"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

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Contents

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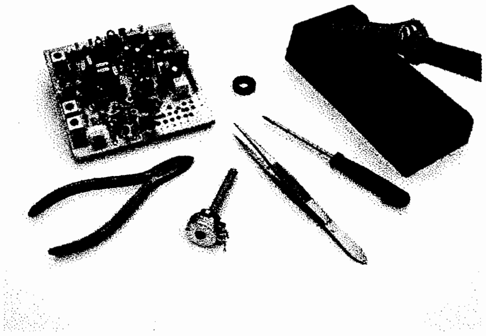
Editorial

This time its raining hard outside and I am delighted!! Our clay soil is rock hard after a long dry period and needs this moisture badly - it is essential just now to ensure plenty of grains in each ear of corn! Nothing to do with radio except that it keeps me inside preparing this!



Having introduced several new DC rigs recently I realise that its about time I thought about superhets again! If one wants the rig to work on the higher bands then stability is the dominant problem. This is quite a challenge while keeping the concepts simple and low cost! Increasingly there is a good case for having a micro-processor in the rig - especially if there is a frequency readout to be driven, however I am endeavouring to avoid it! I do remain concerned about digital clock hash that can emanate from such designs, especially if unshielded so, for the present anyway, I am going to do without micro-processors. Some might say 'He's stuck in the mud' but there is no point in replicating what others can do better. We all need to be different! I shall endeavour to maintain the 'character' that I am told my designs have! Tim

Kit Developments

Those of you who read Practical Wireless will have seen two, maybe three articles, on the new **Sutton** family of DC rigs. After one small gremlin that affected the 160m band cards, I think all is now fine! To date, the **Montis** double sideband phone transmitter is proving more popular than the **Mallet** CW transmitter - which does surprise me given the article on the Montis is not yet out!!

The next task is to complete development of the **Kilve** and the **Kilton**. The Kilve is a very simple DC single band RX aimed at supporting those taking their exams. The intention is that one set of parts will enable it to do 20, 40 or 80m by combinations of inductors and capacitors. It has a conventional PolyVaricon tuned VFO rather than a ceramic resonator and hence can be set for any part of the band. There is just one control for tuning and output is for Walkman type phones. The Kilton is the matching simple stand alone 'crystal' controlled 1.5W CW transmitter - again for any one of 20, 40 or 80m. Both are 50 x 80 mm double sided PCBs. Target prices are low for impecunious students!! But I do have to get them working yet!! Tim Walford G3PCJ

Hot Iron is a quarterly subscription newsletter for members of the Construction Club. Membership costs £7 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

The Hills are Alive with the Sound of Fivehead by Richard Booth G0TTL

To look at me you wouldn't immediately think of winter sports man. Still the perseverance on that first trip in March 2000 paid off. At first my skis had a mind of their own and my knees refused to bend. "Lean to the valley" my instructor would say, it took me a while to realise he didn't mean "fall to the valley taking half my classmates with me". By this time my wife had disowned me as a hopeless cause and I was sent to practice on my own away from other innocent victims, trees and ditches. Five years on I've never looked back and now will happily tackle any run. Where's this leading to? Well a little matter of my holiday to Austria this year when my luggage included amongst other things a little radio I call the Fivehead Compact.

I wanted to build a small self-contained 20M SSB transceiver that needed nothing else than an antenna, power source and microphone to get on the air with a respectable signal. In other words a holiday radio. With it's 100 mm sq PCB the choice had to be the Fivehead transceiver. However I also wanted to squeeze in a 10W linear amplifier, S meter/AGC kit and a 3 digit counter. All in a cabinet not much bigger than the main board!

The most awkward bit to fit in was going to be the linear amplifier. After some head scratching I decided the best way to proceed was to mount it vertically, at the rear of the main PCB, with the heatsinks overhanging. To make the amplifier clear components though I did need to shorten what would be the lower heatsink by about 15 mm. In practice I doubt it would make much difference but I also cut down the upper heatsink to match, my thoughts being that this would help to keep any thermal properties closely matched between the two output transistors. The 3 digit counter also mounted vertically, running front to back along the side of the case. Connections to the front panel displays via ribbon cable. The easy bit was the S meter kit, which I mounted between the back of the meter and a long stand off fastened to the case. Another first for me was to use an ultra bright white led for meter lighting.

