"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

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Issue 74

Contents

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

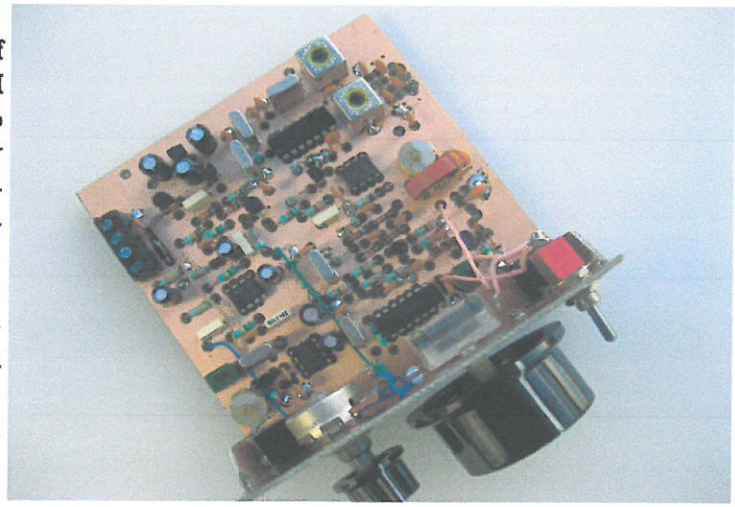
Editorial

A nasty grey day outside so time for a little radio 'work'! I have been playing with the VFO of the Bridgwater for much of the day and now need a break from trying to get it more stable and avoid a tendency to wander. It did start jumping by very small changes in frequency but light tapping with a plastic tool eventually led me to a poorly soldered joint. Listening to a VFO on a stable general coverage RX over a long time is very revealing! I have already put in negative tempco capacitors and it now stays at approximately the right frequency so suspect that the inductance is now the cause of this wandering. Later I will try a T50-2 instead of the TOKO but this means a trimmer is needed to adjust the frequency. Unfortunately all these traditional VFO frequency determining parts are getting hard to source. Its all down to the use of DDS chips in ready made rigs! Nobody uses free running VFOs in commercial designs nowadays. I think I have enough N150 caps to see me out but my stock of the original TOKOs is low - Spectrum Communications do have some modern versions but they are not identical. Luckily many TOKOs can be replaced by powdered iron toroids, whose supply is OK for present, with trimmers - these were also off the distributors lists a while back but seem to have reappeared. Builders don't like winding toroids but this unease is misplaced! Its just another part that needs a little sub-assembly work. If nothing else, this all keeps the grey cells active on a dull afternoon! (Have just found that what I thought were N150 types have different dielectric!) Tim G3PCJ

Kit Developments

Firstly an alert for **Polden** builders! If yours is fine on 20m ignore the note later, but I have felt it wise to alter subsequent versions to overcome snags found on one particular model. The Minster 3 is on hold again too - sorry but it is not right yet and needs a rethink!

Meanwhile the **Bridgwater RX** (right) and **Burnham TX** are progressing well. Together they make a 5W phone superhet TCVR for any single band 20 - 80m - see later. I will soon be able to take some early orders - let me know if you are interested. Tim

