Hot Iron

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Issue 54

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The Walford Electronics website is also at www.walfordelectronics.c

Editorial

Here we are at the start of the 14th year of Hot Iron - I would never have guessed that we could keep it going that long! Two long time supporters Andy Howgate and Richard Booth felt we ought to celebrate in some manner, and had themselves not seen all the early issues, so they hatched the idea of an 'anniversary edition' containing all back issues. This paper version of HI54 is not that but the special will come to you on CD! It should be despatched before Christmas!

Richard has done a really splendid job putting together all the material, which has involved scanning all earlier issues, sorting a collection of photographs of my rigs - ancient and modern, as well as some most welcome ones from other builders, getting some old material from PW (as I have worked with them), writing some software and getting it all produced on CDs for all current members. Thank you very much Richard. Tim Walford

(A word of warning! My early writings in HI 3 on measuring SSB RF power were wrong - so don't take everything as gospel - it was corrected later!)
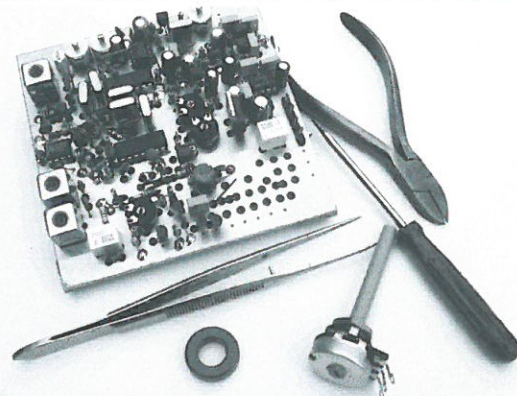
Kit Developments

The **Brean** is now out and available, with an article in the Dec PW. It is a small double sideband suppressed carrier phone *transceiver*. It can be used on any single band 20 to 80m and produces 1.5 Watts peak on a 13.8 volt supply. It costs £44 plus £3 P and P. For the higher bands, you can either use a crystal with a very limited tuning range, or add the Mini Mixer kit which transfers the normal 80m tuning range up to the higher band. I have also now got a few early All Band VFOs (**ABLO**) ready. This provides a digital output, suitable for driving the LO of a direct conversion RX (diode or 602/1496 types) for all the traditional harmonically related bands. I explained the concept in Hot Iron 52. It can be used to drive an all band CW TCVR such as the forthcoming Pylle. It costs £49 plus £3 P and P. It can also be used with CW and phone phasing receivers! See later.

After that, I am preparing a signal generator, the Pylle CW TX and Minster. I am also working up ideas for a good DC RX to replace the Sutton (which has been retired); this is to be called the Knole and would be any single band 20 to 80m but with a better performance than the Kilve.

Meanwhile it is still raining and I ought to be outside sorting our ewes and lambs! Christmas is not far off, so **I wish you all a very happy Christmas and the very best of health**, Tim G3PCJ

Phasing Receivers

The phasing approach is another method of removing the unwanted sideband when an incoming wanted signal is mixed with a local oscillator. It is normally used in conjunction with direct conversion receivers, because superhet receivers usually have a narrow filter which automatically removes the unwanted sideband. The phasing approach avoids this expensive & complex filter, while the DC RX approach can now be made multi-band without too much difficulty.

