"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

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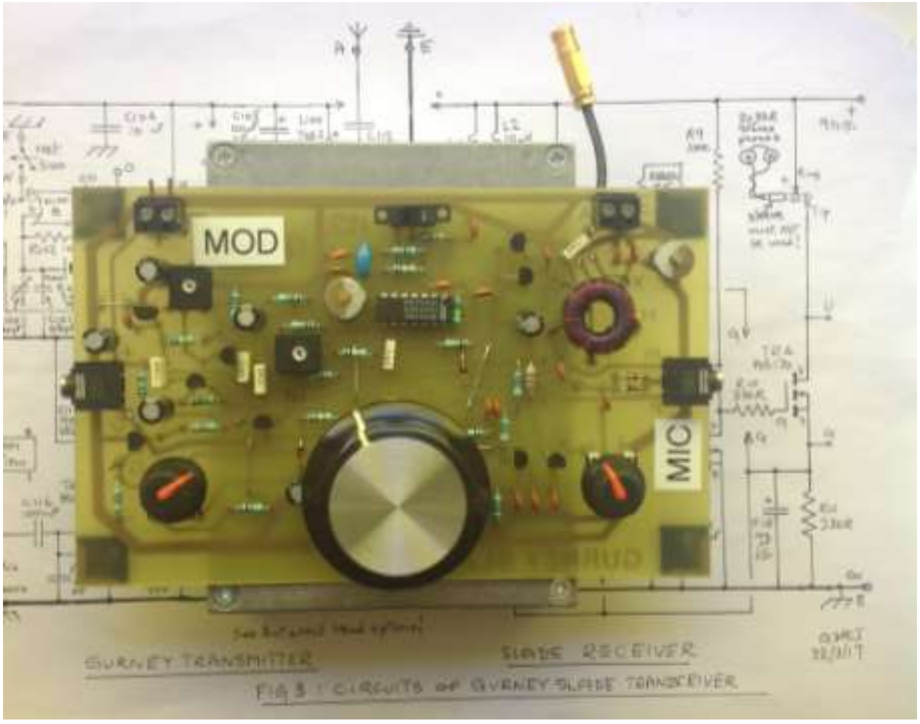
Kit Developments