So after construction and a bit of testing on air it was time to get the skis out of the roof, pack up the car and head off down to Austria. This time around we rented a traditional Austrian chalet house near Kufstein, which was hidden up a lane surrounded by snow clad forests and farmland. We were in the heart of the Tyrolean Alps. The scenery is breath taking, just think of the best Christmas card picture you have seen and multiply this by ten.

Time to get OE7/G0TTL on the air. The first spot of operating was après ski in the afternoons. Whilst my other half was soaking in the tub I got to call CQ on 20M. My 13 watts and a dipole antenna strung up to the tree next to the house (one end fastened to the tree, the other to the upstairs balcony) loaded up fine and I had plenty of contacts. It's true, if you have a slightly more exotic callsign everyone wants to talk to you. The "Compact" worked a treat, it was stable enough once up to operating temperature and I had no complaints of the audio quality on transmit. From the house my best contact was a station in Canada. During the second week the weather turned considerably warmer which meant the tracks used to climb some of the lower peaks thawed, opening them to normal traffic. We had a day off from skiing so my plan was to escape for a couple of hours in the car and play radio up an Alp. Somewhere not far from Kitzbuhel I turned off the main road and followed a narrow winding track past a frozen lake and up to the mountains. Expecting the local police to arrive at any time I set up the antenna on the top of the car (a centre loaded whip), plugged the compact into the cigarette lighter and checked the SWR against the bridge part of the S meter. After a spot of length adjustment at the antenna everything was fine. Conditions seemed not to be so good but I still made plenty of contacts around Europe and Russia. What was good though was the absolute lack of any interference. Not even the click of an electric animal wire fence - in the Alps animals seldom come out to pasture before May. No power lines, switch mode power supplies or broadband internet connections to generate square waves and their infinite harmonics. It was radio, how it used to be in the UK 25 years ago.

As usual the holiday was over too soon after it began, it was time to say our goodbyes and head back to Calais. The Fivehead Compact performed well, better than I expected it to, considering how much is squeezed in. One improvement I will make will be to fit a miniature slow motion drive to the tuning capacitor. If I was to build another one with hindsight I'd mount the amplifier board the other way around and have the heatsinks protruding from the back of the case through cut-outs. This would give a little more space inside and help to reduce heating of the VFO capacitors. G0TTL

(I am indebted to Richard for writing this while away from home in St. Ives! Thank you, Tim.)

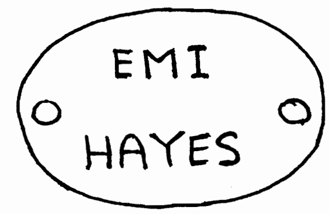
The Joys of Engineering Part 3- by Eric Godfrey G3GC

Since the publication of part 2 in the last issue of Hot Iron I have had a number of comments from people saying that they hoped that I would continue to recall the Joys of Engineering. This was also highlighted at the very enjoyable Somerset Supper held the evening before the Yeovil QRP Convention when I had the opportunity to put a number of faces to the names and call signs of Construction Club Members. I gathered that there was not only interest in the "Solder Wars" side of life, but also in the general state of engineering in those days. I will therefore describe some the various aspects of the Research Laboratories and its controlling company, The Gramophone Company Ltd. located at Hayes, Middlesex within a stone's throw of what is now Heathrow Airport.

The Gramophone Co., locally know as "The Gram", was the controlling company for the various factories manufacturing gramophone records, portable gramophones, radios, televisions together with the Research Department and Works Designs Department. At its peak the Company employed between 15,000 and 20,000 people. The Head Office included the recording studio where Dame Nellie Melba made her first recording. Head Office still remains today although it is now unused and boarded up. The whole of this area occupied by the Company, bordered on the East by the Grand Union Canal was divide by two public roads running through it. East of the canal the Company also owned farmland that was let out to a local farmer. During WW2 one of the dividing roads was closed to the public for reasons of national security. The complex was generally self sufficient and one could get virtually anything from the General Stores; rolls of brown linoleum, toilet paper marked TGC and liquids like "Carbon Tet", Benzine, Metholated Spirits. Even the arrival and departure of the local GWR trains were timed to normal factory hours.

