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Hot Iron

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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

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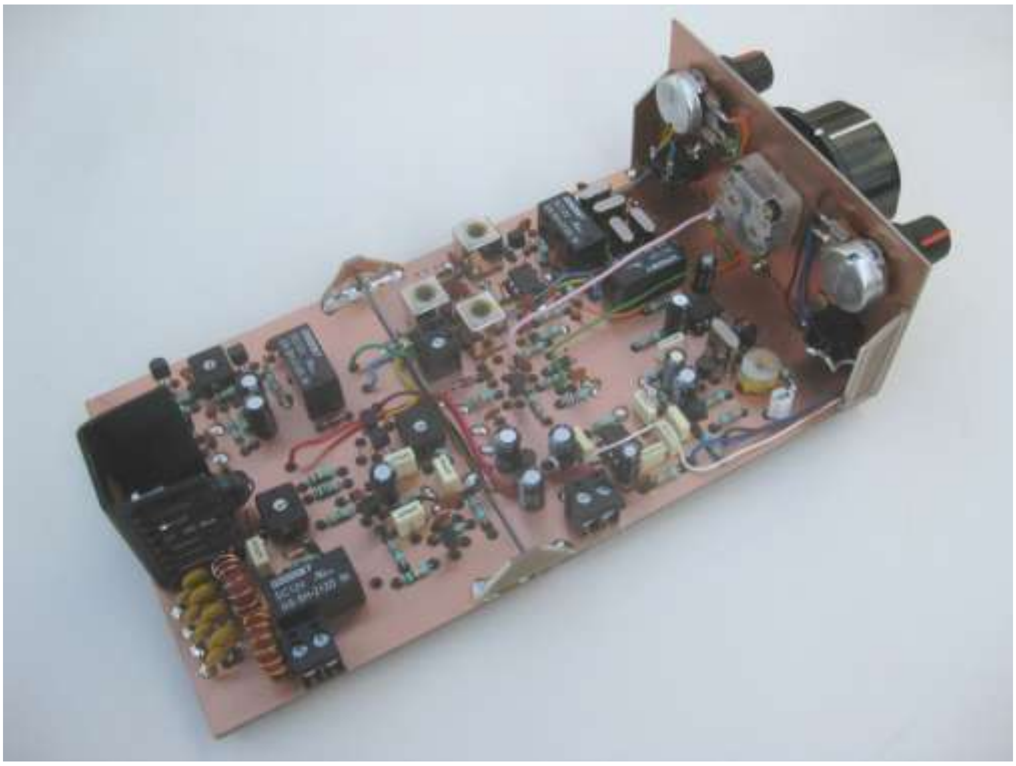
Hot Iron is published by Tim Walford G3PCJ of Walford Electronics Ltd. for members of the Construction Club. It is a quarterly newsletter, distributed by e mail, and is free to those who have asked for it. Just let me know you would like it by e mailing me at electronics@walfords.net

Kit Developments

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!

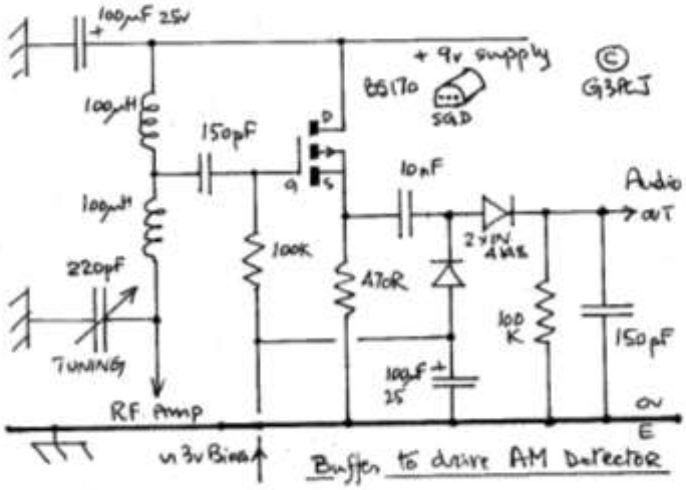


The Rockwell

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.)