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

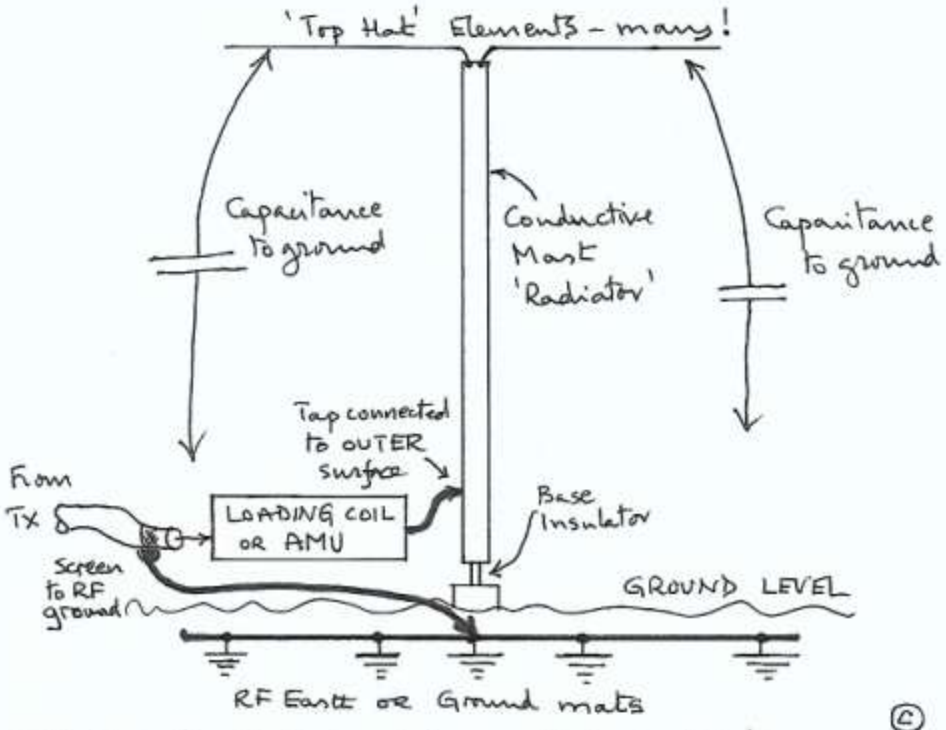


FIG 1: Top Hat Loaded vertical radiator

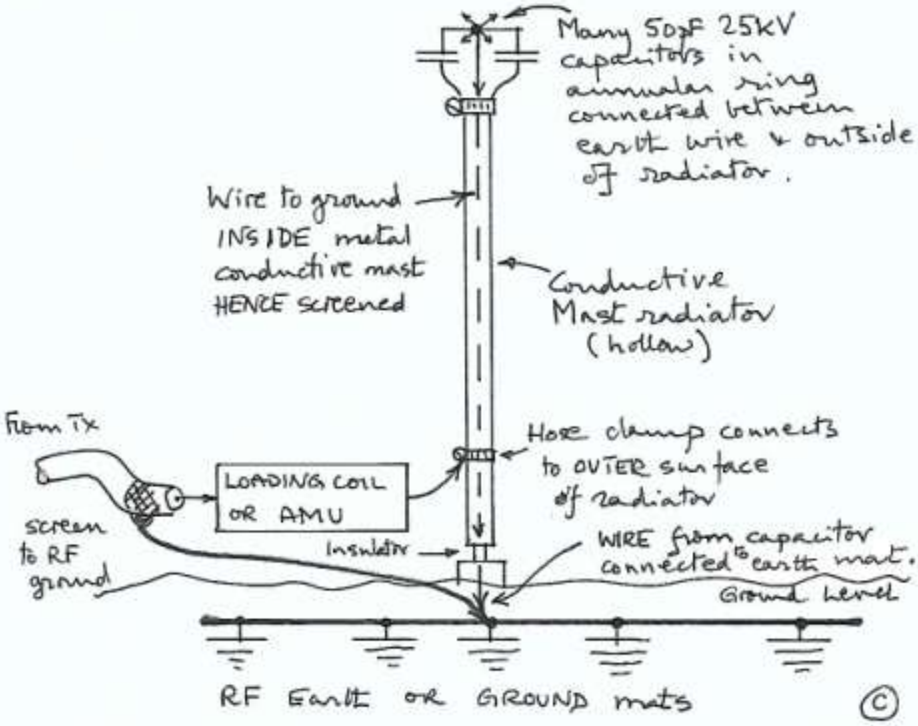
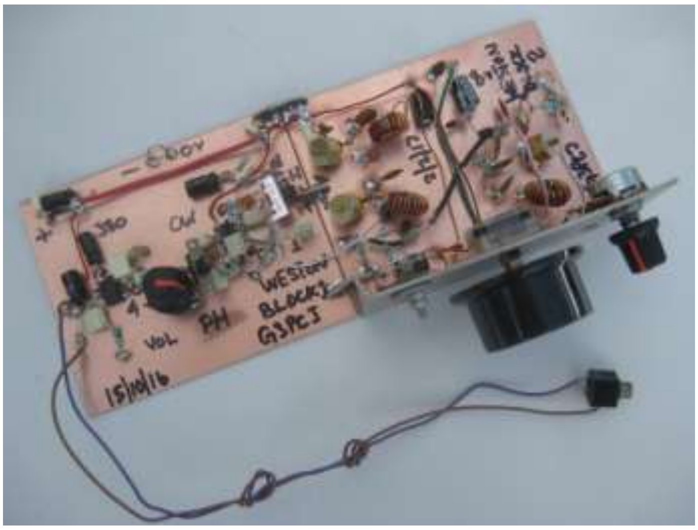


FIG 2: Discrete capacitor loading of vertical radiator

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.

