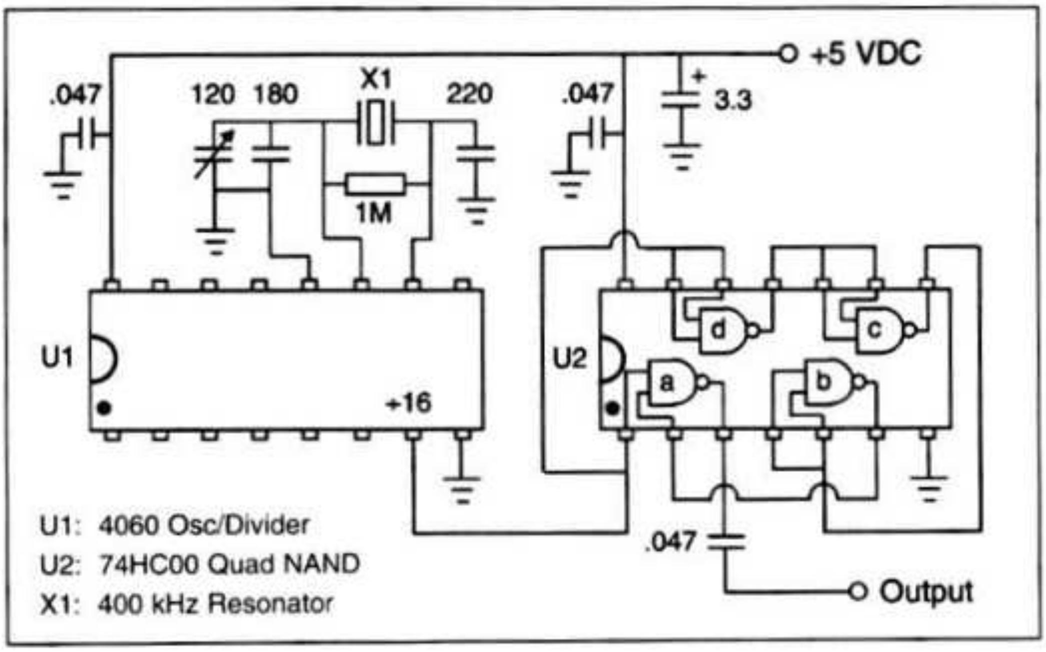
I have also changed the AFG pot to a 4K7 log law one instead of a plain linear taper! Much better gain control now! G3PCJ



My Favourite Circuit – Tony G4WIF

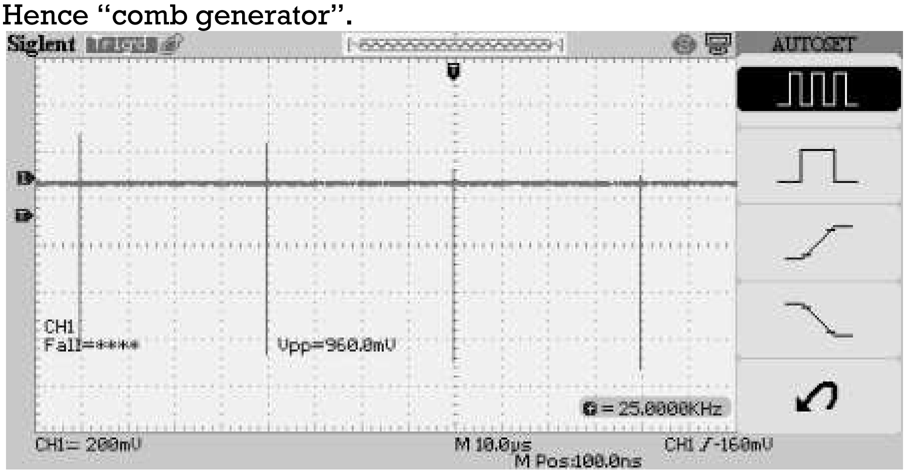
I like playing with wideband noise sources. For years I've used them to get an understanding how well filters which I've built have performed in the real world. Thanks to some advice from Peter Juliano N6QW, I have lately been using LTSpice to compare practice with how the filters should theoretically perform - and thus be able to compare.

My noise source has hitherto been the N0SS Zener diode noise generator. They are simple to build and very useful - but because the simple transistor amplifiers used have a tendency to fall off in gain (versus frequency) the output also falls off considerably – even across the HF bands. I felt I wanted something with a virtual flat output and I found that in a design by Gary Breed K9AY of a Comb Generator which was published in the summer 2009 QRP Quarterly.



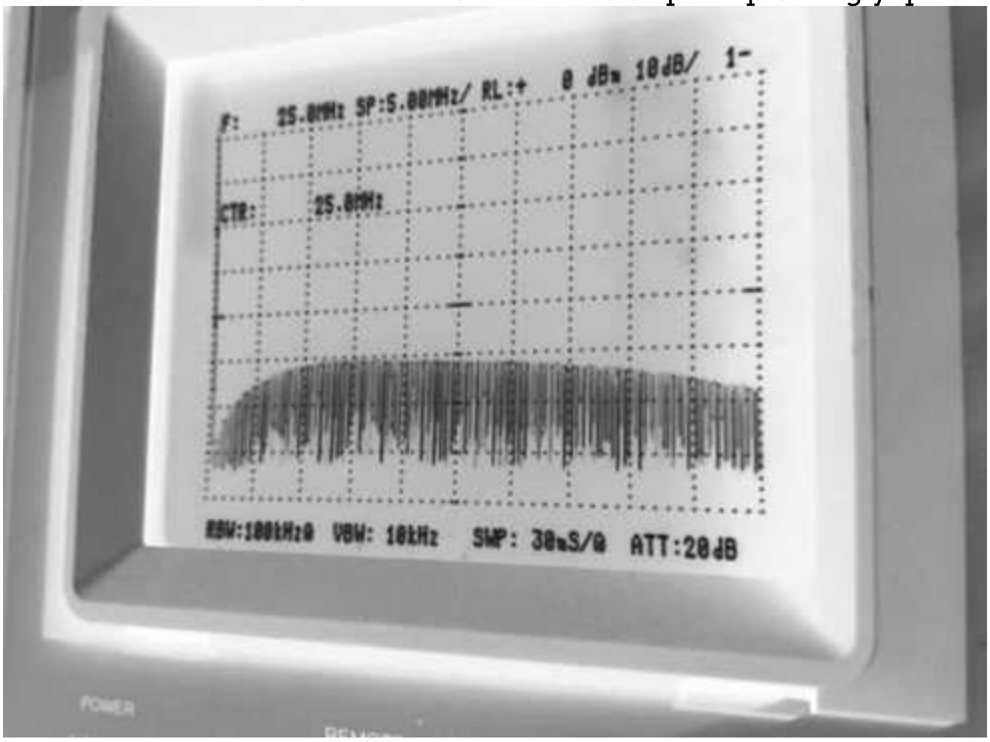
The various "chippery" and resonator cost me less than a fiver. The circuit designed by Gary was so simple that it could be built using any popular method. I etched a board which used surface mounting techniques often referred to as "muppet style". In fact one of the chips used was surface mount style because it turned out to be 50 pence cheaper than the 16 pin D.I.L. variety (which are still available if preferred). The board can be seen and downloaded for duplication from my website at www.fishpool.org.uk.

The oscilloscope trace below shows the output of very narrow 25 kHz "spikes". Hence "comb generator".

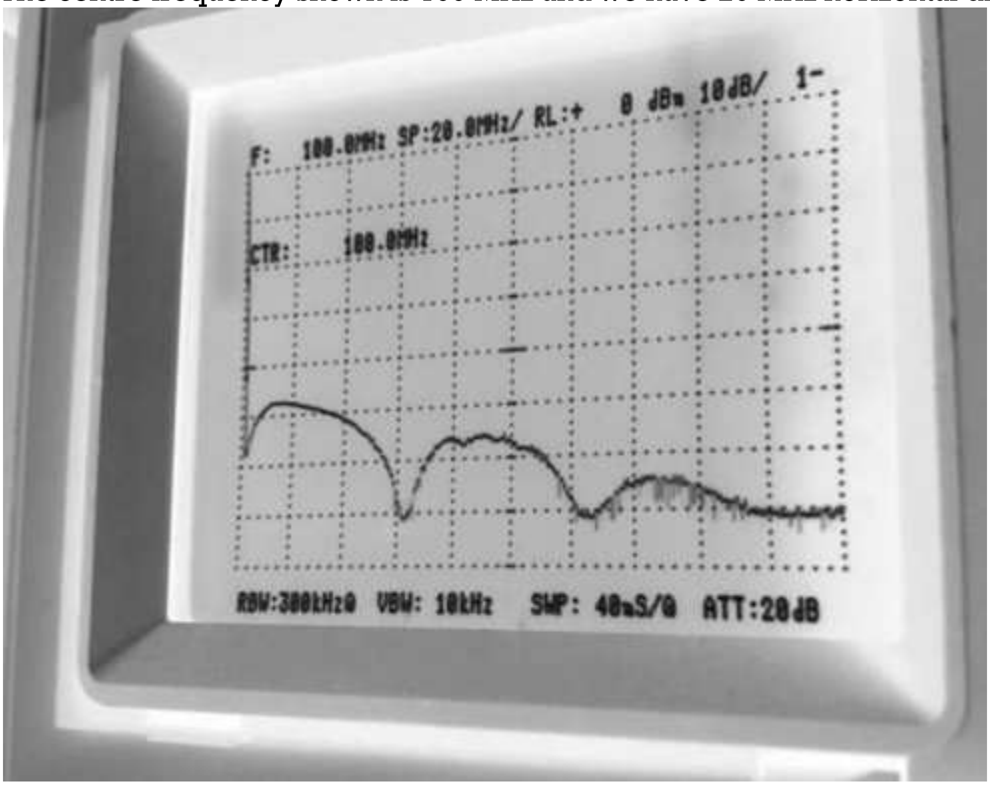


Another purpose that comes to mind is to use this as a calibration source and I later added some extra crystals and a rotary switch to allow that for other frequencies. However the main aim was that the device would generate wideband harmonics and that it does considerably well.

My spectrum analyser shows the output. The centre frequency is 25MHz and each horizontal division is 5MHz. So from 10MHz to 40MHz the output is pleasingly quite flat in output.

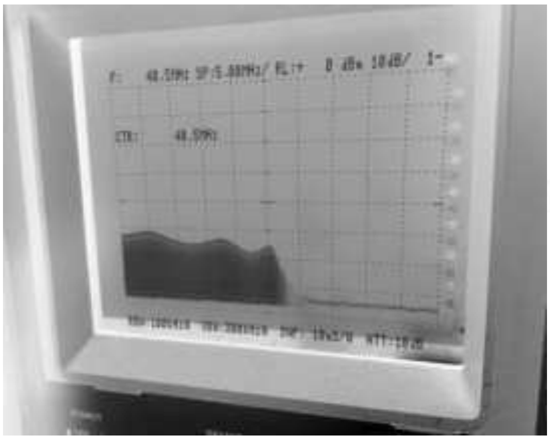


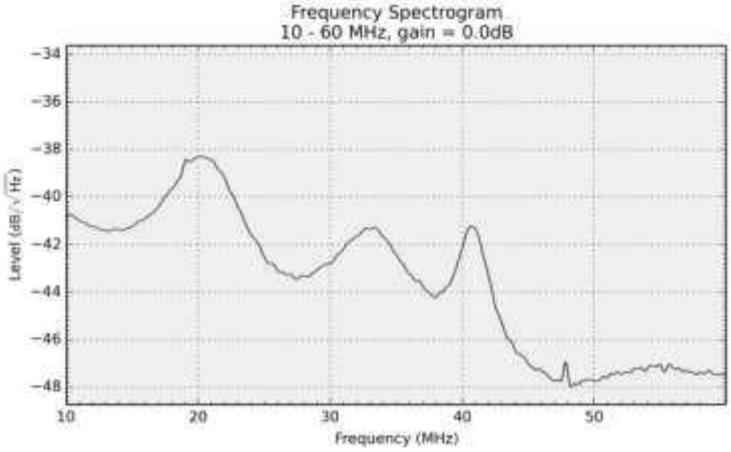
Over a wider frequency span the output gets interesting. Harmonics certainly go very high. The centre frequency shown is 100 MHz and we have 20 MHz horizontal divisions.



I would love to know why output dips at 82 MHz and 124 MHz but that does not present a problem for what I'm currently using it for – filter testing.

I injected noise from the comb generator into a 37 MHz low pass filter that I had built and you can see two things from the result. There is ripple on my filter and it perhaps cuts off a little higher than expected. Now you might think that this is all very well if you have a spectrum analyser, so to the right is a similar result using a TV dongle based spectrum analyser the total cost to build within most radio amateur's budget. The software is free from http://eartoearoak.com/software/rtlsdr-scanner



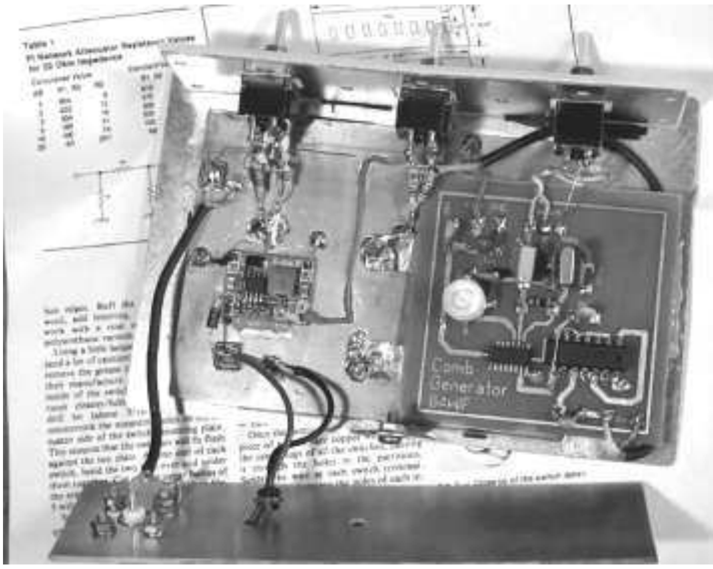


My spectrum analyser is set to 10dB per vertical division while the dongle vertical scale is more "stretched". So it looks more "hilly" on the right - but essentially, it is telling the same story. The TV dongles which are available for around £8-£10 are not very good below 30 MHz but they do perform quite well beyond 1 GHz. To use one to look at HF signals you need a converter.

I confess that I bought mine. It's rather good and not too expensive at £40 via Amazon. Just search for "Ham it up" (from NooElec) and you will find it. For USA readers with access to QST there was a project in January 2016 by WA3TFS. There is also an NE612 based converter described here:

www.rtl-sdr.com/building-a-simple-upconverter-with-a-ne612-ic

So does all this replace a proper spectrum analyser with a tracking generator? Of course, the answer is, "no it doesn't" - but all that comes at a high price beyond many. If you drew a line of usefulness with an absorption wave meter at one end and a spectrum analyser at the other you would be somewhere in the middle with the dongle+converter. You would however have built something that is very useful at low cost, especially if you added a comb generator to the mix.



QRP Quarterly:
www.qrparci.org
N0SS Zener Noise Generator:
www.n5ese.com/noise.htm

Somerton and Dorchester Update!

The aim of this project was initially to build a (many HF) multi-band phone and CW TCVR. One of the highest cost elements (in a single conversion superhet) would have been all the filtering associated with generating the local oscillator signal for each of the higher frequency bands where a normal free running analogue VFO would lack sufficient stability; so how could one avoid so many filters? (Don't say DDS to me!)

Fairly soon one concludes that a VFO below about 8 MHz and an IF somewhere in the range 6 to 12 MHz is sensible starting point. The classic 5 to 5.5 MHZ VFO with an IF of 9 MHZ will provide 20 and 80m just by the choice of RF band pass filter, depending on whether the superhet's first mixer is additive or subtractive. This has to be good but it is only for two bands! What about all the others? How about adding a crystal controlled converter ahead of the main rig for extra bands? This would avoid all the individual band LO filters but the band RF filters and crystals would be needed just like the LO mixing alternative. With 500 KHz coverage for the nominal 20 and 80m band sections, converters for all bands can be done as shown below. From a potential spurii generating viewpoint; converters, a double conversion superhet or the LO crystal mixing approach are much the same due to having the same number of mixers – albeit with different actual spurs. (I am well aware that LO generation is an excellent task for a micro-processor controlled DDS etc but it was not part of my essentially all analogue design concept!)

Band RF freq MHz	Converter Crystal MHz	Converter Sum	Base rig band MHz	Tuning Direction
1.5 – 2.0	16	subtract	14.5	Down
3.5 - 4.0	Not needed			Down
7.0 – 7.5	11	subtract	4	Down
10.0 – 10.5	24.5	subtract	14.5	Down
14 – 14.5	Not needed			Up
18 – 18.5	4	add	14	Up
21 – 21.5	17.5	add	3.5	Up
24.5 – 25	10.5	add	14	Up
28 – 28.5	24.5	add	3.5	Up

By chance I do happen to have all these unusual frequency crystals (left over from a project many years ago) but clearly this is not going to be a simple design for the band and TR changeover arrangements - it all looks a bit clumsy. Probably poor value for money!

However, belatedly I realised that the easy way to add 40m is to just add another VFO running from 2 MHz down to 1.8. Apart from the 40m RF filter, it only needs a simple VFO which can use the second gang of the tuning capacitor and can also share any Fine tuning controls.

This has to be the best way to cover the all important 20, 40 and 80m bands!

With a bit of luck I can now get on with the other main development uncertainties. G3PCJ

Upgrade of WE 10W PA kit to 25/45W PEP output on 13.8V supply

1. Introduction

Tim's 10W PA kit consists of a push pull class AB RF amplifier driven by two IRF510 MOSFETs. They are vertically mounted with individual heat-sinks and the PCB design is neat and spread out across the board area. This allows plenty of scope for modifications. Presented is how to upgrade this kit to 45W of RF power with minimal extras. Thermal stabilisation is added, so bias current and output power do not increase as the temperature increases.

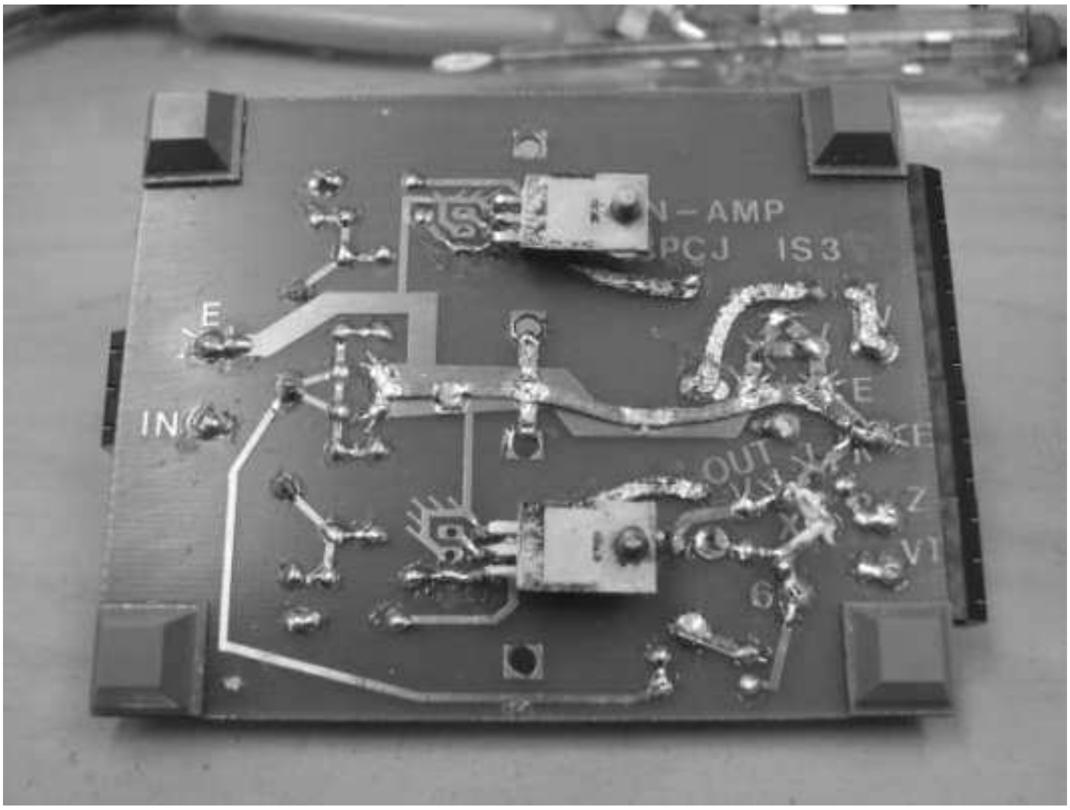
2. Extra parts needed, some optional

2 x IRF520N MOSFETs 1 x 1N4148 diode De-solder wick 2mm wide Terminal blocks

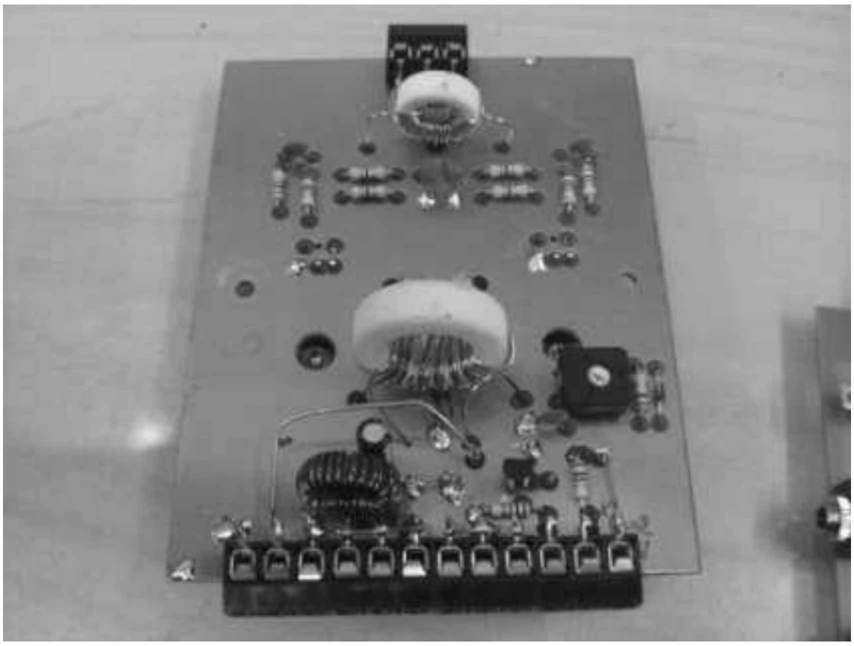
4 x 47R 2W resistors 4 x 100R resistors Flat heatsink, aluminium bracket or plate

1 x T50-2 toroidal ferrite core Enamelled wire, thickest you've got left over from Tim's kits!

3. Modifications



The power MOSFETs will instead be mounted underneath the PCB. Access holes will be drilled in order to fix them to a heatsink or thick aluminium bracket or case. The photo on right shows the underside of the board with MOSFETs attached. Notice that de-solder wick has been used to increase the current handling ability of the PCB layout, as DC input current can be 10A. The path for the main voltage feed is thickened, the feed to the Drains and the GND rail.



The photo left shows the topside of the board.

The access hole on the right hand side just fits, with a tiny shave off the side of the pot with the drill bit. Notice there is an improved input power RF choke, L3, made from thicker enamelled wire on a T50-2 red core, with as many turns as would fit. Use the thickest wire you have that reasonably fits.

For temperature stabilisation, the 6.3V Zener D1 must be removed and a 1N4148 added to it in series and the pair mounted on the underside such that the diode bodies touch the heatsink when the PCB is fitted. The 1N4148 band faces the zener band. A small blob of heat transfer compound (see right) will ensure good thermal contact with the heatsink. Set the bias pot to zero first when setting it to work, as this mod will increase the reference voltage and the bias will need to be reset.

Terminal blocks can be fitted for easy testing and construction. These are soldered to PCB pins fitted to the board during construction.

The input and output transformers can be mounted horizontally for a low profile module.

There are a few options for the input configuration:

1) 1.5W input, 25W output. This is the configuration I use with the Rimpton TX which provides a decent power level without excessive heat and no need for a fan. The input transformer remains the same, as do the 47R resistors at the input network R4-R7.

2) 5W input, 45W output. Change the four resistors R4-R7 to 47R 2W power handling.

3) 1.5W input, 45W output. Change R4-R7 to 100R and alter the input transformer configuration to 5:5+5. (Untested, yet to be confirmed!)

The output transformer ratio must be changed in order to develop the higher power at 13.8V. The new configuration is 3+3:12 with stouter primary winding.

Dan White MW0UZO mw0uzo@gmail.com

Loop aerials

This is a huge subject which we don't really have sufficient space for in Hot Iron and I am certainly not sufficiently qualified or experienced in these matters for an in-depth note! But they can be very useful in situations where conventional wire aerials are impractical.

Magnetic loop aerials usually have a loop circumference value of below about a quarter of the operating wavelength – over this they tend to behave more like some form of dipole. The loop forms an inductor which is brought to resonance for the operating band usually by some form of variable capacitor connected across the ends of the loop. The loop does not have to be circular and can have multiple turns (but beware inter turn capacitance)! The larger the cross sectional area of the loop, the higher will be the efficiency, and with large cross section loop material, the 'efficiency' can approach that of a half wave dipole – figures of 75% being not uncommon. Large copper water pipes (eg 28 mm) with soldered fittings are a good example. Losses must be minimised - these are often in the loop 'joints' and tuning capacitor – especially if it has rather small 'spring sliding type contacts' for connection to the shaft! A better scheme is to use a twin gang capacitor with the loop connected stoutly to both sets of fixed capacitor vanes – this arrangement puts the two moving sections in series without using the shaft's poor contacts so will have far less loss – but the maximum capacitance will only be half that of each gang! The other important factor to consider is the voltage rating (or plate spacing) of the variable capacitor. Ideally it would be a vacuum variable for high power use but even QRP levels can generate several hundred volts of RF due to the likely very high Q of the loop and capacitor. Large sized rigid coax is also an excellent loop material because a very low loss capacitor can be made (& adjusted easily) by just overlapping the two insulated ends near each other and then clamping with a plastic tie! The high Q of a good loop provides another major advantage, that of helping to eliminate unwanted signals away from the resonant frequency. Their small size also often allows the orientation to be adjusted, either to maximise the wanted, or to null an unwanted signal. The direction of maximum gain is in the plane of the loop – equally all round if circular! (Field strengths can be high so keep over a metre away even at QRP levels!) There are many websites devoted to loop design – resonance can be measured with a Dipper.

There are many techniques for feeding the loop. Many builders favour another small feed loop in the same plane as the main loop so they couple to each other. I have never seen any analysis of how they should be designed or located - I suspect there is a fair bit of trial & error involved! I much prefer the simple approach of what is called the 'gamma match' when used with wire aerials – it is very simple and just involves connecting the 'hot wire' of the feed line to the point on the loop where the impedance matches that of the line. The 'cold' wire of the feed line is connected to the 'earth' point of the loop. It is so easy to adjust the tap for minimum SWR in the feed coax by 'clipping on' the coax centre at the best match! For high power you might need something better than my croc clips in the attached photo. (This is the same loop as fully shown in my Gurney Slade experiments mentioned earlier!) G3PCJ

“JOURNAL OF THE CONSTRUCTORS CLUB”

Hot Iron

Autumn 2017 Issue E97

Editorial

The challenge of building electronics on your kitchen table is getting tougher again! For the last few decades, it became appreciably easier but that trend is changing now. A few decades back the business of mechanically mounting your valved project was quite daunting – even those people with modest workshop facilities struggled to make holes in aluminium, or even steel chassis, that were about an inch and a quarter wide (30 mm) for octal valve bases – a circle of badly placed smaller holes had to be filed out and then rounded off! And then you filled the inside of the chassis space up with numerous tag strips for the components carefully mounted between them, with sleeving over all bare wires! Apart from retro projects, thankfully that approach has been superseded by printed circuit boards with etched tracks between the pre-drilled holes for small components that are soldered direct to the PCB – this makes the actual electrical circuit construction almost a doddle!