The phasing scheme involves using two mixers which feed into two audio phase shifting networks, followed by a combining stage that outputs into the rest of a conventional DC receiver. The two mixer channels are often referred to as the I and Q 'channels'. The basic block diagram is shown below. The mixers need their LO signals (at the same frequency) to have a phase difference of 90 degrees. This will cause their heterodyne outputs (the difference between the LO and wanted RF signal) to also have a 90 degree difference in phase. These outputs are then applied to two separate audio phase shift networks which introduce a further 90 degree relative phase shift; the two audio signals are then added together. The sideband which had a relative RF 90 degree lag (say) and then a further relative audio 90 degree lag will be 180 degrees out compared to the other channel, thus when added they actually cancel each other out instantaneously. Conversely, the other two audio sidebands will be in phase and will add enhancing the wanted output. In the design shown below (which is suited to narrow CW audio signals), the audio phase shifting is done by making one channel lag by 45 degrees and the other advance by 45 degrees at the centre of the CW audio filter, thus producing the desired 90 degree relative shift. Audio phase shifters for phone signals can be designed but are much more complex. Only a few extra mixer and audio parts are needed to implement this scheme for CW. It also retains that signal clarity for which DC RXs are renown! I am contemplating a small audio phase shift kit for use with any type of mixer, but my own approach would use two of my standard diode mixer kits. Hitherto, the main difficulty has been to produce LO signals with a 90 degree phase difference. However, the digital approach used in the All Band LO (ABLO) kit makes this quite easy - see the next page. Tim G3PCJ
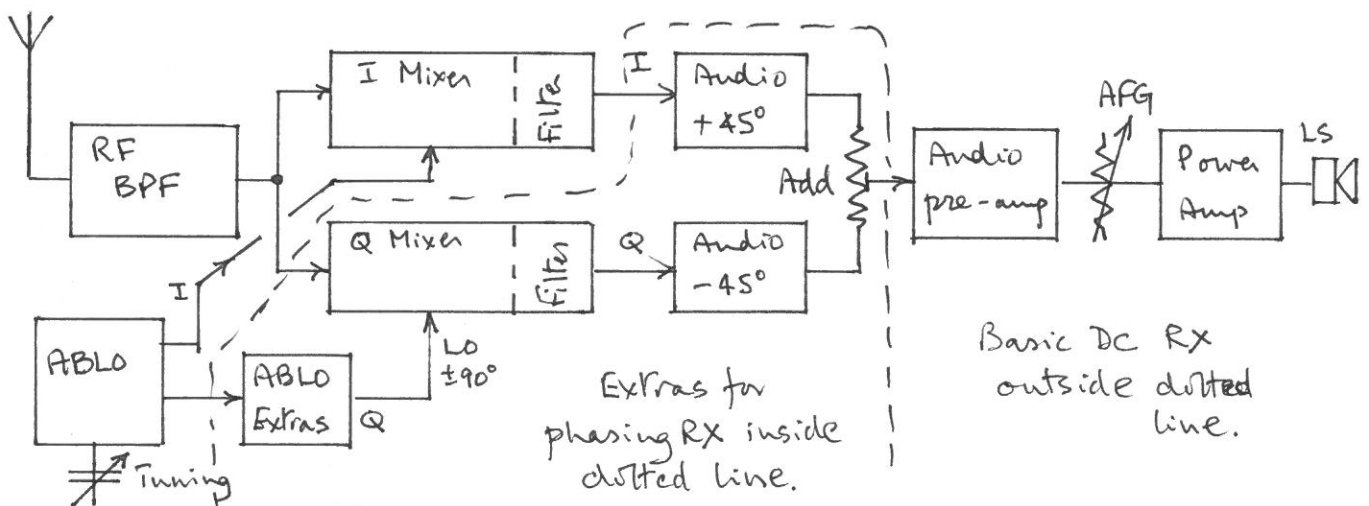

Phasing DC Receiver
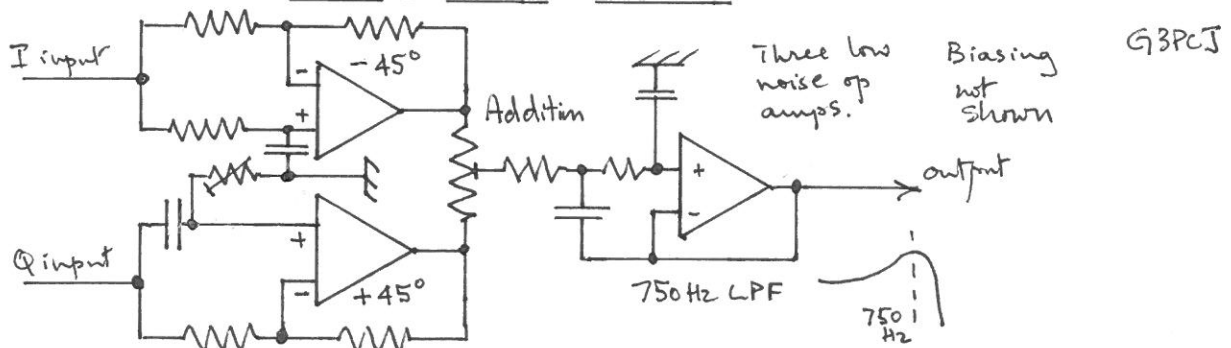
Audio Phase shifters

