"JOURNAL OF THE CONSTRUCTORS CLUB"

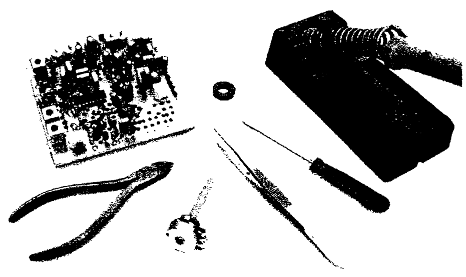
Hot Iron

Winter 2004
Issue 46

Contents

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

Editorial



Its still raining 3 months later after the last Hot Iron! The good news is that it prevents one from going outside unless essential! (Nasty penetrating drizzle this morning but a hard frost was actually forecast! Rain always comes when doing roof repairs - which we are!) Being stuck inside makes the mind turn to future projects that might be of interest to members. Over the years, valve based projects often get mentioned but I hesitate owing to the safety aspects of mains and relatively high HT supplies. I understand there are ranges of low voltage valves which might circumvent these problems - I don't have any knowledge or experience so if any enthusiast cares to direct me in the right direction we (he/she/me) might be able to get a project off the ground. This might turn into an enthusiast's project where you use your own mechanical parts - air spaced capacitors and transformers, audio or mains. Should one go for a RX or TX - AM or CW?? A crystal controlled TX would be easier but do you really want to be rockbound? If not, it probably means crystal mixing and that's as complicated as a superhet RX! Tell me!!

Kit Developments

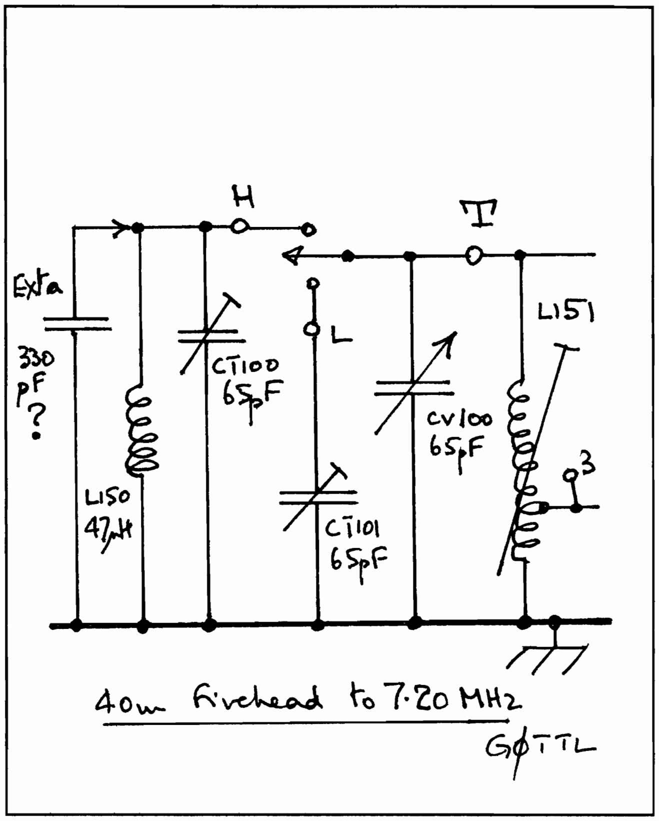
Early reports on the **Catcott** are very favourable and there will soon be a suitable crystal controlled TX - see Mallet below. The **Brent** is also working very well on 80m and I now have mine working on 20m with the Mini mixer kit. I have also added the new Variable bandwidth Filter (see later) which makes a tremendous improvement in signal to noise ratio.

The major task has been the detail design and lay out the PCBs for the **Sutton** RX and associated transmitters. The Sutton is a DC rig using 3.58 and 3.69 MHz ceramic resonators to give coverage of the bottom 200 KHz of 80m. Both ceramic resonators do nominally 100 KHz but these are sub-divided into two sections by a switch/trimmer for a better tuning rate. There is also a fine tuning control which doubles for RIT with the CW TX. It includes LS drive with wide and narrow filters suited to CW and phone. The RX PCB also has space for a LO crystal mixer and a set of pins for a plug in band card so that the rig can then do 80 and any of the traditional harmonically related bands by plug-in cards. (It could do any band but the demand for WARC bands is too low.) The **Mallet** is the matching 1.5W CW TX (includes TR, LPFs, muting, ST etc) and the **Pedwell** will be the matching phone DSB 1.5W TX. Volunteers for early builders please! Tim 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

