"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Autumn 2013
Issue 81

Contents

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

Editorial

Start of another Construction Club year! Time flies by and it seems to be speeding up as I increasingly fail to do many things in the allotted time! (Including getting this out on time!) The list does not seem to get any shorter and helpful people keep on suggesting things or projects that might be worth developing. The most recent was the observation that few black box rigs include 4m - most seeming to stop at HF plus 6m. This was a good point and would strengthen demand potentially. I had thought some months back that a single TCVR kit that could do 6 or 4m would be interesting and tried to find a frequency scheme that used a single crystal mixed with the a low frequency VFO to get to 50 or 70 MHz. For simplicity I had considered a direct conversion scheme. But I failed to find anything that looked really good - a crystal derived 60 MHz (20 MHz xtal tripled) signal +/- 10 MHz VFO looks relatively easy for a DC scheme LO until you realise that 10 MHz is a bit high for good stability and has band edge birdies! Other options are lower frequency crystals but with higher harmonics! Apart from the LO chain complexity, which is inevitable even with a low VHF rig, a linear and easy TX for a few watts needs the expensive RD06 VHF version. Back to the doodling book!

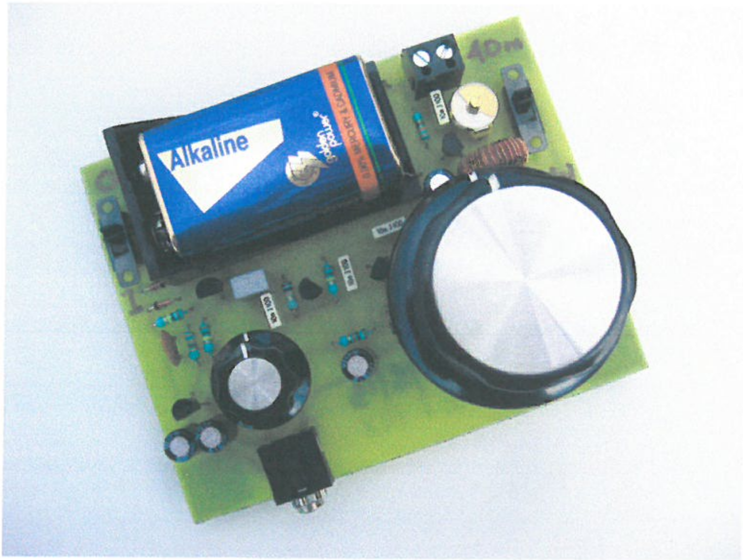
Tim G3PCJ or walfor@globalnet.co.uk

Kit Developments

I have had a very nice report from Luis EA5HWP about his experience with the Berrow (see later). Getting ready for ARiC2013 took much time so about the only new product is the **FiveFET** (picture on right) which I mentioned last time. Steve Hartley very kindly built one and made some helpful suggestions which needed a slightly modified PCB. This is now available and details are on the website.

Next job is to finish building the Minster TX and then write and add the RF Extras.

Tim G3PCJ



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 or walfor@globalnet.co.uk

"F_t" for Birdwatchers by Peter Thornton

If you design an RF circuit, the books say the transistors you choose should have an "F_t" value 5 to 10 times the frequency of service. What is this "F_t" figure? How is it measured, and what does it mean?

"F_t" means "Transition Frequency"; the frequency at which the gain has rolled off to unity. The transistor's gain is assumed to "roll off" linearly as the frequency rises due to the "Miller Effect", the multiplication of the collector - base capacitance by the hfe (ßeta, the current gain) of the transistor. The gain multiplies the capacitance, so a few pF collector - base can become much bigger in (electrical) effect. Take for instance, a BC109. Listed F_t is around 900MHz, so why won't a BC109 work on 2 metres?

It's how F_t is measured. The transistor is set up in a class A amplifier circuit, and driven by a signal generator at a test frequency, say 1, 10 or 100MHz, depending on the desired frequency of service. The input signal is kept low to avoid output distortion (which corrupts the measurement), and the output is measured - giving the gain of the device at the stated frequency and circuit parameters.

Here's some figures. Consider the BC109, a very high gain audio transistor, with an F_t of 900MHz. BC109's are usually tested at 10MHz, and let's say the gain comes out at a respectable 90 - not surprising with a BC109, an extremely high gain audio transistor.