ABLO outputs with 90° phase difference

The All Band LO was outlined in Hot Iron 52; it uses a VFO and crystal mixing scheme to produce stable signals at 28 - 29 MHz and 7 - 8 MHz; which are then squared up in digital gates and divided down using digital flip-flops to obtain square wave outputs on 10, 20, 40, 80 and 160m. There is also a 15m output but it cannot be used for driving a phasing RX as we have to start with twice the wanted LO output frequency. For this reason, it also not possible to use the ABLO on 10m with a phasing RX. Hence the ABLO can only be used to produce the required 90 degree different outputs on 20, 40, 80 and 160m. The photo on the right is the prototype ABLO but without any phasing additions.
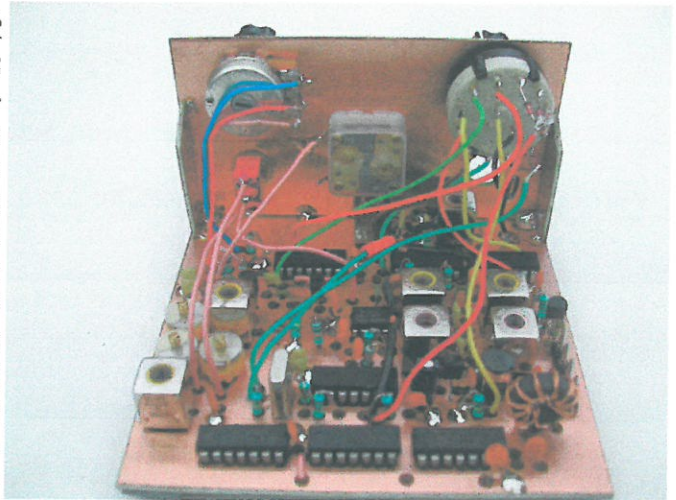
One output can use the normal signals from the bandswitch, which drive paralleled inverter gates connected to the 2:1 output transformer; this enables it to directly drive a diode mixer if required. The other extra 90 degree output comes from an extra flip flop (actually the spare one in the ABLO) that is clocked with the twice the desired LO frequency, but with an inverted clock to introduce the desired 90 degree difference at the output. (The flip flop divides the frequency by two.) The extra circuits are shown below. The extra flip flop drives paralleled gates and a 2:1 transformer just like the original output. This approach is multi-band, provided the second channel has its two times input frequency also altered to match the main channel - this is most easily done by using a 3 pole 4 way bandswitch instead of the original 2p 6w one. Without further arrangements, the flip flops would have a random relative phase at switch on, hence the pair of diodes driving the reset input of the additional flip-flop - this ensures the same sideband will be selected each time it is switched on. By adding a SPCO toggle to select the alternative phase of the main signal for the reset circuit, it is easy to change sidebands too! I intend to use this ABLO scheme to make a multiband CW transceiver using two diode mixers, the audio phase shifter and the standard audio amp kit in conjunction with the Pylle CW transmitter. More about this on another occasion! Tim G3PCJ

Extra ABLO Output for ±90° relative original output
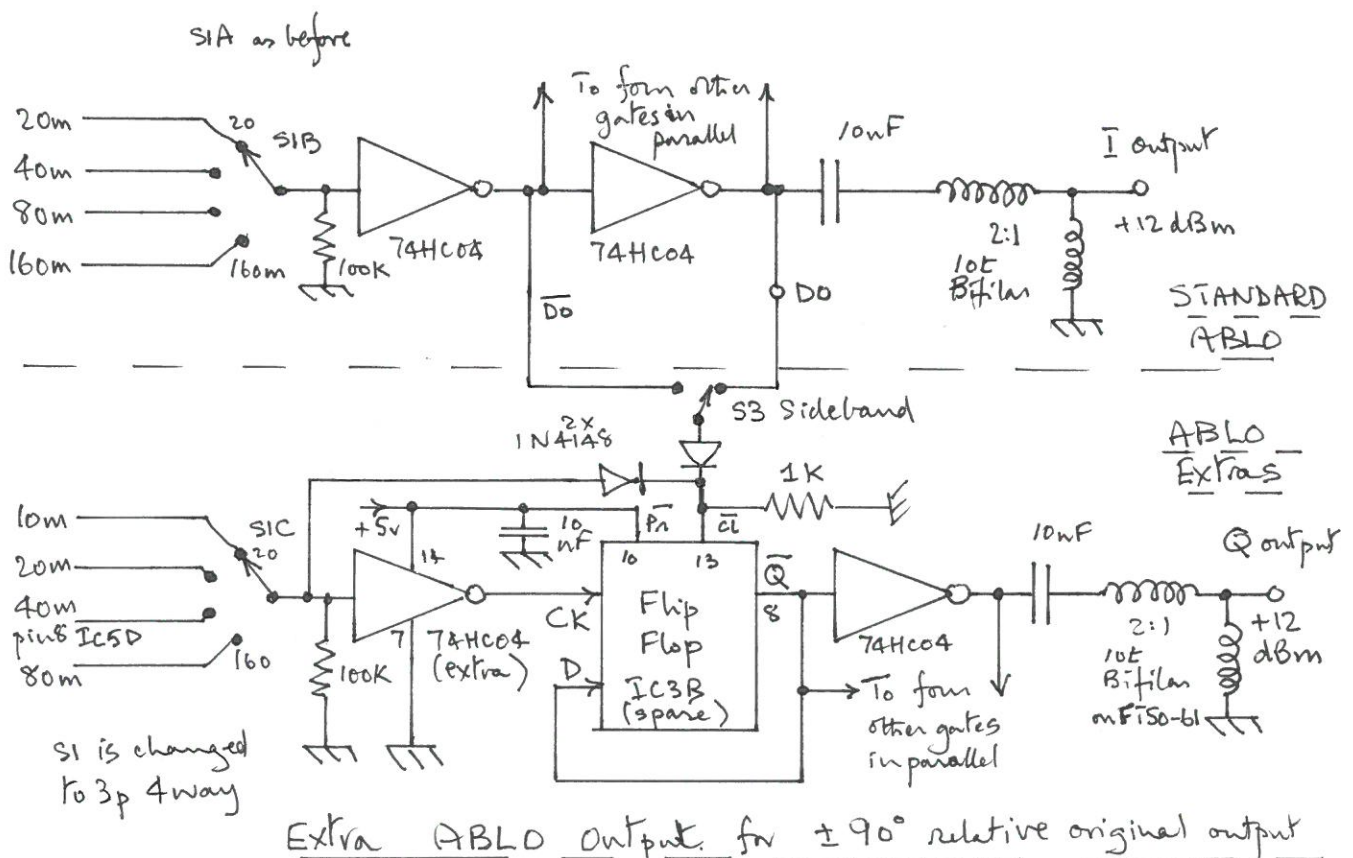
BCI and Q Mulipliers

