"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

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Issue 78

Contents

Happy Christmas to you all!

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

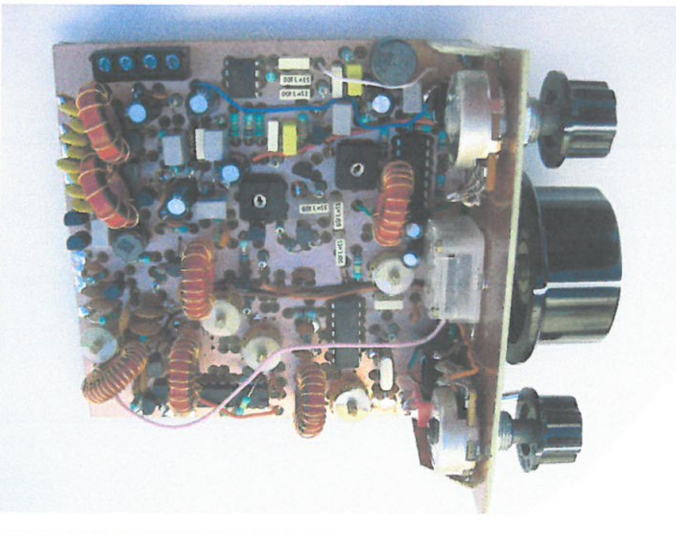
Editorial

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

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

Kit Developments

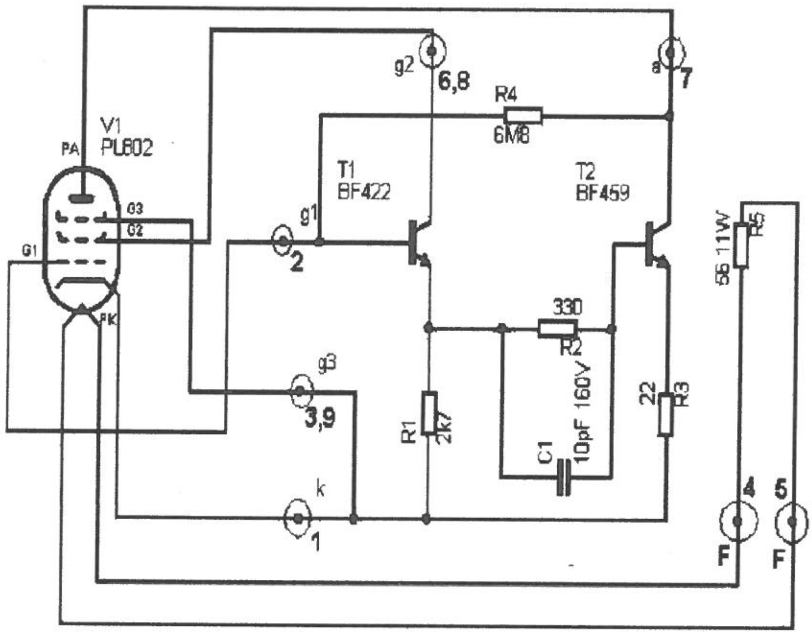
The **Berrow** (see right) is now available! This is the revised any single band 1.5W CW TCVR with a proper VFO for any band 20 – 80m. Its early days yet so a special price for Construction Club members - £55. My thanks to the original Burtle builders and their most helpful comments. Meanwhile I have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



Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £8 per year with the first issue for each year appearing in September. Those people joining later in the year will be sent the earlier issues for that year. Membership is open to all and articles or questions or comments or notes about any aspect of electronics—principally on amateur radio related topics– is very welcome. Notes on member's experience building their own gear, from kits or otherwise is most interesting to other constructors. To keep it interesting, your thoughts and ideas are required please! For membership, I only need your name and address and subscription. Send it or any other suggestions to Tim Walford, Walford Electronics, Upton Bridge Farm, Long Sutton, Langport, Somerset TA10 9NJ © G3PCJ

