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Hot Iron

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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 Apart from retro projects, thankfully that approach has been superseded by printed circuit boards with etched tracks between the pre-drilled holes for small components that are soldered direct to the PCB – this makes the actual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

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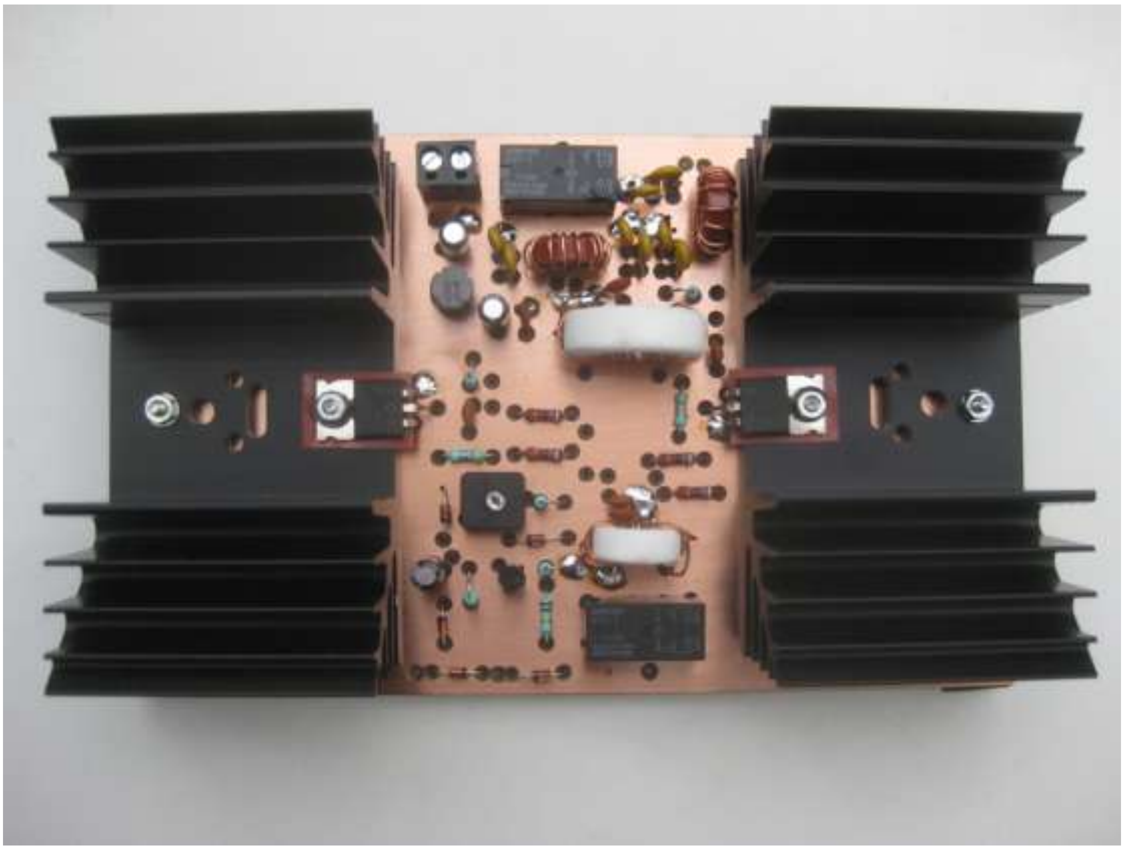
Hot Iron is published by Tim Walford G3PCJ of Walford Electronics Ltd. for members of the Construction Club. It is a quarterly newsletter, distributed by e mail, and is free to those who have asked for it. Just let me know you would like it by e mailing me at electronics@walfords.net

Kit Developments

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.