Simple receivers (of the DC type) can be prone to overloading of their detector stage from very strong signals just outside the amateur band. This is the classic problem on 40m which can lead to un-tuneable mushy signals all over 40m - particularly at night when the broadcast stations at about 7.2 MHz get going! There are two solutions - firstly use a stronger mixer that is better able to handle the big unwanted signals, or secondly to improve the rejection by the RF bandpass filter of the adjacent unwanted signals. The former approach often requires diode mixers with their high local oscillator drive requirement. Improving the RF filter out of band rejection is not easy either!

However, I thought that incorporating the RF filter into a regenerative or Q multiplier stage might be the solution! Its quite easy to make a parallel tuned circuit regenerate by adding a few CRDs and a transistor. The technique is to introduce a little positive feedback so that the stage is just below the point of oscillation. This needs to be very carefully controlled for the best effect, otherwise there is likely to be either no advantage, or it will be actually oscillating! This must not happen because it might radiate and will certainly introduce extra heterodyne whistles! Luckily the point of oscillation can be carefully controlled by adjusting the bias of the extra regen (oscillator) stage. Only very small changes in bias (or other circuit/load) conditions can lead to dramatic changes in the effective Q of the tuned circuit that is on the point of oscillation. As the positive feedback is increased, the Q (or sharpness of the tuned circuit's response) also increases dramatically. It is quite common for a plain tuned circuit, say with a Q of 30 on 7 MHz, to have the Q increased so much that the reduced RF bandwidth then limits the audio sidebands, implying a Q of nearer 3000! I thought this ought to also get rid of the BC signals which would be over 100 KHz away! So I lashed together the circuit right on the front end of a standard 40m DC RX.

It certainly raised the Q alright! But it did NOT get rid of the BCI! This puzzled me for some time until it eventually dawned on me what the real effect of the regen stage actually is! The regeneration was certainly raising the Q and by so doing it was markedly increasing the wanted signal right on the nose of the filter; but crucially, it was also always raising the strength of the off-nose signals - but not so much as for those on the nose because that would imply no change in Q. This is shown in the lower diagram which shows the change in filter response as Q is increased.

Thus the interfering signals presented to the following product detector were not getting any weaker - the opposite in fact; the wanted signals were much stronger but the BCI was still there because the unwanted was not made any weaker! One would have been able to reduce the gain of the following receiver audio stages but the BCI would just have been less noticeable!

The proper solution has to reduce the level of the unwanted signals presented to the product detector. Often this is done by attenuating all input signals, when a small reduction, totally removes the BCI leaving the wanted in the clear. Thus we come back to improving the out of band rejection of the RF filter. One approach is to add a third resonator to the RF filter and this is what I propose for the forthcoming Knole single band good DC RX. G3PCJ