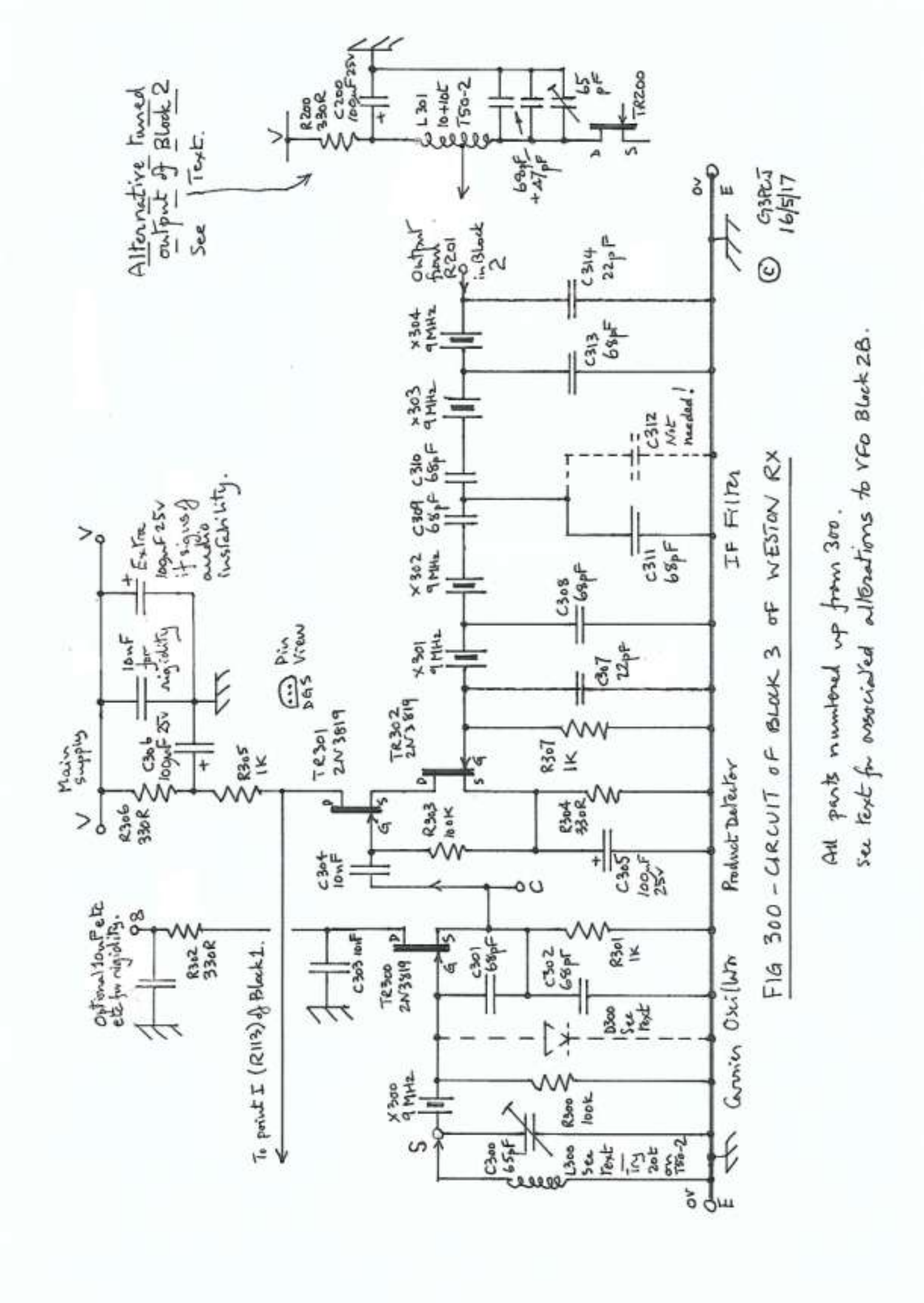


What Intermediate Frequency (IF) is best? For relatively simple single conversion designs like this, it is wise to consider an IF somewhere in the range about 4 to 15 MHz. I like to use an IF that is an integer number of MHz so that a digital frequency readout showing only the KHz numbers of the VFO 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