But what about ‘enclosures’? You can spend lots of money on very smart cases - but is it necessary? For most of us who do not venture up mountains etc, where the physical environment is daunting; a simple open form of construction is quite adequate for bench use and this allows you to build/attach test leads (and alter things) very easily as the project progresses. The next most important item is the front panel. Plain single sided copper clad laminate has much to commend it. It can be cut with a hacksaw or shears and is easily fastened to the main component PCB ground plane by soldering the rear copper side of the front panel section. This really does make it possible to build the rig on the kitchen table! If you are going mountaineering, then by all means make a full enclosure that will give physical protection against shock and temperature changes etc. I always advise an open version first to see if extra controls are needed or whether the project is really worth the effort/cost of a smart box! Of course, if you are a real dab hand at these things (like some of our contributors!), then you will also make your own very smart cases!

Recently the semiconductor manufacturers have taken to only producing the newer devices in surface mount formats, so the devices have shrunk hugely and are rather of-putting for even the moderately experienced home builders because they need excellent eyesight and very steady hands! Finding ways to mount these tiny items is THE challenge for kit designers & suppliers wanting to stay viable, while still allowing you to say ‘I built it’!

We start the new HI year with material from two new contributors, one of them touching on the challenging topic of SDR, and some other splendid contributions – thank you all very much. As ever – please keep your suggestions and material coming! Tim G3PCJ

Contents

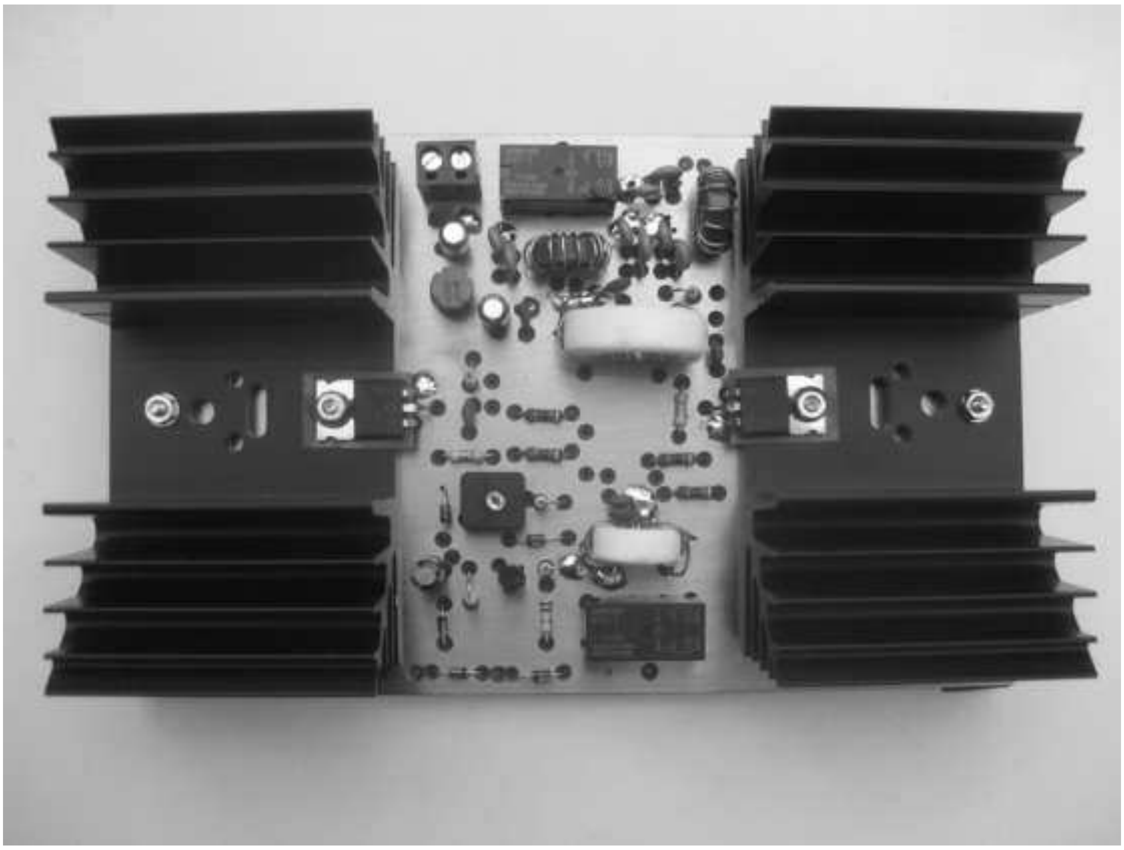
Hot Iron is published by Tim Walford G3PCJ of Walford Electronics Ltd. for members of the Construction Club. It is a quarterly newsletter, distributed by e mail, and is free to those who have asked for it. Just let me know you would like it by e mailing me at electronics@walfords.net

Kit Developments

The two articles in Practical Wireless about the Gurney Slade 80/160m simple/low cost AM TCVR are out. I am happy to give readers of Hot Iron the same discounts as in PW.

Much of my 'electronic' time has been spent doodling about a new CW rig as outlined later; but I have also got on with a ***High(er) Power Linear*** project which was triggered by Dan White's experiments with a highly modified standard 10W Linear as described last time. The new design is aimed at the lower bands where the high gate capacitance of MOSFET devices are less of a problem. With the aim of obtaining a few tens of watts on nominal 12 volts supplies, it uses the IRF520 device which contain two of the 'dies' that are used in the IRF510. This makes the IRF510 better for higher frequencies but will struggle to do much more than 5W comfortably using sub 15v supplies. Both types have a max drain voltage rating that allows for use on up to 30v supplies (with care!) and then their potential really shows!

The new design (below) has much larger heatsinks and includes two high sensitivity TR 12v relays that ought also to be OK on higher supplies. Without any supply, or for reception, the relays are off and bypass the amplifier. Closure of the PTT input turns on the bias supply to the IRF520s so that they can cool down when not required during reception. The actual amplifier has two white RF transformers – the small one at the input having a centre tapped secondary for driving the push-pull MOSFETs. These have a little bit of resistive feedback to help with stability but removal of that might lift maximum output a bit more! The larger output RF transformer has a centre tapped primary for the main drain supply point, with the secondary feeding a twin Pi low pass harmonic filter which would normally be built for the highest band in use. The filter output feeds the output TR relay. The present version is not intended for QSK operation due to the speed limitations of the relays, but if the base rig TR circuits can handle the higher output RF voltages, it should not be too difficult to re-arrange the RF paths for QSK work.



Keen CW operator David Perry (see later note on the T1154) is going to try it out for me!

Top Loaded LF Antennas – Part 2 – Peter Thornton

In the previous edition of Hot Iron I proposed a "short" vertical antenna for LF service using capacitors and a co-axial mast structure, the idea being to replace the huge wire "top hat" capacitors considered mandatory on "short" (i.e. less than a ¼ λ) vertical elements, with fixed high voltage ceramic capacitors. I asked for comments and replies - I had many, for which I thank you kindly - that prompted many thoughts and ideas. One reply, however, stood out a bit more.

Chip, from Florida, has had professional working experience of LF (Med Wave) antennas, and he told me I had stumbled upon the "folded Unipole" (sometimes called the "folded monopole") antenna. At first I thought "folded" meant - literally - an antenna doubled back on itself, thinking "folded dipole" and the like. Until I checked the Internet references, that is.

Chip was absolutely right - the folded Unipole antenna gives sufficient matched bandwidth for Medium Wave band AM stereo - yes, AM stereo transmissions - with good efficiency, in 550 – 1600 KHz band. In the USA, unlike the UK, where MW AM is taken seriously, the folded Unipole is the antenna of choice for a "short" vertical transmitting antenna. The folded Unipole is similar to what I originally proposed; a vertical (tubular) metal mast over a ground plane (in my case, the ground plane is series resonated, as per Les Moxon, G6XN, to minimise the ground plane size and increase efficiency) with a co-axial "screen" of three to five wires connected to the top of the mast, dropping down around the mast (spaced away, connected to the mast only at the top) and terminated near ground level at a concentric copper ring. Somewhat akin to a multi-wire "Zepp" structure? I haven't included here any diagrams or drawings (but please see my final paragraph), as these antennas are very well described on the Internet; Wikipedia for instance carries an excellent article with far better pictures than I can draw!

RF power is fed between the copper ring and the earthed mast base; the match is made by capacitance tuning as the antenna is inductive for heights between 1/36 λ and 1/6 λ; but the nearer the height is to 1/6 λ, the higher the radiation resistance becomes. The maths is not simple; and "local effects" can alter the reactance appreciably at these long, long wavelengths - LF / MW antennas are a very different species than their HF cousins! Once tuned, bandwidths of 10 KHz either side of the carrier, with a good match, can carry AM stereo radio broadcasting reliably and repeatedly without re-tuning. This indicates to me a very low Q, so extra attention to output spectral purity is a must.

My next experiments will be to see if a "shortened short" Unipole can radiate efficiently on the 600m amateur band, as 1/36 λ at 472 KHz is nigh on 17m high! To reduce the length below 1/36 λ is a trip into the unknown; I suspect some top (C or L) loading will be required, but how much or with what efficiency loss I can't predict.

I have assembled a package of public files showing the relevant engineering and Patents for a folded Unipole, which I will gladly email on request - any comments, experience with folded Unipole antennas or suggestions are, as always, most welcome, to me at equieng@gmail.com

A New Day Has Dawned!

Pete Juliano, N6QW n6qwham@gmail.com

In the early 1970's, I built my first solid state SSB Transceiver and the biggest challenges were a stable VFO and a switchable BFO. The IF Crystal Filter was at 9.0 MHz unit and thus a 5 MHz LO would give a choice of either 20 or 75 Meters. I chose 20 Meters.

How do you build a very stable 5MHz VFO? A stout aluminum enclosure made from ¼ inch plate starts the process, as mechanical rigidity is paramount. The variable capacitor, a dual bearing Jackson Bros as well as the 6:1 reduction drive were also in the mix. An external set of gears on the drive made for real slow tuning. The VFO tank was a piece of air-wound coil stock mounted on ceramic stand-offs. The oscillator was a 40673 Dual Gate MOSFET. All of the caps were NPO and the oscillator was followed by a two transistor buffer stage. It was a stable oscillator; but it still had warm up drift and suffered from a long term drift of maybe 100 Hz. Probably state of the art for 1970; but not today!

It took several weeks to build the VFO and the BFO had two oscillators, one for USB and the other LSB, which facilitated netting to the exact LSB/USB frequencies. Switching sidebands was simply powering "on" the appropriate oscillator.

Shown below is my latest rig completed in mid-July 2017. This 5 Watt, 20M SSB transceiver is crammed into a 48 cubic inch box and sports a Digital LO and BFO with a black and white, OLED display. Building the LO and BFO for this rig took all of about **two hours** and is rock stable – meaning no drift. We have come a long way in 50 years. The remainder of this paper will focus on the digital frequency generation scheme for this new rig.

Figure 1 ~ N6QW's 2017 SSB Transceiver

A Tale of Three Pieces

Now that I have got you hooked – one must learn to crawl before walking. I heartily recommend any one thinking about taking on a digital LO/BFO project start first by learning the basics about employing the Arduino. The main Arduino website (https://www.arduino.cc/) has a whole series of tutorials starting with the famous LED ON and LED OFF exercise. It is important to go through these basic exercises as it has two benefits: starting off on the right foot and building confidence. It also is suggested that a stepped approach be used to learn first how generate a frequency and then tackle how to display the information. There is much to be said about Rome not being built in a single day. The You Tube Video Channel abounds with much information about just "how to do it."

Today's digital frequency system has at least three major components which include a Microcontroller, a PLL Clock Generator and finally the Display. Figure 2 shows a block diagram of these elements. Ancillary switches and a rotary mechanical encoder provides the tuning function to round out the mix. A digital technique called "step tuning" facilitates tuning at rates as low as 10 Hz all the way to 1 MHz (or whatever is placed in the code). Thus no reduction drives or external gear boxes. A step tuning rate of 100 Hz seems just about ideal.

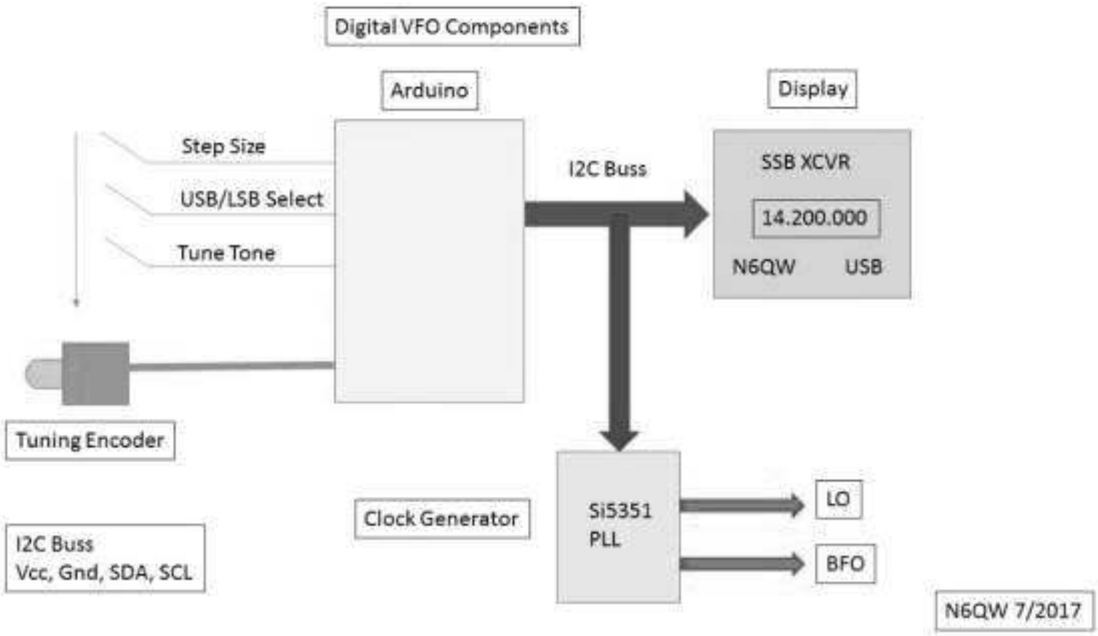


Figure 2 Digital VFO Block Diagram

Relative to the Microcontroller, perhaps the most popular one used in ham radio applications is the Arduino, whose variants include the Uno, Nano and Pro-Mini. These can be seen in Figure 3. The Uno has some very desirable features in that it has pin headers which accept plug in modules. A plug in board called a shield contains various circuit elements that can physically mate with the Uno. Because the Uno's footprint is a bit large it's not ideal for building compact equipment. Therefore I tend to use the Nano or Pro-Mini boards which are much smaller.

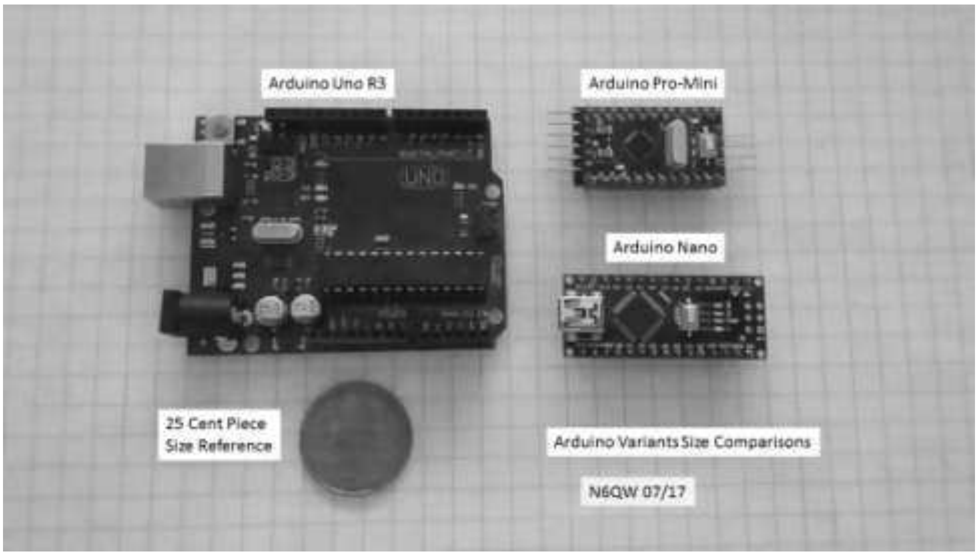


Figure 3 ~ Arduino Variants

So what controls the Microcontroller and that is the brilliance of the Arduino? The main controlling software is called the IDE (Integrated Development Environment) which is nothing more than a standard structure for commanding the Arduino to perform various functions. A free download from the Internet, it is open sourced. The end user creates what is called a "sketch" much like a roadmap, telling the microcontroller to do this or do that or maybe to output info to the display. The user does not have to write Arduino Sketches in Assembly Language which is a huge plus!

Operating in a loop, the software constantly "polls" the peripherals (at a 16 MHz rate), looking for any changes such as moving the "frequency dial" or changing the sideband. Secondly built into the Arduino is the I2C Buss which is a protocol whereby you can attach multiple peripherals to a common buss The software coding directs traffic so that in/out (IO) to the peripherals is done via a common buss. Thus the Display and Clock Generator are essentially connected in parallel with four connections that include + 5VDC power, Ground, SDA (Data Line) and the SCL (the Clock). In essence the devices are connected together but operate independently.

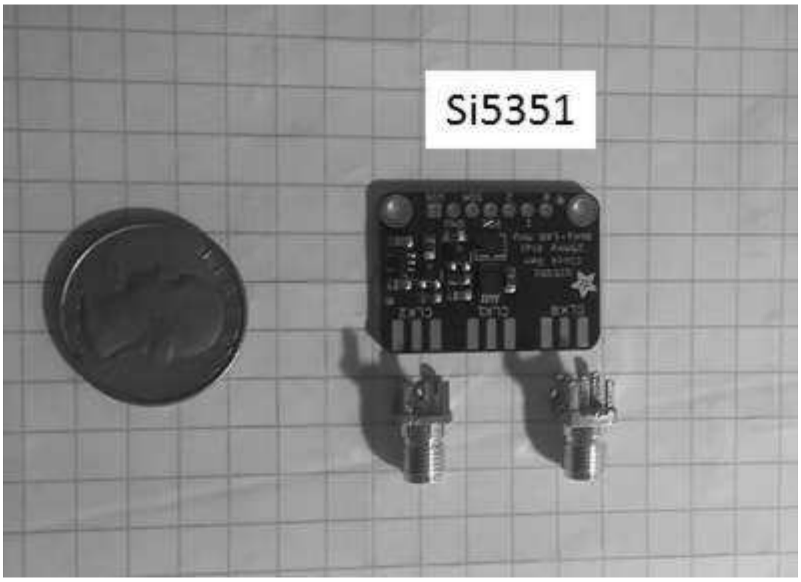
Other software called libraries operate with the IDE to control functions such as generating the display or setting the frequencies in the PLL. These unique libraries much like “Lego Building Blocks” are typically free and there are many “techie” hams who make this stuff all play also provide free sketches. This is a critical concept –as a user you don’t have to start at ground zero for every VFO/BFO – you simply arrange your sketch and then use the building blocks to carry out the heavy lifting. For my part I must decide what band(s) I want the rig to operate on and input the filter/BFO frequencies and HOW I want information displayed as to the type of display and where on the display. ***I do not have to know how to build a clock to know what time it is!***

A free library called “Tone” enables the Arduino to create musical notes. You can easily generate a 988 Hz tone that actually is a PWM Square Wave which after filtering is like a 988 Hz Sine Wave. A pulsed 988 Hz tone of say 10 seconds is simply connected into the Balanced Modulator and we now have TUNE functionality**.** When I place one of my rigs in TUNE, my display screen changes to say “TUNE” and when the timing period is over it reverts back to a normal screen. One push button, some lines of code and you are in a “Tune Mode” and the screen even tells you that.

That said the software sketch written for the Arduino will work with any of the Models. When loading the software via the USB port on your computer you simply make a selection of which model Arduino and then let her rip.

The Si5351 PLL Clock Generator

We are indeed in a Brave New World. The board shown below in Figure 4, is about the size of a very large postage stamp and is compared to a 25 cent piece. The Si5351 is capable of producing three independent outputs anywhere in the range of 8 KHz to 200 MHz and that is just for starters. The IC itself is less than $1.50 USD and the complete assembled board without the SMA connectors is about $8 USD. The three SMA Connectors cost slightly less than $8 USD. So a purchased complete board with two connectors is about $13 USD not including shipping (See Adafruit Industries for more details). As mentioned earlier there are only 4 connections to this board via the I2C buss and that is it. The output is not a sinewave but more like a Square Wave which is OK if you are feeding a packaged Double Balanced Mixer. Code in the software lets you select how much output comes from the Si5351 and that is important if you are using DBM’s which are 3 dBm devices. At max output you can easily drive a 7 dBm device. One of the features of the code developed by NT7S (Jason Milgrum) is that one of the clocks is tunable as you would want for the LO and the second clock can be programmed for either the USB or LSB BFO. A simple external toggle switch can make that selection. The third output of the PLL could be used as a HFO in a dual conversion transceiver.



The Display ~ All Sizes and Shapes

In my transceiver the OLED (Organic Light Emitting Diode) display is approximately 1 inch by 1 inch which I thought that was small. But there are even smaller displays which are perfectly usable with our beloved rigs. Shown in Figure 5 is an example of a smaller OLED display that are low power and only need the I2C Buss connections to make them "light up". Note this smaller OLED is only about ½ inch high yet has the same information as shown on the larger OLED. But there are many other types of displays that could be used including Color TFT (various sizes and 256K color choices) and even the standard 16X2 LCD. Interestingly there are I2C "backpack adapters" that facilitate connecting the standard LCD (at least six connections) to the four wire I2C. To accommodate the various displays a library must be identified in the code for the specific display type use. Figure 6 gives a collage of display possibilities.

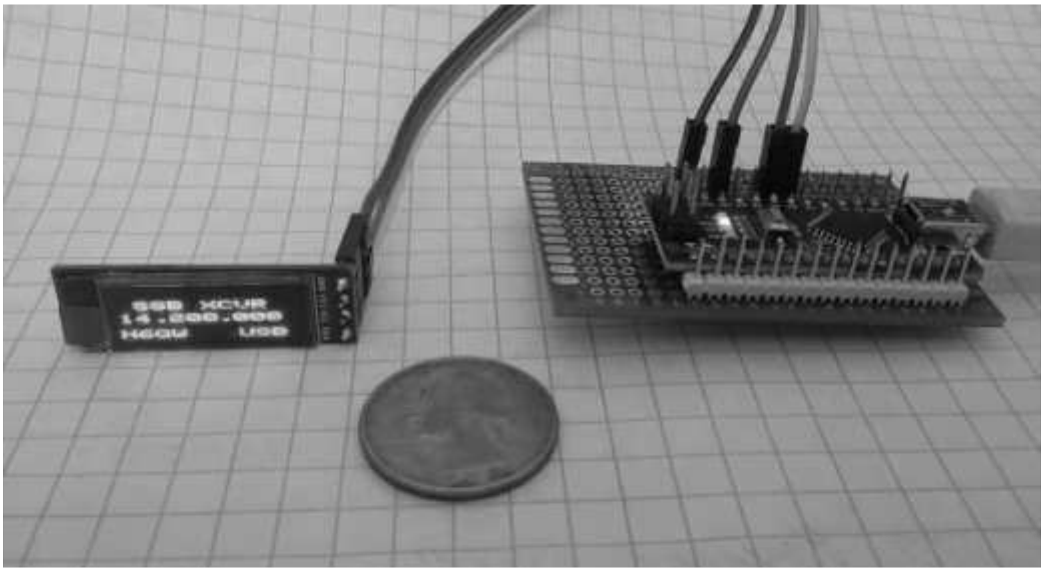


Figure 5 ~ A Really Small Display using a Nano

Figure 6 ~ Display Possibilities All Using Arduino's

Closing the Deal

For those new to the world of Arduino there are helpful publications that A) introduce you to the Arduino and B) are specifically written with Ham Radio Applications in mind. Foremost is the book by Massimo Banzi one of the original developers of the Arduino called Getting Started with Arduino. Another is a book by Glenn Popiel, entitled Arduino Projects for Ham Radio and still other sources abound in youtube videos –including ones by N6QW. I have a website http://www.n6qw.com that features some of my projects and there are code samples for several radios. In 2017, I replicated that 1970's rig only this time using the Digital LO and BFO. The build went a lot faster and the radio works a lot better. See http://www.n6qw.com/LM373.html I also have a blog where there is additional documentation regarding the Arduino, Si5351 and Displays. http://n6qw.blogspot.com. A must place to visit is NT7S's website for more info on the Si5351. See http://nt7s.com/tag/si5351/

73's Pete N6QW

Using the T1154 as a modern CW transmitter – by David Perry

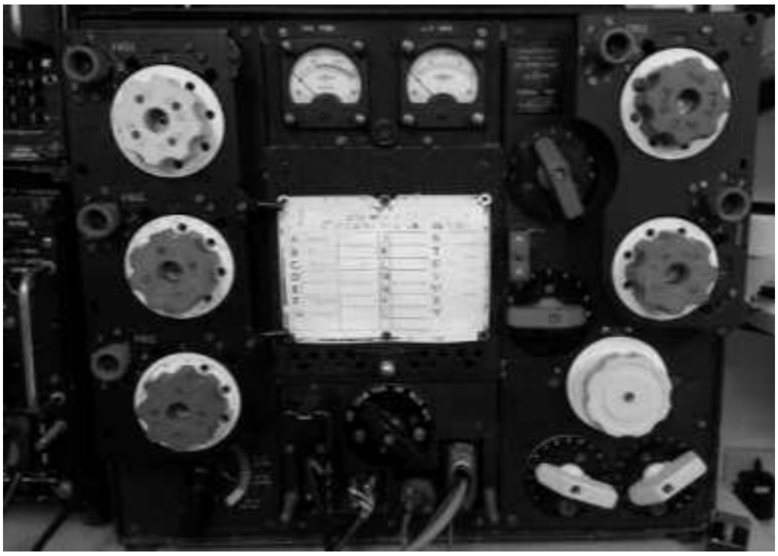
If you are like me you can probably recall some events from your youth that really made an impact on you, even if the actual details of those events are sketchy or failing. I have two I can recall: one was when on holiday in Wales as a youngster when we went to see some model planes being flown, one was a (then modern) Super Sixty model which I fell in love with and which spurred me on to learn to fly models. Model flying has been a passion all my life and I still adore the simple clean lines of the Super Sixty! The second event, the origins of which are now lost to me, was seeing a Marconi pair in a Lancaster…the R1155 and the T1154. The clean lines and the upside down smile of the 1155 and the magnificent primary colours and apparent complexity of the T1154 simply captivated me. I say 'apparent' complexity because of course it isn't complex to use at all, courtesy those very tasty red, yellow and blue knobs…but I get ahead of myself. As a lover of flying machines (I eventually became a commercial pilot) the 1154 was somehow magical but it's rarity meant expense and expense meant I would most likely never have one. However, things changed… A confluence of events led to there being a working pair in my shack, a thing I never expected to happen. Anyway, it did, they work and there's a key fastened to it! But does the system still hold up these days with modern band conditions?

Receiver

Firstly, the gain sayers will tell you that the receivers might have been good *then*, but they won't pass muster today. Let me say that this is simply not true. (It is a superhet, with an IF of 465 KHz I think – G3PCJ). I accept that the receiver is rather wide and that the tuning rather coarse – recall that in 1943 the operator would have been tuning for probably one signal on a band, or certainly one of very few, unlike today when I am listening for one signal amongst thousands!! But this is a challenge, not a problem. Find the signal CW you want and let the Mk 1 earhole do the rest. It's not as easy as a modern filter, and it's sometimes just too hard, but mostly it works. The wiring inside the 1155 is a bit of a rat's nest and some of them still have the original rubber insulation. These days the rubber has largely age hardened and crumbles when touched, so many 1155s have very bad wiring and the rewiring is right pain. However, some were rewired long ago and some, apparently, by REME before demob. Mine is one such (I was lucky) so has good wiring throughout. You will also rarely find a set with the original DF circuitry inside (removed to give space for other amateur things) and mine is accordingly devoid of the DF kit. However, I have a second unit here which not only has the DF circuits inside but it also has a direction indicator and it all works as can be seen when attached to a small loop aerial!