Returning to the labs, my "Circuits Section", was on the top floor and immediately below was the valve and tube section. Here all the development and manufacture of camera tubes (Iconoscopes) took place and it was most interesting to see these large tubes being constructed and finally evacuated and sealed off. It was always very hot in this section due to the use of molten the glass. Many of the operators in order to keep cool drank a lot of water, lemonade etc. which that kept in sundry bottles near them. Unfortunately one operator took a swig from what he thought was lemonade but was actually a caustic solution which resulted in a very painful death. This was definitely not one of the joys of engineering. No doubt "Health & Safety at Work" would probably have prevented it today. This section was useful for having the broken stem of a wineglass repaired.

In the last paragraph of part two I mentioned a junior engineer with whom I felt ill at ease and I later found that he was generally disliked and in future I will refer to him as "JEX" (Junior Engineer X). His attitude to people was such that he bore the brunt of many practical jokes. One that immediately comes to mind was when in 1938 he was going to Switzerland for a holiday, and the Friday before the holiday, he arrived in the labs with an alpine walking stick plastered with mementoes of various places he had previously visited. This was too much for the senior engineer with whom I worked and I was given the job of making a brass memento with "EMI HAYES" punched on it and filled in black. It was beaten into shape to fit the diameter of the stick and the senior engineer duly screwed it to the stick with two wood screws, the screw driver slots of which he filed off for good measure. Needless to say that when JEX returned after his holiday he was not in a very good mood and was to be avoided if at all possible.



It was not long after this that JEX suffered another incident. In the small workshop mentioned in part two there was a drilling machine with the drilling table at sitting height and the electric motor behind it. The two were connected with a belt system allowing for different drilling speeds. One day JEX was using the machine for trepanning a hole some two inches in diameter in a piece of eighteen gauge sheet steel. Trepanning was always a difficult job and JEX was having problems resulting in frequent visits to the grind wheel to sharpen the cutting tool. He was called away to the circuits lab for a bogus phone call and whilst he was out the drive belt on the machine was crossed over resulting in the trepanning tool running backwards and thus failing to cut. He struggled with this for some time with more and more visits to the grind wheel to sharpen the tool and the use of more and more cutting oil on the work. Finally he realised what the problem was and stormed out of the workshop in a very bad mood.

It should be remembered that despite all these things going on there was a great sense of loyalty in the labs with the staff willingly doing a lot of unpaid overtime. Eric Godfrey, G3GC

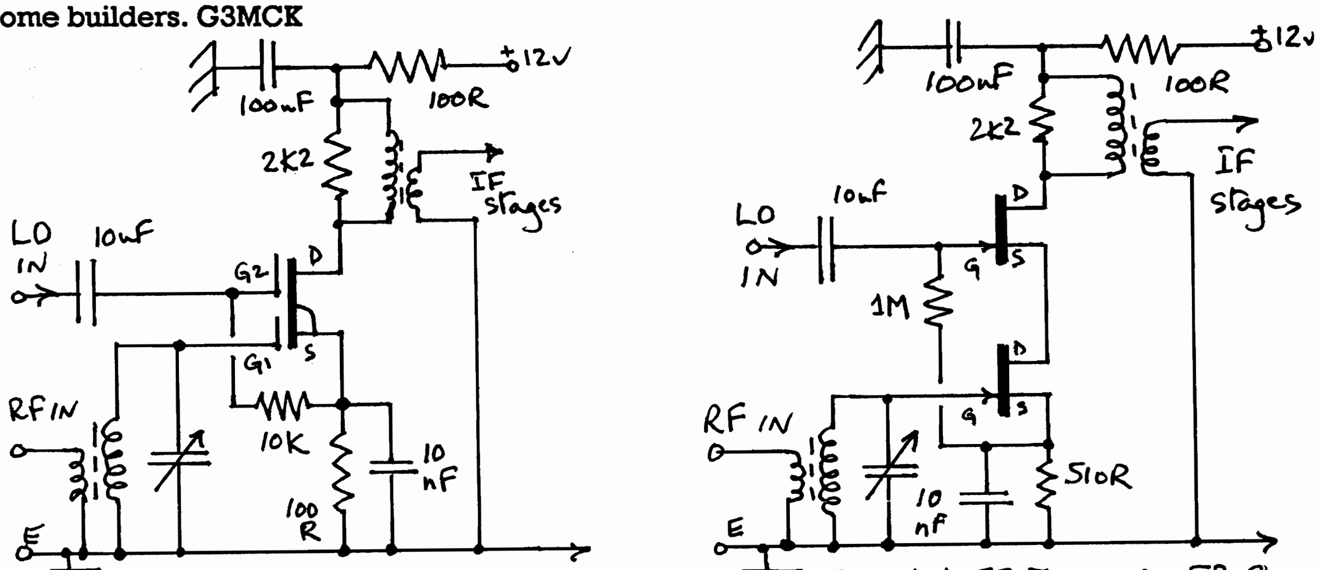
Dual Gate MOSFETs by Gerald Stancey G3MCK