"F_t" = (gain) x (test frequency) = 10MHz x 90 = 900. Since "gain" is a parameter-less number, then the resultant "F_t" value is given in "MHz".

As a guide to application, "F_t" helps, but it won't assure operation anywhere near the quoted Ft. That's because "F_t" doesn't measure the frequency the gain has fallen to unity; it estimates it from a much lower frequency measurement. And that's where the "5 - 10 times F_t" advice comes from.

Mosfet manufacturers rarely if ever quote an "Ft" value - this is because mosfets have such high drain - gate - source capacitances and large (~ infinite) current gain, the "F_t" is meaningless. Better with mosfets is to look at the capacitance (more accurately, stored charge), gate to source, and drain. A bipolar transistor for RF service will have very low input and output capacitances, a few pF. Unless the mosfet has been designed for RF service (and they are extremely hard to manufacture, hence the price) then the massive capacitances of general purpose mosfets have to be taken into account. Just to add insult to injury, mosfet capacitances (remember this is really stored charge) are drive level dependent: they are varactors. Keep that in mind when designing "linear" mosfet amplifiers that refuse to behave!

G6NGR Rule of Thumb: choose a transistor with an "F_t" 5 to 10 times, *and input / output capacitances appropriate to*, the frequency of service. Job done!

Here is Peter G6NGR at ARiC 2013 measuring the Ft of some very basic device (a glowing bulb!). G3PCJ

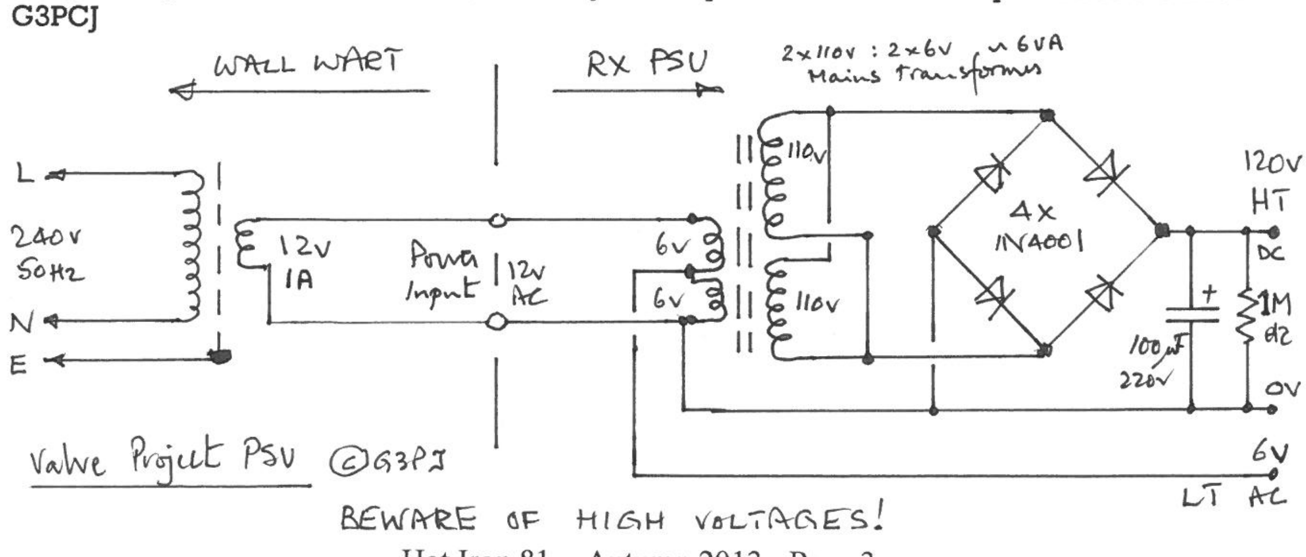
Valve project supplies

Peter Thornton and I have been investigating convenient ways of generating the voltages needed in projects using valves! Don't ask why just yet! There are two main problems to overcome, the first and generally more serious is how to be legal and safe! The other is to be able to use common and readily available (so cheapish) parts.