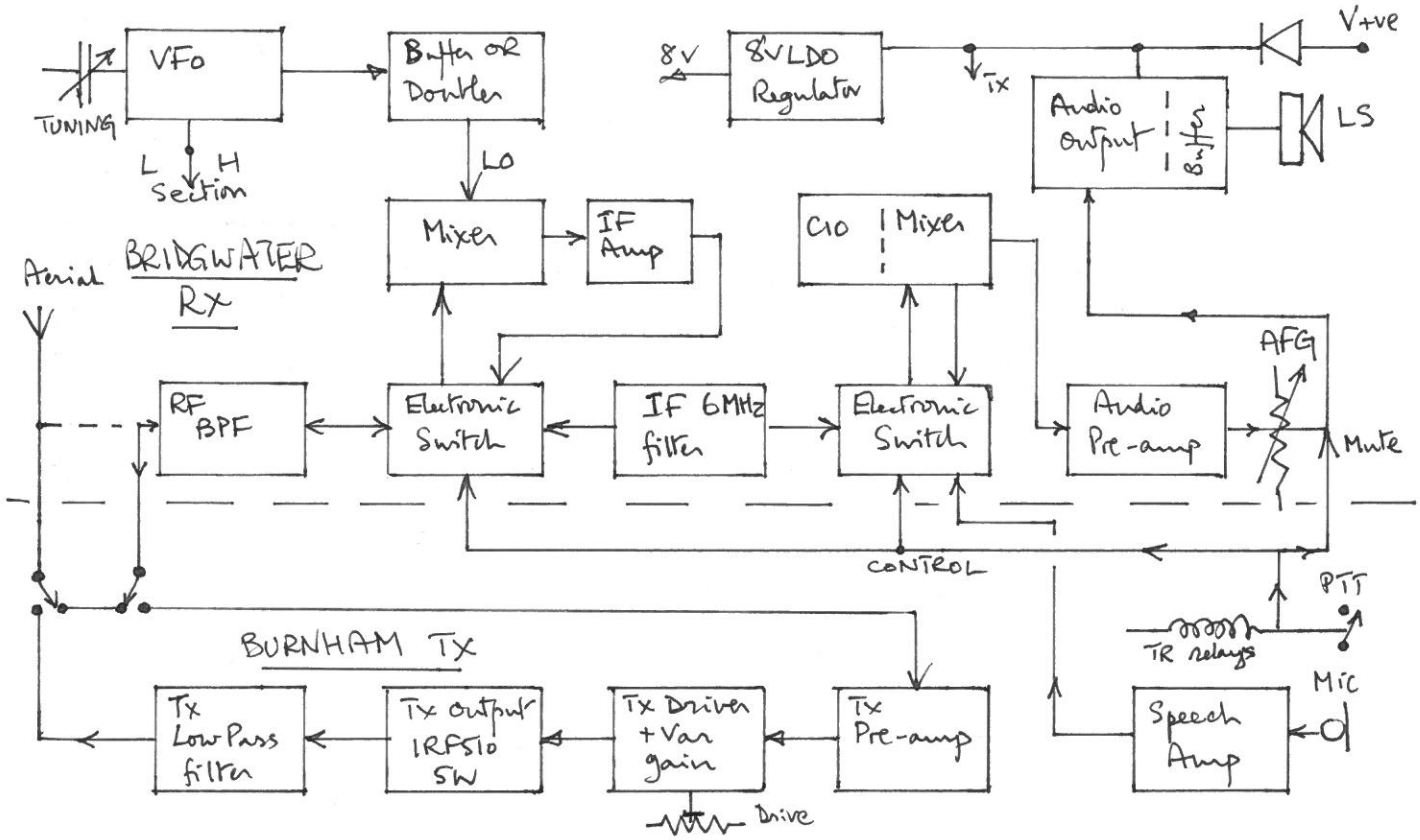


Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or 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

Bridgwater and Burnham

I have taken this new project up again because the Minster 2 was getting too complex - I just could not get the 1496 mixer to stay adequately balanced without lots of extra components! This was injecting a large second harmonic of the VFO everywhere! So needed to have a pause and a rethink!

To explain - this new design is for an any single band 20 - 80m RX and TX in the small upright format. It uses a 6 MHz IF and, as indicated last time in the context of the basic Minster 2, the VFO has a doubler so that for most bands, the LO is above the IF. This reduces the range of frequencies over which the VFO has to be made to work and so eases its design and minimises the range/number of parts required. The RX also has a simple IF amp. Compared to the Tone RX and its associated Parrett TX, the Bridgwater has a bi-directional IF strip using CD4066 switches at the inputs and outputs of the mixers. This means that on transmit, the RX actually generates an SSB signal out of its aerial terminal for driving the transmitter! Hence the TX is much simpler without an IF strip like the Parrett. The TX only has an RF amp, LPFs and a speech amplifier, which makes the whole TCVR appreciably cheaper! The TX uses an IRF510 giving 5W peak on a 13.8v supply. Block diagram of RX and TX below:-