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 µH ~ 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 µF 25v electro C305 (upped to 100 µF), 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

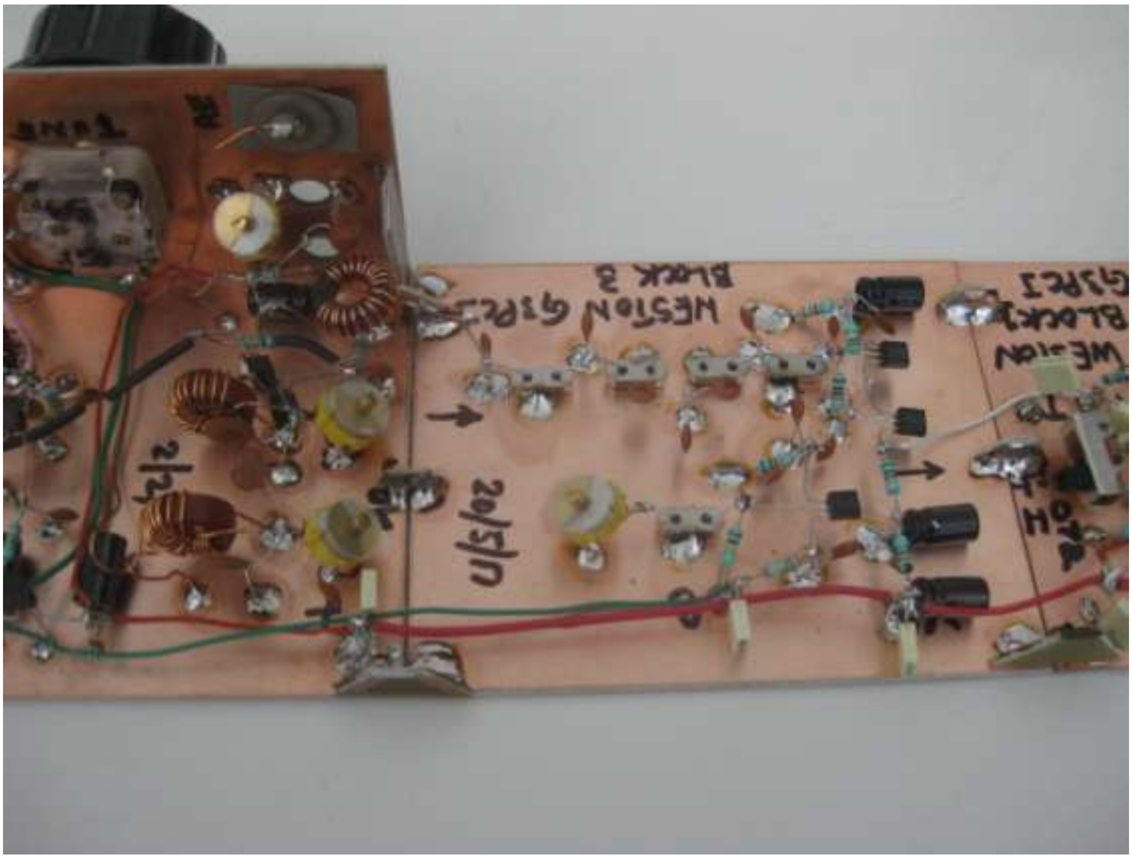
Testing Weston Block 3

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!