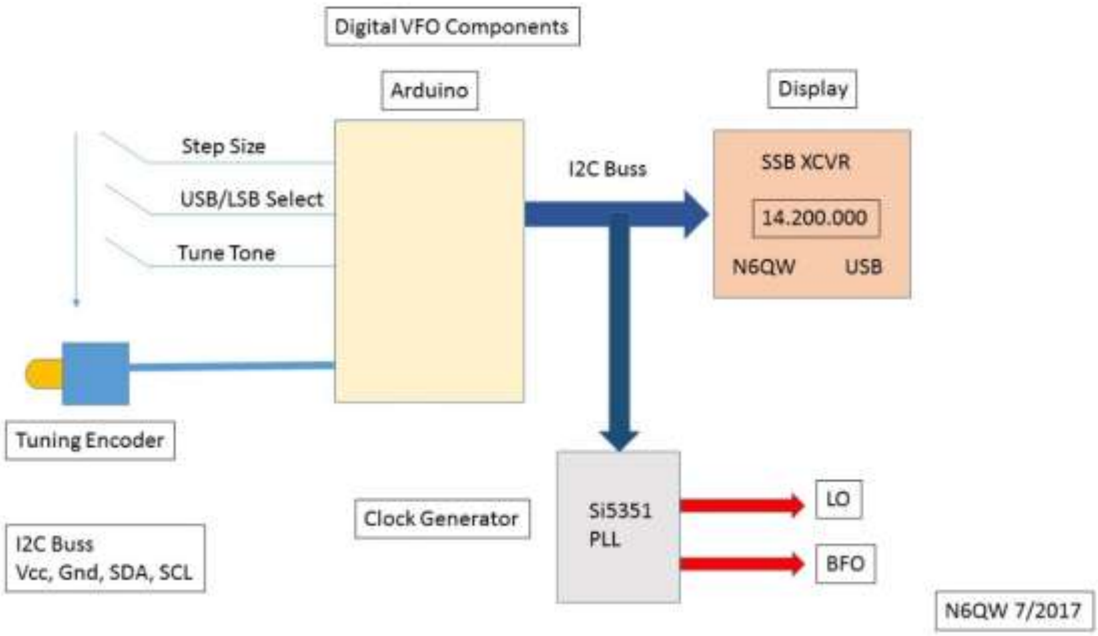


Figure 2 Digital VFO Block Diagram

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.

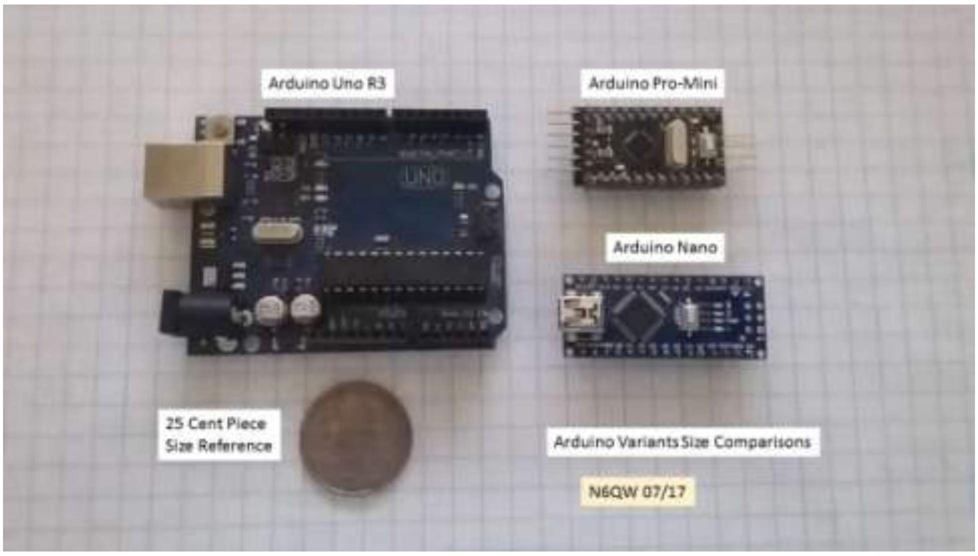


Figure 3 ~ Arduino Variants

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.