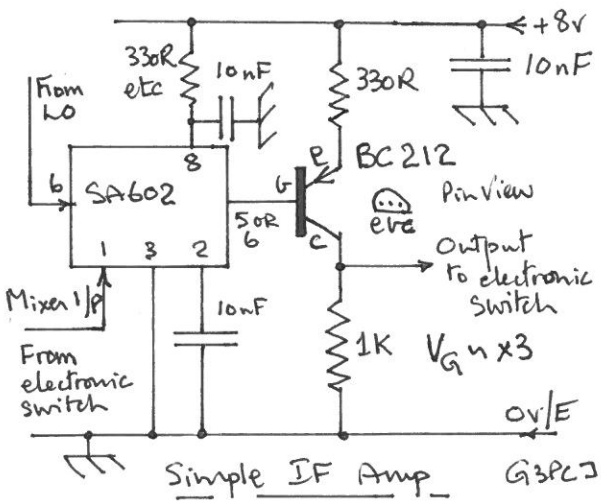


BLOCK DIAGRAM OF BRIDGWATER & BURNHAM

G3PCJ

The VFO doubler needs to be broadband and operate with inputs from about 4 to 6.5 MHz - as ever, its 40m that is hardest, needing a LO of 13 MHz after doubling! The basic circuit was given in the last Hot Iron so no need to repeat here. It needs a capacitive attenuator (6p8 and 22 pF) on the input to reduce the VFO output from about 4v p-p down to nearer 1v p-p so that the phase splitter does not run out of available signal swing.

I think you might be more interested in the simple IF amp (right) that can be added with a BC212 to a 602 first mixer stage and still be correctly impedance matched to the IF and RF input filters when switched by a CD4066! G3PCJ



Radio Magic by Richard Booth G0TTL

Whatever you think you must agree that there is something magical about radio. A bunch of excited electrons forced down a wire suspended above ground creates an invisible electromagnetic wave. This wave can span the globe or given the right conditions escape into deep space. Speech, music or pictures can be hidden within it. Or you can just switch it on and off and send Morse code. The waves are fast too, travelling at the speed of light no less. At the receiving end the same thing in reverse happens, the aerial grabs the wave out of thin air. Electrons get excited in the wire and your radio reproduces the original transmission in your ears. Of course there is a lot more to it than that, but as a six year old it was magic to me and I have been well and truly hooked ever since. To this day I am fascinated by the idea that something as small as a PP3 9V battery contains enough energy to excite yet more electrons and send a radio transmission maybe a thousand miles or further. How can that be possible? A crystal diode, a coil of wire and capacitor to tune the circuit, coupled to a high impedance headphone and you have an am receiver. No batteries required. Now that has to be magic.

Hours were spent back in the late 1970's making crystal sets and three transistor reflex receivers with help from my dad; soldered together on bits of wood using copper nails and OC44 / 71 transistors. I would take our creations into school to show the teaching staff, which in turn worked well for me as seemed to get an never ending supply of old transistor radios donated for spare parts from them. My school report one year stated "Richard is a strange child, he seems very uninterested in school work but excels in making radios and taking things to pieces in class". The time I spent sitting in the garden shed thumbing through 1960's copies of Practical Wireless in search of the next project was priceless. I still do that today! By the early 1980's I had progressed to building EF91 valve based projects and mains power supplies to suit. Yes, I survived to tell the tale.

Well what got me thinking about all the fun of 30 years ago was a recent discovery. Whilst helping to sort out my parents loft I came across a long lost old friend. My first proper 8 valve communications receiver, a Heathkit RA-1. My dad (G8BIW) built this in the 1960's and officially passed it to me on my 8th birthday. I think the plan was I would stop messing about with his AR88 or whatever else I could get my hands into at the time. A lot of fun was had with it and many new experiences - the pink glowing voltage stabilizer for one was mesmerising and I would sit there in the dark, listening to SSB on 40M with the lid removed just so I could get a good view of the valves. Yes that is where I also experienced my first proper mains electric shock. "Don't touch that resistor" my dad would tell me. Of course eventually I did whilst wiggling a valve or gazing at the heaters. Never looked back since! The RA-1 is an amateur bands only receiver with crystal filter, AVC, noise limiting and quite good performance for its time. Or so I remember.

So the RA-1 is back in my workshop. Last time it was used must have been about 1985. Many modifications and some suspect capacitor "repairs" by yours truly back then mean that the radio will need an overhaul, re-alignment and serious going over. So this Christmas break I have a radio project to look forward to. By the next issue of Hot Iron it should be all finished and back in regular use. Then of course more electrons will be excited, this time inside the little B9A valves. The cathodes warm up and the invisible magic starts all over again.

Happy Christmas and all the best for 2012

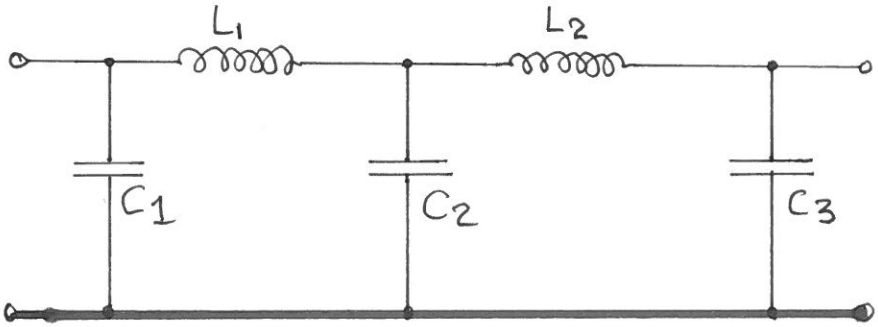
Low Pass Filtering for QRP TXs - How much do you really need?