The first approach is to try and run valves off low HT voltages! Many people have experimented with normal tubes run with supplies way below normal but it gets very challenging when wanting to operate way down with the common 12v supply. Sometimes it works with normal high supply valves but it is not dependable. In the 1940s several valve manufacturers developed tubes specially for low voltage use in cars - using 'space charge' technology. This also turned out to be a bit unreliable due to the wide tolerances on performance. It was also wasteful of power as the heaters were generally run at higher temperatures, and the control grid was often at incoming HT supply voltage so that it too dissipated power wastefully! Not a viable line of approach for most valve experimenters, and the special tubes are also now getting rare!

So having given up on a DC supply, how to generate the high voltages needed from AC safely! I must emphasize the need to be extremely careful with any voltage over about 25 volts. The next plan is to use a mains incoming transformer (with great care!) and hope it can meet the various wiring regulations! Are there suitable ones? Plenty with 110 volt centre tapped secondaries, for use with portable tools on building sites etc but the smallest often has a VA rating of many tens VA - hence too big for our needs and unduly expensive! So consider a transformer with the next lower secondary voltage in smaller frame sizes! This turns out to be 24v commonly, so a plain bridge rectifier on its output will only produce about 25v DC on load. Not enough, so consider a voltage multiplier form of rectifier. They work perfectly well - a quadrupler will get to about 125v nicely but they have two snags - output ripple is very spiky and they need at least four large capacity high voltage electroytics. These are about £1.50 each so not a cheap solution! And then there is the need for another transformer for the heater supply!

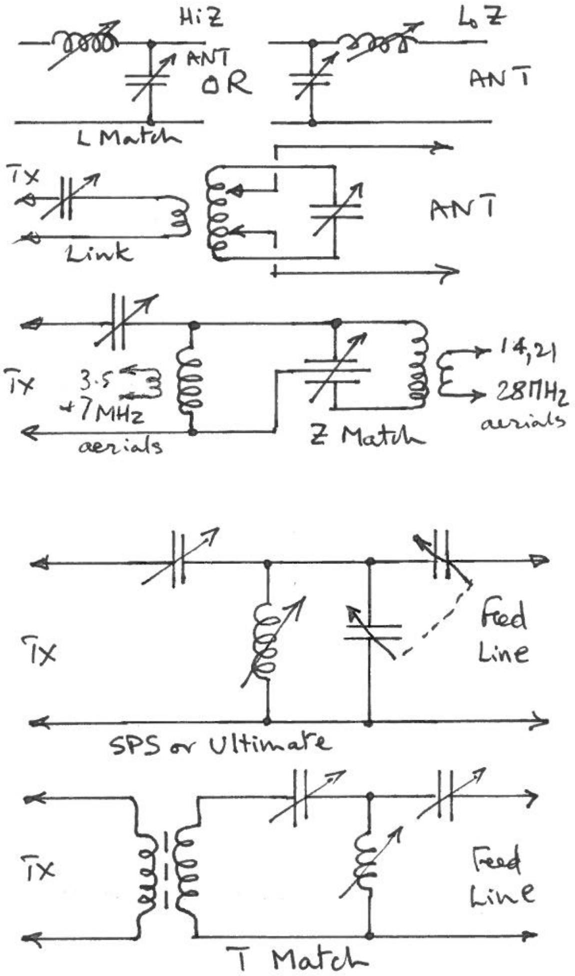
Next consider a low voltage AC main input at either 6 or 12 volts to suit the valve heaters and use a standard mains transformer backwards to get the high voltage. Plenty of suitably VA rated small 6 or 12v transformers with twin 110v primaries. Feed them with 6 or 12 volts AC, provide a simple bridge rectifier and single smoothing capacitor and you get about 120 or 240 DC depending on whether the normal 110v primaries (but actually working as secondaries) are in series or in parallel. The ripple is also now lower and has a less aggressive shape! By luck there also appears to be a UK source of 'wall warts' which have a 12v AC output! These units conveniently solve the wiring regulation problem! With a centre tapped 12v winding on the transformer working backwards, you can also power 6 or 12 volt heaters! Job done - circuits below! (If you need to operate portable from 12v DC, then buy a cheap static inverter that produces the 240V AC!) G3PCJ



Updating the AMU kit

My existing AMU kit, actually the Mk 4 design, has been around for nearly 10 years! It works perfectly well but as with many projects, one particular part is no longer available at sensible prices! The troublesome part is the inductor which is actually a flexible printed circuit strap with 40 conductors laid side by side and bent into a hoop, with the coil turns completed by linking tracks on the underside of the PCB. The last batch were expensive at over £7 each plus VAT!