Expanding coverage the 40M Fivehead

As you probably know a few weeks ago our 40M allocation effectively doubled in size. During daylight hours the new 7.1 to 7.2 MHz band is pretty much free from the continental interference and general racket that is to be heard on the lower 40M frequencies. Which means QRP is infinitely more possible. Hence it was time to stretch out the frequency coverage of my Fivehead rig. It's pretty simple to achieve and only needs a couple of extra components to give full coverage in 3 switched ranges. Here are the steps needed (refer to the original construction notes)



1. Fit L150 at grid I0 (47 uH inductor)
2. At grid H1 point H solder a 330 pF ceramic cap between the pin H and ground.
3. Make sure the VFO switch wiring is connected up as shown in the PCB layout diagram.
4. You will now need to set up the VFO high and low bands by adjusting the two trimmers (see construction notes for more details). On my rig I have about 80 KHz per "band" with some overlap.

That's it, you should now be able to tune right up and down all of 40M. You might need to adjust the value of the 330 pF capacitor, if on the high switch setting the VFO frequency is too high, increase the capacitance or vice versa if it's too low. You shouldn't need to adjust the PA or band pass filters. Tuning wise it seems to be quite linear and has not affected stability in any way.

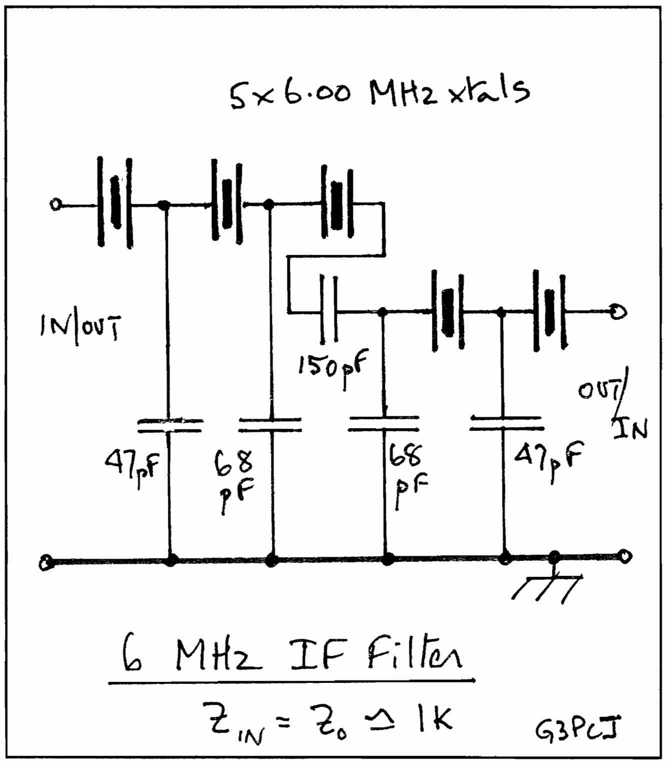
Good luck, you can reach me via QRZ.com if you fancy a Fivehead net on 40M.

Richard Booth G0TTL

6.00 MHz crystals

John Teague has kindly sent along details of a trader who he thinks will have many 6.00 MHz low profile HC49 crystals at giveaway prices - probably just pence each! John saw them at a recent auto jumble event at Blenheim. His name is Andrew Marks and phone number is 01752 208301. (See also the last page of this issue!)

Such crystals can form the basis of a very adequate IF filter for a superhet receiver (or transmitter). The circuit shown right suits direct connection to NE602 style mixers as the desired nominal input and output impedances are about 1K. This gives a bandwidth of near 3 KHz with good 'off the nose' rejection. (Its not as good as a proprietary IF filter - say for 9 MHz - but then it does not cost £40!) Another advantage of using 6 MHz for an IF is that a single CIO frequency (60015 KHz) can give all the usually used phone sidebands for all bands (except 30m) with a suitable choice of LO frequency. High side LO for 40m and down, low side LO for 20m and up! G3PCJ