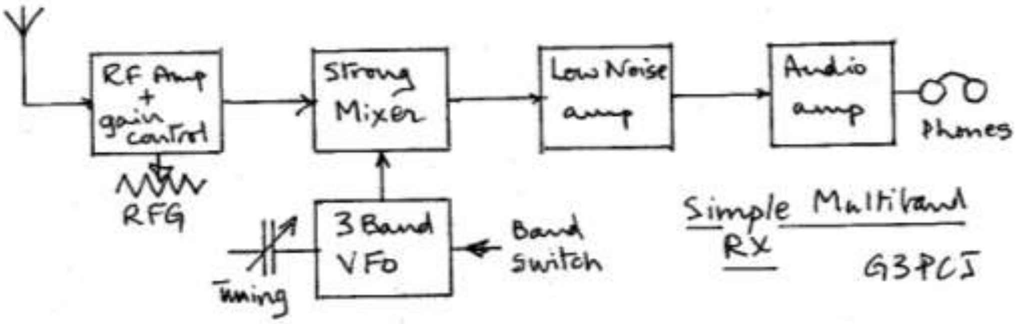
I also mentioned last time that ferro-concrete buildings can act as Faraday cages making it hard for short aerials to obtain enough signal for simple TRF type receivers; one approach to cure this is to add more gain – either in the Radio Frequency or audio stages. Steve G0FUV has done an interesting 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.

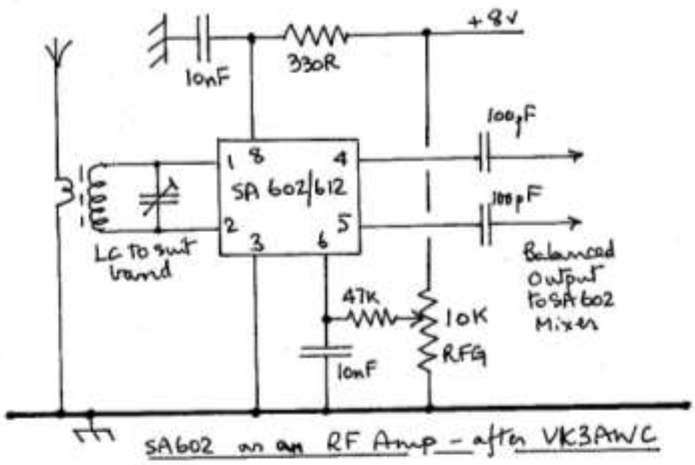
This now leads to another scenario: modules could be directly compared to each other - "plug-n-play". Different kit maker's products could be compared; as new upgrades appear, new devices become available, low cost upgrades become simple. Radio equipment could be assembled by simple inter-wiring - bringing "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!

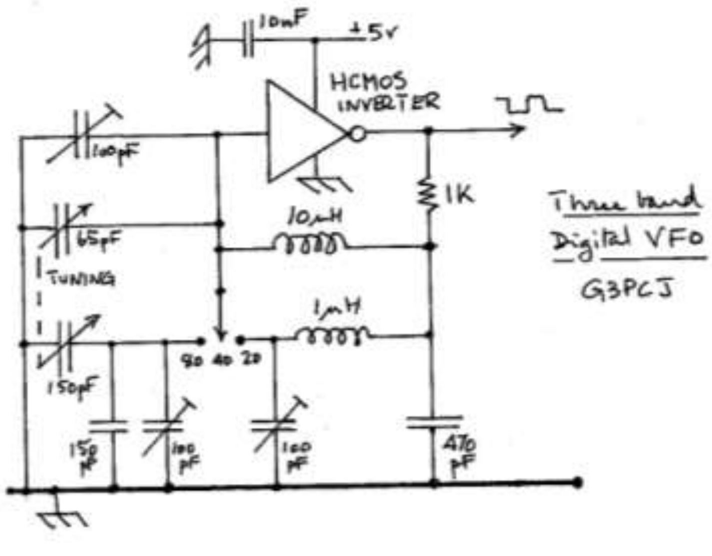
Somebody sent me this suggestion many months back but unfortunately I cannot trace who it was! The idea is thought to have come originally from VK3AWC but has been promulgated by G3ULO/DJ0HF. He wanted an RF amplifier with balanced input and output ports to help remove common mode interference in a simple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