There can be few home constructors who have not used the dual gate MOSFET; equally there can be very few who have not viewed with concern the fact the common types like the 40673, 3N201 and MFE201 are no longer made. They are still available from suppliers such as Sycom but for how much longer? Therefore it was with relief I found that there is a solution to this problem.

The excellent ARRL book Experimental Methods in RF Design, by Wes Hayward W7ZOI and others, shows how two normal JFETs can be cascaded to produce a 'dual gate MOSFET'. One example that he gives is a mixer - the diagrams below show the familiar arrangement for an actual dual gate MOSFET and that for a pair of cascaded J308's. The only comment that Wes makes is that some experimentation maybe needed to set the bias to the correct level.

The March 2005 Issue of Practical Wireless contains an excellent article by G4FYC on the dual gate MOSFET where he shows that it is derived from cascading two JFETs. The article also gives some useful design information.

As they say, when one door closes another opens. Life is full of challenges and fun for the home builders. G3MCK



Dual Gate MOSFET eg 40673 G3MCK Cascaded JFETs eg 2x J308

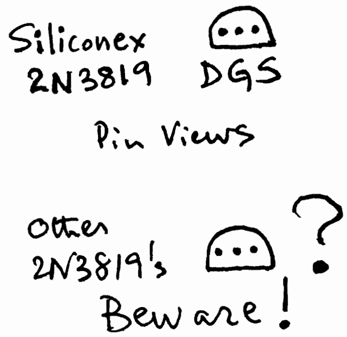
More on FETs!

Although the previously common dual gate types mentioned above are now becoming like hen's teeth, the VHF type BF981 is still available. This is sold as a sort of 'surface mount' device, actually as a bead with four flat legs protruding sideways - as opposed to ordinary leads out of its underside. I have not used them myself but there is no reason why they should not be used at lower frequencies provided precautions are taken to ensure they do nothing un-intended - like oscillate at VHF! This might require gate stopper resistors.

I have always found that the 2N3819 JFET is rather easier to use than the J3XX series, because they have a lower zero bias drain current which means they can often be used with zero gate bias if it simplifies the circuit. The tolerance on the zero bias drain current is quite large for all JFETs (about 5 to 15 mA for the 2N3819) so it is necessary to make sure that the drain supply, and any voltage drop in drain resistors, can accommodate this current without the drain voltage becoming too low for the desired signal excursion. The use of a source resistor, which in effect applies negative feedback, can stabilise the operating current to lower values. Depending on application, the source resistor can be bypassed for signal purposes.

Another point to watch out for is that the 2N3819 is confusingly available with two different pin-outs!! The more common pin out shown top right from Siliconex is unfortunately the more expensive! This is the one that I supply in my kits.

Yet another interesting point about the JFET is that the source and drain are interchangeable because the device is symmetrical! G3PCJ



Simple 50 Ohm Test Gear

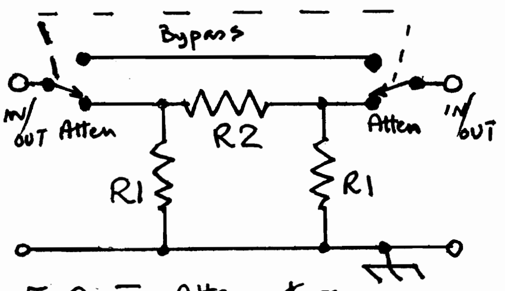
Over the years, these three items have been the most used items of my test equipment - after a scope which is in an altogether different price league! If you contemplate doing any experimental work at HF, where 50 Ohms is the common interface impedance, then these will be invaluable. Items which have 50 Ohm in and out impedances can be plugged together without further complication. That applies especially to these three units.