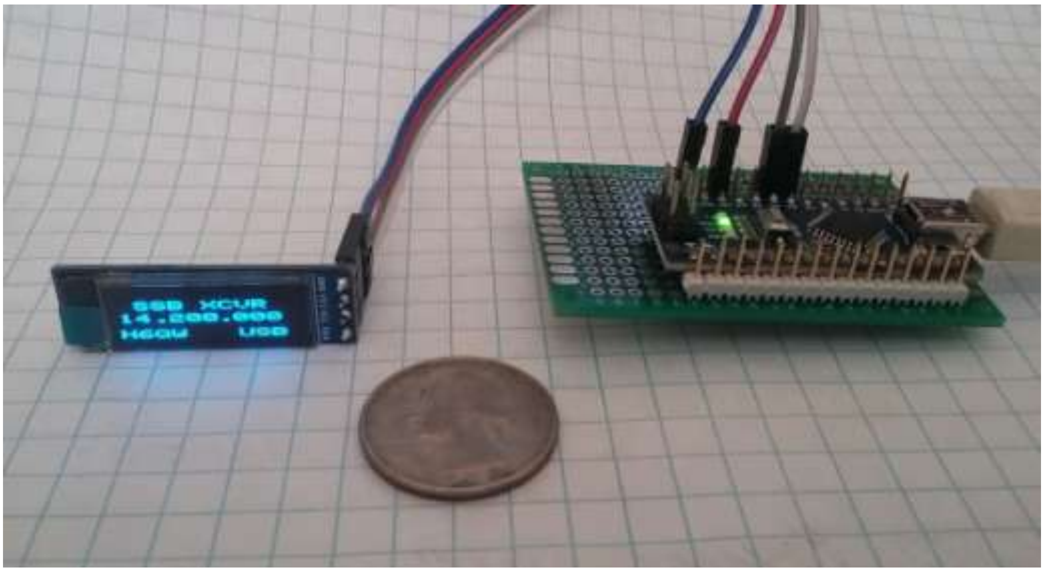


Figure 5 ~ A Really Small Display using a Nano

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

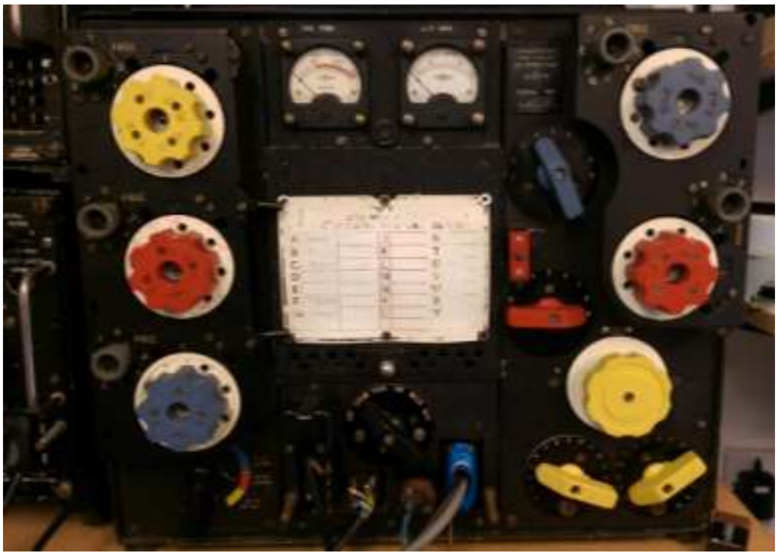
If you are like me you can probably recall some events from your youth that really made an impact on you, even if the actual details of those events are sketchy or failing. I have two I can recall: one was when on holiday in Wales as a youngster when we went to see some model planes being flown, one 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.

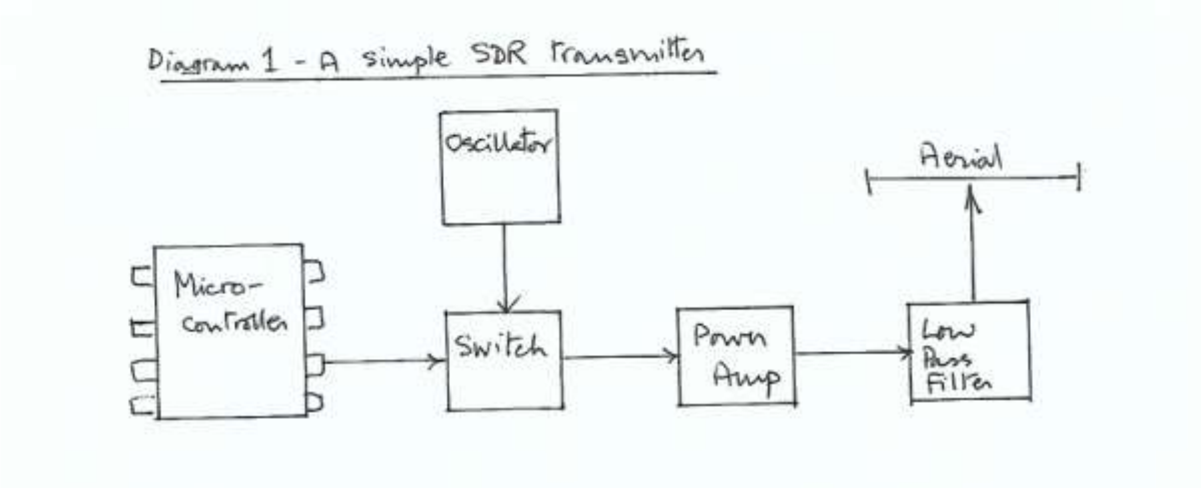
Hams interested in low power modes, such as WSPR and QRSS, make their own beacons. Indeed this is how I started out in SDR thanks to Hans Summers, G0UPL who got me hooked – the photo on the next page is of one of his kits. I want to forget about WSPR at the moment and focus on QRSS. This is a low speed 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.