Transmitter

The transmitter is also interesting because, at least in my case, there is no side tone. I could build a side tone easily enough, or even just put a buzzer across the key terminals, but in reality I find I can read the clatter of the huge rotary relay just as our forebears read the sounder's chattering long ago. No, it's not as easy as a side tone, but it works for me. The other thing about the transmitter is that it wont accept fast keying or QSK of course: I think the manual says it will key at up to 25 wpm and give break-in…yeah, right! I manage around 15 – 18 I reckon and at that the relay is hammering away. I use my old GW Keys brass key for this rig…I have tried the bathtub key but why make things doubly hard!!! The other point of note is that the sets both drift a bit. I am told that the TX drifts up and down causing some amusement on the other end, but as the person I am working knows he's working this classic icon he doesn't mind usually. I end up retuning my own RX too of course as it gets warmer, but after an hour or so it is fine so I live with these idiosyncrasies. All stages of the TX are keyed which accounts for some of the behaviour!



So, how to actually use one? Well, turn the sets on, of course, some time before use…some warming up is crucial or it'll never be stable enough to tune. Then I try to find a frequency that's clear for use, or I cheat and use a modern radio to find a spot freq such as the FISTS CoA. If I do that then I send a weak signal on the spot and tune my 1155 Rx to that. In practice the dial on the sets really is accurate enough to tune by, especially if one makes a pencil mark as the designer anticipated…but to be sure these days I do double check as I say. I usually leave it ten minutes and come back to it to see if it's still there. If it is…stage two! I now set the TX to tune (low power) and into a dummy load set at 50 ohms I send a signal which I tune until I receive it on my 1155. Tuning the TX is quite coarse but they fitted little levers to make fine adjustments; they are stiff nowadays but the adjustment is very fine indeed and it works beautifully. When that's sorted I tune the rig for power into the dummy load, whereupon I switch to my ATU and tune that for lowest SWR into my doublet as per the norm. Now, I know the 1154 isn't set for 50 ohms, but as it was designed to load into a vast range and as I haven't found anyone who can tell me 50 ohms is a bad idea, I use it. If you know different please advise!!

I think the ATU is important: if you get the chance to see the output spectrum of an 1154 on a scope you will see why. The harmonics are all there…they are suppressed, but the ATU lends one an air of confidence. So now I have a 1155 on freq and an 1154 tuned to same…off we go. My set doesn't seem to work on the 'omni' position (where the RX is muted on key down). In fact mine works in reverse…on omni it is muted but becomes open to signals on key down!!! Obviously this is BAD so I don't use it. I haven't yet figured this out…again, if anyone knows why or how to fix it, please advise. I listen on the freq then flick my RX mute switch (a mod by previous owner), switch the TX to CW (which gives ~ 80 watts) and call CQ or the station I want, using the chatter of the relay as side tone. Instantly I then flick the RX back to receive and listen… If I need to fine tune the RX I can, it is very sensitive to dial movement but it can be done. The receiver is quite sensitive - most signals I can hear on my K2 or FTDX3000, I can also hear, and work, on my 1155. It's not the sensitivity that's the issue of course, it's the filter width!

As for AM use, I have used my set on AM only once and that was quite amusing. I was talking to a local amateur on 80m AM using a modern-ish desk mic and he asked me to increase the mic gain! So, accordingly, I cupped my hands round the mic and shouted "yes old man, how's that??". In fact, I don't work AM at all and the set has no SSB (I don't work that either) so it is of little interest. Andover radio Club is about to establish a station at the Boscombe Down Aviation Collection at Old Sarum airfield in Salisbury, and we have another 1155/154 to put there which will work on AM mostly I think.

Technical

If you hear a 1154 on air you will never forget it…whoop whoop whoop it goes! (Probably due to keying of the VFO and power stages - and possibly some feedback of the output into the VFO which might shift the frequency a small amount – G3PCJ) In fact, my first ever QSO on it was remarkable because of that. I called CQ on 80m and a G3 came straight back with "G4YVM…that's an 1154"…my heart leapt…not only had I had a QSO on my boyhood dream, but it had been noted as well!! Amateur Radio gets no better. Even now, amongst my friends, they love working me on 1154 because it is an 1154. Sure, they work hard at reading it – it's almost as much FSK as it is CW - but that is why they love it…it is a challenge, as well as iconic. Technically, the oscillator is a Hartley type and for some reason the designer of the set chose to key that as well as everything else…so on key down, the lot goes down! Hence the whooping sound. I don't know why this happened of course, and the sets were probably designed with a life span of about six weeks anyway (such was the lot of Bomber Command crews back then). Despite their huge size they were, by any standards, disposable. The cases of the sets were either aluminium or steel: the clever clog's will tell you that the aluminium ones were for airborne use whilst the steel were for ground and marine use. The reality is far from that I am afraid to say…aluminium was / is expensive and some one soon realised that saving a pound or two in weight at the cost of a guinea or two in cash for fitting a wireless into a bomber which weighed many tons was a complete nonsense. It didn't take long before steel was used more prolifically and fitted to any established station, airborne or terrestrial.

Other people will extol or decry the design of both 1154 and the 1155. The designs are either very good or quite poor, depending on your point of view. The facts are though that someone needed wireless sets quickly and cheaply, and someone in Marconi delivered the goods. Say what you like, any design that's still going almost 100 years after it was first penned is a good design in my book!

As for the apparent complexity, well it is all so obvious when you use one…the bands are coloured on both TX and RX, so 80m for example is RED. This means that the Rx is set to the red band and then the TX is set to the red band…the operator only ever touches the RED knobs! Easy when you think about it. If you want 40m, then you only need to touch the Blue knobs. It is so straight forward. But one does need delicate fingers because the amateur band coverage of RX and TX is only a very small angle of knob rotation! Of course, there is one last treat in store for the user…turn the lights in the shack off and watch that fabulous 'magic eye' tuning valve flicker away to the incoming CW. Primary colours and a winking green magic eye…and the modern manufacturers thought *they* invented bells and whistles!!

So there we are, the 1155 / 1154 in use today: it is harder work than a modern rig, but it is so enormously enjoyable and a delight to use. I enjoy my pair as much today as I thought I would decades ago when owning one was a far off dream. They aren't for everybody, but I like them. See the next page!

David Perry, G4YVM. FISTS 15868 GQRPC 2568

This is what it's all about…glowing heaters on the T1154 oscillator valves by night. The huge valves to the right are the main PA PT15 valves…expensive but powerful. They are fed with between 1200v and about 900v (most folks run them lower these days to save them). Don't touch the caps! And don't drop one!

Right - the valves by daylight. And keep yer fingers out…there's 1.2 KV in there!

There she is…the glorious 'magic eye' tuning device. When the gap between the pac-man segments is smallest, you have strongest tune. On CW it winks at you (or the pac-man chomps…depending on your age!) G4YVM

A simple introduction to Software Defined Radio (SDR) by Stephen Farthing

Tim asked me to write some notes on SDR for Hot Iron when we met at this year's Yeovil QRP convention. I have been licensed for over 20 years and writing software for over 40 years. So whilst I wouldn't claim to be an SDR expert I have made a few in my time, written some simple SDR programs, and I use an SDR receiver - the amazing SDRPlay, with its companion software SDRCube pretty frequently. As many of you know SDR is a pretty complex subject with a lot of terminology which can be difficult to get to grips with. I will do my best to explain things as simply as possible, but not too simply.

So what exactly is an SDR? I think it's fair to say that it's a Radio where most of the functions are carried out by a computer controlled by one or more computer programs. Why most, why not all? Well whilst computers are very good at rapid calculations they have technical limitations, for example, the limited amount of current available at an output pin. So in most cases there will be some analogue circuitry required to make this output of use in the real world.

I guess most of you have made a simple CW transmitter controlled by a crystal controlled oscillator which sets the output frequency. This would be followed by a power amplifier and a low pass filter to remove unwanted harmonics. There are many designs for such a transmitter. I feel sure Tim has kitted some. And many of you have spent happy times making contacts with one and a straight key. And I guess quite a few of you will have learnt your Morse skills by listening to beacons. And a beacon is probably the simplest example of an SDR there is.

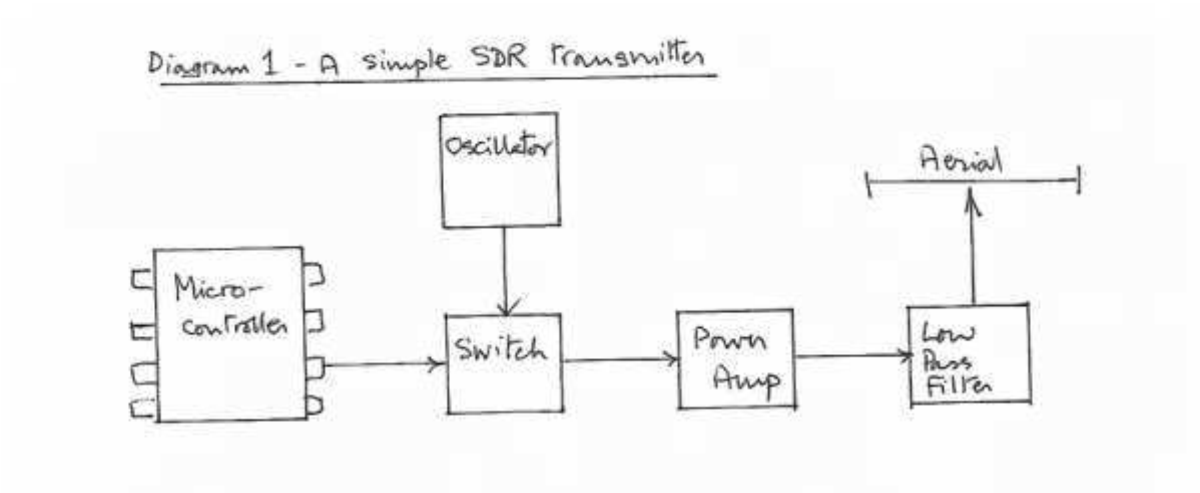
Hams interested in low power modes, such as WSPR and QRSS, make their own beacons. Indeed this is how I started out in SDR thanks to Hans Summers, G0UPL who got me hooked – the photo on the next page is of one of his kits. I want to forget about WSPR at the moment and focus on QRSS. This is a low speed Morse mode, with a maximum speed of 3 seconds for a dot. Accuracy is important as is frequency stability. QRSS activity is focused on a sub band 100 Hz wide in any of the ham bands below 30 MHz. The receiving station has a conventional receiver plugged into a sound card of a computer and the signal decoding is done by software. But for now I want to focus on the transmitter.

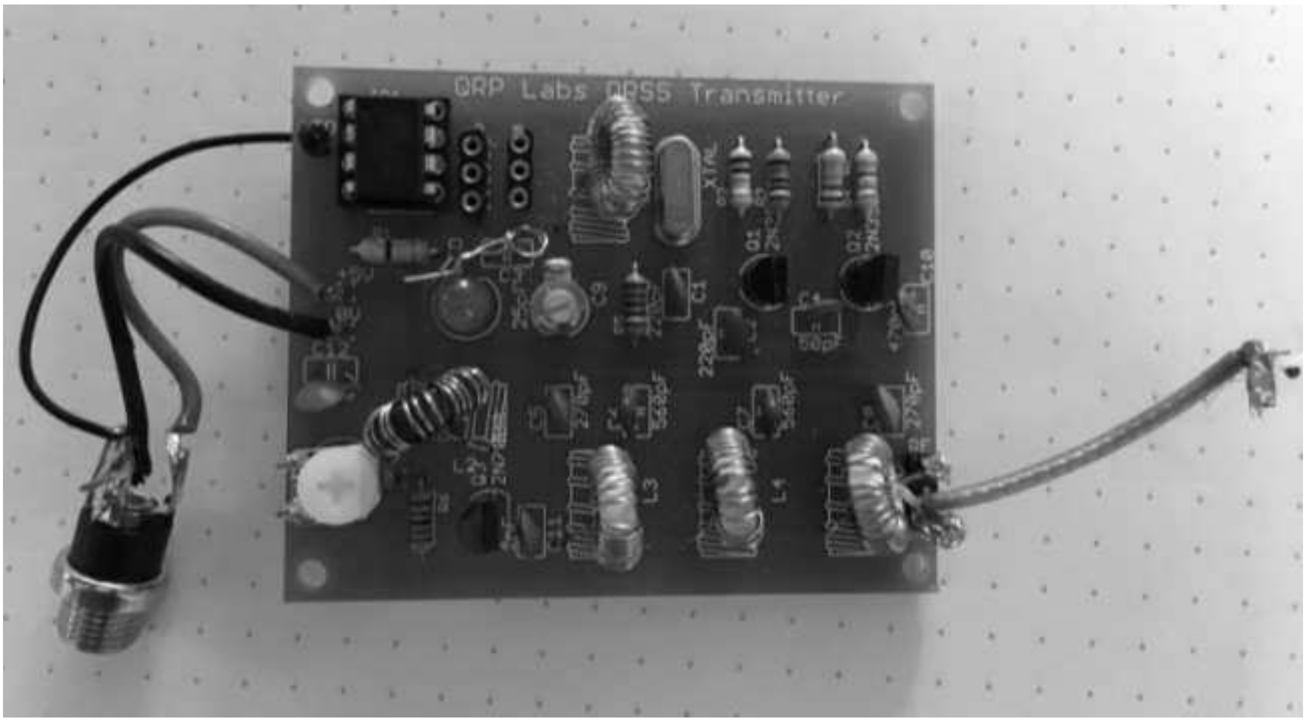
It's not so hard to make a stable crystal controlled transmitter for up to 20 meters. However the thought of manually keying ones call-sign consistently with 3 second dots accurately spaced with nine second dashes for hours at a time would make most of us insane. The answer is to use a computer to do the keying for you. And of course this computer will need to know what to do which requires some software to be written.

The type of computer most suitable for our needs is a single chip called a micro-controller, or microprocessor. There are lots of different types out there. For our project we need one which can use an external crystal as a clock. All microcontrollers require a clock to coordinate processing activities, and software uses this clock frequency to figure out timing for delays, making activities happen at certain times and durations. (Often you will see microcontrollers without external crystals, the clock oscillator is inside the chip and often not very accurate). Normally microcontrollers use a standard clock crystal of 4, 10 or 20 MHz. However for our purposes we will take the crystal from our transmitter and use it to clock the microcontroller.

So why should we do this? To save money on crystals? May be. However if we clock the microcontroller at our desired output frequency we can program the software to put this frequency at one of the output pins. And we can use this pin, with appropriate impedance matching and conditioning, as an input to our power amplifier. Simply put we have replaced the oscillator circuit with a micro-controller and a few lines of software.

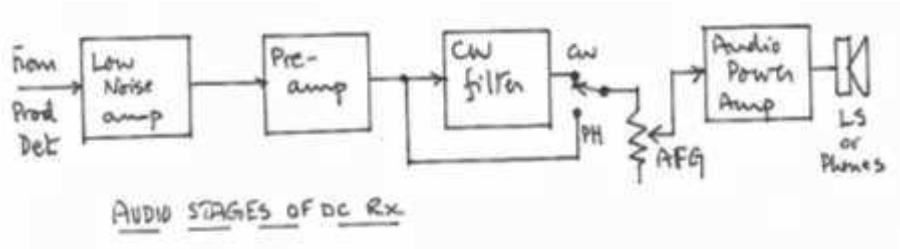
The next step would be to write some software to key the output pin precisely in accordance with our requirements for QRSS. To get the timing right we write the code to derive the timing from the crystal frequency. This is simply a matter of dividing it by a constant number so we can get a value in seconds. Then add the code to generate the dots and dashes and repeat the transmission until the microcontroller is switched off and we are pretty much done. What we have made is a software defined radio CW transmitter – see diagram 1 below! And that's it for this episode. Next time I will take a look at the receiving side of things.



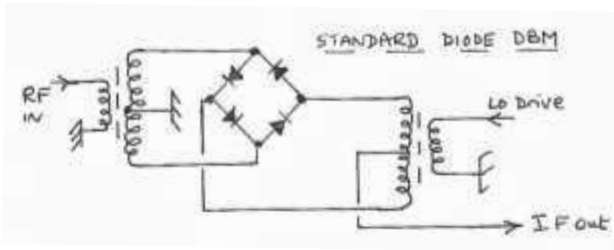


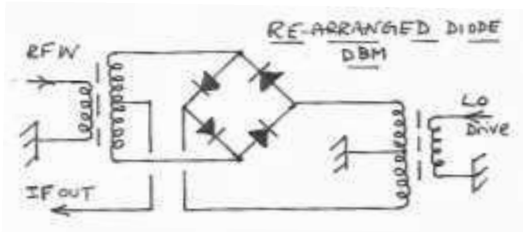
Ideas for the Bere & Stout

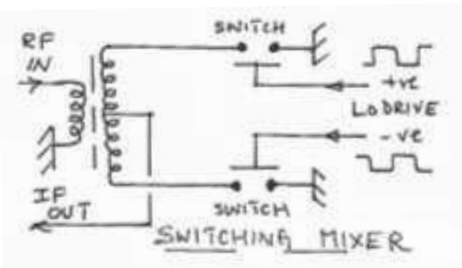
Looking at my kit range recently, I realised it lacked a decent rig for CW enthusiasts. Intending to keep things simple and low in cost, I plan a Direct Conversion receiver with a nominal 5W full break-in transmitter. Seeking more suitable Somerset place names for them, I stumbled on Bere and Stout which are two small hamlets not far from here! The DC RX scheme enables the RX's Local Oscillator source to also directly drive the TX. But to avoid chirp the VFO must not be on the same frequency as the RF output stage – particularly when it is all pretty small – unlike the T1154! The hope is to make it do all (or some – see later) of the three bands 20, 40 and 80m, with 40 and 80m obtained by direct digital division of the 20m LO signal – so the task is to obtain a 14.0 to 14.4 MHz LO that divided down will provide 3.5 – 3.6 MHz. I am hoping that a 4.67 MHz VFO when tripled to 14 MHz can be made stable enough for CW transmission and maybe SSB reception. The RX would be a conventional DC scheme after its product detector – low noise audio amp, more audio gain with phone bandwidth, followed by a switch selectable CW filter, manual AF gain control and output power audio amp. See block diagram right! The challenging bit is the product detector and what comes before it in the RF path from the aerial!



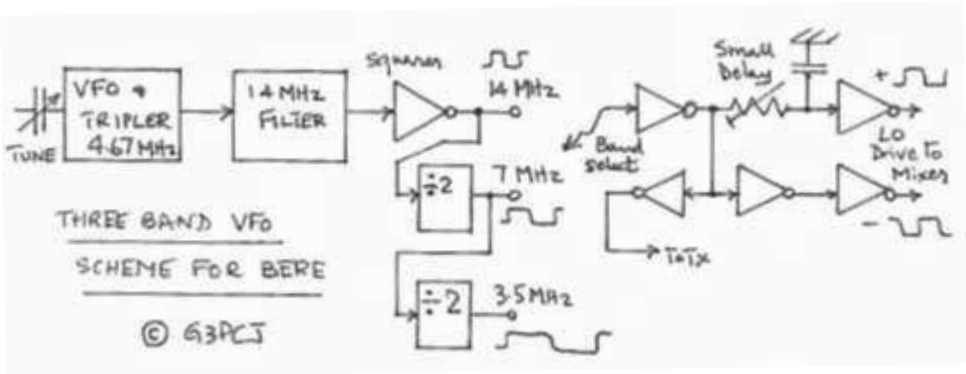
My first idea was to have a strong doubly balanced mixer similar to the conventional quad diode mixers (right) but to use FETs instead of diodes. This might avoid having to have narrow RF bandpass filters ahead of the product detector. None of this is novel but using FETs might avoid having to generate significant LO power to drive the diodes which can lead to unwanted LO radiation. This often leaks from the LO chain backwards through band filters, and any RF amp, to the aerial where its radiation makes the RX prone to hum and other nasties that alter with tuning and supply or earthing arrangements. If there is a nasty click when you connect/remove the antenna connections, this is a good indicator of unwelcome LO radiation! This RF can even get into the rectifiers of your mains PSU, hence to the supply lines and to the rig leading to a roughness in the hum sound! Good supply line filtering at RF is essential and in bad cases may need common mode chokes to prevent it getting from the supply into the RX. The usual quad diode mixer can be re-arranged to extract what is usually the IF output from the centre tap of the RF input transformer as shown above. It is evident that all the LO transformer is doing is to generate the alternate phases for driving the diodes. For an FET mixer, this can be done with digital inverters so avoiding the LO transformer which leads 'conceptually' to the simpler mixer shown right!



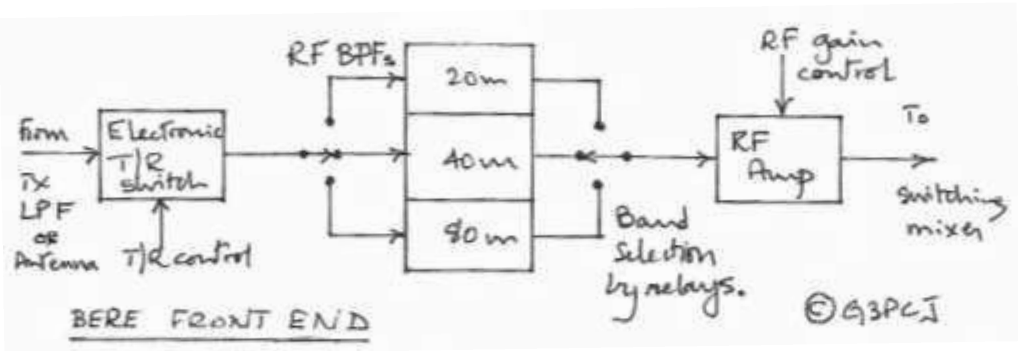




Having now established that the mixer drive can be essentially digital, this makes LO generation much easier for the old harmonically related bands – once a 14 MHz square wave LO has been created, it only needs two flip-flop dividers to also generate LO signals at 7 and 3.5 MHz ready for band selection! Thus the VFO and LO chain is relatively simple for 3 bands and has the advantage of a common tuning point for the bottom edge of all three bands! But unfortunately the incremental tuning scale doubles as the LO frequency doubles.



But what of the rest of the RF aspects?! My experiments with a medium sized aerial, no RF band filters & a BS170 MOSFET mixer still suffered BCI occasionally indicating a lack of adequate balance in the mixer that was allowing the very powerful broadcast stations (just outside the 20 and 40m bands) to break through with un-tuneable mush. It is hardly surprising when you see the size of them on a spectrum analyser! Using digital 'bus switches' instead of BS170s in the mixer/product detector might improve things (due to larger negative maximum signal excursions) but I could only find minute surface mount devices and so one soon comes to the conclusion that you do need narrow RF bandpass filters ahead of the mixer/product detector – this is a shame because they have many parts and involve relatively awkward inductors and, with the switching for more than one band, it becomes complex and expensive. Diode switching can be used but their losses suggest that a little extra RF amplification prior to the diode switches would be sensible to maintain sensitivity; the alternative is to use relays for selecting the filters. A little RF gain after the RF filters is desirable to help suppress mixer potential noise, and provided this RF amp has good attenuation between its *output and input*, it will help reduce LO radiation from the aerial! The scheme right is the probable one!



Whether the final product has one, two or all three bands will very much depend on space on the RX PCB and its place in the range of all my kits! I would like to keep the RX fairly simple and uncluttered on its PCB so that a single standard 100 x 160 mm PCB can be used for the RX and its front panel. The CW transmitter is relatively easy on a half size (100 x 80 mm PCB) because the LO is already at band frequency. Max output of 5W (using a single IRF510) is desired but with a preset to set the actual level, followed by low pass harmonic filters for the chosen band (if more than one with relays) and an electronic TR switch. To include full break in TR control and with transmit sidetone (at an adjustable level)! G3PCJ

That's enough for this issue – keep the material coming please!

“JOURNAL OF THE CONSTRUCTORS CLUB”

Hot Iron

Winter 2017 Issue E98

Editorial

Have we reached ‘peak’ home electronic construction? Commentators talk about peak oil or the peak of all sorts of industries, but are we near that for radio related enthusiast electronics? I fancy we are! As I have argued many times before, it has never been so easy to build simple electronic projects – gone are the days of nasty metalworking to mount your valves or even stage after stage of discrete semi-conductors to realise a multi-band double conversion superhet receiver, let alone the associated single sideband phone transmitter! The ability to mount parts and integrated circuits on copper clad laminate, with or without etched connecting tracks, makes building even single band one-off transceivers relatively easy. This can now be done literally on your kitchen table with the whole project kept in place for next week on a tray that can be safely stored away ready for the next session. Can it get easier than this – maybe not!

How will the technology progress and will it allow keen experimenters to dabble? Undoubtedly, integrated circuits will become more capable – putting the whole RX into a single chip is by no means novel. At the same time, computing ‘devices’ are working even faster so that they can perform complex mathematical functions on ever higher bandwidth signals. The rise of Software Defined Radio techniques is such that very few commercial HF TCVR designs are anything other than a high performance analogue to digital converter followed by a very high speed processor, with a ‘nearly’ analogue power output stages for audio and RF! Inevitably the chips in such designs are made for the mass market in surface mount format and utilising these in an experimental form is very challenging in many physical ways. On top of that, is the challenge presented by the software which is required to make them perform. Very few of us understand the advanced mathematics behind serious digital processing; and the ability to alter or adapt that to suit ones own experimental ideas is minimal unless the original designer built in the software ‘knobs’ to permit such experiments - pretty unlikely if it was commercially developed! Hence I would argue that from now on it will become increasingly hard to use this sort of advanced technology.

So by my assessment, it has never been so easy to build moderately complex electronics and it is likely to get harder in the future – conclusion – we are at ‘peak electronics build’! I hope I will be proved wrong by one of you reading this – please write and tell me so, with a contribution for Hot Iron. Meanwhile, I say, ‘get on and enjoy it while you can’!!

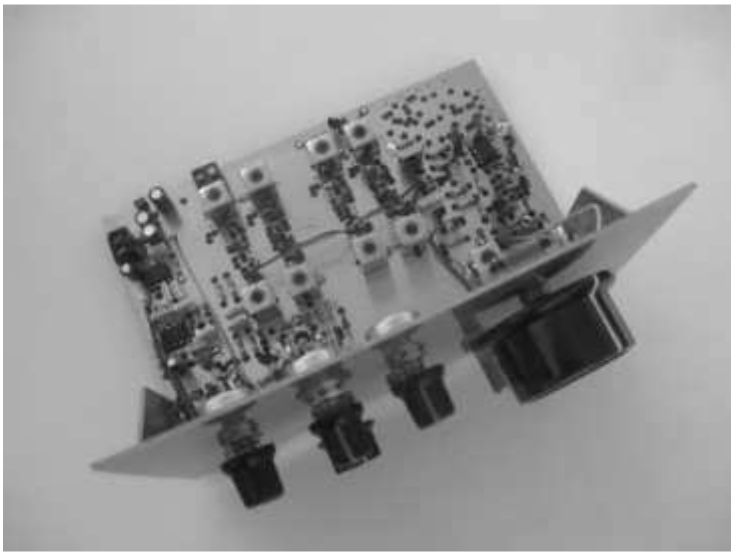
Happy Christmas and a healthy New Year to you all! Tim G3PCJ

Contents

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

Too much of the last three months has been spent on erecting buildings for the farm and starting the process of building a new house – it takes much effort to get through all the regulatory procedures! Most of my electronic time has been devoted to getting the prototype Beer RX (right) working – see later for some circuit snippets. It is a multiband design (in its simplest form shown right, for any 2 of the 4 bands 20 - 80m). The complexity of its analogue local oscillator scheme just shows up the advantage of the modern DDS or phase locked loop micro-processor driven designs. In this photo you can see four double tuned band pass filters for the RF input, and Local Oscillator mixer output, on both of the two bands of this basic form; when extended for the other two bands in this group, the RX needs another four filters (as well as the unavoidable two (or 4) low pass filters for the transmitter!). The days of complex analogue multi-band designs are drawing to a close – this might be my last in this style!