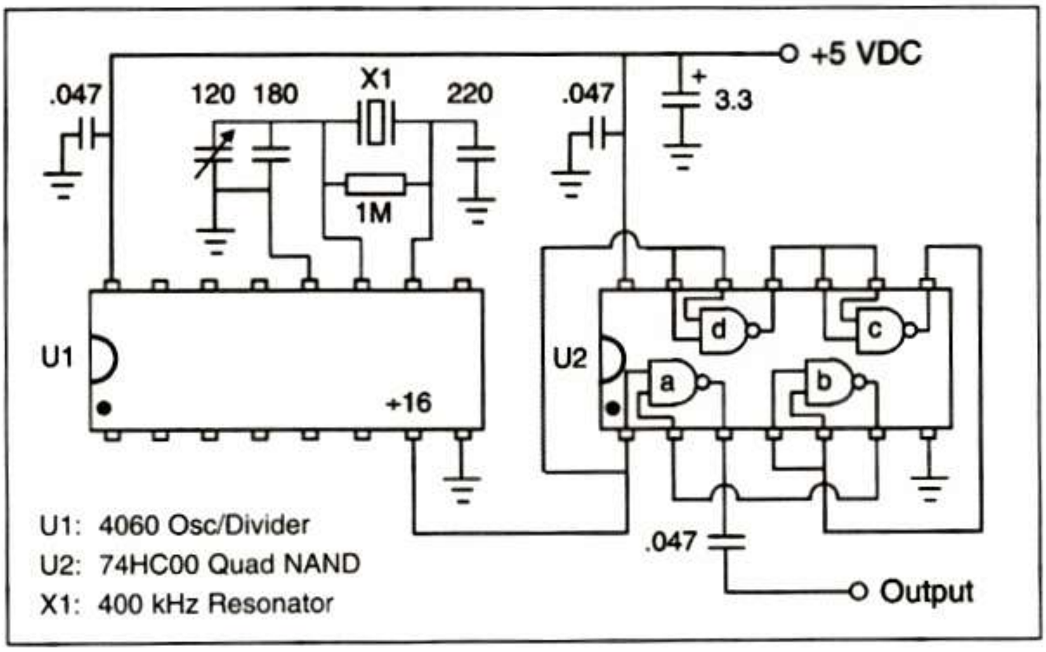
I have also changed the AFG pot to a 4K7 log law one instead of a plain linear taper! Much better gain control now! G3PCJ



My Favourite Circuit – Tony G4WIF

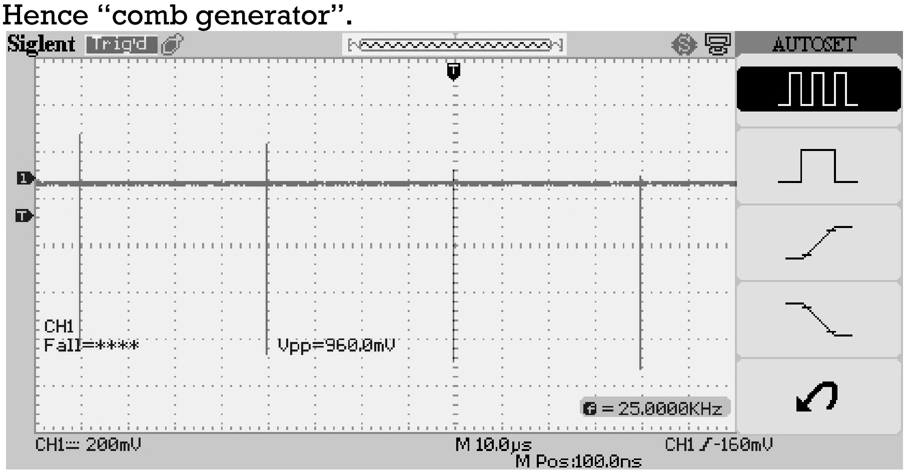
I like playing with wideband noise sources. For years I've used them to get an understanding how well filters which I've built have performed in the real world. Thanks to some advice from Peter Juliano N6QW, I have lately been using LTSpice to compare practice with how the filters should theoretically 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.