So what next for the Mk 5 design? The device has to handle QRP power levels using Poly-Varicons with an RF floating output that can drive balanced or unbalanced loads. Load impedances of about 12R to 2K over 10 to 160m! Its worth having a brief re-examination of the common AMU schematics on the right.



L match Needs an input balun for floating output. Only 2 LC relatively simple components but not as versatile as 3 LC part AMU because Q uniquely defined by impedances.

Link coupled No need for balun. Needs relatively complex main coil format with several taps and switching for load impedance variations. Needs subsidiary coils for the higher bands and variable capacitor always has high voltage RF!

Z Match Interesting design but not possible with PolyVs and has two sets of outputs! Balun not needed. Complex coils.

SPS Match Various versions but most use split stator caps so not possible with PolyVs. Needs a balun.

T Match Needs a balun. Very versatile because all three parts (two C and one L) can be adjusted to achieve suitable Q. Simple coil format but does require several taps. This is the format used in the existing kit so I know its OK!

The above suggests stick with the T match and find a new coil design. To cover 160m the coil needs to have a maximum value of about 50 uH with 11 taps connected to a 1 pole 12 way switch. I started by considering small diameter plastic conduit for the formers but this needs too many turns for convenience when making several taps! I have failed to think of a former that most households would already have (apart from insufficiently rigid loo rolls!) so have to now consider 40mm PVC waste pipe. PVC is not ideal because it is lossy at VHF, but with low power at HF it is adequate. G3MCK gave us the formulas etc in Hot Iron 78 so lets see how many turns are needed with a coil diameter of 1.57 inches (40 mm) and say 1.5 inches long:-

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

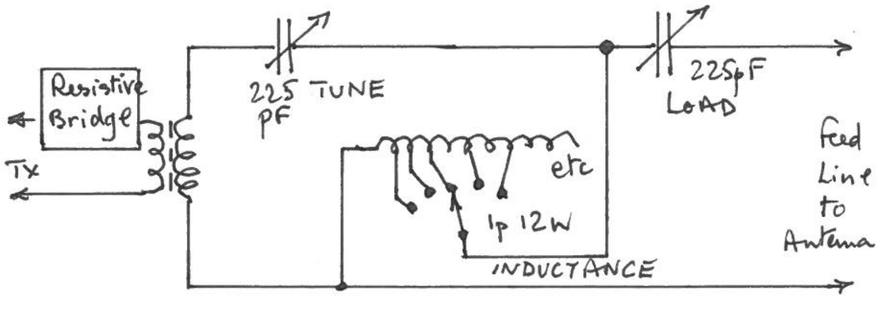
a = radius in inches
b = length in inches
n = no of turns

$$n = \frac{\sqrt{L(9a+10b)}}{a}$$

$n = 33$ turns

L = 50 μH
a = 0.75 inch
l = 1.5 inch

The answer is 33 turns which is just about possible to wind and make 11 taps as you go by twisting a loop in the wire and then continuing with the winding. The taps are needed at something like 1,1,1,2,2,2,3,3,3,4,5,6 turns between them. The kit needs to retain a resistive matching bridge and a balun, or 1:1 RF transformer at the input of the matching section so that it does not have to handle the wide range of feed line loads that are seen at the AMU output. G3PCJ



AMU Designs © G3PCJ

Building and operating the Berrow

This note was originally intended to reflect Luis EA5HWP's experience with this rig - he has worked 44 countries in 5 continents in 40 days of use - one of the first to KZ1H near Boston (left) but also to China at 9783 km - darn good with 1.5W, DC RX & 20m half wave dipole! But he and another builder have had some problems so it might be instructive to see how they were overcome! The main problem was that with RF & AF gain controls fully advanced there was a tendency for the audio to squeal - not quite a sustained oscillation! Luis had soon found that the best way to operate the RX was, in his words, like they used to, 'years ago'! AF gain high and only sufficient RF gain to hear background static with his aerial (or BCI)! The other builder had observed that the instability had only become apparent when the RX RF amp stage was added.