RF Q mult/regen circuit

G3PCJ
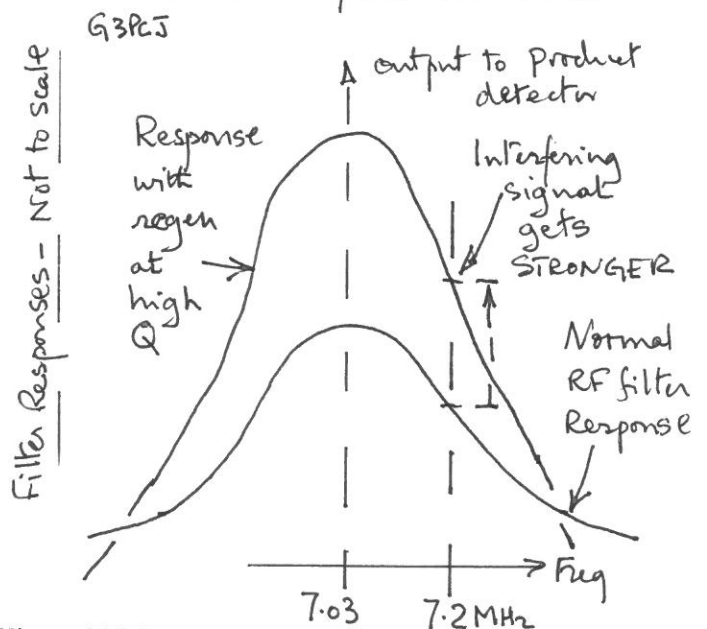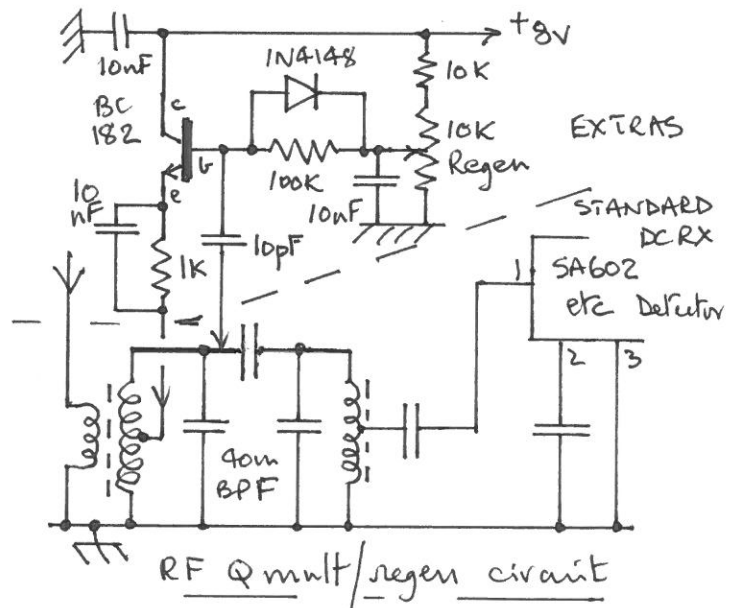
Mains earthing and RCDs (again!)

Steve Hartley took me to task about my earthing suggestions last time! He observed that there is an official advice group who has looked at this for the RSGB. **For all readers of Hot Iron, I must bow to the advice of the legal experts and insist that you consult and take the advice of the relevant electrical professionals — not me.** I write the following notes in the hope that it will help you to closely question any person who you do consult. In some particular circumstances (and I am specifically avoiding stating which circumstances!), their advice is to is to bond RF earths to the mains earth with suitably stout cables. For my own uses (and you must not copy me but just closely question any professional and form your own decision based on their advice), I shall not bond my RF earths to the incoming PME earth terminal. The reason is that I don't want all the local neutral current (potentially many 10s of Amps) zipping down my RF earth if the neutral to this house is broken - it is carried overhead on poles and might get broken by a hedge trimmer or whatever! I much prefer to have my mains earthing done by my own RCD and local earth spike. I doubt there are many RF earths that could safely take even 10 amps of 50 Hz, let alone 100A!

I remain convinced there is some confusion in these matters! Steve recounts that recently 3 students followed the industry advice about bonding of RF earths and found that the protective devices kept tripping - I am not sure what they were in these installations. They were professionally checked by electricians; eventually it was found that in all 3 cases there were several volts (at 50 Hz) in difference between the local mains neutral providing the PME, and genuine RF earth. (This is not surprising on a heavily loaded local mains distribution transformer.) I don't understand why completing the bonding should cause the RCD (residual current device) to trip because the current flowing between the 'few volt high' neutral and RF earth should not flow through the RCD anyway; nor should it flow in any MCB (miniature circuit breaker) that is in the outgoing live (or phase wire) to any particular load. The MCB is there as a modern equivalent of a fuse, and only fitted in the live or phase wire, which is intended to protect the wiring (and maybe the load) from excessively high currents flowing via the correct path back to the supply neutral. If some of that current escapes to earth, the missing difference should be detected by the RCD if fitted (and maybe the MCB if its sufficiently high), which then causes the RCD to disconnect the circuit. In the cases mentioned by Steve there are some unexplained funnies - possibly some unwanted and irregular leakage path between a circuit neutral (ie after the RCD if it was fitted) and the associated circuit mains earth. (This is the difficult scenario that I mentioned last time, where lightning broke down the insulation between a load circuit neutral and mains earth, causing my RCD to trip! This fault can only be found by disconnecting the individual circuit neutrals until the fault is removed.) Enough - take the advice of others! G3PCJ

GU3TUX's Design Challenge!

I regret that nobody really rose to Chris's challenge - only David Rowlands made any comment, and that was not too complimentary about using old London Underground stock in Alderney. He commented on their unreliability but I suspect this referred to their own traction arrangements, which are of course irrelevant when being pulled or pushed by a smart green diesel monster!

Chris did explain to me that they use a system of multiple 'rings' with the existing bells to signal different driving or stopping conditions. This uses all three of the available conductors. Ideally two of them needs to be liberated and I cannot see why the rails/wheels and couplings cannot provide a return for a bell circuit. If wheel to rail contact is sufficiently good for detecting the presence of a rail vehicle on main line tracks, it should be adequate here for bells.