The first is a set of 50 Ohm attenuators. For RF work it is common to consider the gains/losses in decibels (dB) of power. Either T or Pi circuit form attenuators can be used provided they have an impedance of 50 Ohms looking in from both directions. It does not matter which is used as input or output! Its handy to have switches which give increments of 1 dB up to about 30 dB max in any one unit. (Leakage around the switches makes much more than this unwise.) 30 dB corresponds to a reduction in output power to one thousandth of the input power, or output voltage equal to about one thirtieth of the input voltage. See the top box. They can be used to attenuate the RF signals into a RX prone to BCI, or when measuring minimum detectable signals, etc.

The second device is a broadband RF amplifier. By using negative feedback it is easy to make a bipolar transistor amplifier have nominal 50 Ohm in and out impedances with a power gain of 10 dB (10 times). Restricting the gain to 10 dB will keep the bandwidth high (well over 2 to 30 MHz) and avoid winding RF transformers! Two such stages in cascade will provide 20 dB power gain (times 100) or a voltage gain of 10. They can be used to increase the signal of a low power oscillator to drive a diode mixer, or to increase the sensitivity of a deaf receiver, etc! Again its sensible to not have too many stages in one unit for fear of unwanted feedback - two is fine. The circuit right (for a each stage) is very dependable! For linear operation, the maximum output power is related to the standing current in the transistor, which is governed by maximum dissipation. These designs should allow up to about 1/10 Watt output, ie 20 dBm.

The third device is an indicating dummy load power meter. It is based on a peak reading RF voltmeter which can be calibrated in volts or more commonly in power, usually expressed in dBm. For low power RF work, power is usually expressed relative to the power of one milli-watt into 50 Ohms, which is commonly known as 0 dBm - 223 mV RMS. Hence 10 dBm is 10 milli-Watts (10 dB above or 10 times 0 dBm) and 30 dBm is 1 Watt (30 dB or 1000 times 0 dBm). dBs are used because they can be added and subtracted more easily than multiplying or dividing if gain or attenuation figures were used! The circuit right has a RF voltmeter which actually responds right down to DC allowing it to be calibrated from a DC source that can be accurately measured with a digital voltmeter. It has three ranges providing useful indications from about 1 milli-Watt up to 5 Watts.

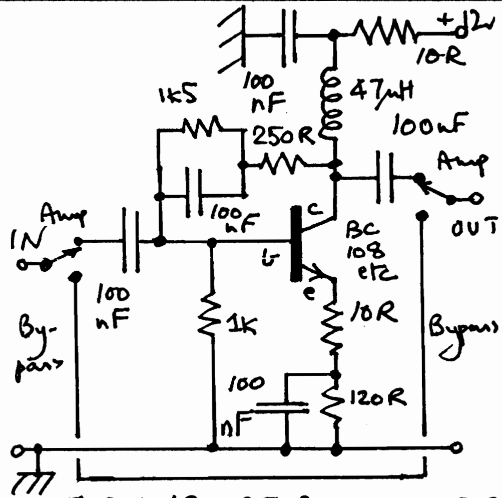
I hope to provide three kits based on these designs at around the £15 mark for each - details to follow! G3PCJ



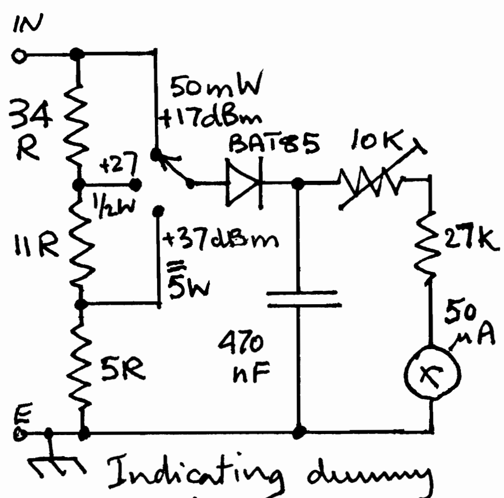
50R Π Attenuators

Attenuation dB	R1 Ohms	R2 Ohms
1	870	5.76
2	436	11.6
3	292	17.6
4	220	23.8
10	96	71