The classic cause of audio instability is the earth return lead for the LS (or phones) being shared with the earth connection of the AFG pot. Not so here! It was soon evident that peaks in the supply current, on audio peaks, were causing the main supply rail to droop a little and hence affecting some earlier stage. Thin incoming supply wires can cause this affect. Usually extra very large decouplers dabbed onto supply lines, can help indicate what is wrong but it did not in this case! I tried adding large amounts of extra decoupling in all stages using the main supply (and also the regulated 5 volt line), but this had no effect whatever! I eventually realised that variations in incoming main supply could (in principle) pass directly to the RF amp because it is directly connected to the TX side of the low pass harmonic filter so as to give full break-in operation. This is not easily changed but I will be altering the coupling capacitors here to be as small as sensibly possible to reduce the feed through of audio frequency signals. But the problem persisted!

After a while I realised that it was the audio filter (a humped band pass design) that was almost oscillating and causing the tendency to ring/squeal. This was intended to have a Q of 5 which is about the maximum recommended for CW work. It is easy to reduce the stage gain (and hence Q) of this filter, by changing a feedback resistor. There will be a slight loss of selectivity but the loss of gain can be compensated by upping the gain of the following output stage.

While experimenting with it on the bench, I did find that parts of the circuit were tender to be being touched - particularly in the LO driver section, where this design has digital stages with consequent very short rise and fall times. I decided this does not need attention because it was not evident till you fingered it! A few tens of pF on the LO gate output, would slow these edges down.

I thought Luis had also noticed a tendency for the VFO to jump a small amount when the key was closed. This could be due to poor supply regulation, ie similar to thin supply wires. A 12 volt regulator near the rig would help. The line and load regulation of the rig's 78L05 regulator is not all that good, so incoming supply variations could possibly get through to the 5 volt line which feeds Fine tuning varactor diode. Changing to a 317 series regulator (which has better regulation) would cure this - see circuit below. Re-reading his mails though, I think he meant the VFO shifts as something warms up when the key is down. Better ventilation or heat sink tubes on the output devices (or a small fan) might cure this, and or fitting of some sort of heat shield (polystyrene) between the RF output stage and the VFO area might help. Luis's rig left! G3PCJ

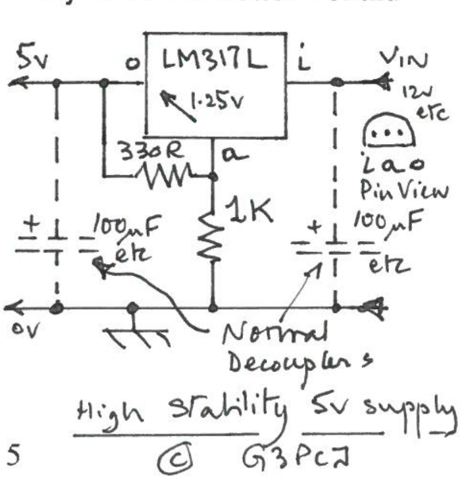
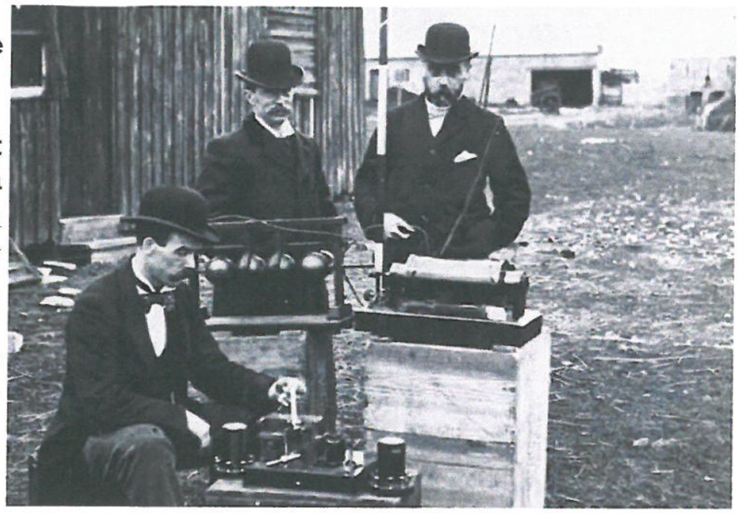


Photo Caption Competition!