The Joys of Engineering by Eric Godfrey G3GC

Despite the fact that I was not enthusiastic about becoming a pen pusher I was entered by my father to sit for the 1936 Civil Service Examination. In those days the Civil Service was a good and secure job and also sons did not argue with their fathers. However as luck would have it, shortly before the Examination I managed to get measles which at the age of sixteen was a serious complaint and usually subject to complications. In fact I got abscesses in both ears also and very nearly contracted pneumonia which the doctor had told my parents could well be the beginning of the end. However I managed to survive and after six weeks was slowly on the mend. By that time the Civil Service Examination had come and gone and as it could only be taken at the age of sixteen I had missed it forever. This allowed my interests in all things scientific to come to the front and together with my amateur radio interests (I was a member of the RSGB and a keen listener on the broadcast and amateur short wave bands) I persuaded my father to let me try to get a job in radio and television. As a consequence in the spring of 1937 I wrote to three companies, namely GEC, Cossor and EMI to see if I could get a job in their research departments. I got a reply from GEC saying that they had not any vacancies at that time but they would keep my name on their files. About a week later I had a reply from EMI inviting me to an interview at their research laboratories at Hayes and I am still waiting for a reply from Cossor!

I was interviewed by Alan Blumlein who was the Chief Engineer at the EMI Research Laboratories and was the brains behind the development of the new EMI 405 line all electronic television system that had begun transmitting from Alexander Palace towards the end of 1936. At the interview he was interested in my amateur radio activities and ultimately said he would like someone else to talk to me. This turned out to be a Dr. White and while waiting for him to arrive Blumlein said how his neighbours annoyed him by having Radio Luxembourg on so loud on a Sunday morning. He then went on to say he had made himself an oscillator that he used to swamp out Luxembourg if it got too bad. Dr. White was in charge of the Television Circuit Section of the Laboratories and he also showed interest in my amateur radio involvement but he mainly quizzed me on mathematics since at school I had taken what was known as Advanced Mathematics instead of a second language for the General Schools/Matriculation Examinations held in June each year. These Examinations have long since been replaced with the current modern examinations but a fundamental difference was that they were examinations in six subjects all of which had to be taken and passed at the same time. I must have made a reasonable impression at the interview as I was offered a job as a laboratory assistant in Dr. White's Section of the EMI Research Laboratories starting on 16th August 1937 with a salary of twenty four shillings and sixpence per week. (A week was five and a half days in 1937).

This preamble seems to have taken some five hundred odd words without really saying anything about the Joys of Engineering but I thought that this general background to life in the thirties might be unknown to the younger members of the Constructors Club. However as you can see one of the Joys of Engineering was already apparent at my interview when Blumlein told me about his jamming operations on Radio Luxembourg. This was only a prelude to the very satisfying life at the EMI, a company with whom I stayed for the whole of my working life of forty-five years. If the Editor is agreeable in the next issue of Hot Iron I will tell you about the fun and games that both lab assistants and engineers got up to and also about some of the peculiar and eccentric people employed in the labs that contributed to the Joys of Engineering.

The photo right is one of only four known to survive of Blumlein. I will ask Eric to tell us more of those experiences but Blumlein had a phenomenally inventive mind, including what we now call stereo. G3PCJ

Voltage Standing Wave Ratio by David Proctor G0UTF

We all know that the VSWR should be near to unity and its something to do with feeder cables. Well let's look at it again with a bit of maths (numbers are better than words!). When an RF signal travels down a transmission line of characteristic impedance Z_o (at just less than speed of light) it eventually meets a termination Z_T. If $Z_o = Z_T$ and is resistive, all the energy is absorbed by Z_T and none reflected. If $Z_T > Z_0$ there is a part reflection back as a wave *in* phase. If $Z_T < Z_o$ there is a part reflection back as a wave *out of* phase

Source Z_o	$V_{incident}$ -> -- <-$V_{reflected}$	Termination Z_T

When **two** waves of **same speed** and **wavelength** are moving in **opposite** directions along the same cable, they set up a **stationary** or **standing** wave. The stationary wave is due to the addition of the two waves, and has maximum and minimum values. By plucking a guitar string, violin string or even a taught washing line, you get a stationary wave which does not move down the string, the string simply moves up and down.

Incident wave V_i ⟶ ⟵ **Reflected wave V_r**

<half wavelength>

amplitude between maxima

.... V_{max}

V_{min}...... ....

When added 0 ______________________________ dist down cable

....