The cut-off frequency of a low pass filter (LPF) is a term that is often loosely used. The author is aware of three definitions: firstly the obvious one which is where the filter starts to attenuate, this can be hard to measure; secondly where the signal is 3 dB down on strength in the passband, this is easy to measure but we would not consider using such a filter in a QRP rig at close to its cut-off frequency; and thirdly a more complex definition which has to do with ripple in the passband. In this article the author uses the first and intuitively correct (!) definition.

The emission of unnecessarily strong harmonics is against the licence conditions and is anti-social. The conventional way of expressing the strength of a harmonic is to say it is so many dB weaker than the carrier and this is referred to as dBc. However what really matters is the absolute strength of the harmonic.

It is instructive to look at the USA amateur licence to see what absolute harmonic power can be legally radiated in the USA. For an output of 1.5 kW, the US maximum, you must have at least 43 dBc suppression which means that you can radiate 75 mW which is about 18 dB down on 5W. It is reasonable to assume that a single ended PA will have a second harmonic that is 10-15 dBc, say 13 dBc. A pi-filter will provide an extra 10 dB giving a total attenuation of 23 dBc of the second harmonic. This means that a simple QRP rig with a pi-filter will radiate less second harmonic than a very QRO American TX. The author therefore feels that using anything more than a simple pi-filter is overkill. A five element half wave filter gives about 24 dB of second harmonic attenuation so the radiated second harmonic will be 37 dBc which is more than adequate.

In practice the attenuation of the second harmonic may be much better as the above assumes that the TX is feeding a trap dipole which may also have a feed impedance of 50 Ohms at the second harmonic. If you are using a mono-band dipole this will not be the case and you can expect to pick up a further 15 dB or more of second harmonic attenuation. The attenuation through a half wave filter does not reach 0.1 dB until the frequency is 15% greater than the cut-off frequency. This means that you can design the filter and operate it somewhat over the cut-off frequency with impunity which may enable you to use parts that are to hand. Suitable values for the half wave filter, and other five element filters, can be found in many books such as the ARRL and RSGB Handbooks.



Half Wave Filter G3MCK

For use with 50 Ohm coax at the cut off frequency:-

$X_{L1} = X_{L2} = 50$ Ohms, $X_{C1} = X_{C3} = 50$ Ohms, $X_{C2} = 25$ Ohms

Contributed by Gerald Stancey G3MCK

Note from G3PCJ! It just so happens that the value of two end capacitors then become approximately10 times the nominal wavelength of the amateur band, and the centre capacitor is double that! Thus for the 80m band, $C_1 = C_3 = 800$ pF and $C_2 = 1600$ pF. C_1 can be conveniently made up of 330 pf in parallel with 470 pF so the whole filter needs 4 x 330 pF and 4 x 470 pF. These values of capacitors can also be used for all the higher bands to 20m - 470 pF for 40m, 330 pF for 30m and 330 pF in series with 470 pF for 20m! The inductors can be conveniently wound on T50-2 powered iron toroids with turns adjusted for band in use - 20t for 80m, 14t for 40m,12t for 30m, & 10t for 20m

Circuit construction without etched PCBs!

I suspect that most readers of this journal would like to dabble with their own circuits but do not always have etched PCBs for all the interconnections. There are many ways that you can assemble a project and for it to be mechanically stable and hence able to stand normal use in the shack. I will assume that you have access to un-etched PCB material in plain copper clad sheet form - not necessarily in large pieces though! It nearly always is an advantage to have a continuous copper sheet for a ground plane, either on the top side or, less easily managed, it can be underneath. The ground plane makes it easy to do all the numerous connections to 0 volts which nearly always dominate all circuits, as well as providing a very low impedance 0 volts everywhere. The challenging bit is how to make the connection points that need to isolated from 0 volts, sufficiently rigid.