I received two suggested captions for the Three Old Gents photo on right.



First prize, a small regen TRF informal kit called the Littleton, goes to Rob Mannion G3XFD who suggested "I do wish that Tim Walford's Amateur Radio In The Country event could become a casual dress day out!"

The other entry was from David Proctor who suggested "Ebenezer, you did charge the accumulators didn't you?"

Snippets!

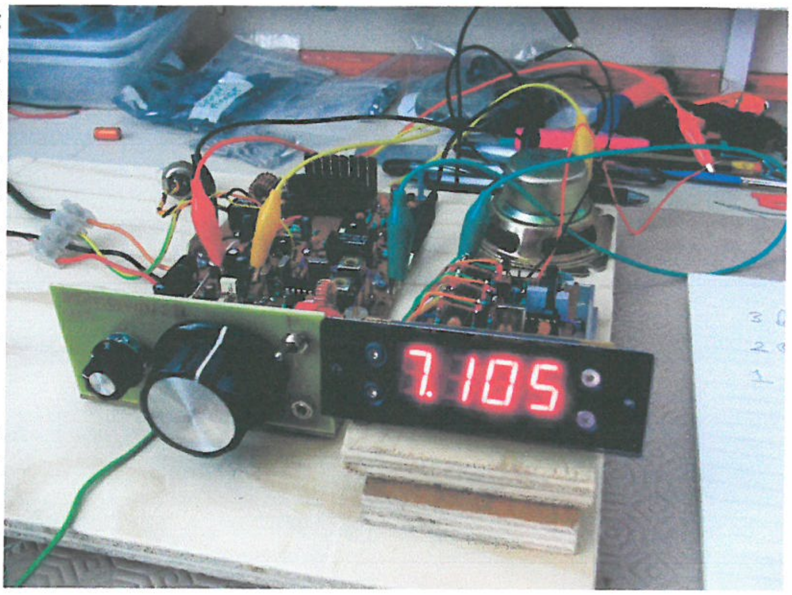
Novel dielectric! A team from the National Physical Laboratory has come up with a new lead free dielectric aimed at high temperature automotive applications. It is good to 200 °C and does not suffer the capacitance reducing phase change at around 125 °C experienced by the modified barium titanates ($BaTiO_3$) used to produce X7R and Y5V class capacitors. Dielectrics fall into two groups - linear materials like Al_2O_3 which are not ferroelectric, so have low dielectric constant and are used for high performance low dissipation (0.1%) COG style capacitors (these have a nominally zero coefficient of change of capacitance with temperature, very similar to NPO specimens!), and those that are ferroelectric like $BaTiO_3$ which do dissipate much more heat and hence suffer much larger changes in capacitance. The new material is bismuth ferrite-strontium titanate $(BiFeO_3)0.6(SrTiO_3)0.4$ and is aimed at making X9R class capacitors. It has dissipation of 0.3% so is almost as good as COG types but can be used for 5 nF to 100 nF and up to 1kV with a capacitance change of only about 17% when at 200 °C. The normal $BaTiO_3$ X7R material is much worse!

MEMS Oscillator matches quartz! Silicon Labs have introduced new MEMS (micro electromechanical system) resonator technology which achieves +/- 20 ppm over 10 years from –40 to +85°C. Within the 4 pin chip is a voltage regulator, variable frequency oscillator in a phase locked loop, temperature sensor and the new resonator in its own oscillator circuit that provides the reference for the PPL. The new resonator is built from a combination of poly-SiGe and SiO_2 over processed CMOS. The resonator is suspended by springs from its corners and sits on a central post with transducers around the edges all inside a vacuum! The special material has passive temp compensation which is an order of magnitude better than quartz which enables the electronic compensation to be much simpler. The initial Si504 can generate any frequency in range 32 KHz to 100 MHz, adjusted by a one-pin serial input with a consumption of just 1.7 mA with a foot print of 3.2 x 5 mm.