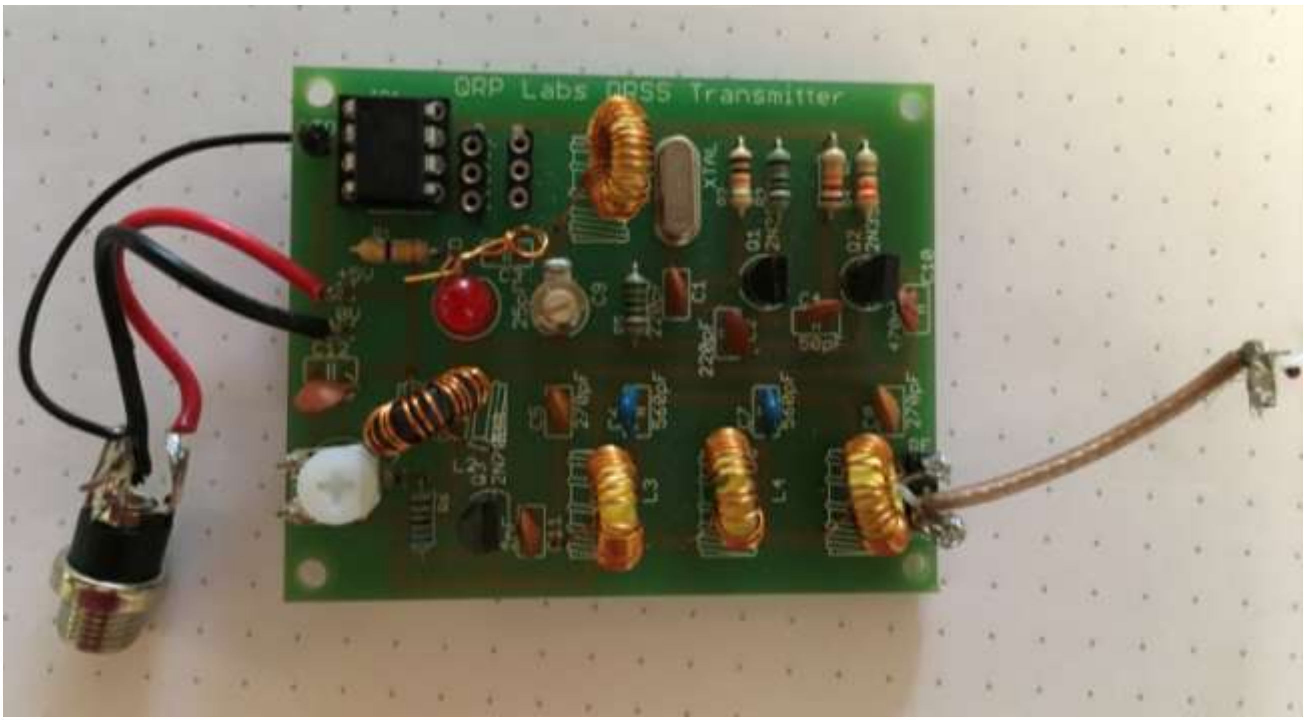
It's not so hard to make a stable crystal controlled transmitter for up to 20 meters. However the thought of manually keying ones call-sign consistently with 3 second dots accurately spaced with nine second dashes for hours at a time would make most of us insane. The answer is to use a computer to do 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.

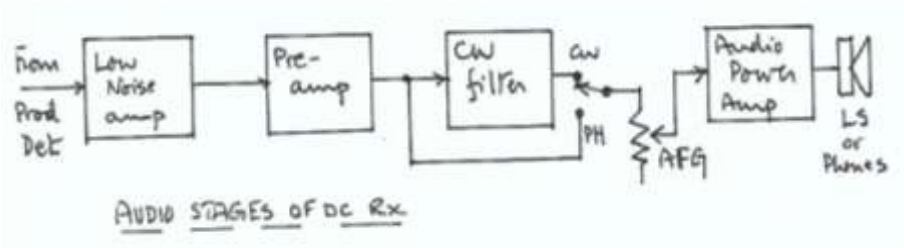
The next step would be to write some software to key the output pin precisely in accordance with our requirements for QRSS. To get the timing right we write the code to derive the timing from the crystal frequency. This is simply a matter of dividing it by a constant number so we can get a value in seconds. 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.