The next article **'VFOs and all that'** comparing the merits of different of techniques to produce stable RF signals (mainly in a frequency sense) is highly relevant. Pete Juliano N6QW threw down the gauntlet in the last issue of Hot Iron, so I sought a defence of the traditional HF analogue approach. Peter Thornton G6NGR took on that task but says the days of complex analogue 'VFO's are over! I don't entirely agree - the analogue approach has considerable merit for very simple single band designs such as those two ideas outlined below – mainly on a 'performance for cost/complexity' basis. This has led to the following doodling suggestions:-

The **Sheppy** might be a simple single band 1.5W CW DC transceiver based on a ceramic resonator for 80m, or a crystal for the higher bands to avoid drift/chirp. This is the sort of small simple rig that should make it possible to take out and about without trailing a large suitcase for all the extras! It should fit easily into the small upright format with a minimal PCB front panel. Another 'use' would be for demonstration of simple radio techniques across relatively short distances (half mile or so across playing field) when visiting schools. Target price is to be under £40. The name Sheppy is a river in Somerset, & continues that 'theme' for such simple CW rigs!

The **Quantock** might be a simple DSB phone TCVR; again with a DC receiver and using an 80m ceramic resonator. For the same reasons as above, crystals are needed for the higher bands. For those wishing to avoid the wonderful simplicity of phone using ancient Amplitude Modulation, the next easiest technique has to be double sideband modulation with a suppressed carrier; which is of course fully compatible with stations operating conventional single sideband phone. This would be an update of the very successful Brendon DSB phone TCVR that was used by many Buildathon groups. Again the target price is under £40 and it should fit into the small upright format easily. The Quantocks are a small range of hills (near the Brendon Hills) in north-west Somerset – which is the theme I have adopted for my DSB designs!

VFOs and all that – Peter Thornton G6PNR

Introduction

This is a comparison of the "Variable Frequency Oscillators" available to amateur constructors: L /C circuits and mixer VFO's; Pulled Ceramic Resonators; analogue with digital error correction (Huff and Puff and similar drift correction); pure digital (synthesizers and DDS methods). I haven't considered crystal oscillators or VXO's as they are different beasties; besides, the frequency you can pull a crystal is - - - not a lot!

My criteria for the VFO standards are: (1) Cost; (2) Construction difficulty; (3) Drift performance; (4) Purity of output note (harmonic content, spurs, noise sidebands, phase noise, micro-phony); (5) "RIT" for receiver local oscillators. I have split the Amateur RF spectrum into sections, as VFO's for each section face different demands: (1) LF, 132kHz - 1MHz; (2) Low HF, 1MHz - 5MHz; (3) Mid HF, 5MHz - 14MHz ; Hi HF, 14MHz - 30MHz; (4) Low VHF, 30MHz - 70MHz; (5) Hi VHF, 70MHz - 200MHz. Above 200MHz (realistically) only synthesizer or DDS methods fit if you want full VFO functionality; or for microwave SSB you're looking at temperature compensated crystal oscillators feeding multiplier chains - or the very esoteric DDS technologies currently appearing that have internal spur and noise cancelling. ECL gates can be used for GHz Huff-n-Puff stabilisers, but these are mostly experimental at this time.

The following tables summarise the results I've found over the years.

L/C Variable oscillators

	LF	**Lo-HF**	**Mid-HF**	**Hi-HF**	**Lo-VHF**	**Hi-VHF**
Cost	Mid-High	Mid-High	High	n/a	n/a	n/a
Construct.	High	High	High	n/a	n/a	n/a
Drift	Low(ish)	Low-Mid	Mid-High	n/a	n/a	n/a
Purity	Good	Good	Good	n/a	n/a	n/a
RIT	Possible	Possible	Possible	n/a	n/a	n/a

Cost is high, as is hassle in explaining why you've spent $'s, £'s, Euro's (delete as appropriate) on that superb Jackson variable capacitor, the oh-so-rare Oxley "Tempa-trimmers" and the beautiful analogue tuning scale and reduction gearbox you'll need to build and use the beast.

Construction is difficult in that you'll be milling solid blocks of aluminium, annealing wire, toroids, and other components; changing capacitors for the next week, using a hot-air gun and freezer spray knowing that if you take it outside you'll have to start all over again.

Drift - note that LF and Lo-HF L/C oscillators are intrinsically stable - this probably means that drift is a complex function of frequency, supply volts and temperature. They are fine for most modes below 2MHz; however, for WSPR, QRSS and similar esoteric modulation, you'll need a more stable oscillator, perhaps by digitally dividing a higher frequency oscillator. A rule of thumb: if your 5MHz L/C oscillator achieves a drift less than 20Hz / minute, it's good; if it drifts less than 5Hz / minute it's amazing.

Purity of the output depends very much on the oscillator having correct biasing, stable power supply(s), lack of vibration and being buffered properly (amongst many other variables). The big advantage of an L/C oscillator is they don't generate "spurs" or many noise sidebands.

RIT can be done by switching in additional capacitors to shift the oscillator slightly. Sudden switching causes "chirp" and harmonics. RIT applied by manually adjusting a small value trimmer capacitor is not as prone to "chirp", but the oscillator will take time to settle and this can produce "warble" notes.

Range is set by the L/C ratio, but as the oscillator components age and/or transistor gain drops, L/C VFO's can suddenly stop oscillating for no apparent reason when tuning. Some ageing L/C VFO's have a nasty habit of stopping at odd frequencies whilst tuning across the range, but starting again once the tuning stops! In this instance, try looking for dried up electrolytic decoupling capacitors.

Mixer type L/C VFO's

	LF	**Lo-HF**	**Mid-HF**	**Hi-HF**	**Lo-VHF**	**Hi-VHF**
Cost	High	High	High	High-Tricky	High-Painful	High-Painful
Construct.	Complex	Complex	Complex	Complex	Complex	Complex
Drift / min.	Low-Mid	Low-Mid	Low-Mid	Low-Mid	Low-Mid	Low-Mid
Purity	Good/Excel	Good/Excel.	Good/Excel	Good/Excel	Good/Excel	Good/Excel
RIT	Possible	Possible	Possible	Possible	Possible	Possible

Cost - The oscillator mixes a VFO with a fixed crystal oscillator, and the sum or difference frequency is filtered out. You get the adjustment range (and drift....!) of a VFO, plus stages of filtering for the wanted output without all the unwanted mixer products. This costs money, space and power, and it takes a very subtle design to minimise the oscillator signals and mixer products appearing on the desired output as phase noise and sidebands. It CAN be done, but it needs expertise and experience to get the design right (if you're lucky).

Construction is complex, with two oscillators to power, set up and mix, keeping levels within the range the mixer can work with properly. The frequency you want has to be filtered out and the filter has to be both wideband to work over the full range of the VFO, yet have sufficient Q to reject the unwanted mixer products. Not an easy job above 20MHz!

All other features are as an L/C oscillator.

Ceramic Resonators

	LF	Lo-HF	Mid-HF	Hi-HF	Lo-VHF	Hi-VHF
Cost	Low	Low	Low	Tricky	n/a	n/a
Construct.	Reasonable	Reasonable	Reasonable	Reasonable	n/a	n/a
Drift / min.	V. Good	V. Good	V. Good	Good	n/a	n/a
Purity	Good	Good	Good	Good	n/a	n/a
RIT	Possible	Possible	Possible	Possible	n/a	n/a

Cost is low - if (and it's a big "if") you can find a stock value that's the frequency you want. Custom resonators are available; be prepared for "how many thousand are you ordering, Sir?" If you can use stock frequency resonators you can make a very good oscillator very cheaply and in minimal PCB space.

Construction is as crystal oscillators; the "super-VXO" circuit with two resonators in parallel can give amazing shifts (+/- 10's of kHz in some instances) in frequency, but temperature induced drift increases dramatically as more "pull" is applied. Ceramic resonators are notoriously temperature sensitive, nowhere near as stable as a crystal.

Drift - Temperature is the biggest cause of trouble, then supply voltage and biasing - you have to avoid internal heating, too. Don't expect anything like the temperature stability of a crystal oscillator, but you'll run SSB/CW no bother on 160, 80, 60, 40m; possibly 30 and 20m. (My experience suggests not higher than 80m is best G3PCJ!).

Purity of the output depends very much on the oscillator having correct biasing , stable power supply, lack of vibration and loaded to a minimum (amongst other variables). Ceramic Resonators are distinctly micro-phonic - tap one with a pencil whilst monitoring the note on a receiver!

RIT can be done by switching in additional capacitors to shift the frequency, but this can be "chirpy". RIT applied by manually adjusting a small value trimmer capacitor is not as prone to "chirp", but the oscillator will take a finite time to settle, and this can produce "warble" notes.

Range is as per crystal oscillator methods - the "super VXO" being very effective. (I would have said the tuning range for ceramic resonators is often near 1 to 2 % of their frequency – very much higher than for a crystal oscillator, so makes them viable for low cost 80m rigs. G3PCJ)

Huff and Puff digital correction

	LF	Lo-HF	Mid-HF	Hi-HF	Lo-VHF	Hi-VHF
Cost	Low	Low	Low	Low	Low	n/a
Construct.	Reasonable	Reasonable	Reasonable	Reasonable	Reasonable	n/a
Drift / min.	V. Good	V. Good	V. Good	Good	Good	n/a
Purity	Good*	Good*	Good*	Good*	Good*	n/a
RIT	Easy	Easy	Easy	Easy	Easy	n/a

* depends on output LPF if sine wave required.

Cost Using 50MHz clock "74HCxx" logic is amazingly cheap. You'll need tuning varicaps to get the range, though the varicap diodes can be LED's, 1N4001's etc. The simplest circuit I've seen to implement Huff-n-Puff uses two 74HCxx logic chips, and a "fast" mode (statistical) H-n-P with three! PIC's and other micro-controllers can implement H-n-P's easily and cheaply - but why bother if a couple of 74HCxx gates do the job? Keep in mind you're using an L/C oscillator but tuning over LF and low/mid HF bands that are very crowded is easy.

Construction Be aware that 74HCxx logic has nS edges; high speed PCB techniques are mandatory and fast edges create hash, so watch the screening and isolation. An output LPF is needed for applications requiring a clean sine wave as the output is logic level pulses.

Drift - You can't polish muck; neither can H-n-P stabilise a poor oscillator. Start with a decent L/C oscillator and a H-n-P will render it superb. The tuning goes in steps of a few Hz depending on the timing period and counter/divider ratios; by using fixed NP0 and mica tank capacitors shunted with varicaps you can cover any of the amateur bands easily. A H-n-P will take some time to phase lock but once locked will hold the frequency (lock range > capture range).

Purity Depends on the quality of the basic oscillator the H-n-P correction is applied to. Start with a poor design and the system cannot phase lock. A decent oscillator with H-n-P applied become a superb oscillator; not perhaps to DDS or synthesizer levels but perfectly adequate for WSPR, QRSS, and demanding SSB adherents.

RIT Can be done by switching in additional tank capacitors to shift the oscillator slightly. Sudden switching causes the oscillator to jump to a new frequency; RIT, if not excessive, will not lose phase lock but the loop will take time to settle and might skip steps. Alternatively a slow (C-R) ramp voltage to the varicaps will allow the phase lock to hold.

Range Depends on the L/C oscillator and phase lock characteristics of the H-n-P; this is a function of the division and timing ratios.

Comment by G3PCJ. Implementing Huff and Puff often needs an extra tuning 'device' (eg a varactor) to implement the small capacitance corrections – in some instances, making sure this aspect of the control loop is stable can be problematical!

DDS / Synthesizers

	LF	Lo-HF	Mid-HF	Hi-HF	Lo-VHF	Hi-VHF
Cost	Low	Low	Low	Low	Low	Low
Construct.	Reasonable	Reasonable	Reasonable	Reasonable	Reasonable	Reasonable
Drift / min.	< 1Hz	< 1Hz	< 1Hz	< 1Hz	< 1Hz	< 1Hz
Purity	Good / LPF	Good / LPF	Good / LPF	Good / LPF	Good / LPF	Good / LPF
RIT	Easy	Easy	Easy	Easy	Easy	Easy

Cost It is low and falling. The biggest expense is probably the controller (Arduino, Butterfly, PIC, etc.) and the display, but the prices are dropping every day. Direct frequency readout eliminates dials and associated mechanics so what's not to like?

Construction High speed digital switching and displays create hash up to many MHz so watch the screening and isolation. An output filter is mandatory if you want anything other than a logic level digital output.

Drift - Literally "rock solid". Expect stability fully equal (if not better) to a similar frequency crystal oscillator.

Purity Depends on the quality of the output filter, as the output is logic level pulses. Some applications, like switching mixers and diode double balanced mixers are happy with logic level drive; but if you want a clean sine wave for a transmitter you'll need a good output filter. The job is easier with a DDS with active internal "spur" reduction (bless the engineers at Analog Devices!). Considering the frequency range of a modern DDS (kHz to GHz) the filtering for a clean sine wave is probably the biggest factor. You'll be looking at switched banks of filters if you're covering many bands.

RIT Can be done by a few digital manoeuvres; no bother at all.

Range Hz to Ghz in modern devices!

Comment by G3PCJ. There maybe some drawbacks! Are they as well understood as the simpler form of oscillator – definitely NO! Can they be adapted as easily as the simple LC form of oscillator? This depends very much on what has been provided in the software of the driving micro-processor and the programming skills of the builder to alter that software. You need also to be aware that the processor (being digital) could also generate hash that might interfere with the reception just like the Huff and Puff approach! You might also need to be a dab hand at combining more than one form of electronic construction if attempting this yourself!

Summary Chart

This chart shows the frequency band horizontally, and the potential drift vertically. The higher up, the higher the drift.

	LF	**Lo-HF**	**Mid-HF**	**Hi-HF**	**Lo-VHF**	**Hi-VHF**	**μ-Waves**
L/C	YES!	YES	yes/maybe	NO	NO!	NO!	NO!
Mixer	YES!	YES!	YES	yes	no	NO	NO!
Cer. Res.	YES!	YES!	YES	maybe	no	NO	NO!
Huff-n-Puff	YES!	YES!	YES!	YES!	yes	maybe*	NO**
DDS Synth.	YES!	YES!	YES!	YES!	YES!	YES!	YES!

*if a hi-VHF signal is pre-scaled then H-n-P methods will work, but stability is an issue as loop gains have to be higher, effectively multiplied by the pre-scale factor.

** new GHz pre-scalers might make H-n-P a feasible and cheaper alternative to DDS for narrow bands or spot frequencies; or ECL gates in conventional H-n-P circuits running directly at GHz.

Key:

YES! = Without a doubt, what are you waiting for?

YES = Definitely, get on with it, use good construction and don't skimp.

yes = You can, use good construction and parts.

maybe = Well, maybe...

no = Not really, perhaps a waste of time; but please feel free to prove me wrong.

NO = Don't waste your time and money, but try it if you really insist...

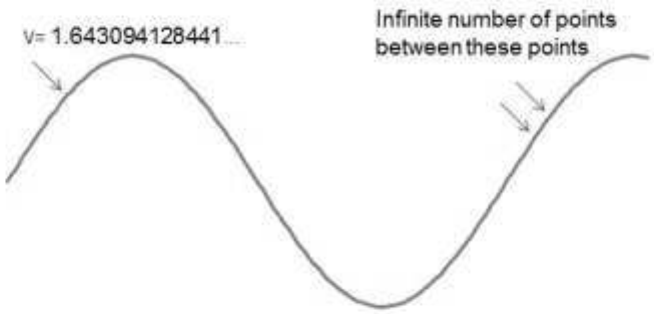
NO! = Don't bother. No, honestly, DON'T BOTHER.

The next note continues the theme from the last Hot Iron, of improving our understanding of the mathematical processes that occur in a modern Software Defined Radio.

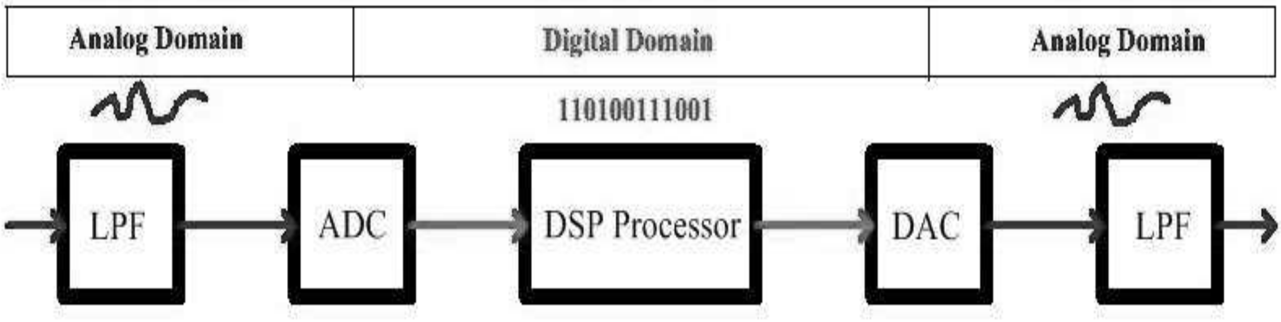
DSP Fundamentals By Gary C. Sutcliffe, W9XT

To hams used to working with analogue circuits like VFOs, audio amplifiers, RF linear amplifiers and the like, the current trend towards DSP (Digital Signal Processing), SDR (Software Defined Radio) and the proliferation of the digital modes like PSK and the WSJT suite can seem a bit daunting. This article looks at the fundamentals of DSP with simple examples without going too deeply into the math.

Let's start with looking at the characteristics of an analogue signal such as the one shown right – Fig 1. It is a simple sine wave. We can pick any random point in time on the signal and measure the voltage to any arbitrary number of digits limited only by the quality of our instruments and by noise. Another key aspect of analogue signals is that you can pick any two points in time and there will be an infinite number of points between them. This is called a continuous function. There are no gaps between any two points on the signal.



We can take an analogue signal and make changes to it. We can reduce the voltage with a resistor voltage divider or make a filter with resistors, inductors and capacitors. We can amplify the signals with transistor or tube amplifiers. The laws of physics determine how these components will affect a signal fed into the circuit. Digital systems like computers and microprocessors work in a different world, often called the digital domain. They take discrete numerical values and can perform mathematical operations on them. For example, it can take two numbers, X and Y, and multiply them together to get result Z. Microprocessors are getting faster and faster and perform math in real time if the processor is fast enough compared to the frequency of the analogue signal. The circuit will collect data on the analogue signal and convert to it to numerical values. The processor can then perform math on the data, and finally convert the result back to an analogue signal.



The diagram above Fig 2 shows a block diagram of a simple DSP system. For now, ignore the low pass filter blocks (LPF), the analogue signal goes into a device called an Analogue to Digital Converter (ADC). An ADC is essentially a volt meter that measures the analogue voltage at one point in time and converts it to a number in binary format. The processor takes the values provided by the ADC and performs mathematical functions on them. Finally, the processed data is fed into a Digital to Analogue Converter (DAC) which generates the analogue voltage equivalent of the binary number given to it.

Now, the processor can do some trivial math on the digital data. It can divide the signal by some number and essentially be equivalent to a resistor voltage divider. It can multiply it by some number and become an amplifier. If it multiplies the signal by -1 it simply inverts the signal. Of course, if this is all you want to do, it is much simpler to just use conventional electronic components. The real advantage is when you want to do complex DSP algorithms.

Let's back up a bit and take a closer look at some of the processes involved. As mentioned before, analogue signals are continuous functions. Computers must work with discrete values, at least until infinitely fast computers are developed. So, the data must be fed into the processor in chunks separated by time.

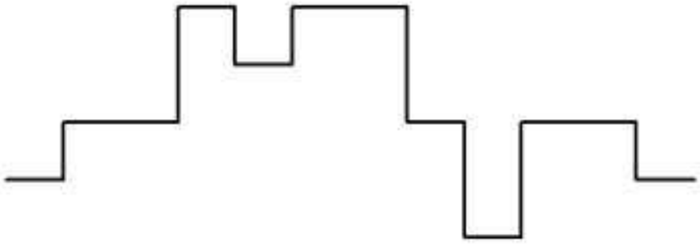
Figure 3 below shows a signal that is "sampled" at regular intervals, and the table of data that is created. Each dot on the waveform is the point where the signal is sampled. The table shows the values at each sample period.

0.000
0.479
0.841
0.997
0.909
0.598
0.141
-0.351
-0.757
-0.978
-0.959
-0.706
-0.279
0.215
0.657
0.938
0.989
0.798
0.412

Note that all the values of the signal between sample points are ignored. We are losing fidelity of the signal by ignoring these lost segments of the signal. However, Nyquist's Theorem states that if we sample at least twice as fast as the highest frequency present, we can recreate the original signal. In practice samples are usually done at a higher rate than specified by the Nyquist criteria. Going back to Figure 1, a low pass filter is usually placed in front of the ADC to prevent higher frequency signals getting into the system. Those signals will result in errors in the signal processing.

In selecting an ADC, two important specifications are considered (there are others but are beyond the scope of this article). First is the sample rate. That is how fast signals can be converted to the binary format. As pointed out by Nyquist, this will affect the maximum frequency signal that can be worked with. Another important specification is the resolution. The output of an ADC is in the binary number system used by computers. Analogue to digital converters are specified in the number of bits, 8 bit, 12 bit, 14 bit, etc. The number of bits indicates the number of different values the input signal can be divided into. For example, an 8 bit ADC can show a signal as a value up to 2^8 or 256 values. A 14 bit ADC can represent that same signal as 2^{14} or 16384 different values. More bits are required if your application requires a high dynamic range and/or more precise measurements. Making an ADC with both high sampling rates and high resolution is hard, and has been a factor limiting how fast DSP developed. Today High speed/high resolution ADCs are available that are capable of direct sampling at RF frequencies. This has allowed development of direct sampling SDRs which don't require mixing the desired RF signal to a lower frequency.

Before going into the processing of the signal let's take a quick look at the other end of a DSP system, the DAC as shown in Figure 2. Like the ADC, the number of bits and the maximum operating frequency of a DAC are critical in determining the capability of our DSP system. The output of a DAC will look something like shown in Figure 4 right. Because the DAC operates on discrete values that change at a regular rate, we can't represent the signal as a continuous analogue signal. The voltage will remain constant for the entire sample period. We can however clean that up by putting a low pass filter on the output of the DAC as shown in Figure 2.



The real magic of DSP occurs in the processing and the algorithm implemented in the software. To start, let's look at a very simple implementation of a low pass filter. Figure 5 below shows a sine wave with some noise added on the left. This was created in a spread sheet where a table was created by using the SIN function. A small amount of noise was added by using the RANDOM function to cause slight variations in the signal. The PLOT function draws a graph of the resulting table. It is clearly seen as a sine wave with some noise.

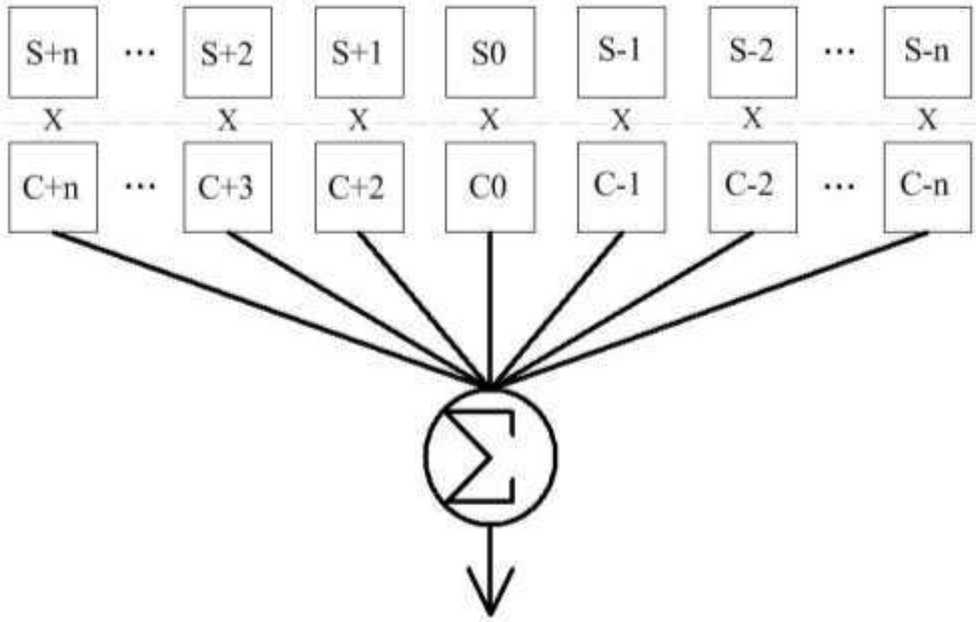
To implement a very simple low pass filter we can just average the signal. In this example we take a value, add in the previous and next values, and divide by three. We do this

0.185424	0.244936
0.549383	0.462038
0.651308	0.696421
0.888572	0.790422
0.831386	0.924232
1.052738	0.972532
1.033471	0.972644
0.831724	0.904917
0.849558	0.755619
0.585576	0.631673
0.459885	0.430243
0.245268	0.198822
-0.10869	-0.08733
-0.39857	-0.35708

for every value in the table. The right hand waveform above shows the resulting plot after averaging. While all the noise (look closely at the peaks) has not been removed with this simple filter algorithm, it is certainly closer to the original sine wave without noise added. You can create a spreadsheet and play around with different methods of manipulating the data if you are interested.

This example is very simple and probably would be better implemented as a simple analogue RC Op amp filter, but it shows the basic method that many DSP algorithms use. These algorithms take a given sample, then take adjacent samples and multiply each sample by a specific coefficient number then add them all together. Our simple example we only used three samples and used an effective coefficient value of 1/3 for each value. Typical DSP algorithms use many more cells, usually factors of 2 like 32, 64 or 128 samples. The magic is in setting the coefficients that each cell is multiplied by to get the desired function on the signal.

Figure 6 below shows a generic form used by many DSP algorithms. The top row represents the samples taken in time. S0 is the current sample being processed. S-1 is the sample taken previous to S0. S-2 is two samples back, etc. S+1 is the sample after S1, and so on, out to some number of samples, n. The second row shows coefficients that are multiplied by each sample. In our simple averaging filter, we only had 3 samples (S-1, S0, S+1), and the same coefficient for each sample. Of course more complex algorithms will have different coefficients, and are the key to implement different functions. The results of all the samples multiplied by their respective coefficients are added together to produce a single value that will ultimately be sent to the DAC. When the calculations on a single sample are complete, the values in the top row are shifted right. A new value will be shifted into S+n, and the value in S-n will be discarded. This will produce a stream of values for our processed signal. As the number of cells increase, and the frequency of the signal increases, the processor must be more powerful to perform all the operations before the next sample of data comes in. Special DSP processor chips have been developed that do the multiply and accumulate functions very efficiently. The sound card and video chips in your PC have DSP processors to do these jobs.



So, why is DSP much better in many applications? There are two main reasons. The first is flexibility. Say you have a conventional analogue radio and are using it to listen to SSB transmissions. If you want now to listen to an FM transmission you need to have a FM demodulator circuit. All the extra circuitry increases cost. With DSP you just change software much like you use your pc browser to surf the web then bring up your spread sheet program to work on your budget. Software is expensive to develop, but every copy is essentially zero additional production cost.