Here is a scheme but it does need two batteries. It might be possible to use the engine battery for the cab end? Perhaps easier than running an extra pair of wires through the carriages! G3PCJ
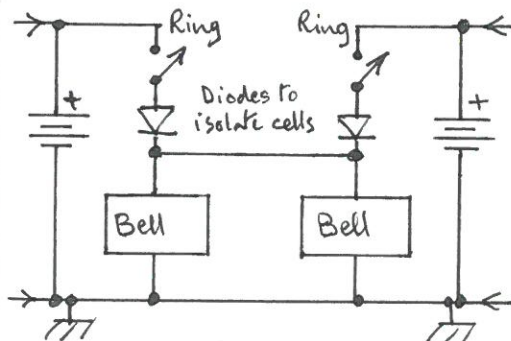
The design basis for kits

It has been suggested that I explain what goes into designing a kit! My fundamental objective is to utilise technology that is easily 'buildable' (ie not use surface mounted parts normally). The next point is to provide a performance which is good for whatever a particular customer decides he can afford - high or low. Often this involves many re-iterative stages of scribbling in my notebook to devise a block diagram that meets the task and is efficient in terms of parts that are required. I specifically avoid using any part whose cost is way above the general run of parts for that type or class of kits - for example, a filter costing me £15 would be totally out of place in a kit having a target selling price of £30! I also use parts in as many kits as possible for better purchase discounts. I have to use new parts, ordered from reputable suppliers who I can go back to time and again; this makes it impossible to source them from rallies or other non-professional sources. I tend to use the major distributors Farnell, RS and Rapid, with specialist things from a few other firms.

Deciding what the target rig spec should be is the first hurdle. Obviously, there needs to be a range of kits having different complexity so that builders can select projects to match their skills. They also need to address the differing interests of the hobby like phone or Morse methods of communication. Others will be more interested in test gear if their interest is in building projects rather than just operating the equipment. Some will only wish to natter on 160m while others will be avid contesters on 10m only so the question of single or multi-band rigs is relevant! These different 'axes' of interest all cross in different ways and can lead to a gap in any logical sequence along one axis. As a general rule, the higher the frequency of operation, the more challenging it will be to make a satisfactory rig with good frequency stability. This is why I do not currently offer anything over 10m because most builders ability to fault find in the low VHF (and upwards) region is pretty limited. I once did a 2m design which worked as a lash up on plain copper sheet built dead bug style, but it took me ages to get it working properly after transferring to proper PCBs, because my test gear was not adequate for the job.

As an example, I decided earlier this year that I needed a simple direct conversion receiver costing about £20; to provide an alternative and lower cost starter kit to the ubiquitous regen TRF (the Catcott). At this price one has to give up quite a bit so I decided the Kilve RX should only cater for driving phones, not load speakers, and to omit an audio gain control, and to have a simpler RF input filter. By adding a few extra holes to allow alternative part connections, it was not too difficult to make this design suitable for any single band 20 to 80m with just one set of parts - important for minimising my time spent picking the parts to make up kits and to reduce the total quantity needing to be held in store to meet my aim of despatching kits the same or next day. Designing a reasonable receiver is always harder than doing most transmitters - especially for CW TXs. Hence the CW Kilton TX works very well and provides better performance for money than does the Kilve RX!

This has led me to realise that a better receiver is needed for serious use with the K series transmitters. By coincidence the Sutton RX has been around for long enough and should be retired soon, so it became clear that a new good DC RX is required. It needs to be slightly different to anything before and hopefully have some improvements that don't add too much cost! Its going to be called the Knole and its block diagram is sketched below. It will be any single band 20 to 80m design for CW and phone with a proper VFO giving full band coverage and improved RF filters for better BCI rejection.
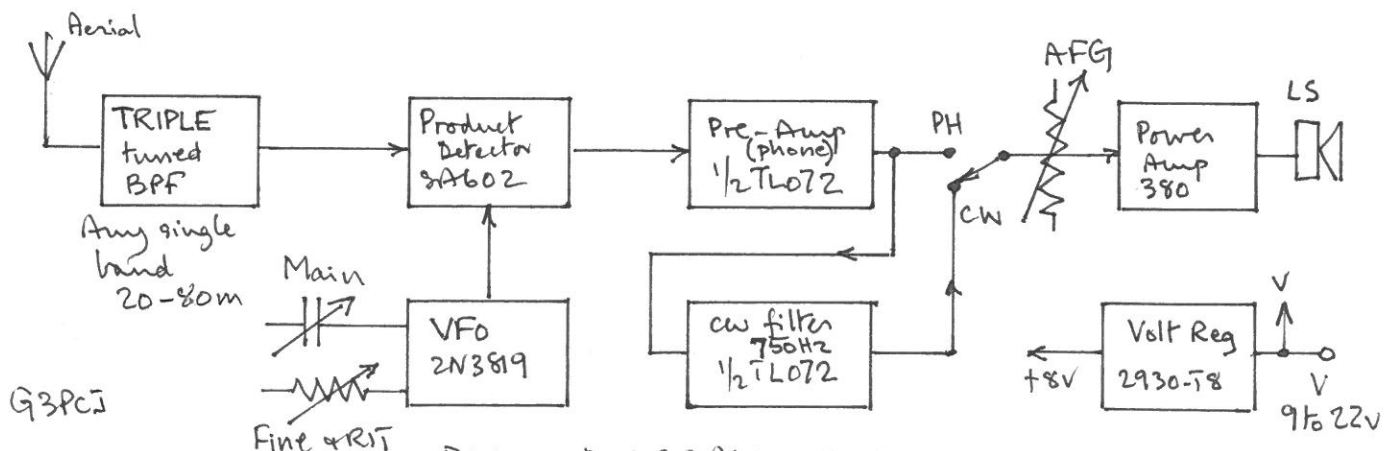