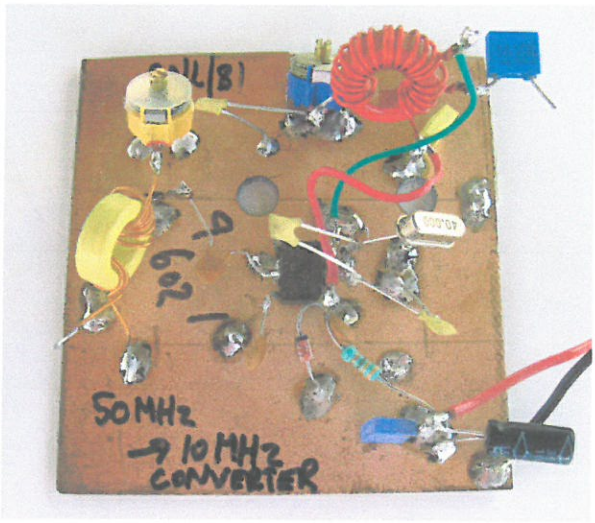
One approach is to carefully cut isolating grooves in the copper foil across the top side ground plane at say 3 mm or 1/8th inch intervals; do this one way several times and then do it again but at right angles so as to make rectangular isolated patches of copper. They will then need 'cleaning' up with wire wool to remove the rough edges and also a check between adjacent squares to make sure they are isolated from one another! I have never liked this method as it is hard to get just the right depth of cut if the laminate is more than an inch or two wide!

The next approach is similar but this time, you cut the PCB sheet right through into small squares! You end up with small rectangles of copper isolated by their backing material (fibre glass or cheaper alternatives) which are then stuck down onto the rest of the uncut sheet. You can use either single or double sided copper clad board. A dab of superglue is placed where you need an isolated pad and then you just plop a rectangle down on-top! The electronic parts are then soldered on the top of these pads (after checking for whiskers etc!). This is much easier to do and can provide an excellent mechanical framework for a circuit. You can even make up the outlines of typical circuit patterns and make yourself some blank development boards!

My own preferred method avoids the hacksaw work but at the expense of lots of 10 nF disc capacitors and maybe a few 1M resistors! As before single or double sided copper clad PCB sheet is used for the main base plate and for all 0 volt connections. You can then arrange a series of 10 nF discs, with one side soldered to the copper, all along the topside; these can be linked together by a rigid (maybe insulated) wire that will form the positive supply rail. If needed, repeat at the bottom of the sheet for a negative rail. Add a few electrolytic caps (say 10 /uF) at the ends of these supply lines - making sure their polarity is correct! You might even wish to break or amend these rails to fit a voltage regulator part way along. If it is of the 78XX series, then its middle common leg is just soldered direct to the ground plane with in and out leads to the now heavily decoupled in and out supply wires. Extra 10 nF discs, with one end soldered to 0 volts, can be used wherever extra rigidity is required on any supply rail - you can never have too many of them!

The 1M resistors are used if there is any doubt about the mechanical rigidity of signal or other isolated points in the circuit. This does need a little bit of thought just to make sure that the circuit impedances at this proposed anchor point are appreciably less than 1M. Ideally one would not add 1M across any point where the impedance is of the order of 100K or higher - such places might be the gate inputs of any type of FET, or op-amp inputs. These are not always high impedance points and if all the associated resistors are well below 100K you are probably all right.

How to mount integrated circuits? Easy - on their backs, legs in air - hence the name 'Dead bug construction'. A useful tip is to write the pin numbers of the four corner pins on the sheet before it is soldered in place (so you can check easily!) The ground legs of the chip are just bent out flat and soldered direct to the ground plane. The supply pin(s) are mechanically attached with a 10 nF disc between the pin and 0 volts. Resistors and capacitors that have to be mounted between chip pins and other nodes, have their leads shortened as required and then soldered one to another - ideally in a rectangular grid that makes it look smarter. Something like a tidier version of one of my bird's nests right! G3PCJ