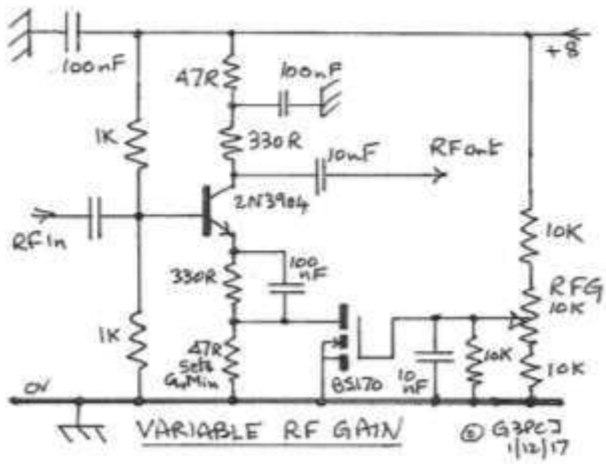
The other reason is that some functions are difficult and/or expensive to implement in hardware. One example is a very narrow filter with sharp skirts and low bandpass ripple, say for CW reception. You can make them but you need to use a lot of components. These components need to have very tight tolerances to get the desired results, and precise components are much more expensive. Furthermore, over time the components age and change value. The filter will not perform as well over time. Digital systems don't have this problem.

Hopefully this very brief introduction to DSP will give you a better feel for what is involved with the digital revolution that is hitting ham radio.

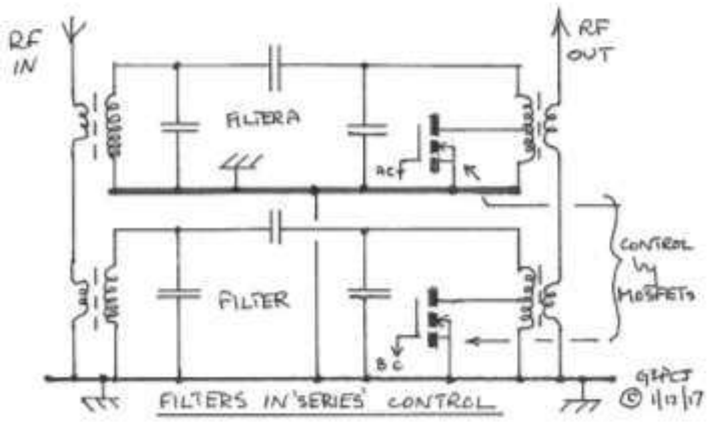
Thank you, Gary, for that excellent explanation. For those wanting a good reference book I can recommend An Introduction to Software Defined Radio by Andrew Barron ZL3DW. It is ISBN-13: 978-1500119935 and ISBN-10: 1500119938 originally published in July 2014. Thanks to Jim Gailer for lending me this more detailed explanation of SDR techniques. Tim G3PCJ

Circuit ideas to avoid RF wires to front panels – as in the Beer RX – by G3PCJ

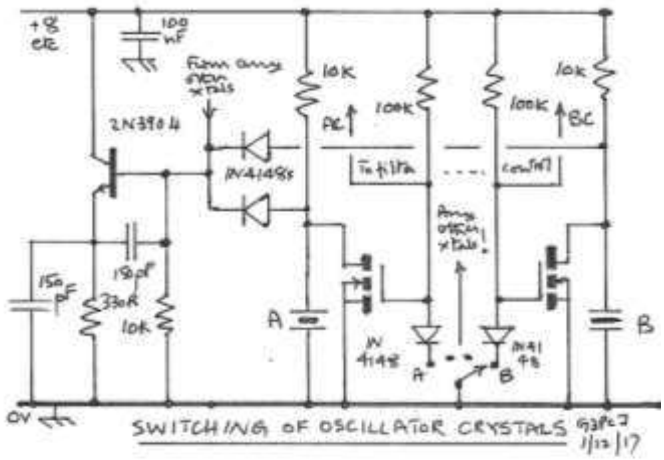
Variable gain RF amp – one scheme is to have an RF amp stage using a bipolar (2N3904) in the 'common emitter' configuration with a 'RF hot' variable resistance in the emitter lead to control the gain. Substitute a MOSFET for the variable and its On resistance can be changed by the DC voltage on its gate. It is convenient to put a fixed resistor in parallel with it to set the minimum gain. The resistors in series with the control pot are to restrict the gate voltage to near the useful range of approx 1.75 to 3 volts for OFF to hard ON. Voltage gain varies from about x 5 to x 20.



Band switching - normally this would be done by re-directing the low impedance input and outputs of the various bandpass filters. An alternative is to wire these low impedance windings in series and by some means short out the unwanted ones when not wanted. This can instead be done with the high impedance windings where the short would be reflected back across the low impedance winding. A switch across the whole of the secondary would not be good owing to the stray capacitance, but a switch across half of the high impedance winding would be enough to disable that filter! Make the switch a MOSFET and it can be controlled hard on/off by DC volts on its gate from the band switch. TOKO 333X series inductors often have a suitable tap!



Crystal switching – a Colpitts oscillator with a grounded crystal makes diode switching easy. Add some biasing resistors to turn the diodes ON when wanted, and also a reverse voltage (to minimise diode capacitance) when NOT wanted. Then add MOSFET switches, with the same hard on/off characteristics as for band switching above, across the crystals and their small off drain capacitance will not upset the crystal when it is active. The only slight drawback is potential changes in oscillator signal amplitude when changing from one crystal to another.



Happy Christmas to you all!

"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Spring 2018 Issue E99

Editorial

I am delighted to report that my editorial about 'peak electronic construction' last time did generate several comments! The two publishable contributions (see later) said I was wrong and unduly pessimistic! Spring is on its way so we must be optimistic and the lawn will soon want its first cut! (The earliest I have ever done that was in the middle of January so, based on a huge sample of 1, global warming is definitely not the problem that many would have us believe!) Time soon for some antenna work and in our case, a bit of thinking on where to put them up around our new house that is slowly emerging from the mud! My desire is a balanced (centre fed) dipole of some sort fed by open wire feeders but that is yet fully approved! We had a discussion recently with the electrical contractor and it is more of a potentially nasty EMC scene than I expected! At least these matters are now being given far more thought by equipment manufacturers; but my professional experience years ago taught me that although individual pieces of equipment can be compliant, it is quite easy for the whole to still have problems when there are transmitters of any sort in the vicinity and nowadays all homes have many! Heat pumps with multiple thermostats, induction heating cooking hobs, CCTV with digital communication/storage, solar photo voltaic power inverters, standby generators or UPS for mains failure in a rural area, mobile and portable phone/internet/computers, smart utility meters, broadcast digital TV and radio services, WiFi and even potentially fibre optics in a modern home are quite an interesting mix! And that's without amateur radio! One of the advantages of living in an old Victorian building currently is that nearly everything can be easily taken to pieces – you can lift an upstairs floor board when a new screened cable is needed between two rooms - not so in a modern place where floors are either solid concrete downstairs or large sheets of plywood upstairs! But they will be warmer so I am told!

Personal Data

Under new European Union rules, those of us storing the data on other people, have to be much more careful about protecting it. This applies to Hot Iron readers. The data that I have on you is minimal &, except in special cases, is only an e mail address. For many of you, I don't know a surname and in some cases not even a Christian name! For a vey small proportion, where I do hold a physical address, this is because we have sent each other physical items. Any physical address data is not stored electronically but is an old fashioned address book! I don't accept orders for equipment by credit card so I don't have any of that information – if you do order using Paypal, you card info never gets near me anyway! If this concerns you and you wish to cease getting Hot Iron, all you need to do is send me an e mail saying please un-subscribe and your miniscule amount of e address data will be deleted. I hope you won't! 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, sent by e mail, & free to those who want it. Just let me know you would like it by e mailing me at electronics@walfords.net Under new rules I have to tell you that I only store your e address so I can send Hot Iron. If you do not like that, tell me & I will remove your data!

Peak Electronic Construction?

Pete Juliano N6QW disagrees with my (G3PCJ's) observations last time:-

So by my assessment, it has never been so easy to build moderately complex electronics and it is likely to get harder in the future – conclusion – we are at 'peak electronics build'!

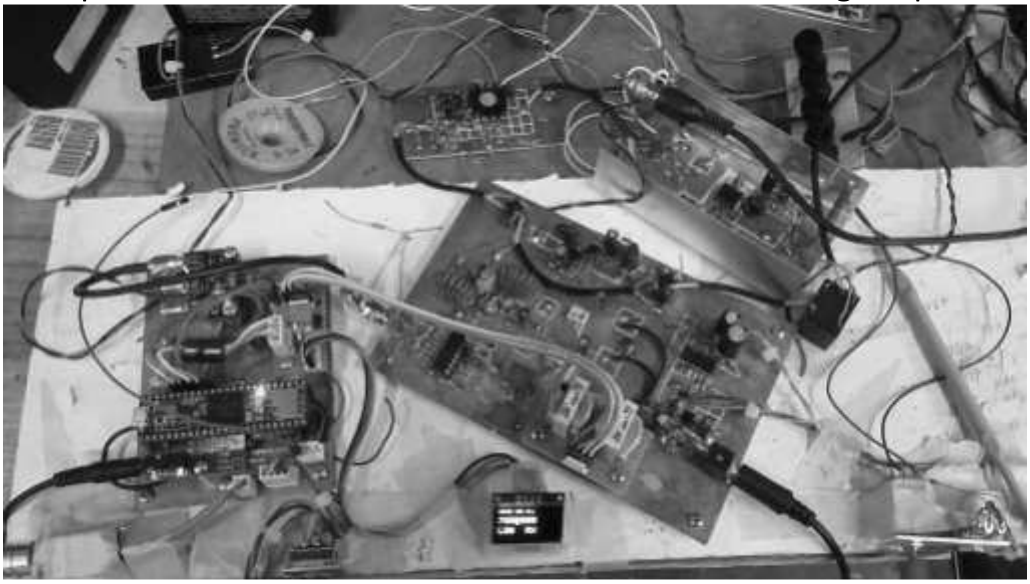
His editorial then proffered a challenge to anyone who would disagree with that position. I am taking up that challenge! Some questions raced through my mind such as the peak is the end and it is all downhill from there. Or is it a peak in the sense it is Mount Everest that can only be climbed by a few hardy souls?

In a completely unrelated event (reading a special edition of Scientific American for 2017/2018) I spotted an article that suggested the perfect premise for my response and that had to do with a chess experiment where the participant's ranged from expert to novice and the intent was to explore the Einstellung theorem. This theory posits a person's predisposition to solve a given problem in a specific manner even though better or more appropriate methods of solving the problem exist. The Einstellung effect is the negative effect of previous experience when solving new problems. Perhaps the real issue is that we are looking at the peak through eyeglasses of the past. [I suspect most hams today need eyeglasses –I do!]

Firstly let us be clear – Tim Walford and I are of the same vintage (we are the same age) so it is not a generational thing. I maintain and frequently state that this an amazing time to be homebrewing all sorts of electronic devices whether it be transceivers or test instruments. The reason this is quite clear and that being the availability of cheap, relatively abundant new technology hardware that can be had for pennies. I believe that G3PCJ clearly acknowledges that point. So let's connect the peak in electronics with the Einstellung effect. If I had a backward time scope on my test bench were there similar comments about a peak when the spark gap gave way to the CW transmitters? Or perhaps a mere 69 years ago, when the transistor was invented. How about the 1960's when there was a widespread shift from AM to SSB. Or perhaps like a recent comment from a Top Band aficionado who was lamenting there are no more DX stations on 160 Meters using SSB or CW –they are all now on FT-8.

But some of these examples are not in the same vein as Tim's comments as it appears his bent was the hardware and not a shift in the modes of communications Thus, let us focus on that aspect. If I read G3PCJ correctly he puts the laser beam on two aspects; one of which is that the parts being used are not simple ¼ watt leaded resistors or 25 VDC leaded 100 nF caps; and two, the devices are complex integrated circuits that must be programmed with the software being the bigger challenge.

Is it these two factors: complex systems on a 64 pin substrate and the need for operational software that drive that peak? Enter Einstellung – we think these two factors put us at the peak when in fact our old paradigm is large size leaded components that require no software to operate. When I once mentioned a Si5351 PLL Clock Generator to a very close friend – his response was "just show me the 2N2222's". The new paradigm is large scale integrated circuit block chips and the specialty software to run them. Recently I built a homebrew SDR transceiver that uses a 64 pin Teensy 3.5 Microcontroller and an Audio Codec Board. These two devices are the heart and soul of the rig. Embedded in the software are Hilbert transforms (I & Q) and a 2800 Hz bandpass filter (in software). I can't spot any 2N2222's in the rig but it sure works well. It is important to mention that I was merely replicating the work of Charlie, ZL2CTM. Yes I did add a dab of "Pete Stuff" but by and large I lifted what he did. For reference purpose this a 5 watt SSB transceiver operating on 40 Meters and the larger PC Board is 4 X 6 inches. Yes it is a prototype and looks like crap but has logged about 3 dozen QSO's in about 2 weeks of operation. Notice the liberal use of masking tape –an old paradigm.



So the real question is not so much have we reached the peak as it is how do we now work with the new components and learn the software? [Einstellung]. We eat the elephant one piece at a time AND we do have help in the form of resources found on the Internet. You Tube videos abound in things like curing water intrusion problems in a 1995 Jeep Wrangler to SDR Transceivers. (Yes both from N6QW – the Jeep one has had 32K views.) The other pieces are ham radio blogs and websites where there is literally tons of info on how to use the new devices along with program examples. We should not also forget User Groups and Forums. There is another aspect and that is those who enjoy are hobby who are ever giving of their time energy and support. I mentioned Charlie ZL2CTM – he spent a lot of time emailing me with help and assistance and support. I am deeply indebted for now I too have a homebrew (not a kit) SDR transceiver.

Perhaps the not so obvious answer to Einstellung is the collaborative effect derived from the Internet. It is no longer a single chess player playing the game – it is a whole group playing the same game.

Earlier I had mentioned the Hilbert Transforms and the 2800 Hz Low Pass Filter Software. Iowa Hills Software provides a free download of programs to design both the transforms and other tools to software build Low Pass, High Pass and Band Pass Filters in the audio range. Their program lets you visually see the filter shape and cutoff frequencies with the final result being a listing of coefficients that define the filter and transforms. The Audio Codec Board [from PJRC and costing about $15 USD] has free design software that will respond to these coefficients. The Teensy 3.5 microcontroller runs at 120 MHz and is programmed using the standard Arduino IDE. Did you all catch the number of times I used "free software".

The new electronic peak also drives the tools we need. I am fortunate in that having spent $250K sending my third son to university to study Mechanical Engineering, in return he designed, built and gave to me a $2500 CNC milling machine. The point here is having a CNC mill is an enabler to address the new hardware and is a step up from tack soldering parts to a copper board ugly style. The boards in the photo above were made on my mill. The really good news is that CNC Mills capable of doing this work are 1/10 the cost of the one I have. [It is OK to check eBay right now and you will find one costing $230 shipped to your door.]

Thus CNC Mills can be put in reach of more hams than those who sent their son's to an expensive university. The real beauty of the mill is that a lot of software needed to generate the cutting patterns are a free download and since it is a stored program when I want another board – all I have to do is load the machine with stock and punch the "Start" button! My major problem now is that I keep running low on PC Board stock.

The biggest problems in facing the pseudo peak are twofold: 1) getting off the couch and turning off the "tele" and 2) taking the time to learn how to use the new hardware/software and tools.

Answered and responded to: It is not a peak but merely an exciting opportunity!

73's
Pete N6QW

David Perry G4YVM also writes about peak electronic construction:-

The advent of DDS / micro processor controlled, rig-on-a-chip kits has certainly changed things as you say. I do agree that with old style components becoming harder to find and new style components becoming harder to work with, things look gloomy. However...the advantages in terms of facilities provided by new methods are undeniably attractive and attracting newcomers. Witness the simple maths of sales: how many of your last TRx did you sell? The little rig-on-a-chip QCX from QRPLabs has sold over a thousand copies! At 40 quid a pop that's a LOT of revenue. Clearly people are buying the facilities of the new digital kits. Another HOWEVER...if a chip fails, as it has on a friends kit, it is almost impossible to fault find. So a £40 kit becomes literally useless and goes in the bin. My friend managed to isolate the issue and buy a spare chip, so all is good. Yes, the kit could be returned but would YOU accept a built but dead kit back for replacement? I doubt it. Fault finding may be provided but it costs...and if it's factory mounted SMD chips it's just not viable.

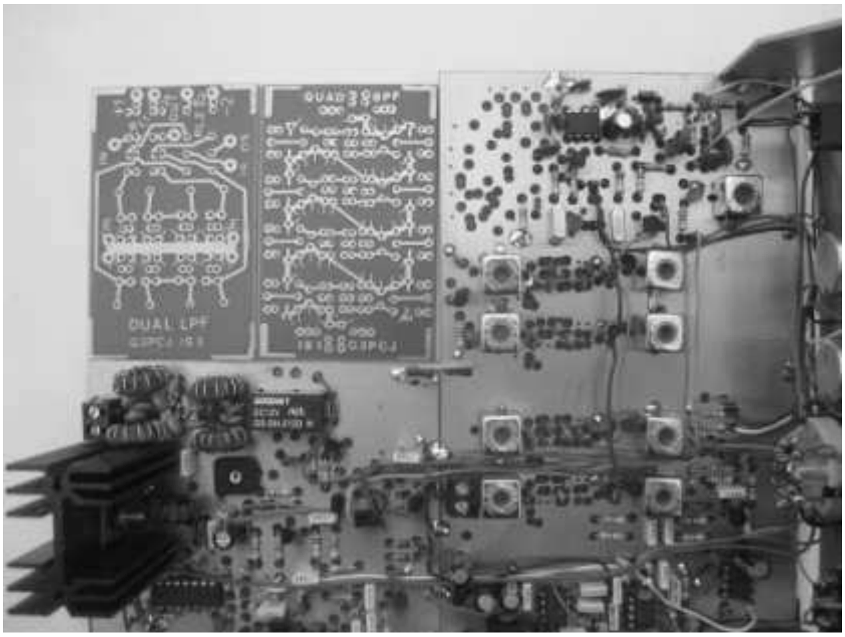
So, on the one hand you are right...we may have peaked. BUT...how long will Kenwood, Yaesu and Icom keep making radios for our market? Sure, they'll all be SDR anyway very soon because these can be programmed for any user but will the amateur market sustain development? Also into the mix goes this: the people running many of our institutions are ageing...the QRP club, FISTS, Waters and Stanton, Lynch and so on and on...in honesty, is there a generation left in these things? I fear not. Which leaves the amateur with no old style kits, no hope with SDR style and no suppliers of commercial gear! I suspect then a resurgence of real old style homebrew, as you say, kitchen table stuff. We will have to build because it's all we can do. And the builders will be using half SDR chips and half wire ended I am sure. Even if wire ended components disappear the ingenuity will continue.

Perhaps, just perhaps, the future of amateur radio is going back to it's roots...fully home brew, cw radio separates with rallies of small scale enthusiasts getting together to swap stories, ideas and spares. The chaps who also sit on 27.555 won't like it and will vanish, but those of us who love radio will thrive and continue to enjoy our hobby.

David
G4YVM

Kit Developments

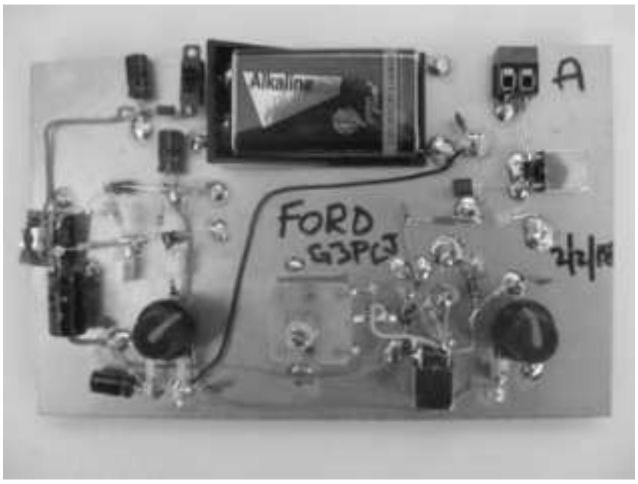
The Beer RX and Stout CW multi-band CW TCVR are now on my website. I am just waiting for the first batch of PCBs to come back from drilling. The photo right shows my two band version ready to take the extra (upside down) PCBs to make it a four band version.

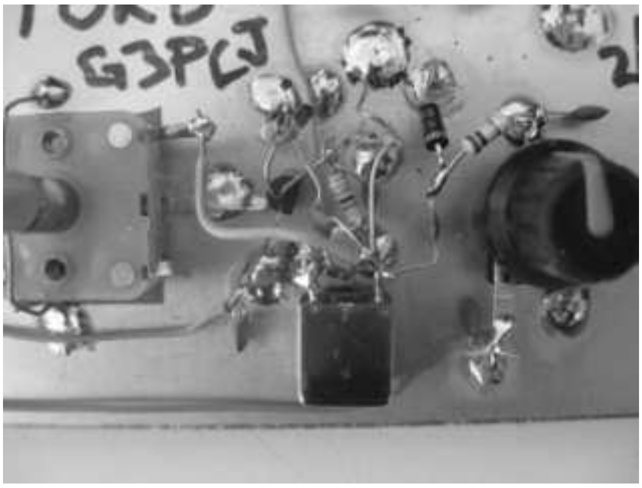


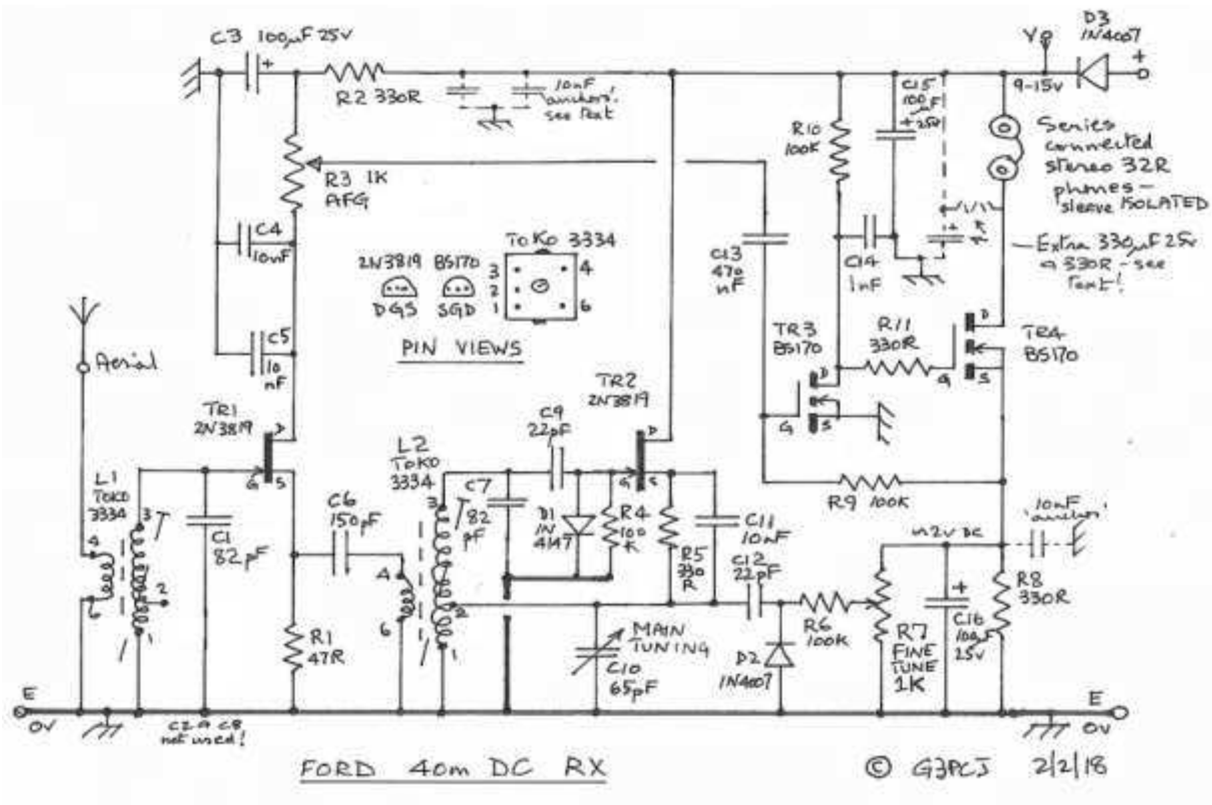
To keep the brain and brawn active, I have been working on a couple of new projects – the Ford and the Culm.

The Ford

I realised recently that I didn't have a very simple direct conversion plain single band receiver – hence the Ford. It is so simple, I built the prototype in an afternoon! It uses just four transistors – two Junction FETs and two MOS FETs. I wanted 40m as a compromise (usually busy) band without frequency stability being too poor from this form of 'in-air' construction without a specially prepared PCB! Plain copper clad board is excellent for circuit 'trials' - like experimenting with the tuning – it has Fine tuning with a power diode instead of an obscure varactor! I added an AF gain control but its hardly needed! Output is to modern 32R stereo phones. Build it yourself! It has a few extra 10 nF discs - not essential but they help with rigidity. Use the extra 330 µF when optional D3 is included; the 330R is for feeding an external amp.