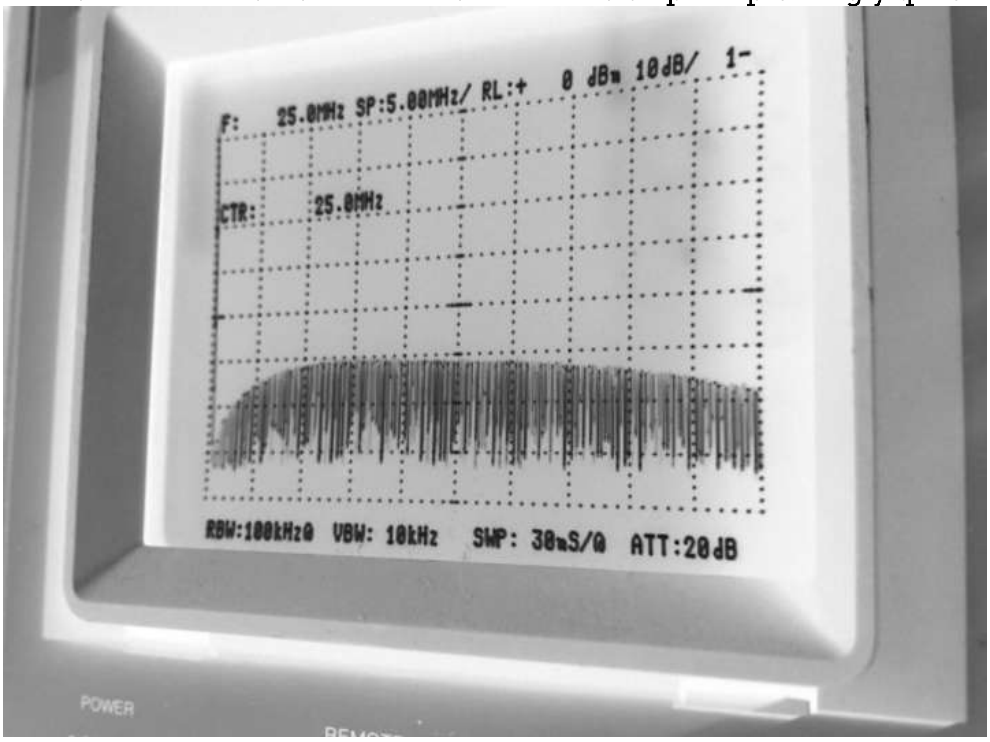
The various "chippery" and resonator cost me less than a fiver. The circuit designed by Gary was so simple that it could be built using any popular method. I etched a board which used surface mounting techniques often referred to as "muppet style". In fact one of the chips used was surface mount style 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".