....

$\boxed{\text{VSWR} = V_{max}/V_{min}}$ ⟵ **This is the definition** $V_{max} = V_i + V_r$ and $V_{min} = V_i - V_r$

At the termination, we say there is a **voltage reflection coefficient** (p) which is the ratio of reflected voltage to incident voltage = $\mathbf{V_r/V_i}$ which van be positive or negative.

So, VSWR = $V_{max}/V_{min} = (V_i + |V_r|)/(V_i - |V_r|) = (1+|V_r/V_i|)/(1-|V_r/V_i|) = (1+|p|)/(1-|p|)$

$\boxed{\text{VSWR} = (1+|\rho|)/(1-|\rho|)}$ ($|p|$ = magnitude of p e.g. magnitude of $-0.5 = +0.5$)

This equation shows us that if reflection is zero, p = 0 so VSWR = 1

If you know Z_o ,your characteristic impedance, and your termination Z_T you can find

voltage reflection coefficient, p .... $\boxed{\rho = (Z_T - Z_o)/(Z_T + Z_o)}$

EXAMPLE:- Z_o = 50R Z_T = 100R, p = (100-50)/(100+50) = +1/3 so **|p|** = 1/3

VSWR = (1+1/3))/(1-1/3) = 2

REFLECTED POWER

We do not want power reflected back to the PA of a transmitter, so keep VSWR close to 1, that means p close to 0. The fraction of the outgoing power which is reflected back = $(p)^2$, so in the example, fraction reflected back = $(1/3)^2$ =about 11%

In practice the values of Z_T are nearly always reactive (not just resistance) so the maths can get complex, literally. However, this gives us the idea about reflected waves adding to incident waves to get a standing wave. With resistive loads this maths is quite correct, and shows us why matching is so important.

(Apologies for the mix of Greek and English letter p for the letter rho! Computers - Ug! G3PCJ)

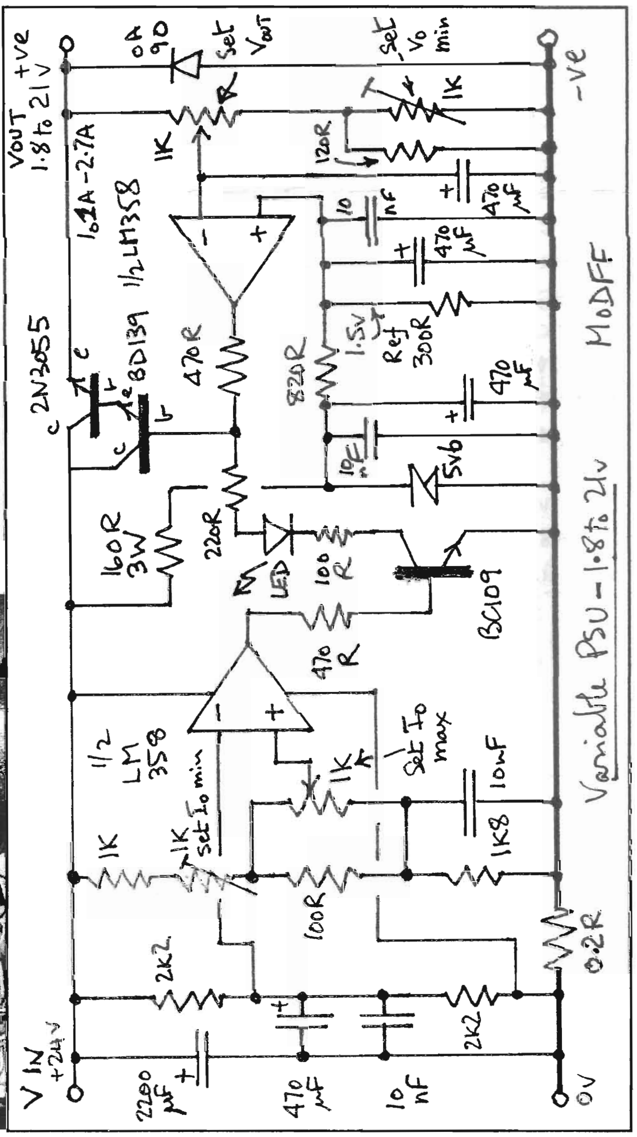
A Basic Linear PSU by Mark Bywater M0DFF

The need for this power supply came about when experimenting with many of the Walford kits - it being useful to have a variable output voltage and variable overload current. There are commercial units on the market with a commercial price tag as well. I decided to use my existing 24 volt 3A unit to provide a variable output from 1V7 to 21V with a trip current that could be set from 1A to 2A7. Another option would be to use two 12 volt batteries for the incoming 24 volts.