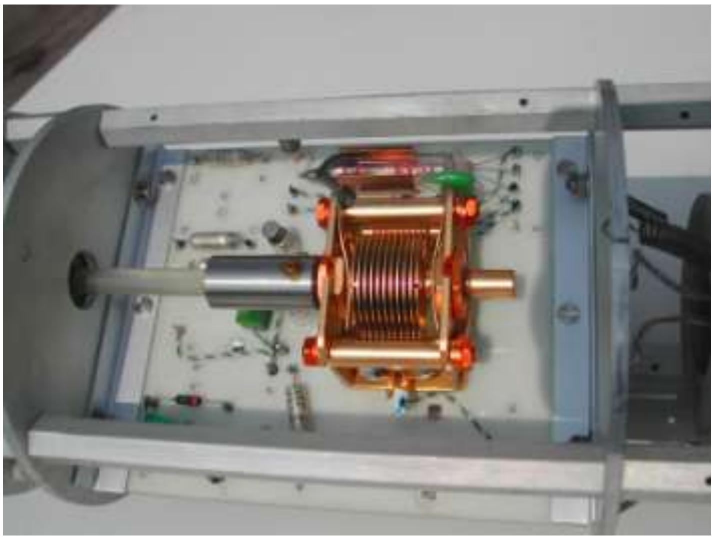
I happen to live about 2 miles from what was Somerton Radio Station. It opened in 1927 as one of the main HF receiving 'Beam' stations conceived by Marconi to conduct international Government and commercial traffic on the 'short waves' instead of the alternatives of under-sea cable, or by radio on low 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.)

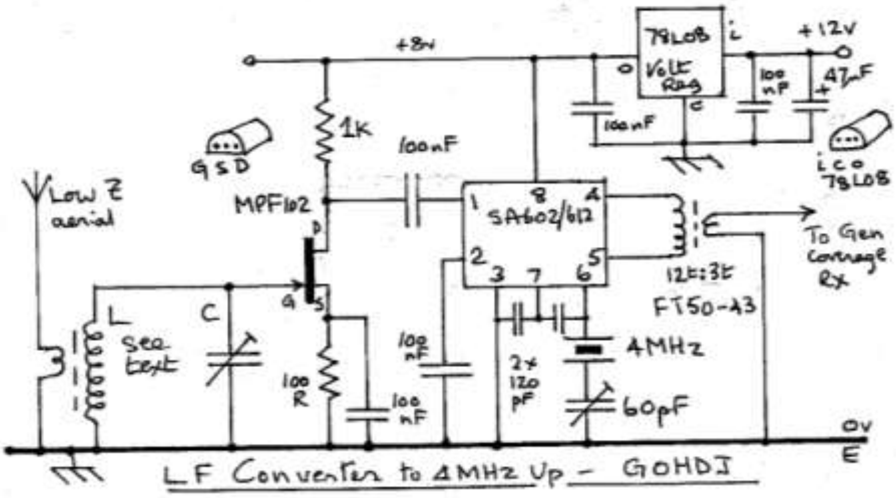
What emerged was a most unusual structure to my eyes – the crystal was mounted in a sprung mounted enclosure with heavy thermal insulation. This is obviously to add to the temperature stability provided by being down 30 foot deep tubes. The associated circuits were built with pin and wired boards & discrete 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