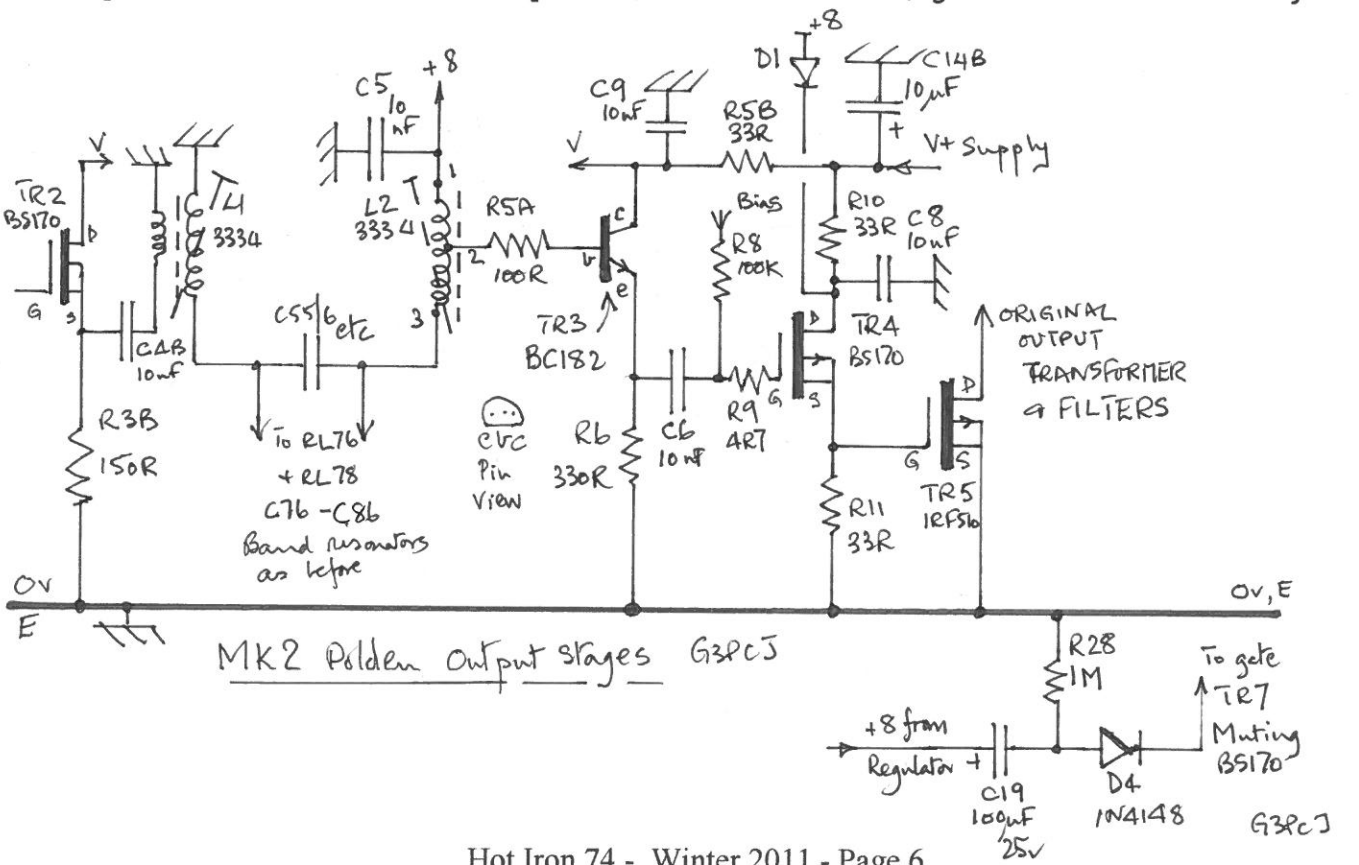


Polden TX Mk 2

I have decided to do a MK 2 version because one customer had trouble on 20m which took quite a bit of curing! My own Polden shows no sign of these troubles so if yours is fine then ignore these suggested changes. The problematical rig was fine on 40 and 80m but on 20m it went 'awol' above a few milli-watts of output with an apparently significant amount of unwanted output at 7 MHz as well as 14 MHz! Although I have changed the associated Mendip RX also to Mk 2 version, the circuit is identical - I have just altered the instructions so that it can be sold as a basic 3 band DC TCVR for £99, with an optional extra kit to suppress either unwanted sideband for £11 bringing the whole back to the original £110. The Mendip Mk 1 is fine with either version of the TX.

It was fairly easy to establish that the problematical Polden on 20m was producing 7 MHz when it should not, but finding out why had me stumped for a while. I eventually found some SPRAT articles (Numbers 91 & 107) about this effect by Ha-jo Brandt DJ1ZB which provided some clues although my own explanation of the causes is slightly different. I eventually concluded that the high gate capacity of the IRF510 output FET needed a much lower driving source impedance than I had originally provided. I am guessing that this did not show up in the early versions because the gate capacitance does vary widely between specimens. I think my pull down resistors in the gate drive circuit were just not low enough to discharge the gate capacity properly before the next positive peak came along! This is because the source follower diving stage has a much higher negative going impedance than it does going positively; this is because the driver DC standing current is the maximum that can be *extracted out* of the following stage's gate capacitance - the current that can be *injected into the gate capacitance* from the source follower is much higher.