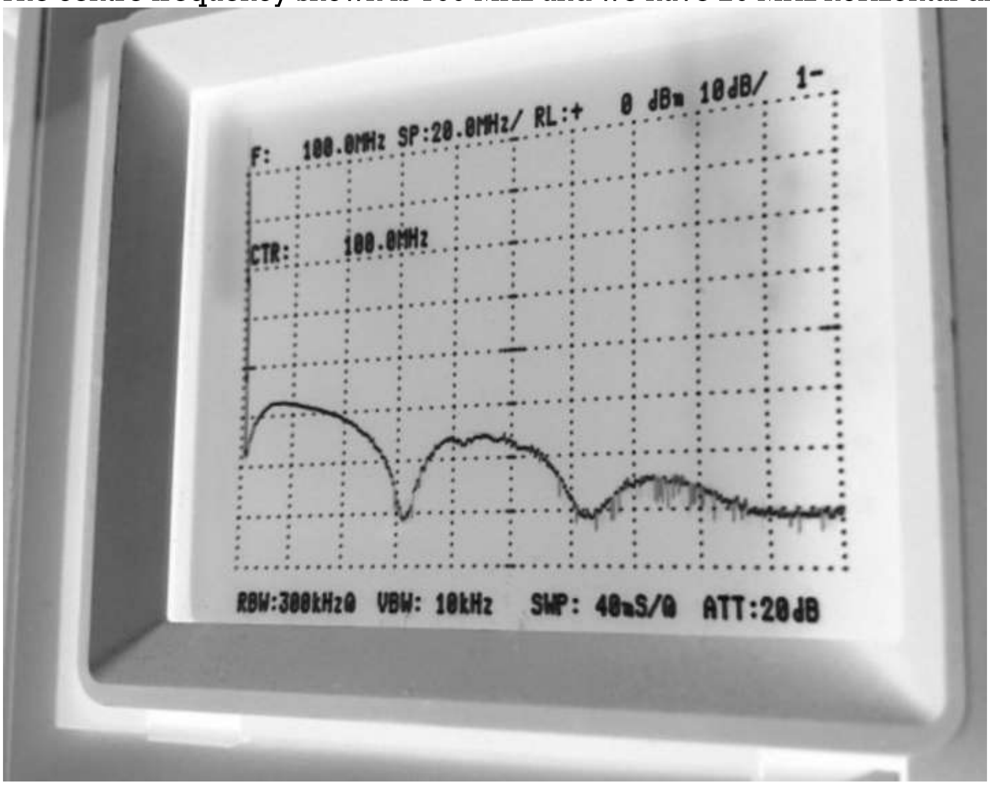


Another purpose that comes to mind is to use this as a calibration source and I later added some extra crystals and a rotary switch to allow that for other frequencies. However the main aim was that the device would generate wideband harmonics and that it does considerably well.

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.

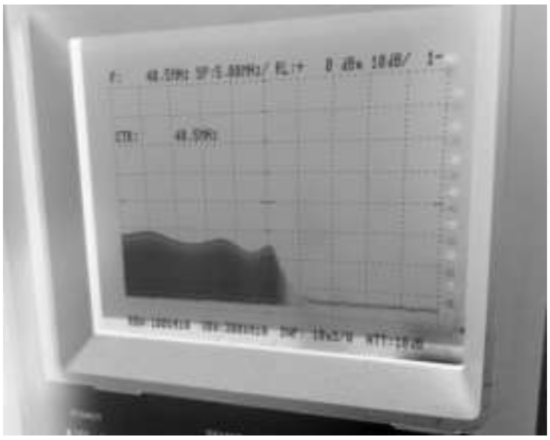


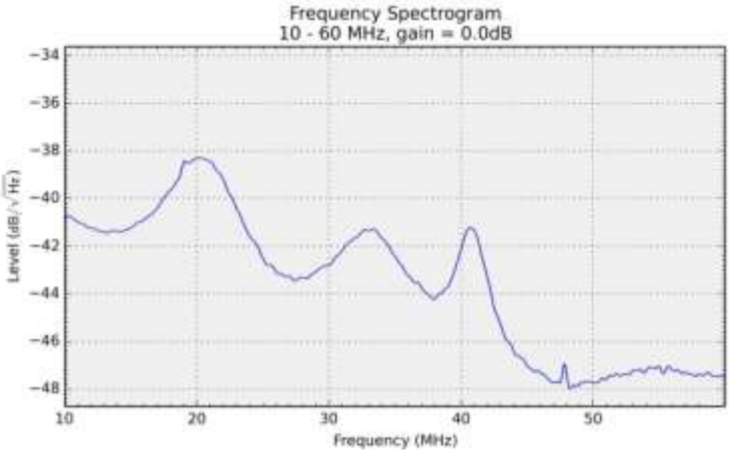
Over a wider frequency span the output gets interesting. Harmonics certainly go very high. The centre frequency shown is 100 MHz and we have 20 MHz horizontal divisions.