Mounting surface mount Varactors One of our Construction Club members is investigating the possibility of having commercially manufactured small PCBs made up with surface mount varactor diodes already fitted - so called 'break-out boards'. The intention behind this is to make it rather easier to use these parts by those whose eye-sight, or general facilities, are unsuited to handling very small surface mount parts. A couple of my recent kits do include 3 tab surface mount varactors because I cant get anything else at sensible prices and in quantity! I reckon that these 3 tabbed (or terminal) devices are not as bad as many fear provided you take reasonable precautions in handling them so they don't disappear down cracks in the floorboards! They can be soldered with a narrow tipped 18W iron satisfactorily. A device with more pins or smaller size would be challenging! If any body is interested in the alternative of a small break out board, please get in touch via me - Tim G3PCJ.

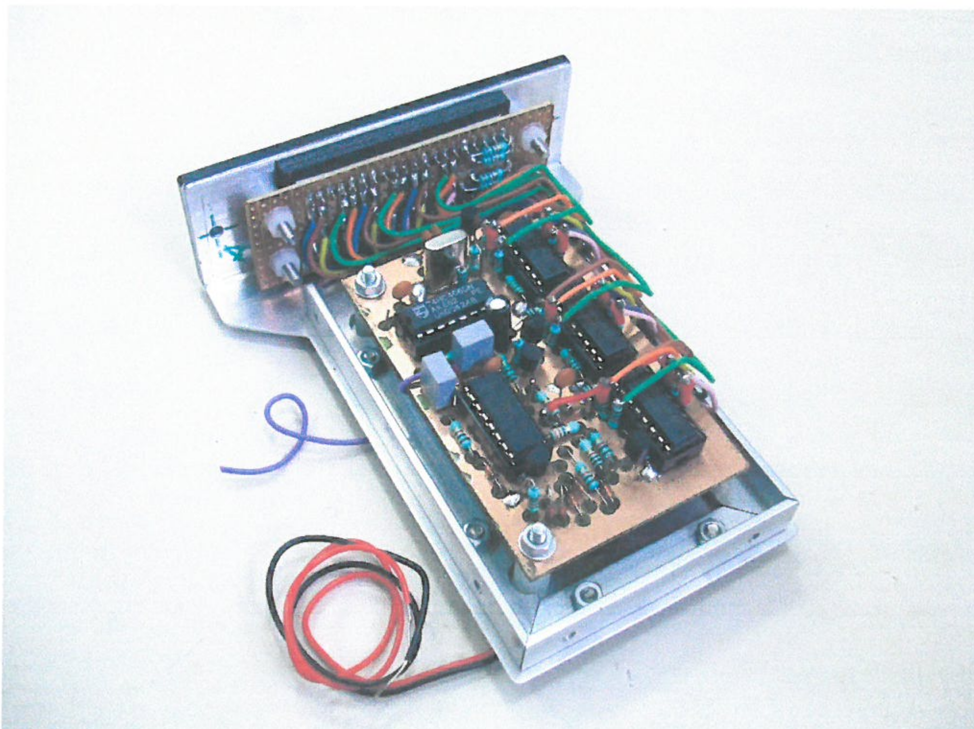
Building the Bridgwater and Burnham by Mick M0GWD

After originally getting hooked on kit construction by making Tim's Tone Receiver kit at the 2012 Bath Buildathon, I decided to take things further earlier this year and bought the Burnham / Bridgwater combination and the 10W Linear Amp kit. The plan was to make the 10W Transceiver along with some of the accessory kits, including the 3-Digit Counter and build it into a metal case with the best 'professional' layout and appearance that I could achieve.



Although progress is somewhat slow due to other commitments, I am now at the stage where I have built the Transceiver, the Linear Amp, the AGC Board and I have a working S-Meter after building the small add-on board. I have also completed and tested the 3-Digit Counter, and with my proposed layout I have decided to mount it immediately above the transceiver board, with the main tuning moved to the right.

To make installation into the case easier, in particular the front panel, I made the 3-Digit Counter into a self-contained module, which requires just two fixing screws. The module is made on a sub-chassis made of 1mm aluminium, which holds both the PCB and the counter displays. As I have built the 40m option, I have added a hard-wired digit '7' and a decimal point, following Tim's instruction sheet. The displays are attached to vertically-oriented strip-board, which is itself fixed behind some 3mm grey-smoked acrylic sheet. Using strip-board with the copper running vertically allows for easy breaks to separate the pin connections, whilst leaving the top and bottom centre-ground connections unbroken. Also with the hard-wired digits, the resistors can be fitted to the board, making for a neat installation.