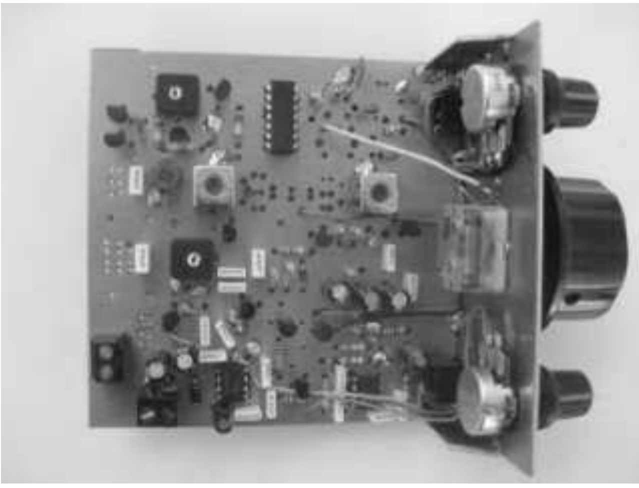


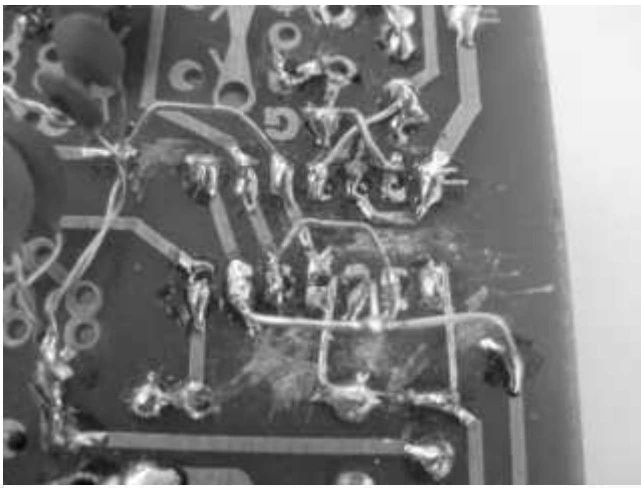




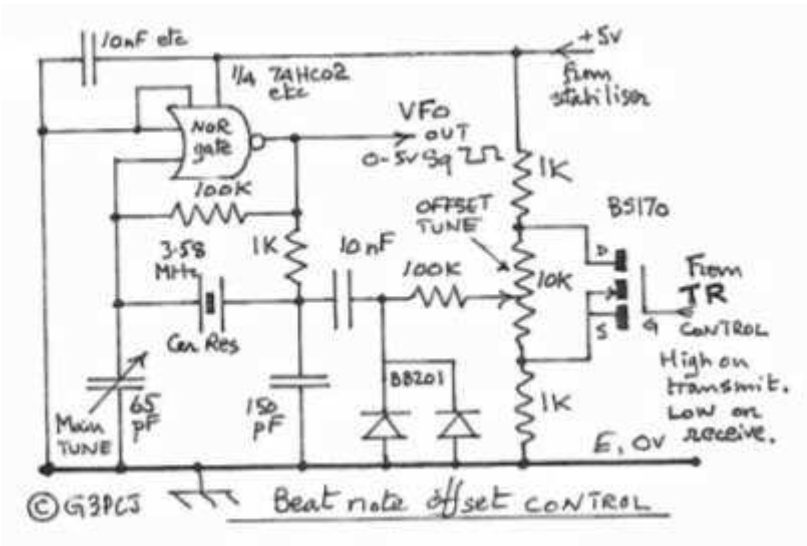
The Culm

This is single band direct conversion CW transceiver & is named after a small river that rises in Somerset but flows into Devon – my small CW rigs are all named after local rivers. It has a ceramic resonator VFO for 80m and is intended to take crystals for higher bands up to 20m. The left-hand photo shows it part way through proving, with the receiving RF filter capacitors not yet fitted properly (underneath temporally) and also missing the transmitter low pass filters (which I have as a piece of test equipment), while I tried it out on different bands. In the early experiments I was not using the RF amp stage and had the antenna fed into the normally unused (in this design) low impedance winding of the first RF filter resonator; but interestingly, the RX had bad microphony and hum problems. Adding the grounded gate RF amp stage, which in effect simulates the impedance step up in the primary to secondary of the filter resonator, made the very nasty noises all disappear. Overall sensitivity from a 50R feeder is similar! It just shows how important it is to minimise LO radiation from the rig into the local environment, which is one of the benefits of adding the RF stage. The right hand photo shows what happens when you mirror image your IC pin layouts by mistake! The rig is working well on 80m, with a ceramic resonator for the VFO. It has main tuning by the PolyVaricon and Fine tuning by a potentiometer acting on a voltage controlled variable capacitance diode. The circuit for this aspect, below,

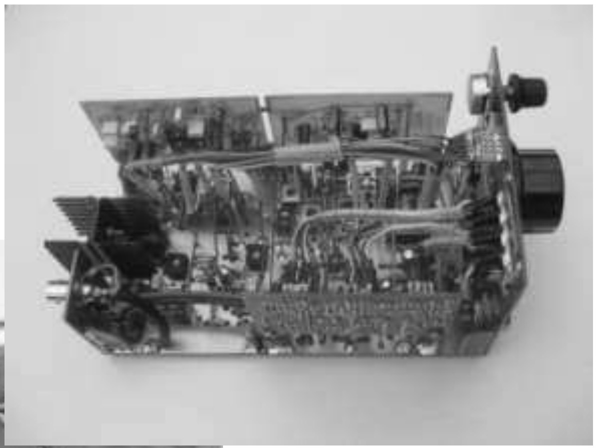




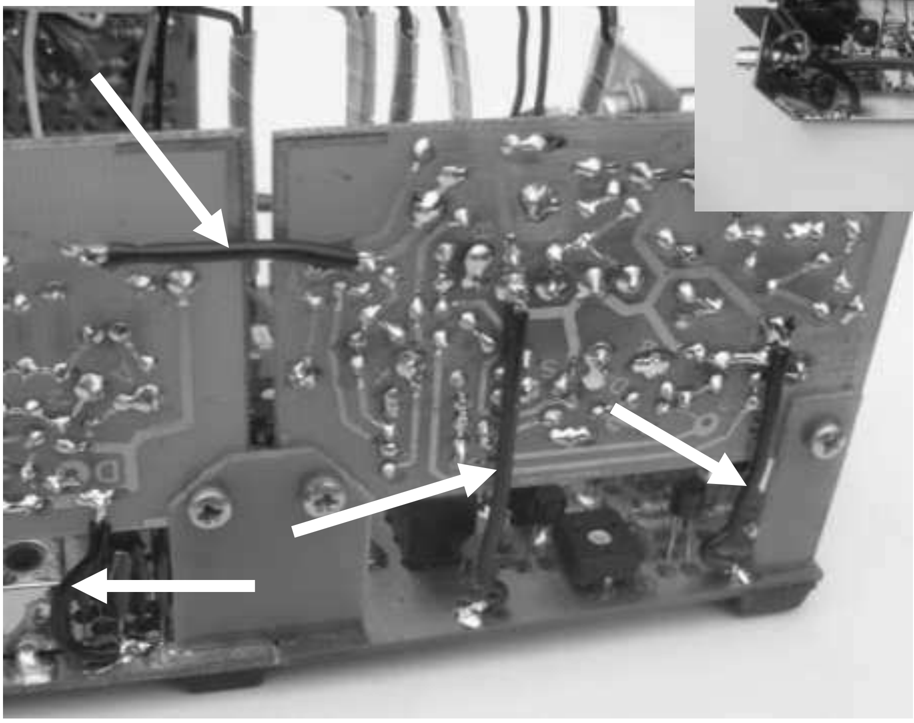
uses a MOSFET under the control of the transmit/receive switching to remove the Fine tuning beat note frequency offset when transmitting: the procedure being to tune the Main tuning for zero beat of the other station with the Fine control centred, and then to use the Fine control for the desired beat note – this can be done either way so you can use whichever sideband has least interference form other stations. When you go to transmit the pot is shorted by the MOSFET, so it is effectively centred, which makes the VFO run on the zero beat frequency. Adapting this scheme for the very limited pulling range of a crystal is proving challenging just now! G3PCJ



The importance of good grounding

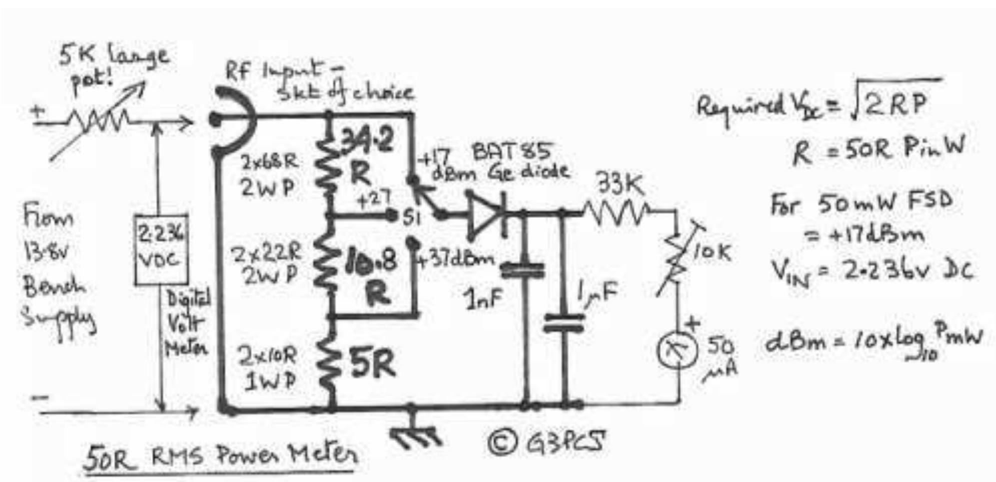


This very well built rig came back for sorting & tweaking up after adding CW & AGC boards; the rig was working well on phone SSB with the original main circuit board, but on CW it was going haywire! The only thing I could see as suspect was the single thin ground or 0 volt supply leads to each of the two extra PCBs. This was easy to improve by adding the four heavy black leads (arrowed) between the main PCB ground plane & 0 volt tracks of the extra PCBs. That cured it completely! Don't skimp on the 'copper in the ground'! G3PCJ



Simple RF RMS Power Meter

This is one of my most used pieces of test equipment! It is so simple I am surprised the circuit does not get more publicity! It presents a load impedance of 50 Ohms from DC up to several hundred MHz depending on how small you make all the RF parts which I have drawn with thick lines. It is peak reading which enables you to calibrate it easily at DC with your most accurate DC meter. Apply 2.236v DC (quickly via 5K pot to 12v), set for highest sensitivity & then adjust preset for full scale. If you work this out in RMS power terms, it is 50 milli-watts into the 50R load, or expressed another way, this is +17 dBm – meaning 17 db above 1 milli-watt into 50R. You can mark the meter with intermediate (non-linear) calibration points in 1 dB power steps down to about 0 dBm. The less sensitive scales add 10 dB or x 10 in power to give a max of 37 dBm or 5 Watts. G3PCJ



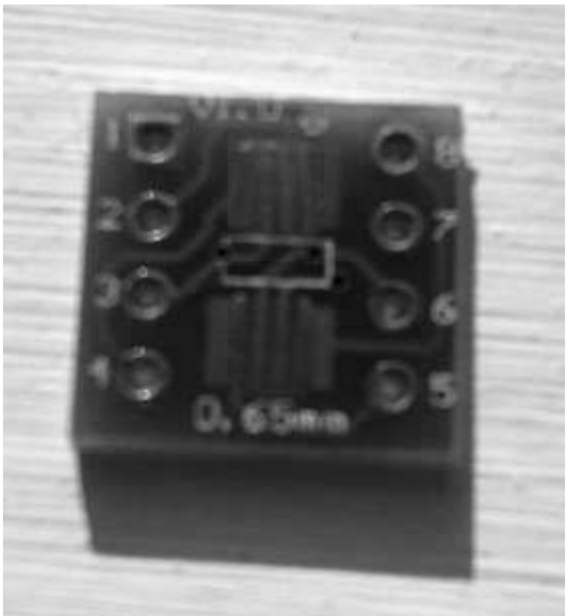
Continuous Improvement – Peter Thornton G6PNR

The Japanese invented this phrase; it meant for us in the UK semiconductor manufacturing industry continuous change and cost reduction in manufacturing silicon chips, transistors and integrated circuits. To make silicon devices, you need 'Process Engineers' to design the chemistry and physics creating the P-N junctions and MOS structures (to name but a couple of the structures Process Engineers use); 'Equipment Engineers' to keep the machinery running, maintain the best performance at the lowest running costs; and Production Engineers to organise the plant's manufacturing and get the maximum throughput for the 'product mix' required, today, tomorrow, next week. Each of these disciplines are involved in 'Continuous Improvement' and a change in any one inevitable creates change (for better OR worse) in either or both the others!

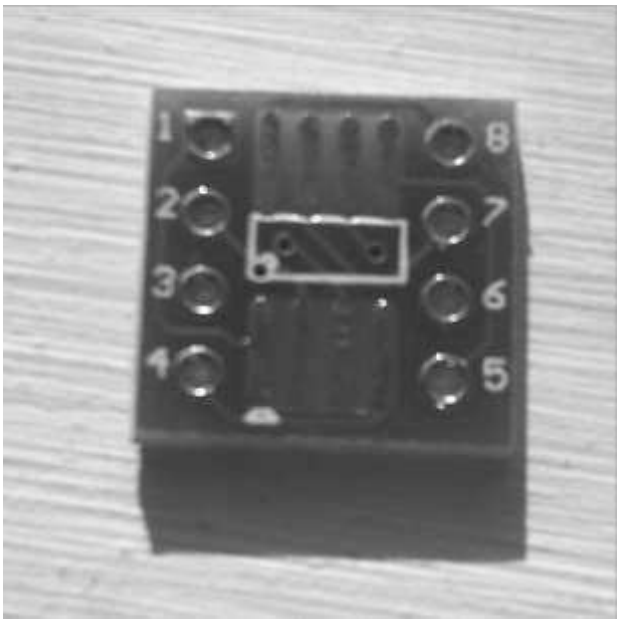
The whole point is to keep competitive. Improvements in manufacturing have to be made every day, every week, every month - if you stop improving, you're a dead duck; competitors will overtake you with technology, manufacturing or lower price. That's why customers always want the latest chips from the production line - they have all the improvements in performance, quality and price. "But," you might ask, "how does that affect me, a radio amateur?" Well.... the chips made a few years ago won't be quite as good as today's products - maybe the balance, gain, leakage, noise factor - as they won't incorporate the latest improvements. Might not be a bother if you're knocking up an 80m 'local natterbox'; but might be vital if you're after digging a signal out of the noise, or wanting the best SSB carrier suppression.

It's tempting to use 'N.O.S.' (New Old Stock) devices; and for an average job, they are cheap, and for any job not too demanding. OK, keep in mind the passivation oxide over the silicon die doesn't stop sodium contamination or water vapour ingress forever; new old stock can be leaky or noisy compared with new devices. It's best to use the latest devices; but it isn't that easy for an amateur - manufacturers responded to customer demand for miniaturisation with surface mount devices, and your chip of choice (like an SA 612) isn't available any more in a DIP-8 package. Here's a trick used by engineers prototyping a circuit, who prefer DIP-8 packages for easy alterations to get the design spec. required. Their solution is an adapter PCB: to convert the SO-8 surface mount package to an 8 pin 'DIP' (Dual-In-Line) package, using component lead off-cuts to substitute the pins of a conventional 8 pin DIP.

Adapter PCB's are available cheaply from the usual auction sources, but beware: not all are manufactured for RF service. Many are not 'lead-free' solder compatible, being tinned with leaded solder; most are not 'through-hole-plated' for best RF impedance. Many don't have screen printed pin identification, and SO-8's are not so easy to get straight without an outline marking. Pictured below are multi-layer adapter PCBs - these take a surface mount 8 pin device and convert it to an 8 pin DIP format, to fit 0.1" pitch circuit boards or sockets. You can/might be able to see the minimal length interconnect tracks, numbered pins, fully plated through holes and the alignment outline screen printed to aid bonding prior to soldering.



SO-8 (0.050” pitch leads)



TSO-8 (0.025” pitch leads)

These pictures are of the same adapter PCB - the front and back support different surface mount component profiles. The pads fit 0.050” pitch leads or 0.025” on the obverse. (I am afraid my camera is no good at these really close shots!) They are fully through hole plated, electro-less coated with pure (99.999%) tin for lead-free compatibility and will mount the universal amateur radio chip, the SA612, with ease, as well as any other 8 pin IC of the same pin pitch. You can see the pin numbers on the vertical sides, pin # 1 has a square pad and the chip profile is screen printed to eliminate mounting errors. These PCBs have run SA612's successfully in balanced mixer duty at 450MHz test, and quad FET op-amps in sensitive leakage applications. The easiest way to mount the devices is as follows:

- Fit 8 resistor lead offcuts to the 'DIP' holes, and trim to 6.5mm / ¼ ” long below the PCB.
- Using Blu-Tack or similar putty, set the PCB horizontally, resistor lead 'pins' down, and 'dry fit' the chip with tweezers to check alignment and leads contacting every pad (use a magnifying glass!).
- Lift the SO-8 chip, and apply a tiny dab of super glue with a cocktail stick to the centre of the screen printed outline on the PCB. Don't apply too much!
- Replace the chip, making sure the leads align with the pads - use a magnifying glass - and press down with the cocktail stick to secure the package to the PCB.
- Using minimal solder, solder each lead with a *temperature controlled soldering iron* and a *clean bit* , *quickly*, (italics = important!) in a diagonal pattern - solder pin 1, then pin 5; pin 2, then pin 6, etc. *DO NOT OVERHEAT* or you'll damage the chip!

The adapter PCBs shown above are available from: Equipment Engineering Co., Manchester, UK. equieng@gmail.com for more information.

<u>Homebrewing a SDR</u> by Jim Gailer G3RTD

Background

Over the past 10 years or so, the use of software defined radio (SDR) has moved from the domain of the 'bleeding edge experimenter' to what will, before long, be commonplace. Other than the need to overcome a fear of surface mount printed circuit assembly, however, the homebrewer can continue to build receivers and transceivers that provide a big improvement on the performance of 'traditional' radios.

In this article I will describe my 'journey' in this technology and describe the basic skills, equipment and techniques that you can use to homebrew in this fascinating technology. I will also describe a fascinating new open source project that will allow you to build a QRP transceiver from scratch, or just to assemble the wire-ended components on a preassembled surface mount PCB. All this for a very reasonable price.

Software Defined Radios

SDRs have been around for a fair time now and people seem either to love them or to hate them. It is true that if you want to dig deep into the fundamental principles of design, you are exposed to quite advanced maths very quickly. Being software defined, someone will clearly need to write digital signal processor software and in most cases, Field Programmable Gate Array (FPGA) code as well! Ah, but don't panic! Your editor has told me not to go there (as if – my teacher put me off maths for life at A-level!). This leaves most of us with a few alternatives amongst which are …Stick with hardware - only radios, 2- buy a SDR radio (shudder) or 3 - build our own SDR and use someone else's software.

I have taken route 3. I do write my own software, but only for utilities, such as to provide links between the SDR and an antenna tuner using the CAT (Computer Aided Tuning?) interface. Don't let me put you off radio programming though. You can generally leave the complicated maths alone and use classical building blocks for mixers, filters and so on. There is even free software (GNU Radio) that will let you design your radio software by connecting building blocks on a computer screen. I was surprised a few years ago that when designing a data averaging circuit (for a bat detector!) I had designed a classical low pass filter and even more amazing, it was the right filter for the job!

So, if you haven't used one before, put aside any preconceptions you have about SDR and find someone who has one that they will lend you to give it a try. It can take a little getting used to at first (unless you are using like an Icom 7300 which is an SDR but looks like a 'normal' radio). The first thing you will likely find is that the radio uses a computer screen and is controlled using a mouse. This usually means using the mouse wheel to tune with, but you can make or buy a tuning knob as a substitute. I did this but I have since bought a Logitech M90 mouse whose mouse wheel can spin free, giving you smooth flywheel-like tuning rather like the old Eddystone tuning drive. Try tuning a SSB station. You know where the stations are because you can see them in the spectrum display on the screen. Look at the 'waterfall' display, which shows the history of the band falling or rising on the screen. You should see the sharp cutoff at the tuned frequency of the SSB signal or the carrier and both sidebands for an AM signal and so on. You can <u>see</u> any splatter and give an accurate report if needed. Because the radio provides bandpass filtering using digital processing, there is no distortion because of misaligned crystal filters, nor filters using low-grade crystals. The filter passband is like we dreamed of in an analogue radio and can be moved or varied in width to help get rid of adjacent channel splatter and so on. Look for an empty frequency on the spectrum display and listen to the noise. I find that it is much less harsh than a conventional radio, again because of the clean filtering. Try a CW signal. Wind down the bandwidth; you should hear hardly any ringing on noise and the CW will be crisp at much narrower bandwidths than with a crystal filter. There's a lot more; give it a couple of hours and enjoy your audio reports too!

Can you tell I'm a convert yet? Enough rant…

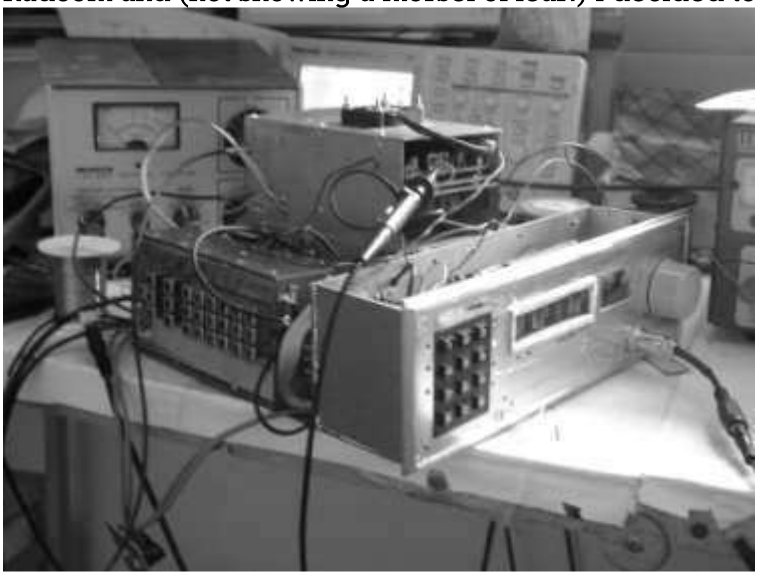
Types of SDR

There are three main types of software defined radio in my mind. Firstly the 'Softrock' type[1], based on the use of a Tayloe mixer and using an audio A/D convertor, often in a computer. These are kit radios and have been available using non-surface-mount technology. A second type uses a conventional superhet design, usually with a very low second IF, so that sound card A/D convertor chips can be used to interface with a computer or a stand-alone digital processor. Finally, designs using an A/D convertor that samples in the 100MHz+ range so as to digitize signals directly without using IF amplifiers, roofing filters and so on. I have built examples of all three, but have settled on the direct sampling design (the last one) which provides a continuous coverage of the HF bands.

Building SDR Radios

I started building my own radios at the age of 9 (one valve TRF kit using a 954 valve) and got my ticket at age 17 (my call sign tells all!) using an 1155L (receiver) and 19 set (as a transmitter), mostly on top band. Then I became a bedsit dweller when I left school and amateur radio was not really possible. After I retired and then my wife died 14 years ago, I bought myself a receiver just to have voices around the house and then joined a local radio club who twisted my arm to get back on air.

My initial thought was to modify my receiver to tap into the frequency synthesizer and add the transmit circuitry. About that time the Pic-A-Star articles[2] by Peter, G3XJP, were running in Radcom and (not showing a morsel of fear!) I decided to give it a go.



My original Pic-A-Star on test

Pic-A-Star is quite an ambitious project, requiring home etching of printed circuits with surface mount assembly of many-legged components. It had been some years since I had used a soldering iron! The project however was well supported (and is still supported though there are a few difficult-to-obtain components) and people have still been starting builds quite recently. The transceiver is a double superhet with a final IF of 15kHz which is then digitized and all of the transceiver modulation, demodulation, filtering and other functions is carried out digitally in a dedicated processor (no PC required!). Nowadays, this might not be considered a 'true' software defined radio since the digital conversion is not close to the antenna – there is a roofing filter in circuit for example. The radio performs very well, however. On both transmit and receive, it sounds much 'cleaner' than a traditional analogue design, probably because of the use of digital filtering.

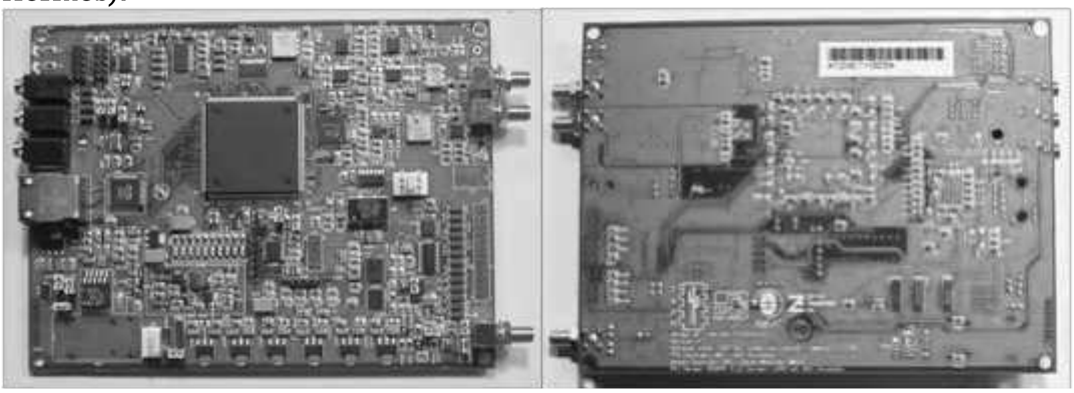
Open HPSDR

HPSDR in a 'Pandora' enclosure. The 10W PA (Pennywhistle) is at the left of the picture.

My second radio was the original HPSDR[3] which used three pre-built boards on a mother board, further simpler boards (power supply, VCXO frequency reference and power amplifier) being home constructed. HPSDR is an international collaboration, both for the hardware and the software. It is a true SDR in that, other than an A/D convertor driver amplifier, a switchable attenuator, and a low-pass filter, the A/D convertor is very close to the antenna. Likewise, the transmitter which after the D/A convertor is low pass filtered and amplified to about 500 mW. With the OpenHPSDR software, this provides a superb transceiver that is still supported for new firmware and software releases. I came particularly to appreciate the spectrum displays provided.

The Hermes Transceiver

Kevin, M0KHZ, redesigned the transmitter and receiver boards to fit on one PCB (named Hermes).



Hermes, showing both sides of the board

This was used by Apache Labs to build the ANAN 100 radio and who also provided bare 4-layer PCBs for homebrew. I bought one of these for a very reasonable price and built it successfully. I have used it as part of an integrated radio with a 15-inch touch screen intended for a point of sale terminal. The radio has a built-in PC motherboard and despite my initial self-interference concerns, with care this turned out not to be a problem.

Before moving on to the final (Hermes Lite) project, I think its worth setting out what it takes to use surface mount devices, as I know that this is what puts many people off homebrew (other than antennas and of course some kits from Somerset) nowadays.

What You do and Don't Need To do Surface Mount Construction.

You don't need sharp eyesight!
You don't need small fingers.
You don't need steady hands.

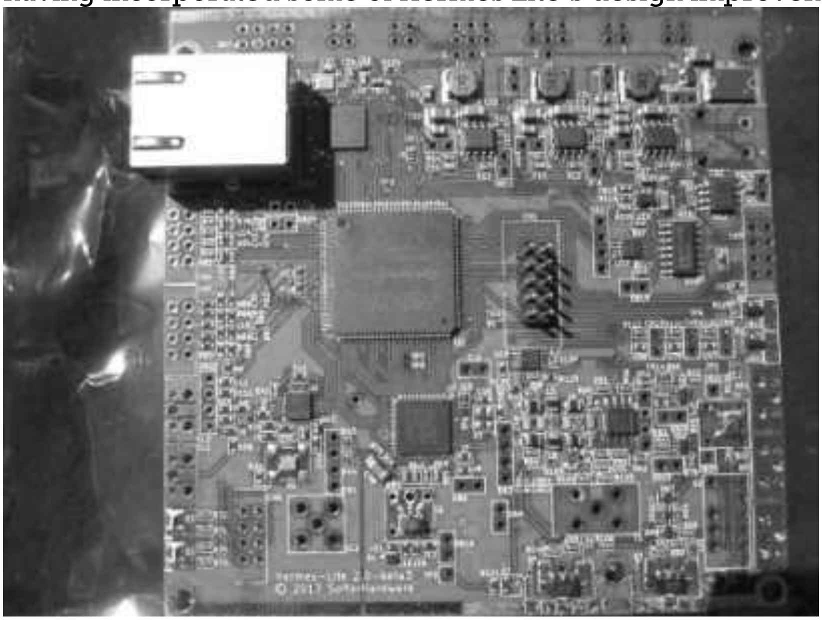
1. You need a decent area of clear table or bench, so that you can find components when you drop them! Mine is 2' by 3' and I treated it to an antistatic mat.
2. You need to be able to see the component. There are lots of ways to do this, but you must have stereo vision or you cannot judge whether the soldering iron is about to melt the solder or is hovering above the PCB, for example. I use an illuminated magnifier lens that I can see the component through with both eyes. Head-mounted magnifiers are supposed to work well or even two pairs of glasses!
3. You need a pair of tweezers that are designed for the job. Some steel ones will get magnetized and will not let go of some components. Stainless steel is usually OK.
4. You need a temperature-controlled soldering iron with a very small pointed or flat bit.
5. A good light.
6. If the design is complex, create a colour-coded layout chart or charts with a different colour for each component value
7. You will find plenty of internet instructions for surface mount soldering, for example, google "surface mount soldering 101 – YouTube" (e.g. [4]) but:
   - Use lead-tin solder with a small percentage of silver in it.
   - Rest the heel of your tweezers hand and your soldering iron hand on your worksurface; this will steady them.
   - Apply a small amount of solder to one pad of the component, then melt it with the iron as you slide the component into place. Solder the other pads then re-solder the first one. Use extra flux if the joint is not satisfactory and it has enough solder.
   - If you get shorts between integrated circuit pads, use fine de-soldering braid with a small amount of no-clean flux.
8. Some solder called ChipQuick[5] lets you de-solder the two- or many-legged chip to replace it (or to rotate it 90 degrees!). No connection to me – look for the smallest pack – it's a lifetime supply.
9. If you can't solder a fine pitch or ball grid array chip, there are companies who will do it for you. I have used Allgood Technologies[6] (Peter G8RXJ) for a ball grid array chip. Again, no connection.
10. And a little practice…

The Hermes Lite Project[7]

This is a reaction to the high cost of buying a ready-built radio such as the HPSDR Hermes card, which provides, with no compromise, a low power transceiver on a single board.
Hermes Lite was started a couple of years ago. It has the objectives, amongst others:

1. Low cost. The aim has been to provide a transceiver for about the same cost as a Softrock radio, if the cost of Softrock's sound card is included.
2. Open source. All of the project design files are available freely on the internet[8]. The printed circuit is designed using Kicad[9], free open PCB software. Gerber files are available should you wish to have bare boards made.
3. PCB available with all surface mount components ready fitted. The PCB design files are available so you can have boards made and assemble your own. (I shall!)