BLOCK DIAGRAM OF KNOLE DC RX

Theory - Resistive dividers

Here is a handy aid to picking resistors from your junk box to achieve a desired output voltage using a resistive divider. It saves having to punch a calculator through the many combinations that you might have available in your junk box! The complete table is based on standard 1% resistors for best accuracy but you can use it with wider tolerance types. The standard 1% series are actually logarithmically spaced in increments of 1/96th of a decade. The complete series of values are shown in the table below for one complete decade - this can of course be for any decade, say from 10R to 100R, 1K to 10K, or from 100K to 1M etc.. The commonly available 1% resistor values are shown in italic bold underlined, but if you have not got these in your junk box, you just search on for another pair that you do have because there are masses of combinations that will achieve your desired voltage reduction.

The first step is to work out a small sum which gives you the number of steps (in the table) between the two resistors that will give you the desired output voltage for your input voltage. See the circuit right where it is assumed that the voltage comes from an ideal zero impedance source and there is no loading from any following circuits. This sum is based on the formula in the box, but you don't have to work that out!.

You need to work out on your calculator, N, the number of steps separating the two values in the table below:-
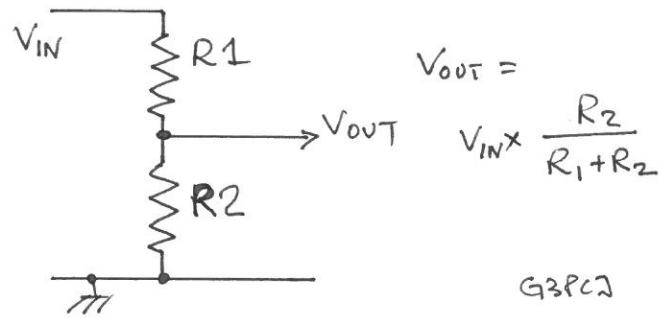
$$N = 96 \times \log_{10}\left(\frac{V_{IN}}{V_{OUT}} - 1\right)$$

Having done this, round the answer to the nearest whole value; pick a value (in your junk box) for R1 and count N steps through the table and see if you have the R2 value listed at the Nth step - if not try another value for R1 that you do have and try again until you find two values that you have which are separated by the required number of steps! For example, suppose the input voltage is 1.5 and you want 0.6 volts out, the number of steps is 16.9 which rounds (up in this case) to 17. Thus if you stick to the more common values, you could use 1K and 1.5K, or 1.21K and 1.82K, or 1.62K and 2.43K, or 4.99K and 7.50K. Or if N were to calculate to 15.2, that rounds down to 15 and you could use 47.5K and 68.1K etc. I am indebted to the Maxim Engineering Journal for this interesting aid! G3PCJ

| Steps in table	0	16	32	48	64	80
0	*1.00*	1.47	2.15	3.16	4.64	*6.81*
1	1.02	*1.50*	*2.21*	3.24	*4.75*	6.98
2	1.05	1.54	2.26	*3.32*	4.87	7.15
3	1.07	1.58	2.32	3.40	*4.99*	7.32
4	*1.10*	*1.62*	2.37	3.48	*5.11*	*7.50*
5	1.13	1.65	*2.43*	*3.57*	5.23	7.68
6	1.15	1.69	*2.49*	3.65	5.36	7.87
7	1.18	1.74	2.55	3.74	5.49	8.06
8	*1.12*	1.78	2.61	3.83	*5.62*	*8.25*
9	1.24	*1.82*	2.67	*3.92*	5.76	8.45
10	1.27	1.87	*2.74*	4.02	5.90	8.66
11	*1.30*	1.91	2.80	4.12	6.04	8.87
12	1.33	1.96	2.87	4.22	*6.09*	*9.09*
13	1.37	*2.00*	2.94	*4.32*	6.34	9.31
14	*1.40*	2.05	*3.01*	4.42	6.49	9.53
15	1.43	2.10	3.09	4.53	6.65	9.76