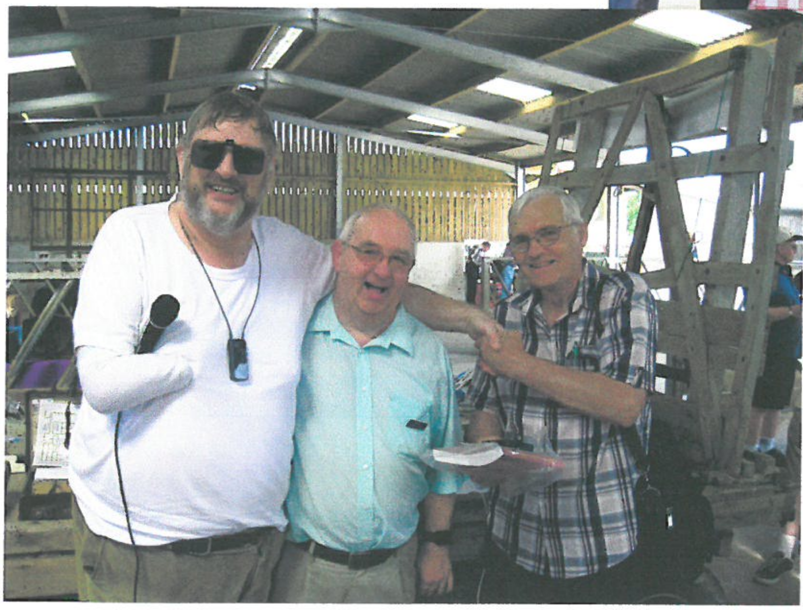


The module can be screened if required, by fitting aluminium sides to the angle sections, with the top screening completed by the transceiver case, forming a box. Only three wires connect the module. The input wire, which when installed will be about 40mm in length, plus the two wires for power and ground. The display works very well, and I hope to give a further report on overall progress of the transceiver in due course. M0GWD

Amateur Radio in the Country 2013

About 300 people turned up here on July 21st for what turned out to be a very fine and hot day! An excellent attendance and thank you to all readers of this publication who came. There were many stall takers who had come in previous years, local Club exhibits as well as a few new displays. It takes an appreciable effort to put on these displays etc so a big thank you to all who 'exhibited'. I must also say a big thank you to my wife and her catering team (below) who managed to cook a prodigious amount of bacon, sausages, burgers etc.

Robert Van de Zaal also came all the way specially from Holland to oversee the beer barrel supplied by my next door neighbour! In addition, that farm also produces some excellent cider which was a total sell out! (When I came to settle up with the cider maker, he asked if we would act as wholesalers!) In view of the anticipated heat, many had opted to have their stalls in the barns, so the photo above is the rest in the field! My wife also collected for the farming charity Send a Cow which helps those in many parts of Africa, with a raffle. First prize was a years subscription kindly presented by PW Editor G3XFD Rob Mannion. This raised the splendid sum of £146.



With the help of Graham Firth G3MFJ of the GQRP Club, who kindly came all the way from Lancashire to judge, we had set the informal Construction task to be that of designing and building a 'good' sidetone oscillator that could be keyed either directly or by sniffing RF from the transmitter. There were two proper entries apart from the demonstrators produced by Graham and myself! Regrettably one of the entries failed to work on the day, the other was from keen constructor Craig G0HDJ who pressed a 555 timer into service as an oscillator controlled by the key/RF. Accordingly he won the prize which was the ARRL book Radio Frequency Design by Wes Hayward. This prize was also presented by Rob Mannion (above). Judge Graham (in the middle) reckoned his demonstrator was superior to mine, but this depended on interpretation of the entry notes!

Finally I must say a big thank you to Rob M G3XFD for all his help and encouragement in the holding of radio events here and elsewhere over many years. With his partial retirement from Editorship of Practical Wireless about to happen soon, we wish you the very best for the future and hope that we will continue to see you round and about at radio events for many years to come. G3PCJ