It is an open-source development and uses HPSDR design elements and interface, which means it can use the same software. The project has also returned the compliment, HPSDR having incorporated some of Hermes Lite's design improvements.



Hermes Lite 2, beta test PCB, awaiting fitting of through-hole components

Free and open-source software is available: the hardware is compatible with OpenHPSDR compatible programs running on Windows (e.g., OpenHPSDR[3] and SparkSDR[10]) and Linux computers (e.g., Quisk[11] and PiHPSDR). PiHPSDR by John Melton, G0ORX[12], will run (well) on the raspberry Pi2 or 3 with the 'official' 7-inch touch screen. There is a design that integrates the Raspberry Pi and touch screen with a tuning knob and other controls. This provides a stand-alone 5-Watt transceiver (no PC needed).

OpenHPSDR, running under Windows, also supports the amazing 'Pure Signal' software that cleans up the intermodulation distortion in your PA.

The main compromises of Hermes Lite, compared with the OpenHPSDR Hermes board are:

1. The A/D convertor is 12-bit rather than 16-bit. This reduces the overall dynamic range, but will only affect you if you have extremely strong signals (e.g., a broadcast station) nearby. Filtering of the receiver (even your antenna tuner) will generally solve this. I live in a fairly rural location and can see no difference at all here.
2. Maximum frequency is 30MHz rather than 50MHz.
3. No audio input/output is provided on the board – you need to use the computer's sound card and software such as VB-Audio (free).
4. Only two receivers can be run (compared with Hermes, currently with 4) reducing the width of spectrum that can be displayed to 384kHz.

The radio will fit in a small extruded aluminium case, including the 5W PA and a filter board.

The design is currently in beta test prior to issue at version 2, which looks likely to be early this year. The current build is beta 5, for which a batch has been built in China and the cost looks like it will cost about $165. You can get a set of beta 5 boards made today if you wish to make one yourself.

Version 1 was homebrew, including mounting the surface mount components. It used an Altera BeMicro CV FPGA (Field Programmable Gate Array) prototype board, now difficult to obtain, to avoid the need of soldering the FPGA (version 2 has the FPGA on the board). I built versions 1.1 and 1.2 and I could not really see any difference between their performance and that of the OpenHPSDR Hermes board (I live at the edge of a small village, well away from other transmitters). The version 1.2 board can (with special firmware) even run the Pure Signal software which pre-distorts the transmit signal to cancel out transmitter intermodulation distortion.

References:-

1. Softrock radios: http://www.wb5rvz.org/ensemble_rxtx/
2. Pic-A-Star: https://uk.groups.yahoo.com/neo/groups/picaproject
3. HPSDR: https://openhpsdr.org/
4. https://www.youtube.com/watch?v=3NN7UGWYmBY Curious Inventor SMT soldering
5. ChipQuick: http://uk.farnell.com/chip-quik/smd1/removal-kit-smd/dp/1850214
6. Allgood Technologies: https://www.allgoodtechnology.com/
7. Hermes Lite: http://www.hermeslite.com/
8. Hermes-Lite Github: https://github.com/softerhardware/Hermes-Lite2
9. KiCad: http://kicad-pcb.org/
10. SparkSDR: http://www.ihopper.org/radio/
11. Quisk: http://james.ahlstrom.name/quisk/
12. PiHPSDR: http://g0orx.blogspot.co.uk/

When the obvious is not obvious! By Pete Juliano N6QW

When the car won't move and the tire is flat that is an obvious cause and effect! But when your rig does not work – the problem may not be obvious and the cures applied may be totally wrong. I wanted to share a trouble shooting experience in hopes other will take up the charge before applying a 10 stone sledge hammer to your beloved homebrew rig. But let's back up a bit and start from the beginning. I have a large box of rigs that were built perhaps 20 to 25 years ago and somehow didn't work, worked once and died or would never work. Since I am one not to give up, my comment when placing a rig in the box is "someday". Well that was a case with one such rig that was rebuilt over the Christmas 2017 holiday.

The rig was on 20 Meters, had a 9 MHz IF and originally started as a receiver as shown on page 104 of the Solid State Design for the Radio Amateur. Some twenty years ago I figured out how to make that receiver into a transceiver. It "sort of worked" but not too well and my 2017 goal was twofold: 1) fix the rig and 2) update the rig with a digital VFO/BFO and add a super cool color TFT display. All went well with the two goals being met and I had it on the air making contacts. As it turned out, one of my original problems was a bad crystal filter! Suddenly without warning I noticed that the receive function on my rebuilt rig was intermittent. Not that it would die; but that it would periodically lose signal strength and then regain same. The problem appeared only on the receive side but not the transmit side. Now there are many common circuits for both transmit and receive; but some are exclusive solely to the receive end. Thus my concentration was on these receive specific circuits.

I looked for the cold solder joint or perhaps two wires coming in contact and lastly perhaps an intermittent cap or even a device going south. In desperation I rebuilt the whole front end mixer stage which originally had a 3N211 Dual Gate MOSFET. I did find two components that were not the original values specified. So my faulty reasoning was that with age the circuit drifted and now those different values became critical. So the wrong brute force solution was applied where I completely rebuilt that stage with all new components including using a NIB 3N209. That seemed to have cured the problem for a short time; but then it returned again. Next I looked at the homebrew single balanced mixer that followed the MC1350 IF stage. On receive it was a product detector and on transmit it was the transmit mixer stage. I pulled that circuit and replaced it with a packaged TUF-1 reasoning perhaps some bad diodes. Same problem –works and then intermittent. I was running out of things to replace.

At this point I decided to put aside this rig and use another rig to make a few contacts. Boom same problem, different rig. I tried a third rig, and there was that same issue. Then it hit me –something is coming down the antenna. I thought about it overnight and the next day I simply hooked up my DSO (Digital Storage Scope) across the antenna leads and there it was a very strong signal! In fact at one time it was 200 milli-volts pk to pk. All sorts of light bulbs went on when my scope told me that the incoming frequency was 14.07475 MHz. Here it was –a digital station on 20 Meters that was desensitizing my front end. I have a ham directly behind me (maybe 300 meters away) and on my daily walk I noted a new antenna is his yard. To affirm the same I dialled in my rig to 14.07475 while powered on and I could watch the signal on the scope and see my S Meter get pinned and of course a very loud sound from the speaker. The problem was my ham neighbor was running JT-8. There is a you tube video of this discovery.

https://www.youtube.com/watch?v=hRQDWG3tSkI&t=175s

So the lesson is to have a disciplined process for troubleshooting & to also think outside the radio and look at what is coming through the antenna. Smart money would have had me connect the rig to a dummy load and use an RF Oscillator as a signal source – when it was not intermittent that would have been a clue.

Have now added to my process: check signals coming down the antenna! N6QW

The External Variable Frequency Oscillator

Keen constructor Charles Wilson M0CDD, sent along some notes on how he built the VFO for his beautiful replica spy set – on right. He had visited a steam enthusiast who had a single boiler for his many engines and it made Charles realise that one really good external VFO, would be preferable to several mediocre ones! 'Less of the best is better than more of the worst!' (Before you say this is all old hat now we have DDS etc, I must point out this project started many years ago! G3PCJ) The main part of this rig (central box) is a 9 MHz IF superhet so for 40m he included a 2 MHz VFO, and later decided to add 20 and 80m with a separate alternative VFO running 5 to 5.5 MHz; there was not enough space in the main case so he added the small VFO box nearest camera. The furthest box has a loud speaker, another VFO with space for a huff-n-puff stabiliser. (Charles adds the comment that the valves are decorative! I know of another replica spy set where G0HDJ has installed all the transistors in the metal valve cans! Tim)

After taking them out in the field, and much use under arduous conditions, Charles' VFO suggestions are:-

Keep the VFO frequency as low as possible. (Consider crystal mixing for higher frequencies.)

Front panel should have a light colour to reflect heat or sunlight!

Use negative temp coefficient fixed capacitors to compensate for positive tempco inductor.

Have two stages of amplification or buffering after the VFO to avoid pulling by cable changes.

Build it in a metal diecast box for rigidity and screening.

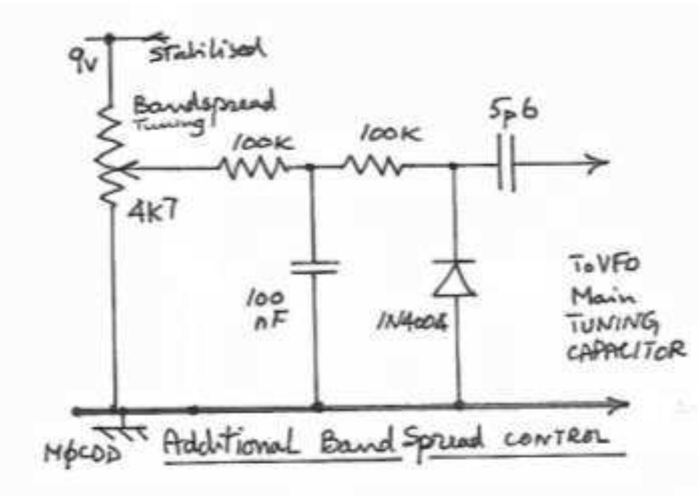
Decouple the power lead heavily at both ends and use good voltage regulators.

Use good quality miniature coax for all leads – RF out, DC power in and any RIT etc.

Check the cable (and any intentional) attenuation produces the right level for your rig's mixer. (NB. SA602/612s only need 150 mV p-p instead of about 1- 2 volts for diode mixers.)

Use good quality air spaced variable capacitors with slow motion drives and large dials. (Mainline Electronics of Leicester are thought to still have stock of Jackson parts.)

Consider adding band-spread capacitor – small air variable or electronic as circuit sketch below.



That's enough for this time – my thanks to all our contributors and keep the material coming please - enjoy the Spring good weather! Tim G3PCJ

“JOURNAL OF THE CONSTRUCTORS CLUB”

Hot Iron

Summer 2018 Issue E100

Editorial – all change!

This is the hundredth issue of Hot Iron and its time for me to stop electronic waffling! A lot has happened in those 25 years and the nature of our hobby has changed a great deal. Perhaps more than anything is the massive invasion of digital techniques into what is actually an analogue world! I have sounded off on this topic before and it is quite obvious now that the larger projects (due to lots of facilities or many operating bands etc) will have digital signal processing at their core. This is a whole new ball or technical game which, for various reasons, I am not able to ‘play’ – certainly not just at this moment – due to house moves and changes in the way we run the farm with our son. Over this last 25 years I have had fantastic support from a very large number of people – technical contributors, publishers and others who have waved their flags publicising this journal; we would not be here now without their generous help and for that I want to say a very big THANK YOU to all of you and them. Some of you have very kindly put up with my arm twisting and your articles lend a most important variety into what can be pretty dense prose! And of course, I must also thank you the readers. Inevitably, it is only a few who actively contribute to any journal, but the mass of readers must also be broadly happy with this sort of rambling, otherwise you would all have asked to be removed from the list! So thank you to all readers as well!

But Hot Iron should definitely not cease! Many of you will have seen regular contributions from Peter Thornton G6NGR who has kindly agreed to take on the role of putting Hot Iron together in future. Decades ago Peter and I both worked for different branches a UK firm that was at the forefront of all sorts of electronic applications – sadly it suffered a financial disaster and no longer exists – but he brings a vigorous alternative view about the technology of the future! Later in this issue he outlines his plans for Hot Iron and you may expect several of our regular authors to continue their offerings; I am not stopping production of radio kits so I will continue to write on my favourite themes for Peter from time to time!

To avoid you all having to re-register your desire to continue receiving Hot Iron, I have passed the distribution lists to Peter Thornton G6NGR on the basis that you are all happy to continue getting it and with ample opportunity to say otherwise earlier. He will be keeping all the data very securely in line with the new EU regulations. If any of you are unhappy with this and do wish to stop any further issues, please e mail either me electronics@walfords.net or Peter equieng@gmail.com and say unsubscribe! Peter has outlined his background and intentions for the future later in this issue. So a big thank you from the first Editor of Hot Iron and I now pass you into the capable hands of the second Editor! Tim G3PCJ

Contents

Hot Iron is published by Tim Walford G3PCJ of Walford Electronics Ltd. for members of the Construction Club. It is a quarterly newsletter, sent by e mail, & free to those who want it. Anybody wishing to receive Hot Iron in future should ask Peter Thornton equieng@gmail.com to add you to his list.

Peter's background and his intentions for Hot Iron!

Tim and I worked for a national electronic, electrical, power distribution and instrumentation company for some years; Tim in digital and analogue design and me in semiconductor manufacturing. As a Technician / Graduate Apprentice I was involved with Research and Development of light emitting diodes, in the late 1960's and early 1970's, building and testing equipment designed by PhD physicists working on sub nano-second pulse gallium arsenide laser LED's and gallium phosphide Shottky barrier LED's.

This brought me into sub-nano second design, which, of course, is the foundation of RF engineering, and the realms of people like Ivor Catt, who propounded radically different principles than Maxwell's equations predicted: this "sideways" R&D view of electrical phenomena has stuck with me all my life. We had superb professional RF engineers working on silicon power RF transistors for Military purposes, who taught me a great deal about RF methods, measurements and test, and Production Department who manufactured devices in quantity. I became a familiar sight around the plant, and soon found a source of unique knowledge in the Maintenance Department: for all-round electronics experience and knowledge, you'll not beat a Maintenance Department!

I was soon applying my newly gained knowledge of RF to high power RF power generators, used in silicon epitaxy (the growing of nano metre single crystal silicon layers). These RF generators fed 500kW of RF to water cooled work coils, mounted beneath a graphite "susceptor" to heat it up – fast. Fast, as from room temperature to 1250°C in less than 5 minutes! The process ran in a hydrogen atmosphere – any air leaks and the process is a bomb! I had already handled cathode ray tubes and their EHT power supplies – safely working with 200kV / 10mA DC supplies every day brings about a steady hand and mind when repairing their Test Gear!

My working with RF soon had plenty of radio amateurs from the plant calling round, as we had esoteric bits like 4CX250B valves (and bases!) by the bucketfull – when the RF output dropped, we changed them out, but they were perfectly adequate for amateur service. We had dozens of vacuum variable capacitors, co-ax by the mile, all sorts of highly prized amateur components as it was very much a "build it yourself" age – commercial equipment was available but very expensive and un-fixable to a great extent – so we built our own in the main.

As Tim mentioned, the Company ran aground financially for various reasons ("lions led by donkeys in my opinion") so I became self employed and worked in any and every opportunity for power electronics, electrical engineering and instrumentation – telecomms in mines, renal dialysis monitors, opto-electronic bottle inspection machines in breweries, to name but a few jobs I was involved with – and loved the working life all over the World, meeting people, different cultures and methods of working.

So that's my background: build it, test it, use it, fix it when it goes "bang" - if it's 12 volts or 12 kilovolts, 20kHz or 20GHz, fA to kA. Modern DDS and associated programming I find personally quite do-able; though I'm no software designer, but I know software designers who have offered to help Hot Iron readers. Similarly, several world class RF designers are willing to publish their ideas in Hot Iron.

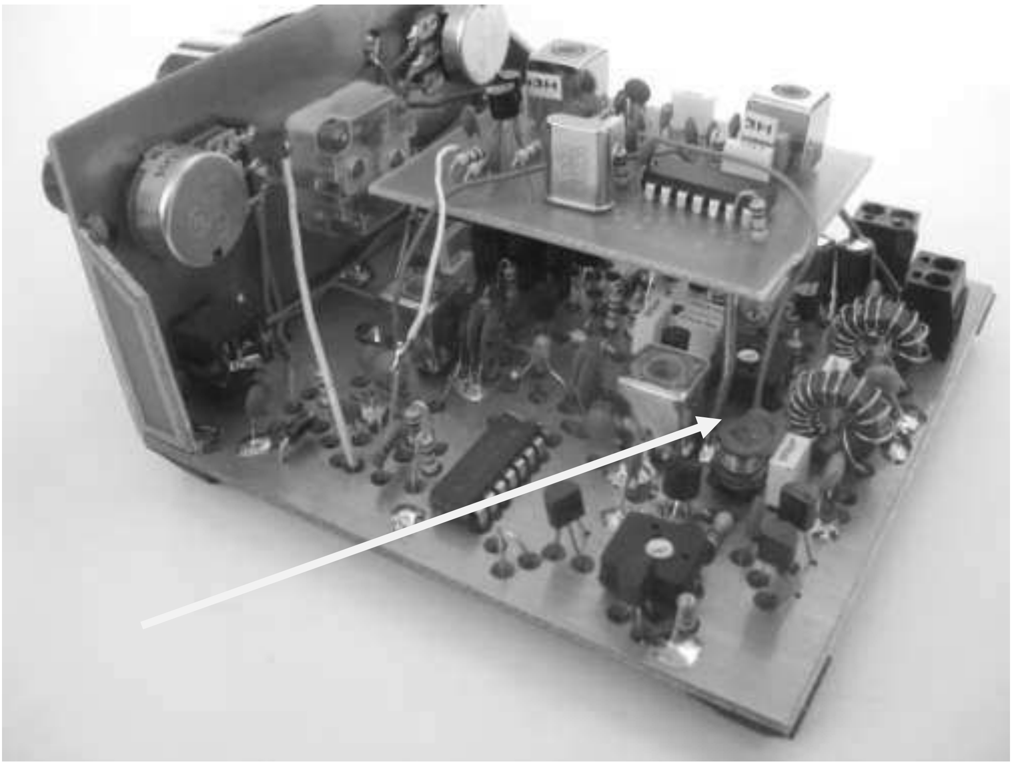
Tim, of course, has a permanent place in Hot Iron. "Tim's Topics" is a regular spot for Tim to keep us up to date with his superb and elegant analogue designs, and his comments on the World of Amateur Radio. I want to keep Hot Iron very much in Tim's mould, "home construction" being the key with "best out of the least" as a guiding principle. Hot Iron has a World-wide readership, and the different "flavour" of Amateur Radio is very much appreciated by all it's readers and offers refreshing alternative views. Please continue to enjoy Hot iron; I welcome any and all comments and ideas. Keep them coming. Hot Iron exists to make amateur radio home construction open to anyone, whatever technical, financial and workshop capabilities.

Hot Iron is for it's readers: feedback, ideas, suggestions are most welcome. Direct them to me please, at equieng@gmail.com on any and every topic relevant to amateur radio. The new EEC directives about data security apply to Hot Iron and in future I will be keeping your e mail addresses suitably securely. I will assume, since you have not asked to be removed from the list that you wish to continue receiving Hot Iron. If you do not want any more Hot Irons, please send a mail to Tim electronics@walfords.net or me Peter equieng@gmail.com saying 'unsubscribe'.

Peter Thornton G6NGR.

Kit Developments

The Culm After the unfortunate PCB layout error that I mentioned last time, it was clear that I had to revise the track pattern quite extensively! This was more annoying than difficult and I am pleased to report there were no further problems! It is working well and being given a through exercise by Geoff G3WZP who writes later about his direction finding experiments for school kids. The basic rig uses a ceramic resonator for 80m, or a crystal on the higher bands, which leads to a very restricted tuning range due to the inability to pull a crystal more than a few KHz owing to their very high Q. There is not a lot you can do about this because ceramic resonators are a bit prone to change their resonant frequency with temperature variations – over about 5 MHz this effect is too bad even if you can find a standard resonator in a suitable part of any band!

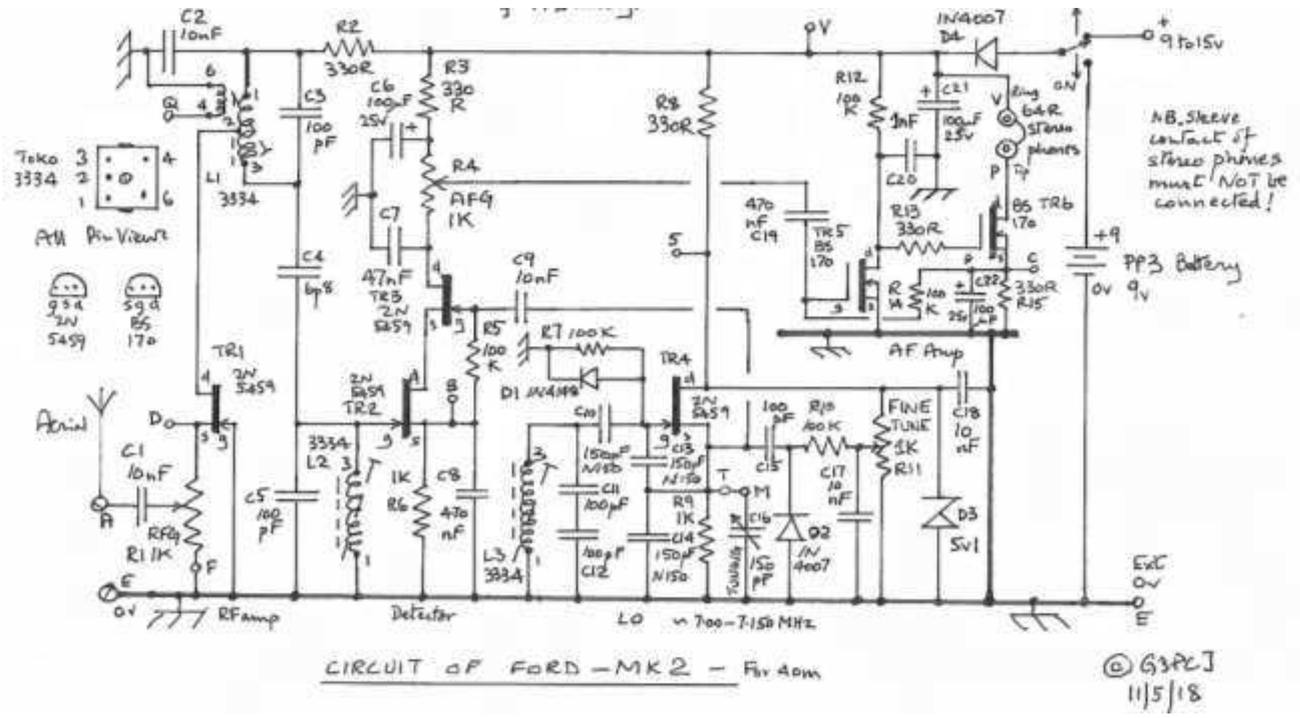


So more head scratching! Crystal mixing using the Mini Mix kit with a conventional VFO is the obvious answer but that would require changing the Culm's oscillator to a LC oscillator and would need quite a lot of track alterations. Instead, fitting a 4 MHz (or 2 MHz) ceramic resonator to the original circuit and then mixing this with a suitable band crystal is a simpler approach. This requires less parts hence the smaller Digi-mix kit which is shown mounted piggy back on the four copper stout wire supports (one arrowed)! The frequency schemes for these higher bands are shown below. G3PCJ

Band	Centre Freq KHz	Variable Oscillator KHz – ceramic resonator	Crystal Oscillator KHz
20m	14060	3940	18000
30m	10120	3940	14060
40m	7030	3970	11000
40m	7030	1970	9000
60m	5262	1986	3276
80m	3560	1940	5500
80m	3560	5440 (LC VFO maybe!)	9000

The Ford – Mk 2

Steve Hartley G0FUV has been in touch, as he has been considering using the very simple Ford for a 40m Buildathon project this summer. It made me try the rig again rather more thoroughly with a view to a reproducible production model. It soon became clear that some improvements would add little to cost while much improving performance! The audio stages were fine and catering for output to modern lightweight 32R phones is much easier than driving a loud speaker which is not as readily available as phones are nowadays – so no changes there! But at night the simplicity of the mixer showed its weakness to the nearby 40m high power AM



broadcast stations.

A change to series connected JFETs product detector (simulating a dual gate MOSFET), with a double tuned RF filter instead of single tuned and an RF gain control, much improved its ability to eliminate the BCI! But it was still full of microphony and prone to hum when the aerial was connected! This all points towards unwanted radiation of the Local Oscillator signal which then beats with itself in the product detector and makes the whole RX very tender! The cure is very simple – add an RF amplifier which does not pass the LO signal from the mixer back through it to the aerial and these troubles then disappear! The extra stage can easily be another JFET and the improvement is huge. It was also convenient to change the oscillator to a Colpitts circuit and with coverage of the whole band desired, a Fine tune control becomes necessary. Frequency stability against supply variations then suggest an internal Zener supply is needed! After these modifications the RX is no longer a toy but is capable of some serious listening! Free space wired version right – Pete N6QW calls it ugly construction! I have now laid it out on a single sided PCB with plenty of space etc. Revised circuit above! G3PCJ. Photo by G0FUV.

A New Tool in the Tool Kit!

Pete Juliano n6qwham@gmail.com

For those who perhaps have seen my websites or my blog, you are probably thinking that I now have some new Arduino based "Tool" that completely functionally tests a homebrew transceiver. Sorry to disappoint you but it is not that tool. That said—I am thinking about such a device; but mind you we are just thinking at this point.

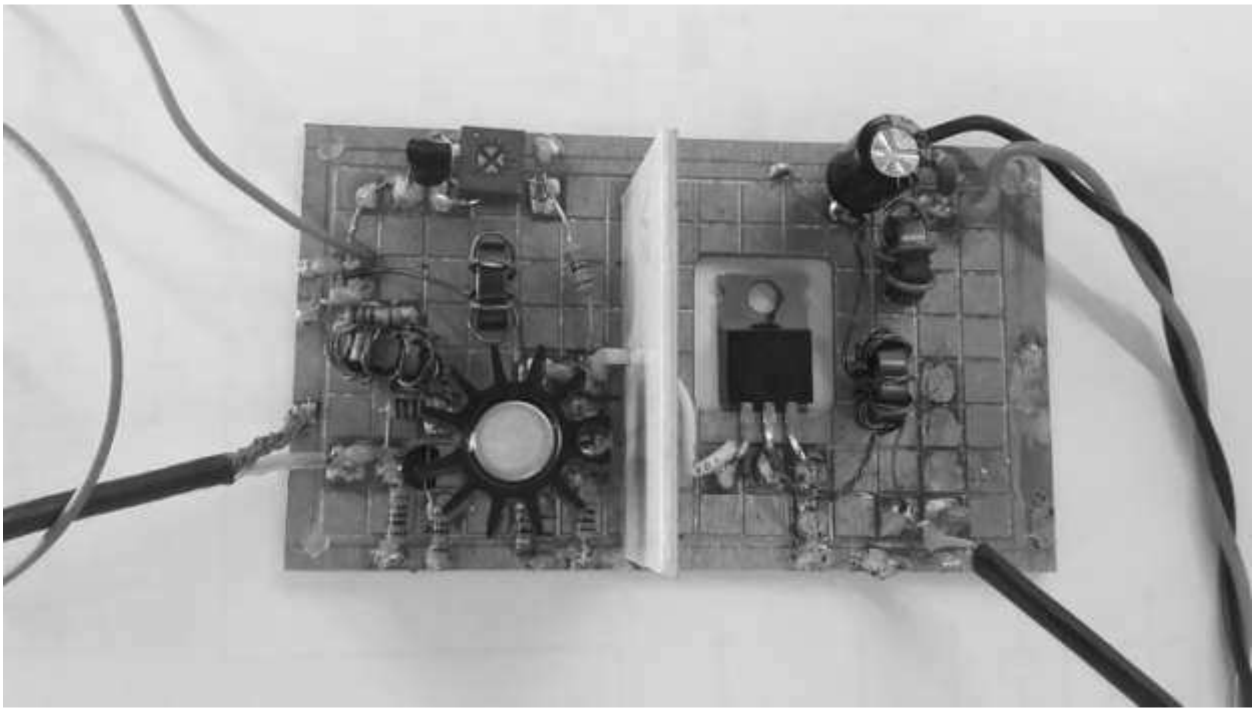
My tool is more fundamental as it involves the making of PC boards using a CNC Milling machine. Remembering back to when I first started homebrewing, one of the most critical skills was metal bashing. Often virtually all of the project time was consumed metal beating and filing out round and square holes. A problem with this approach was that if anything changed –more metal bashing and many more holes in the chassis. With the advent of solid state devices and their widespread use – putting large holes in a metal chassis was like the wearing of brown shoes with a black formal tuxedo.