Theoretical Values G3PCJ

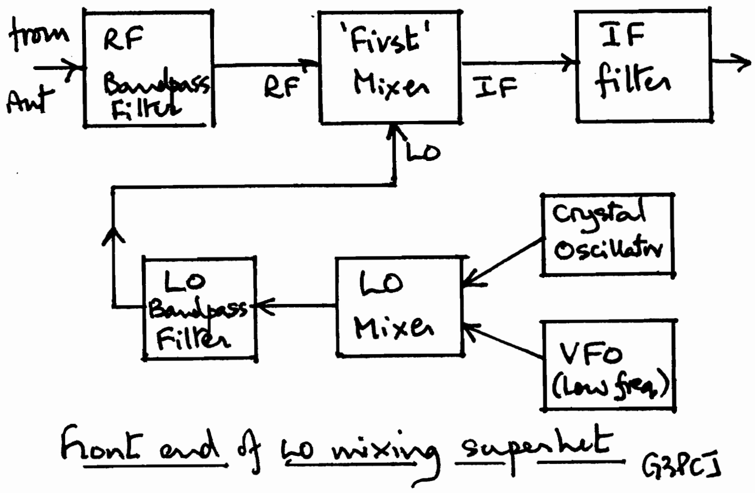


50R 10dB RF Amp G3PCJ



Indicating dummy 50R Load / power meter G3PCJ

Frequency Planning for Superhets



When designing a new rig, there are many aspects of its frequency 'plan' that have to be considered. The plan can be quite simple if it has only to work on a single low frequency band, because the VFO is likely to have a low frequency that will ensure its stability. If the operating band is much above 15 MHz, then a local oscillator (LO) mixing scheme is usually needed to preserve the stability of a lower frequency VFO. Often the LO mixing is done with a crystal and the unwanted mixer sum filtered out before injection into the rig's first mixer. This arrangement is shown right for the front end part of a superhet RX.

If the rig is to be multi-band, then life gets a lot more complicated! The first consideration is what Intermediate Frequency (IF) to use. I have now standardised on 6 MHz because a phone bandwidth ladder filter can be made with 5 low cost crystals, and which has a reasonable impedance match to the 1K5 in and out impedance of 602 mixers that might be at both ends of the filter. (Another reason for choosing 6 MHz is that it allows direct LO injection for all bands up to 14 MHz while keeping below 8.5 MHz for the VFO, which is adequate for stability aspects.) The next consideration is sideband switching! If the LO is above the RF for 30m to 160m and below for 20m up, then a single Carrier Oscillator frequency of 5998.5 KHz will provide the conventional sideband for amateur phone work on all bands with the exception of 30m - but it does not matter which sideband is used for 30m because it's a CW only band! This means that the digital frequency counter must be able to count the LO frequency and add, or subtract, the CIO frequency as bands are changed. (Another advantage is that this form of counter operation is much easier than other plans which might need LO-CIO and CIO-LO!)

Next comes the tricky bit - finding a crystal/VFO mixing scheme that avoids unwanted products/harmonics from the VFO, crystal or LO at the IF, the RF image frequency or reception band! The table below I think meets this bill – its based on a 6 MHz IF, 500 KHz wide operating bands, with all bands tuning the same way, and a 2.5 to 3 MHz VFO with crystals to suit! All frequencies in MHz.

There are some potential nasty birdies but they are outside actual amateur bands, except for 160m. Luckily many of the crystal frequencies are either standard values or used in other rigs, so it needs only four 'specials'. I expect to adopt this scheme in the replacement for the Bristol. Tim

Band	**Local Oscillator**	**RF image**	**Crystal for 2.5 - 3 VFO**	**LO Unwanted Mix**
1.5 - 2.0	7.5 - 8.0	13.5 - 14	5.0	2.5 - 2.0
3.5 - 4.0	9.5 - 10.0	15.5 - 16.9	7.0	4.5 - 4.0
7.0 - 7.5	13.0 - 13.5	19.0 - 19.5	10.5	8.0 - 7.5
10.0 - 10.5	16.0 - 16.5	22.0 - 22.5	13.5	11.0 - 10.5
14.0 - 14.5	8.0 - 8.5	2.0 - 2.5	5.5	3.0 - 2.5
18.0 - 18.5	12.0 - 12.5	6.0 - 6.5	9.5	7.0 - 6.5
21.0 - 21.5	15.0 - 15.5	9.0 - 9.5	12.5	10.0 - 9.5
24.5 - 25.0	18.5 - 19	12.5 - 13.0	16.0	13.5 - 13.0
28.0 - 28.5	22.0 - 22.5	16.0 - 16.5	19.5	17.0 - 16.5