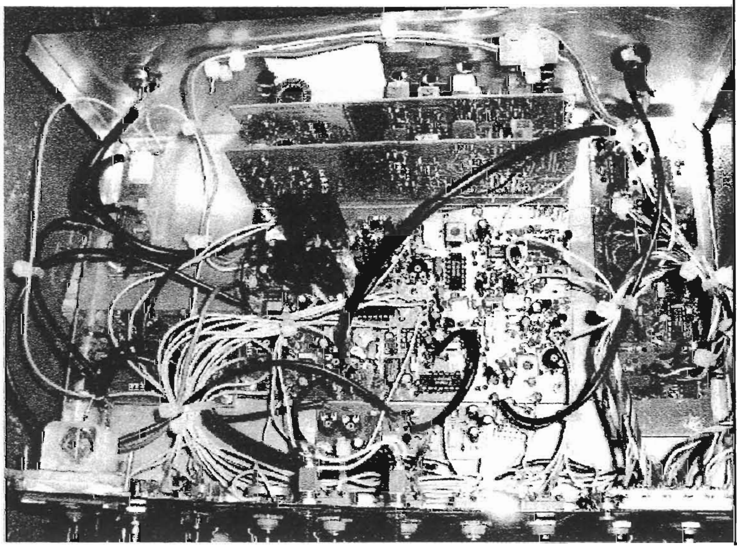
Circuit description There are two sections, the voltage regulator part nearest the output and the excess current override part on the input end. The voltage regulator part uses a 5v6 zener for best temp stability of the reference voltage; this is tapped down to about 1.5 volts and applied to the positive input of the controlling LM358 op-amp. A portion of the output voltage, dependent on the setting of the voltage control pot, is fed back to the negative input of the op-amp. Heavy smoothing is applied to eliminate unwanted electrical noise. A OA90 diode is fitted across the output to give protection against reverse polarity voltages on the output. The main 'pass' transistor is a 2N3055 with a BD139 in a Darlington configuration to provide sufficient base drive from the op-amp. The 2N3055 is fitted on a large heatsink because it might have to dissipate up to roughly 50 Watts!

The over-current part of the circuit relies on the load current flowing though a 0.2 Ohm resistor in the negative supply line. Two resistive potential dividers feed the over current op-amp inputs, so that as the load current increases, the difference between the inputs increase to the point where the BC109 transistor is turned on to remove the base drive from the voltage control op-amp so reducing the output voltage. The output side voltage divider pick off point is adjustable to set the over-current trip point. The 'shunted' away output drive current, of the voltage loop, is passed through the LED to indicate the over-current condition. Why the combination of 1K pots in parallel with 100R and 120R fixed resistors? Because I didn't have 100R pots in my component stock!

Construction and setting up. The overload was calibrated with a few low value power resistors, a volt meter and ammeter. Construction of the circuit was on plain matrix board mounted onto a PCB "chassis" via plastic stand offs. It has been tested with a high current/inductive load which was over voltaged. The load failed but the PSU lives on! There are many improvements that could be made, but it works well for what it is - a basic PSU of standard components.



Mark has also sent along this photo of his Bristol complete with most of the optional extras - two band card switch kit, five digit counter on the right, the meter kit and speech processor are all in there! A big project which I hope did not cause the over-current trip to operate too often during building! Well done! G3PCJ