Enter the era of Manhattan construction and its first cousin "ugly construction". Manhattan for those who may not know is the use of small copper squares that are super glued on to a piece of copper PC Board. Using these isolated pads provided convenient soldering points for connecting wires and components. The term Manhattan reflected that often components would rise from the pads like skyscrapers much like the New York (Manhattan) skyline. Ugly construction just tack solders anything, anywhere. Often 20 Meg Ohm resistors are vertically soldered to the board and provide the anchoring points as not very much of a signal passes through 20 M Ohm.

There are some advantages to both these types of construction and chief among these is rapid prototyping as you just tack solder here and tack solder there and move right along. But there are some issues as well with these methods.

- Circuit interaction –in the haste to "get er done" there are issues of possible feedback paths with the close proximity of components and wiring. Layout is critical but often neglected.
- There are many opportunities for shorts and solder bridges as the random process of ugly construction simple takes the shortest path. Mind you I have seen some very sanitary ugly construction builds that rival a PC board. Then again there are some plain "ugly ones"!
- Circuit tracing becomes problematic especially when "get er done" doesn't "get er to work"
- Repeatability –suppose you want to build an exact second unit?

Enter the modern era table top CNC Milling Machine. Machines capable of building circuit boards such as shown next can be found in the $200 to $300 range.



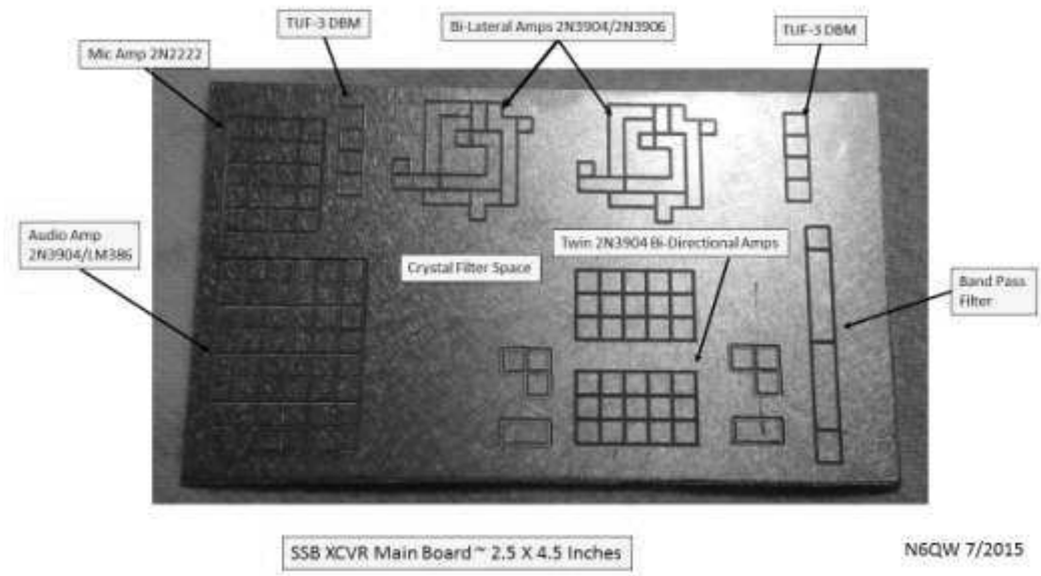
Linear Amp Board for one of my SSB Transceivers.

This linear amp board has the 2N3904 driving a 2N3866 (from EMRFD) and the second half has an IRF510 final amp.

Essentially the outside of the board area is like a picture frame which when bolted to the chassis is a common ground. Using the CNC, I milled out the area where the IRF510 (with a suitable insulator) is bolted to the back of the case where the case becomes the heat sink. The squares are 0.2 inch and thus the board is less than 2 inches wide.

The squares give you the flexibility to make changes without any metal bashing. A piece of PC Board vertically soldered to the board and then grounded to the window frame provides a shielding between sections. The Bias Circuitry for the IRF510 is in the upper left hand corner of the board. Originally I had the LPF on this board (lower right hand corner) but decided to locate it at the antenna terminal so that the LPF would always be in line for both transmit and receive.

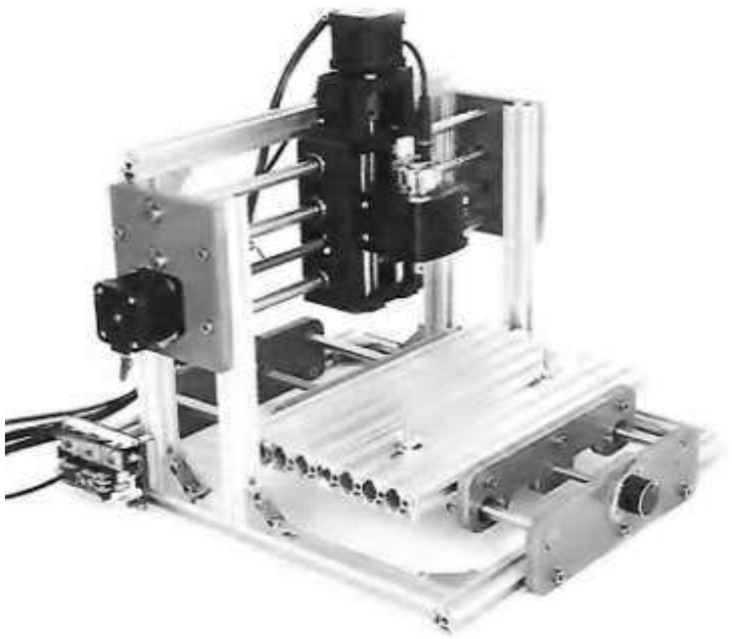
One might think of this as an Uptown Manhattan as the squares are cut with a CNC Milling machine and can be any size of an array (4X4 or maybe 6X8 or a complete board). I have these stock arrays in the computer and thus can choose to have a small array at one location on the board interspersed with larger arrays such as shown below.



I used my CNC to build my KWM-4 (a solid state version of a Collins KWM-2), as the machine can build more than just circuit boards. The front panel “Collins Look Alike” Escutcheon was made using the CNC Mill and it is important to note that I have just basic skills with the machine and thus if I can do it you can do it! Yes that was a piece of copper PC Board! You have to admit it does look like the Collins gear.

So what does it take to get started using the CNC Mill for your project? There are but a few minimum requirements to start making CNC Milled boards in your lab/shack.

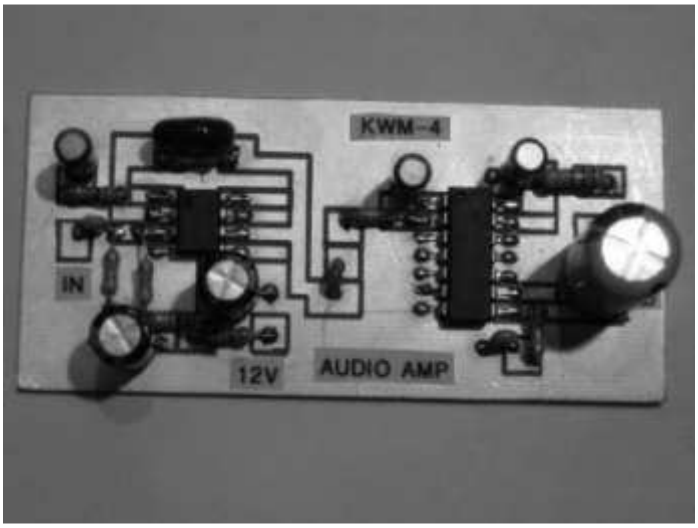
- The first piece is the CNC machine itself. These are sold on eBay and other auction sites and are advertised as CNC Engraving and/or table top milling machines. The low end machines are in the $200 to $300 range; but the most critical item is the work surface area. Look for ones that have a work area of 100 mm by 150 mm. For guys like me, on this side of the pond, that is about 4 X 6 inches. You will likely need to fabricate some hold down clamps which typically fit in the slotted sections of the mill bed. Holding the part secure is paramount to the successful board construction. Don't forget to anchor the mill to your work bench. The machine will move when it is cranking away cutting material, a scary observation indeed! For cutting PC Board I use a 60 degree engraving bit. For other cutting (like milling out the IRF510 hole) I use a four flute 1/16 inch end mill.



This is a typical example of one of the CNC Mills that can be had in the low dollar range. The bed has two posts with wing nuts so that the board can be held in place during the milling. Most of the machines can be used with computers running XP through Windows 10 and some even Linux.

- Next is the design software. I use a free program called G Simple which is not a PC Board specific program. My boards are usually the "island squares" as I can easily call up a rectangle and I know that IC's have 1/10 inch spacing on the pins. You can get pretty good at doing this with nothing more than squares and straight lines. A secret revealed: I use ¼ inch graph paper to first layout the circuit that starts first by drawing an XY axis on the graph paper and then where each square or line is placed, the coordinate of that square or line is noted. I call each square 1/10 inch—keeps it simple. Transferring that into G Simple is a simple matter of using the graph paper coordinates as the input coordinate for G Simple. The output of the completed design is called a .dxf file. This file is the subsequently loaded into another free program called KCAM. This step is need to translate the .dxf file into "G Code". The G Code is what tells the CNC where to cut. There are some other actions taking place in the background where the G Code actually sequences the cuts for the most efficient use of the machine. It is really weird to watch the CNC start cutting at one location and then move to another place and then later on to back where it started – it is all about efficiency. Bottom line –you design it in G Simple and then the "ghost in the machine" takes over from there. There are other design programs which are PC Board Specific and have templates for IC's and transistors. That is too complex for my old and tired brain.

Here is a board design that started with the graph paper and then a cut board. The photo shows the board stuffed with parts. Keep in mind the short comings expressed earlier. I can trace this circuit and have minimized short circuits!



This board is in my computer so when I want another audio amp module I call up the program and cut away. A little labeling makes it look quite professional. This is an LM380 audio amp that uses an NE5534 as a pre-amp stage. I have a similar layout that uses a 2N3904 in place of the NE5534.

- Finally the computer can be almost anything and that might be a good use for that old 300 MHz laptop that is kicking around the junk box. In the case of the new machines that are being sold the actual cutting software comes with the machine so you get a bonus with the purchase. In my case my son built me the machine (it is a little uptown from the eBay ones) and it uses Mach III for the milling software but is running on a windows XP machine.

There is a learning curve here so start really simple with small arrays and as a suggestion go to a tile store that sells vinyl tile squares. Often the store will give you a free stack of obsolete tiles. Tiles make wonderful practice pieces. Often I will test run a design and if all looks good I will then load a piece of PC Board and fire away.

Hopefully this has sparked your interest in CNC Milling your next project.

73's

Pete N6QW

The Culm and Direction Finding

As a volunteer with the Royals Signals Museum visiting schools to talk and demonstrate equipment and seeing how the youngsters like "hands on" exhibits, I suggested that a small transmitter hidden in school grounds and located by DF would show how easy (!) it was to locate SOE radio operators in Occupied Europe by the German authorities …particularly as the exhibition features the short life of the mainly female wireless operators during World War 2. At one stage I looked at getting the Museum's "SOE SPY SET" operational but there was a reluctance to tamper with this set and young students near HT voltages was not deemed acceptable. (Too much paperwork if we electrocuted a student or a teacher!)

Looking around for a reasonably priced and straightforward way to achieve our aim, I contacted Tim and he suggested an ISLE TX and a YEO RX to proof the concept ….and so I ordered a kit of each and waited by the front door for the kits to arrive. To my astonishment there was no sign of an aluminium chassis, International Octal or B9A valve holders just a number of small packets of components and comprehensive instructions. Well after checking out these mysterious looking components out came the 40W pencil bit soldering iron with the 200 Watt soldering iron consigned to the cupboard and the kit building began …(bearing in mind I am a valve man and own an AR88 , BC348 and Sommerkamp valve TX/RX).

Initially I would prove the concept on 3.5MHz before utilising a dedicated freq in the MOD/ Cadet Force allocation in the 4 - 6 MHz (yet to be confirmed). Well the YEO was straightforward apart from my poor eyesight mistaking a Zener for an IN4148 all worked well with plenty of European stations being heard in the early evening. On to the ISLE which again was straightforward except my ignoring some of the "test as you go" stages in Tim's instructions which meant I had to backtrack a couple of times but soon it produced 1W or so of RF on 80mtrs.

Next was a quick DF loop made from 14mm Copper tube and 7 turns of wire tuned with a POLYVARICON variable and a 1 turn tap to the YEO RX. Despite the measured loop inductance I couldn't get it to tune (Probably excess inter-turn capacitance – G3PCJ), so a bit of empirical design work resulted in 5 turns which peaked mid tuning range with variable cap. To increase the amount of signal being received a second loop was made with a 22mm copper tube and a larger loop diameter (right) so this time 4 turns were resonated with the variable capacitor tuning mid range and a separate 1 turn loop to feed the RX. Note - the outer copper pipe loop is a shield which does not form part of the resonant circuit. The results were very good and sharp nulls could be obtained some half a mile away with the ISLE TX feeding a 30 feet wire without any matching and running at 9v input.

So far so good BUT the design parameters from the Museum changed - would it be a good idea to have a remote team hidden sending CW messages to a team based in the school with both being DF ed?

So back to Tim with yet another E mail and he quickly came up with CULM transceiver combining the two on one PCB and after a quick design and prototype build by Tim, which worked well, I ordered 4 CULM and waited the arrival of the new kits. Tim also designed the DIGIMIX simple mixing kit to achieve a wider tuning range on 7MHz.

Well I had learnt my lesson and built the CULM with every stage being tested as per Tim's instructions and soon had the RX receiving CW on 80mtrs in the early evening with my fairly low, end fed wire connected. The TX section quickly followed and yes there it was lots of RF output on 80mtrs with a nice clean keying action. So what about contacts asked Tim? Well a quick change of taps on my lashed together ATU (note to self tidy it up!!) and I managed to get the SWR down to 1.2:1 and RF seemed to be getting into the aerial and not coming back so called F6FAI without too much hope of a reply and yes - you've guessed it a QSO resulted with a creditable report of 559 from Brittany ….haven't been that excited since my first QSO with a CO – PA TX (6C4 and 6CH6) with a 3.55MHz 10XJ Crystal and a R1155 RX back in November 1967!

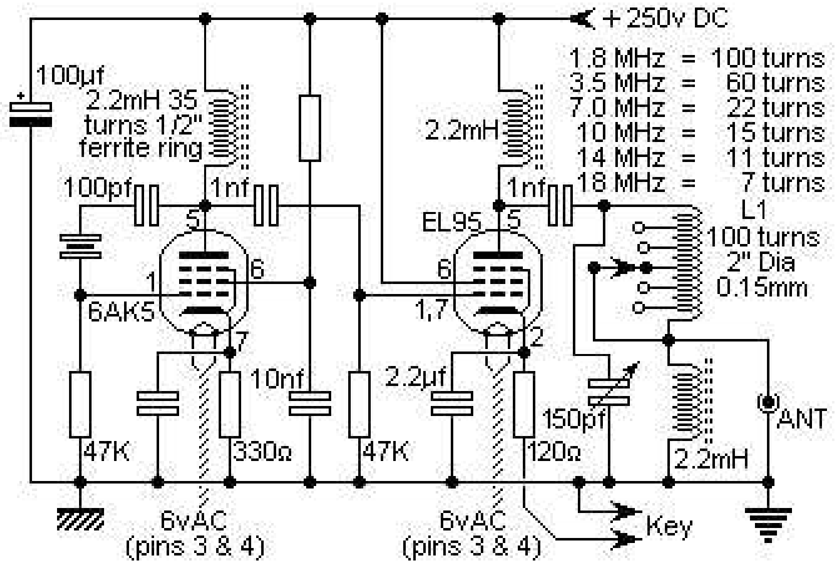
Casting around for a suitable housing, my love of tea drew me to the kitchen for a quick cuppa and I realized a YORKSHIRE TEA TIN was just the right size! A classic dilemma …which would prevail - my love of tea or the need for an enclosure? Well this is where the staff at YORKSHIRE TEA came to my rescue and after an E mail detailing the project, a parcel arrived with 4 tins inside ….. see picture below for the prototype unit now fully operational and just as important the XYL still has a container for the Tea !

Next stage of the project is a demonstration for the Museum Staff and construction of 3 more CULMs with one for personal use on 40mtrs with /P operation to hopefully escape my high urban noise level.

Coming soon … the next installment on the conversion of a G3 valve man to the new fangled semi-conductors ! Geoff Budden G3WZP

Back to the Future? ***A new look at old ideas – Pt 1 - The TX***

Below is a typical circuit diagram for an amateur radio transmitter of 60 years ago (from http://www.sm0vpo.com). Whilst it is "old tech", it's a good reference for an easy project that can be built on the kitchen table. It is fair comment to say that valve days are past for most of us, but stick with me – there are beautiful features you won't find in modern designs using a +12v power supply.



Let's take a look at the circuit: the 6AK5 device is a small signal pentode ideally suited to the oscillator section of this design. If you think of the 6AK5 as a "JFET", you'll recognise a Pierce oscillator, the crystal feeding back from anode to control grid ("drain" to "gate" in JFET terms).

The signal from the oscillator (which runs continuously) is coupled into the control grid of the EL95, an audio pentode, to be amplified to the final output level of typically 5 – 10 watts depending on the frequency. The output power is developed across the 2.2 mH anode choke and fed to the tapped coil and 150pF tank circuit via a 1nF (high voltage ceramic) capacitor. The taps are for impedance matching and the lower 2.2mH choke is for DC safety: if the 1nF anode capacitor fails short circuit, the lower 2.2mH Radio Frequency Choke shorts the anode power supply to ground and blows the fuse, so the antenna never has DC present.

The first thing to note is the frequency range this transmitter covers *without any change of components*. The second is that the output can be *connected to any antenna*. The third is the overall *component count*: it's very low for the power output. Fourth is the Radio Frequency Chokes are non critical; they are simple home-made devices, because the RF power is developed at *high impedances*.

The items above *in italics* are the key: this design is radically different than a typical 12 volt supply transistor or MOSFET design as regards impedance levels. A transistor design for this power, running off a +12 volt supply, would have to have (at least) a 1:4 ratio transformer coupling the collector/drain for impedance matching to 50 ohms: the collector/drain impedance would be estimated from (Supply Voltage)^2 divided by (4 x Power Output) in watts (for class A operation). Therefore for 12 volt supplies, and an output power of 5 watts, the collector impedance is ~ 7.2 ohms! For class C operation, it's roughly double that; 15.2 ohms!

Calculating the value for the valve circuit above, the anode impedance is 4500 ohms for class A operation, and 9000 ohms for class C; a huge difference that simplifies the design parameters, matching and eliminates "lossy" high current components (losses are proportional to i^2R) - and most likely of frequency critical construction. Antenna matching in high-Z circuits is very simple; coil taps or an over-wound link of a couple of turns over the tank inductor can be used. You can't get simplicity with effective harmonic reduction with a 12v supply is a fundamental truth.

There is, of course, a price to pay for simplicity: it's a high voltage anode supply that is (usually) neither portable nor convenient – and not thought safe! To sum up the problems in today's terms:

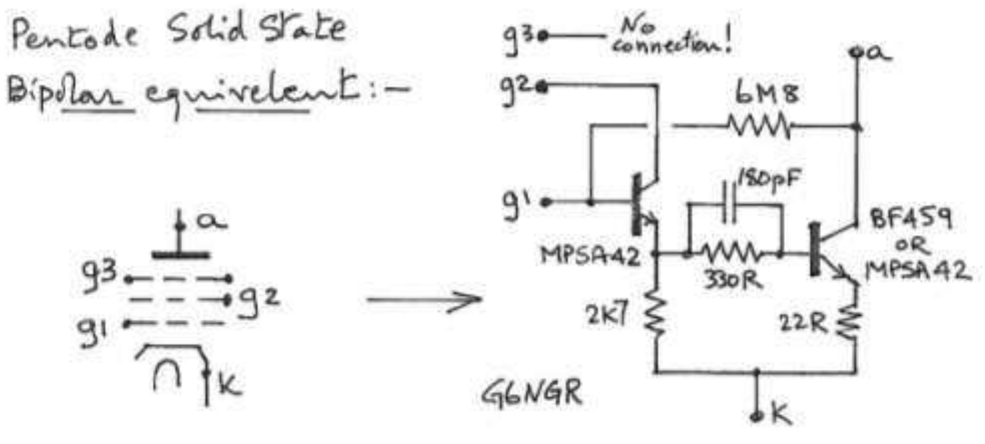
- a high voltage power supply is required
- valve heaters that consume many watts of power
- valves are hot, large and fragile
- are becoming hard (or expensive) to find/buy/scrounge

How to overcome these problems and bring the design, with all its plus points, up to date? A modern design has to be portable and rugged, low volume and weight, and efficient in power terms. The answer is a dose of solid-state!

There are designs for solid state replacements for valves; they were created in the 1960's to replace the fast disappearing valves as transistors began to seize the market, being both cheaper and easier to use than valves, considerably smaller and more robust, too. The transistors then couldn't give high voltage with high frequency capability; but improved modern transistors fit the bill nicely for a "solid state valve".

The need for high voltage supplies is the price to be paid for simplicity. This isn't as serious as it seems: valves don't need more than a few tens of milliamps (for 10 watts RF or so), the design of a power supply is non-critical – it can be a low noise design with an off-the-shelf toroidal transformer (= low cost). That then is the proposal: the problems outlined can be beaten with solid state technology, making the simple "valve" circuits a real contender for rugged, reliable, portable equipment.

The circuit detailed below is designed to "plug into" the valve circuit above, as substitutes for the 6AK5 and the EL95 pentodes.

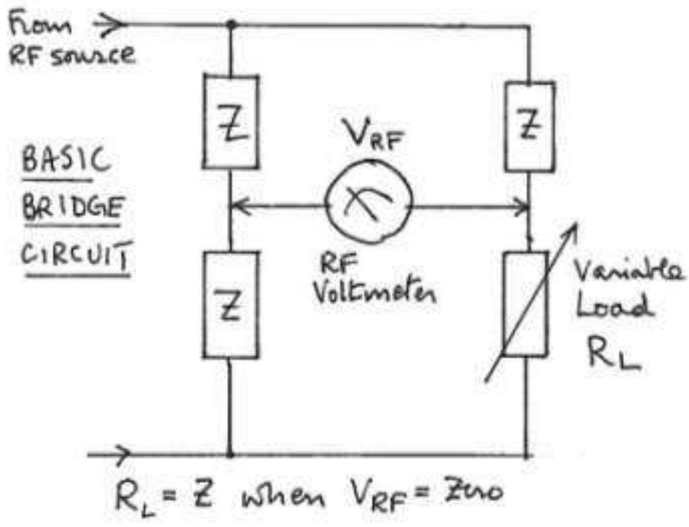


For the oscillator, you can use two MPSA42's, as the stage is low power because the cathode resistor limits the cathode DC current. Try BD129 or BD159 (or similar NPN 350v / 500mA high speed devices) as substitute the BF459 if needs be, all of which require adequate heat sinking. The "g2" voltage must not exceed 300v, to avoid damaging the MPSA42.

For HT rails above 300v, fit a dropper resistor to reduce the MPSA42 "g2" voltage below 300v, and decouple with a 10nF HV ceramic to ground; the BD129/159 will need replacing with a higher voltage device, TV line output transistors such as the BU508 and the super-alpha BU806 would make some very hefty power outputs possible. Peter Thornton G6NGR

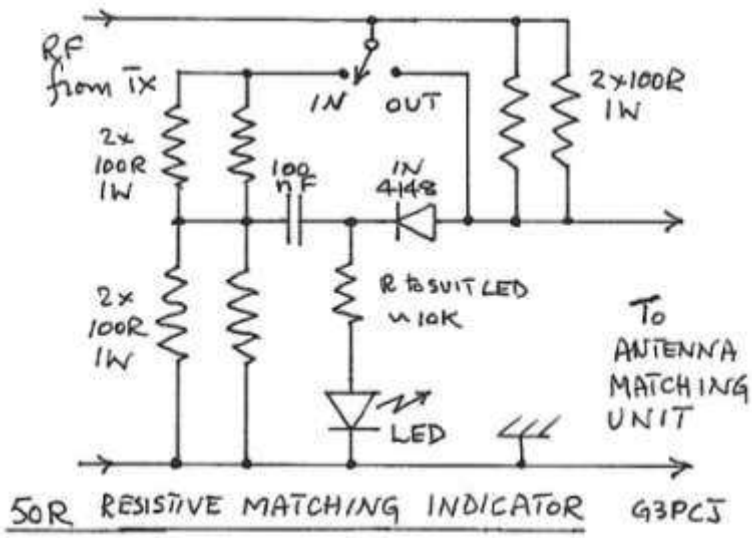
The Resistive Matching Bridge

The ideas behind this circuit are ancient and I do not claim any credit for them, but it is most useful, especially when your transmitter runs only a few Watts of RF output power. The purpose is to protect your transmitter's output stage from unwelcome loads while you adjust your Antenna Matching Unit. The circuit has two arms in a conventional bridge so that when the RF voltage across the 'central points' is zero, you know the bridge is balanced and the matching conditions are those desired. The first diagram right shows this condition for a simplistic bridge made up of three equal impedances of value Z and the unknown load R_L from the antenna matching circuits. When the mid points RF difference voltage is zero, then R_L is equal to Z. Very simple maths will show that the load on the RF source – the transmitter – is then also Z!



Let us assume that you want the matching circuits to present the common 50 Ohm load to the transmitter when in normal use without the matching bridge in circuit. Connect the matching circuits (with antenna connected) as the lower right hand side bridge arm and then make the other three bridge impedances (Z) be 50 Ohm resistors. When the bridge is balanced by the matching circuits creating a load of 50 Ohms, then the load on the transmitter is also 50R as desired. A little bit more simple maths will show that for the extreme cases (pretty unlikely) of the matching circuits presenting either an open circuit, or a short circuit, then the load on the transmitter would be 100 or 33.3 Ohms respectively; these are values that are exceedingly unlikely to trouble your transmitter if designed for a 50R load, so that while normal adjustments are made, the load will always be somewhere between 33.3 and 100 Ohms – hence always safe! Another small advantage is that only a maximum of one quarter of the transmitter's output power is actually radiated, so you will cause less trouble to others when tuning up!

The next aspect is a practical circuit to detect bridge balance. The easiest is a simple RF voltmeter circuit working on the difference between the central points of the two arms. This requires a diode and a capacitor in a rectifier circuit with some sort of variable indicator – this can be a meter or a LED. Bearing in mind that the matching circuit adjustments are correct when the bridge is balanced – ie when there is NO difference in RF voltage between the central points of the two arms – your task is to adjust the matching controls for least glow from the LED. (I say least, because if the transmitter has poor RF filtering and generates some unwanted low level harmonics, the matching circuit will not provide a 50R load for the harmonics as well as the fundamental – so there will be some residual imbalance in the bridge due to the harmonics.) The circuit below shows the practical reality with a switch that puts the bridge IN or OUT of circuit; this particular version uses a single pole switch instead of the common circuit with a 2 pole switch that completely removes the bridge when not wanted. The advantage of this scheme (apart from being simpler/cheaper!) is that the RF indicator remains active when the bridge is switched OUT, giving an indication of full RF output voltage because the left hand side of the bridge has no RF voltage in it. Note that it responds to RF output voltage, so if it is to 'show' output power, then it will need square law power calibration. The circuit's power handling ability is determined by the wattage of the resistors – using six 1 Watt 100R values as shown allows for up to about 15 to 25W output if you are quick in adjusting the matching controls! The resistor in series with the LED controls the brightness at full RF output – it is desirable to be over about 5K. You can see what happens when you apply a short or open circuit to the output, or even a 50R dummy load which will also absorb all the harmonics! Tim G3PCJ



Once again, many thanks to all past contributors and readers – over to you now Peter! Keep the ideas coming please! Best wishes for the future, Tim Walford G3PCJ