Altering the driver stage to do this enabled a few other changes which have reduced the chances of the original source follower stages self oscillating! These circuit details are sketched out below. One of the consequences of these alterations is higher dissipation in TR4 - on normal 13.8 volt supplies this is of no consequence but do be careful if you think about using a higher supply for a larger RF output - hence my advice is to keep below 16 volts. It was convenient to make the track alterations by adding a little extra decoupling by adding what has become R5B and C14B but this is only needed for layout purposes really! I also found that the transmitter RF BPF filter driver stage TR2 could do with more standing current so R3B is reduced to 150R. I have also included the 3 extra parts to mask the problem of switch-on squealing in the Mendip! It is not difficult to alter an existing PCB to the revised circuit. If anybody needs the altered parts for their Polden, please let me know. But I do emphasize, if all is well on 20m, ignore this note! Tim G3PCJ

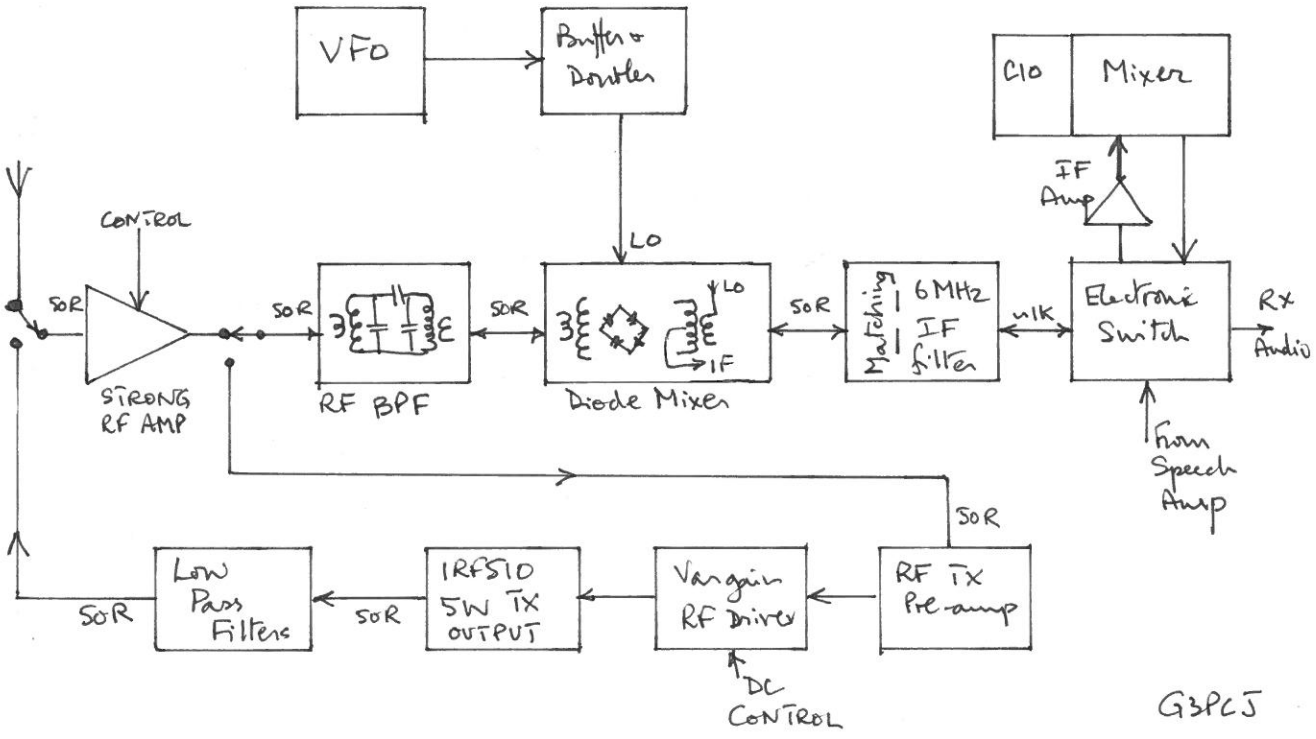


Snippets!