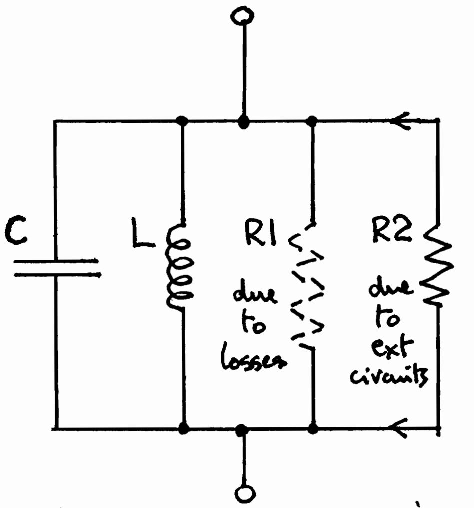
Bandwidth and Q

In this note I will only consider LC resonant circuits, although the considerations for other forms of filter circuits are very similar. Either series or parallel resonant circuits can be considered, but to keep things simple, I will stick with the parallel form because that is what one is most likely to encounter. The behaviour of this circuit as frequency is changed is very dependent on the effective 'resistance' across the ideal L and C components. This effective resistance has two components, firstly R1 due to losses (because the L and C are not ideal parts - L is usually far more lossy than C), and secondly R2 which is applied by the external circuits to which the resonant circuit is connected. These are shown right as R1 and R2 but a combined value R can be used instead, whose value can be worked out using the resistors in parallel theory.

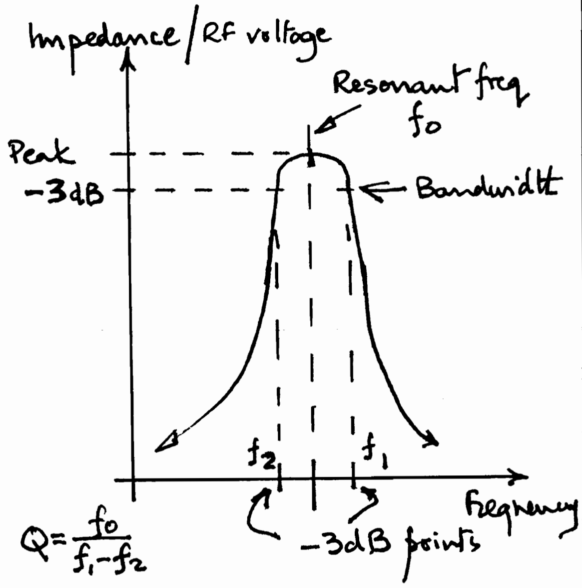
The familiar impedance curve for the parallel form is the 'hump' response shown right with its high maximum impedance at the resonant frequency. The width and height of this hump is related to the value of R. The high impedance is usually desirable to give the best response to a wanted signal while rejecting the unwanted - for example in RF bandpass filter circuits at a receiver's front end. (If the circuit is a series resonant circuit, then the impedance is a minimum at the centre frequency - which is why it is used as a trap to attenuate unwanted signals.) The bandwidth of this circuit is the numerical difference in frequency between the points where the response is 3 dB below the peak. For example, a filter for the front end of an 80m CW receiver, would need a minimum bandwidth of 3.60 less 3.50 MHz which is 100 KHz.

The 'goodness' or Q (quality factor) of this circuit is related to the resonant frequency by dividing the resonant frequency by the bandwidth - in this example, 3.55 MHz divided by 100 KHz (0.1 MHz) which means the circuit has a Q of 35.5. It is a dimensionless number and generally the higher the better! If needed, it can be lowered by adding real resistors across the circuit but cannot be raised above the values implied by the losses in the L and C, without any contribution from the external circuits.