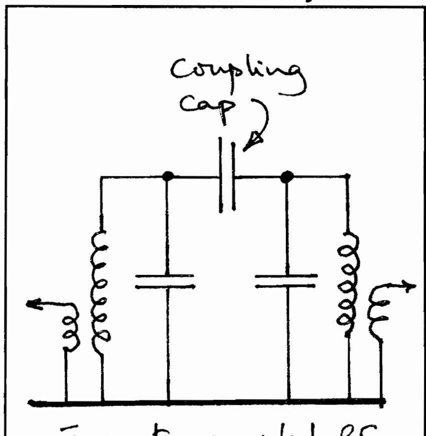


Variable Bandwidth Filter

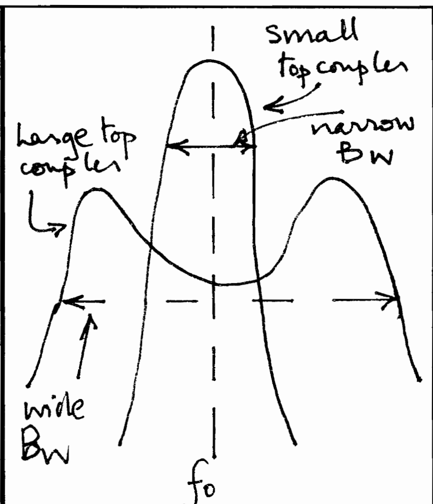
This project has taken 41 years to mature!! But its darn good now!! It is actually an audio filter for adding to a CW receiver but it is based on work that I did for my university thesis! I have been searching for a better CW filter for some months now but there always seemed to be a drawback - complexity to get the performance and often not easy to use! Using a low pass filter to remove the high frequency signals above say 800 Hz is good and simple but not versatile - what is really wanted is a variable bandwidth bandpass filter. It can be used 'wide' for general listening around but then narrowed down for digging the weak signal out of the wideband noise/interference from other stations close in frequency. Although a variable centre frequency would be nice it is less important than variable bandwidth/good HF attenuation.

Often the 'state variable' filter is advocated because frequency and bandwidth can be independently adjusted with a choice of outputs - low, high or bandpass. But the simple forms do have drawbacks - it needs three op-amps and gain usually varies with bandwidth or Q. Due to the single CR on high and low sides of the peak, the response slope only falls off at a poor 10 dB per decade away from the central bandpass frequency. Improving the 'off nose' rejection by increasing the Q dramatically, will make it ring and be tiring on the ears. Hence a second state variable section is suggested with 3 more op-amps to give 20 dB per decade attenuation - all too complex! This was the basis of my thesis years ago but it did also have variable bandwidth by adjustment of an overall feedback loop - this made the two filters behave just like two top coupled resonant LC circuits where the coupling capacitor is used to adjust bandwidth. See the left diagram below and the nominal effect on the response shown in the middle diagram.

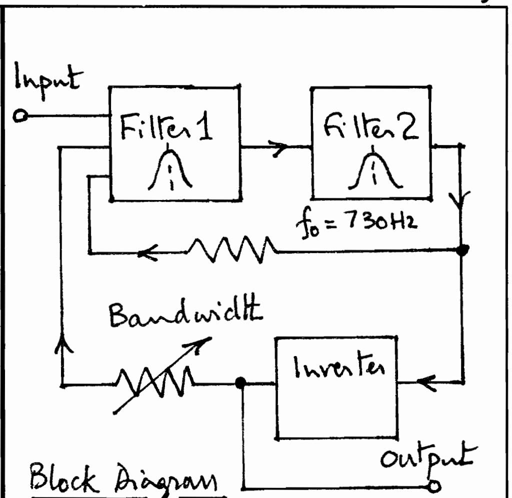
Since a fixed central frequency is acceptable, the normal single op-amp bandpass filter is quite adequate. The kit uses standard value parts for a nominal 'nose' central frequency of 730 Hz with a Q of 5. Two of these are connected in series which gives a slope of 20 dB per decade away from the nose with the two op-amps in a single IC. The output of the second is in phase with the input signal so a little of this fed back will increase the Q and narrow the bandwidth. A value is chosen which just makes it ring so that, when an inverted version of the output is also fed back, it will partly cancel out the in phase feedback. With careful choice of the feedback factors, variation of the out of phase part will alter the response between the shapes shown in the middle diagram! A final objective was to make the gain essentially fixed to avoid having to reduce gain as Q is increased. A recent note in Electronics World suggested a suitable method. In fact I have arranged it so that the voltage gain increase from unity to times two on the nose - this helps to lift the wanted signal out of the noise. After trials with signal generators, I connected it up to my Brent and was very surprised at how well it works. The noises disappear and the wanted signal stands out nicely. The actual block diagram is shown right. The kit also contains two extra pairs of CRs to reduce the height of the peaks when set for wide bandwidth - hence the slope approaches 30 dB per decade on both sides off the nose. As the best place to connect such a filter is just before the rig's main gain control, it is not designed to be able to drive a loud speaker directly although it will drive Walkman type series connected 64R phones. It is a 50 x 80 mm single sided PCB with PCB mounted shafted present for bandwidth adjustment. It needs 9 - 16 volts, about 20 mA and costs £15 + £2 P and P. G3PCJ



Two top coupled RF circuits resonant at fo.