TCVR schemes! With Minster 2 on hold, I have been doing a bit of doodling on alternatives for the first mixer, which converts the received signals to the 6 MHz IF. I want a stronger mixer than the SA602 which probably means using a diode mixer. It needs to be doubly balanced as in the conventional 'quad diode plus two centre tapped transformers'. These mixers can be bi-directional between their RF in and IF out points. Two other blocks of a superhet can also be bi-directional - RF input and IF filters! So in principle, it could be bi-directional between RX aerial and IF output! This might simplify the transmitter!

A diode mixer is lossy so the RX will be deaf unless there is extra gain to make up for this loss and the missing gain of a Gilbert cell mixer (often about 10 dB). An obvious approach is to put a strong RF amp in the 'aerial' lead after TR switching but just before the RF BPF. This gain can be shut down during transmission to prevent instability. It would be better to put the RF amp after the BPF but this needs another set of relay contacts and makes the transmit RF path a bit convoluted.

The rest of the rig would be fairly conventional! It would start life as an any single band 20 - 80m rig using the VFO buffer/doubler approach of the Bridgwater. A 5W output using an RD06 FET (for up to 10m) driven by a variable gain RF amp to set the gain for each band remotely. Maybe add CW and then try to get the lot below £100 for the single band base TCVR! Pretty dense on a single 80 x 100 mm PCB but an interesting concept that I will consider a bit more. The potential block diagram is something like below. G3PCJ



POSSIBLE TCVR SCHEME WITH BI-DIRECTIONAL FRONT END

Happy Birthday 4000 Series!

A recent note points out that it is 40 years since Intel introduced the world's first commercially successful micro-processor the Intel 4004! It had 2300 transistors and was first made in 1971 using 10 µm processes, which are of course huge by modern standards. From this came the 8008 and then the x86 processors that are still Intel's bread and butter today, and of course includes the hugely influential 8080 and Z80 processors. They were initially designed by a team including Frederico Faggin, Ted Hoff and Stanley Mazor with considerable input by the Japanese from Matatoshi Shima of Busicom. The fact that really grabbed my attention was that Intel are still shipping Z80s at the rate of about 40 million per year 20 years after their introduction! Faggin's 8080 architecture still dominates the world's computer industry via the Pentium Pro series of processors!

More Snippets!

'Loss-less' power diode When large groups of solar PV panels are connected in series to drive mains connected inverters, there is a problem when one cell is in shade but the rest are producing useful output. The solution is to put a normally reversed diode across each panel; but even the normal Schottky diode drop of about 0.4 volts wastes too much power. The solution is a so called 'active diode' with a forward voltage drop of only 50 mV when passing up to 20A! I guess that it has a watty MOSFET which is turned hard on by the reverse voltage working in conjunction with a charge pump - all done without an external supply so it is still a 2 terminal device! Pretty clever!

LDMOS up to 3.8 GHz! Semiconductor firm NXP has been in the market for high power LDMOS (Laterally Diffused MOS) devices for use in avionics and cell phone base stations for many years. In 2000, their devices used a gate length of about 800 ,um but by 2010 this had dropped to about 200. Meanwhile, the gain has risen from about 7 dB to nearer 14 dB when using a 28 volt supply at 3.6 GHz. These advances have enabled increased power density (in Watts/mm^2) to rise from about 0.6 to over 1. This translates into single devices able to produce 600W! Ought to make a good Linear amp for 10 or 2m if you can afford one!!

QRP in the Country 2012

The date is fixed! Make a note now of **July 15th 2012** for those of you who can come. All Construction Club members are especially welcome. As before it will be here at Upton Bridge Farm, Long Sutton, Somerset TA10 9NJ. If anybody coming from afar would like help with accommodation overnight let me know.

To make things a little more interesting next year, I thought we ought to have an informal **Construction Challenge**. Steve Hartley G0FUW has kindly agreed to be the judge and there will be a small prize. The detailed rules have not been decided yet but are likely to be based on the following task and I will put it into the National press for anybody to have a go. You lucky fellows get a sneaky pre-view opportunity to put your thinking caps on! The task is likely to be to build a RX for any MF or HF amateur band using no more than 10 discrete components and optionally, one integrated circuit and one power supply regulator if you wish. They are to be demonstrated here using a long wire aerial or signal generator in conjunction with the builder's own, or a provided PSU and LS/phones as appropriate. Steve will set his own judgement criteria but will obviously include the three S's - sensitivity, selectivity and stability! Lets hope we can be outside again like 2009 above rather than inside as last year!

Happy Christmas to you all!