Sutton Band Cards   I have recently decided to withdraw the Sutton RX and Montis/Mallet transmitters. I do still have various band cards for that project (3 x 10m, 1 x 15m, 1 x 40m, 1 x 160m, and 4 band card PCBs awaiting any band's parts – except WARC). £10 each, two or more £8 each, plus £3 P and P! Also, four Montis DSB phone TX PCBs! Anybody want them? Stand alone TX? G3PCJ

Crystal Conundrum by Richard Booth G0TTL

Whilst constructing one of the prototype ABLO kits I ran into a puzzling problem. After assembling the 5V supply regulator the first real stage of digital electronics to build is the crystal reference oscillator. This uses a 74HC02 NOR gate arranged as a 24MHz square wave generator - see below. A well proven building block, with a minimum of components it's about the simplest crystal oscillator there is. (You can use just a single inverter! G3PCJ) Not much to go wrong there you might think. It didn't work. If the oscillator is running you would expect there to be 2.5V DC present at the output of the gate - this being the average of a 0 to 5V square wave and of course a whopping great 24MHz signal to listen to on a RX. Not a peep. The output was stuck up at 5V which didn't seem right at all. My first thought was that the logic IC was faulty. Not having a spare one to hand and after discussing this with Tim, the general opinion was it's very unlikely to be the case. Check the gates manually was the reply. So this I did, by removing a couple of resistors on the PCB I carefully applied 5V to the "crystal" input of the NOR gate - whilst watching the output on a multi-meter. As soon as 5V hit the input pin the output went low – nothing wrong with that then. The next thought was to check the biasing resistors, not just by sight but actually test them with a meter. Both were fine, but still no output from the oscillator. Next thought "Give it a bit more persuasion by reducing the value of the feed resistor to 470 ohms". Still nothing. Between the three of us (Andy Howgate had now joined in the quest for oscillations) we were stumped. Surely the crystal was OK. They don't go wrong do they? I didn't have another 24MHz crystal to try so I dug out a new 18MHz type. Soldered it in place but didn't bother to ground the can. I wasn't expecting much to happen when I plugged the power supply in and looked up at the frequency counter. However a glorious sight awaited me. It started oscillating quite happily and just to be sure I tuned into the carrier on my receiver. So it looks like the original crystal is faulty after all. Once again I fitted the 24MHz component back in place, for a final test. I didn't bother to solder the can to the ground plane. To my surprise it was working. What was going on?

Taking a screwdriver and shorting the can of the crystal to ground killed the output, and also solved the puzzle. Out of circuit I measured the resistance between the crystal can and it's two leads. One measured 62Ω, the other several MΩ. Both should really have been at least 20MΩ. In a conventional analogue oscillator circuit this component might have been OK for use, assuming you had the low resistance end connected to ground. However in this crystal oscillator circuit it's useless as both ends should be isolated. The final question to answer is why there was 5V present at the output of the gate when the oscillator wasn't running. It's simple really; as the oscillator wasn't running the gate was operating as a standard NOR. Both inputs were effectively grounded, therefore the output of a NOR in this state is 1 or in other words 5V.   Just in case you are wondering, this looks like a one off manufacturing fault. Between us we've tested several more from the same batch of crystals and they all work fine in the ABLO exhibiting excellent insulation properties! G0TTL
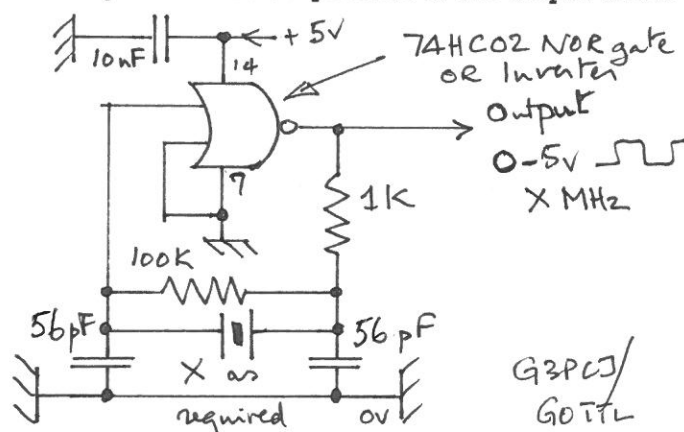
The Somerset Supper and Yeovil QRP Convention

The third supper will be held on April 14th 2007 in Sherborne for locals and those staying overnight. This is the evening before the Yeovil QRP Convention. As before there will be a small display of items from each diner's home built radio equipment! This will qualify you for a _free_ place at the supper table! The display will be judged by **Ben Nock**, the well known contributor to PW who specialises in World War 2 radio equipment, who is also staying for the Convention. Places by advance booking **only** by Mar 31st so please tell me if want to come. Hope to see it and you! Tim G3PCJ