The theory gets a bit heavy if you really need to work it out fully - there are excellent notes in the ARRL and RSGB handbooks. However for casual experiments, a rough approach is to ensure that the external circuits imply a load R2 on the resonant circuit greater than very roughly 5 KOhms. This can be done by tapping down the L, or using a small link winding, both acting as a transformer (see earlier theory about impedance transformation), or less commonly, by a capacitive tap using a large C value (at ground end) in series with the smaller resonating C value. G3PCJ

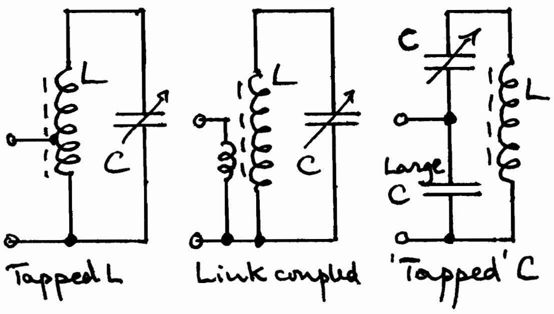


Parallel Resonant circuit with 'losses'
G3PCJ



$Q = \frac{f_0}{f_1 - f_2}$

Parallel Resonant circuit response



Alternative methods to couple low Z circuits to maintain high Q.
G3PCJ

Physical Layout Question?!

My next major superhet is likely to be a CW and phone 5W TCVR for any band up to 20m with everything on a single 100 x 160 mm PCB, but capable of working to 10m - with an external card containing the LO crystal mixing extras. To make it work on a single higher band this might be a version of the existing Min - mix kit; but it would be more interesting to have the additional PCB also provide extra 'fitted' bands, most likely two, with the band parts soldered into the PCB. Another option might be to make the extra unit cater for any band in the main rig and one, maybe two, 'pluggable' bands using small band cards like the Sutton. Either approach would make it into a two, or three, band rig - perhaps changeable. The main single band rig would cost roughly £90, the additional unit for two extra bands about £25, or in the region of £15 plus £15 per band if 'pluggable'.

I would be delighted to have any comments on these ideas, especially from those who might be interested in such a rig. No promises on those prices though! Tim G3PCJ

FOR SALE!

My existing oscilloscope is surplus to my needs. It is a two channel 40 MHz Goldstar OS9040 with dual timebase etc. and is working excellently. I have had it since new in Dec 1993 when it cost £340 + VAT. If wanted, I can include two suitable probes. If you are interested, please give me a call and make an offer!

I also bought the following by mistake in quantity! Can anyone use them?
0.3 inch wide 7 segment high intensity common anode LED displays - fine for hard wiring top digits
24 volt standard sized 2 pole changeover PCB mounting relays

Construction Club member Jim Geary has passed me his mostly completed Bristol which he offers to a good home; it includes a single band card for 160m, twin band 10/17m & 15/40m, with card switch kit. The PCBs have been built very carefully and has all the controls etc. Needs a box!

Tim Walford G3PCJ on 01458 24122 before 6:30 pm.

The Somerset Supper!

This was duly held the evening before the Yeovil QRP Convention, and a good time was had by all! Rob Mannion G3XFD, Editor of PW, kindly presented the prizes to Nicky Marriot M5YLO and Ray Lawrence G8AWB, he also presented me with a loaf of bread as his entry ticket since he didn't bring an electronic device! The entry ticket devices brought by diners can just be seen on the right! In the foreground is Brian Purkiss who deserves a medal for doing all my PCB drilling. Date for next year is April Sat 8 and Sun 9th 2006. G3PCJ

Subscriptions!

I am afraid its that time of year again! If you wish to continue receiving Hot Iron, let me have your cheque for £7 before Sept 1st for the next issue.

I still have loads of crystals if wanted. Free apart from postage at two first class stamps!
Parallel Resonant 30 pF load – MHz - 5.0688, 5.6914, 5.752, 6.0177, 7.20, 9.30, 9.60, 10.2775, 10.44, 11.0258, 12.73819, 14.84830, 15.375, 16.5888, 16.623333, 17.9, 18.26, 20.105, 20.78
Series Resonant – MHz - 15.0, 18.0, 20.0, 21.0, 24.0
TTL oscillators (sq wave output) - MHz 24.0, 30.0, 32.0 for four first class stamps.

Send off your cheques now!