Solid State Valves - by Peter Thornton

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



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

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

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

Easy Inductance Calculations by Gerald Stancey G3MCK

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

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

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

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

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

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

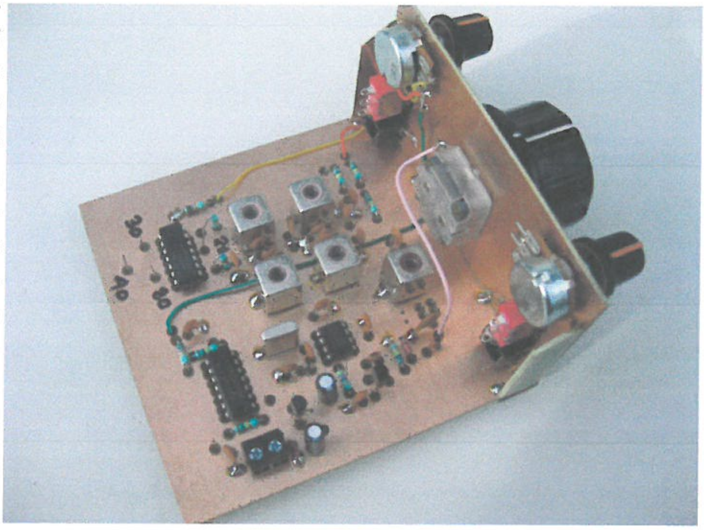
G3MCK For a=1 & b=2

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

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

The Cadbury

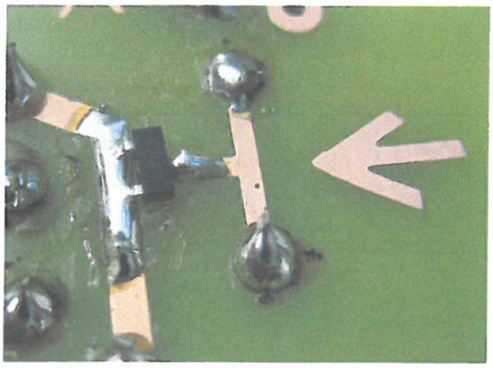
This is a new project that has four main elements. I am hoping this will feature in PW so I cant give too much detail yet! It stems from an idea for an article on VFOs - originally this was to be about getting them frequency stable by using 'quality' inductors and temperature compensating capacitors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



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

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

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



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

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

Old Sentimental Top-band

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

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

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

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

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

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

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

PCB Production – Ironing Method by Derek Alexander G4GVM

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

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

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

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

New atomic element found!

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

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

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

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

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

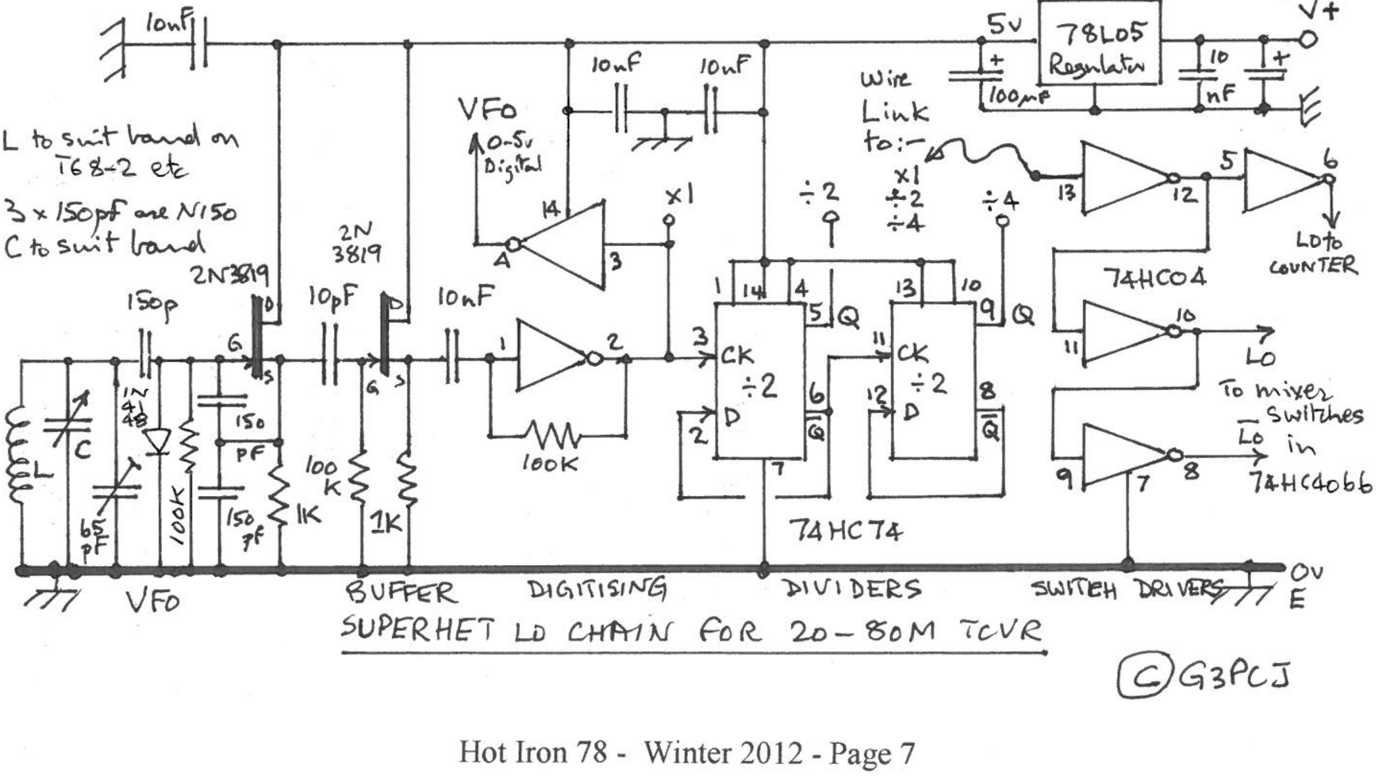
Multiband Superhet VFOs!

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

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

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

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



RF Amp architecture

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

Snippets!

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

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

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

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

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

Happy Christmas to you all!