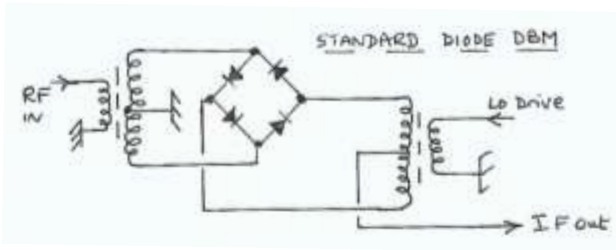


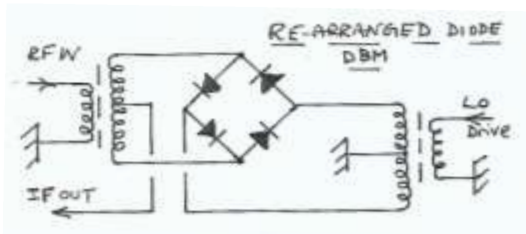
Ideas for the Bere & Stout

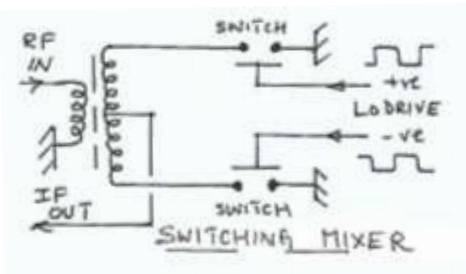
Looking at my kit range recently, I realised it lacked a decent rig for CW enthusiasts. Intending to keep things simple and low in cost, I plan a Direct Conversion receiver with a nominal 5W full break-in transmitter. Seeking more suitable Somerset place names for them, I stumbled on Bere and Stout which 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!



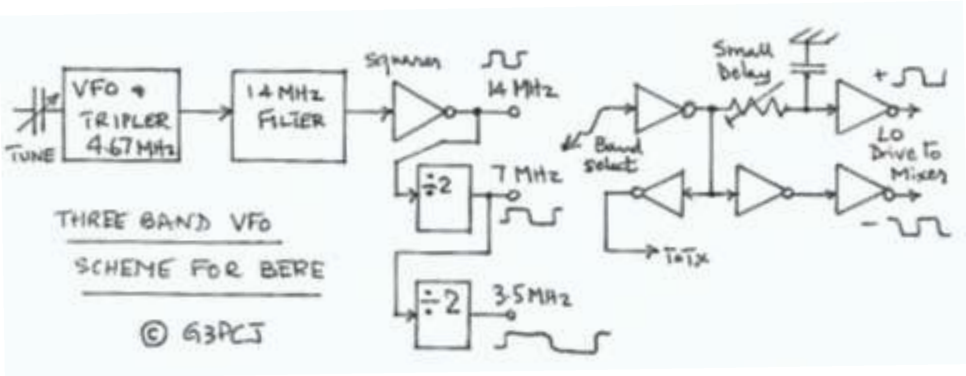
My first idea was to have a strong doubly balanced mixer similar to the conventional quad diode mixers (right) but to use FETs instead of diodes. This might avoid having to have narrow RF bandpass filters ahead of the product detector. None of this is novel but using FETs might avoid having to generate 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!



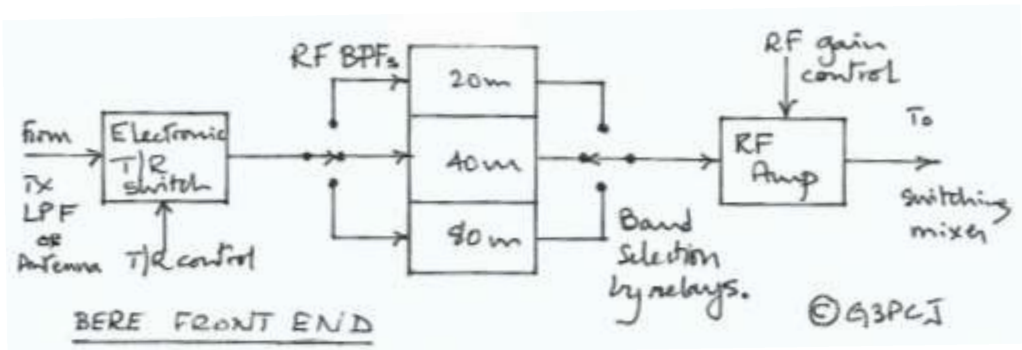




Having now established that the mixer drive can be essentially digital, this makes LO generation much easier for the old harmonically related bands – once a 14 MHz square wave LO has been created, it only needs two flip-flop dividers to also generate LO signals at 7 and 3.5 MHz ready for band selection! 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!