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



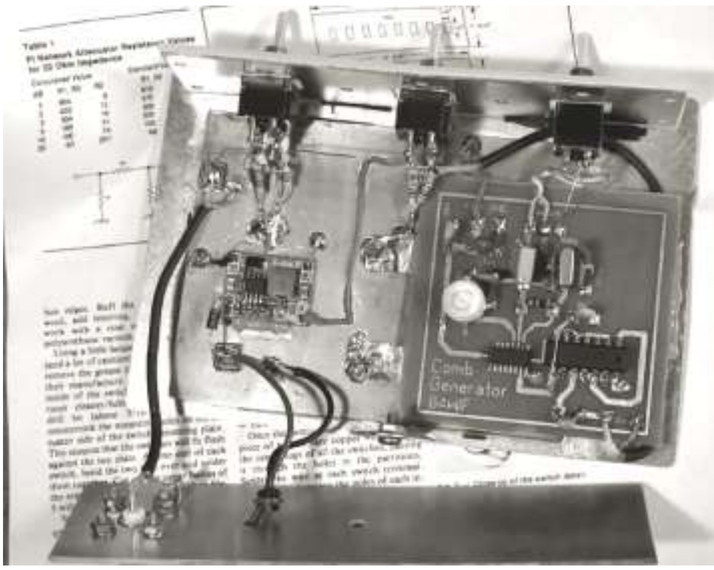


My spectrum analyser is set to 10dB per vertical division while the dongle vertical scale is more "stretched". So it looks more "hilly" on the right - but essentially, it is telling the same story. The TV dongles which are available for around £8-£10 are not very good below 30 MHz but they do perform 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.

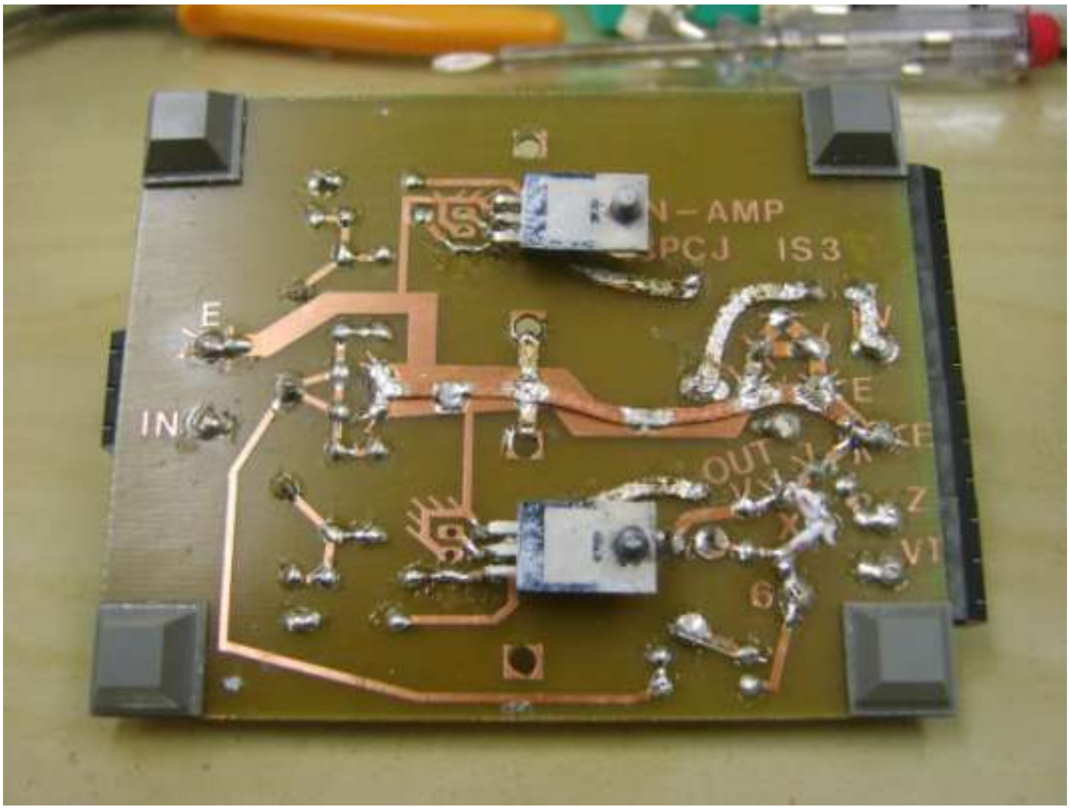
2. Extra parts needed, some optional

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.

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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