Variable Bandwidth filter



Block Diagram of Variable Filter G3PCJ

Torrid Toroids!

They are definitely NOT that bad! There are two main types. Firstly those made from **powdered iron**; these are always painted - red and yellow types being mostly used for HF work but there are green, white, black and other colours also. Powdered iron ones are generally used for resonant circuits and are known as Txy-z where xy is the outside diameter in hundreds of an inch and z denotes the mix/colour. Hence these are easily identified. The red ones are suitable for 2 to 30 MHz and the yellow ones for about 10 MHz to 50 MHz. The other main type of toroids are made of *ferrite* material - I will deal with them next time. Ferrite ones are usually unpainted black or a dark greyish colour and often slightly dusty looking.

In both cases the inductance of a given number of turns is dependent on toroid size and material. The table top right gives this A_L value for each of the common **powdered iron** types. The inductance is given by:-

Powdered Iron Toroid Type		Designation & A_L value	
Colour	Mix	0.50 inch diameter	0.68 inch diameter
Red	2	T50-2 49	T68-2 57
Yellow	6	T50-6 40	T68-6 47

Key	Action	Display
15	enter no of turns	15
÷	Divide	
100	constant	100
=	calculate	0.15
×	square	
=	calculate	0.0225
×	multiply	
40	A_L value	40
=	calculate	0.9 uH

Answer

Calculating Inductance

G3PCJ

Inductance L (/uH) = $(n/100)^2 \times A_L$
where n is the number of turns
and A_L is dependent on the toroid core

The steps for this calculation are shown in the next box down using my scientific calculator for a winding of 15 turns on a yellow T50-6 core. The answer is 0.9 /uH. Note that these figures assume the winding is *spread evenly* around the whole core; if the winding is bunched up with the turns close together the inductance can be much higher - maybe by 25%!

More frequently, one needs to work out how many turns are required for a desired inductance. The above formula turns around to:-

Number of turns n = $100 \times \sqrt{(L/A_L)}$
where L is the desired value in /uH
and A_L is dependent on the chosen core

The steps for this calculation are shown in the bottom box. This shows that to achieve a winding of 5 /uH (that would resonate with 380 pF for 80m) you need to put on 29 turns for a T68-2. Round down the actual number of turns to the nearest whole number or even one less if the lead lengths are likely to be a bit long. Remember that the actual inductance can be increased a little by bunching the turns together. Each time the wire goes through the central hole of the core, it counts as one turn even if it does not wrap around the outside all that much! The easiest way to do the winding is to slip the core onto the middle of a suitable length of enamelled wire, put on half the winding with one end (pulling each turn tight), and then the other half with the other end. Its easy!! G3PCJ

Key	Action	Display
5	Desired Inductance in uH	5
÷	Divide	
57	A_L value for T68-2 toroid	57
=	calculate	0.087719
√	Square Root	0.296174
×	Multiply	
100	Constant	100
=	calculate	29.617

Answer Use 29 turns

Calculating no. of turns

G3PCJ

Correspondence!

Following Eric's G3GC interesting article on squeeze keying, may I present my case for having nothing to do with it?

I find it hard to accept that for the average amateur squeeze keying has any positive benefit. In fact I would go so far as saying that the benefit is negative in that it is an excellent way of making lots of errors! Amateur radio is a hobby and we are all free to do it as we like (within the law) and learning new skills is part of the fun of the hobby. If learning to squeeze key gives you pleasure then all well and good, however don't learn it because you think that this is a prime requirement for being a good CW operator because it isn't. I have done a mini survey of people I rate as being top class CW men and very few of them squeeze key. In fact quite a few of them use single lever paddles. Whilst it can be invidious to name calls may I suggest that you listen to the immaculate fast CW coming from G3FBN who uses a single lever paddle.

A few years ago W9KNI, Mr Bencher, wrote an excellent article extolling the virtues of squeeze keying and suggesting that time spent in mastering the technique was time well spent. However in the last paragraph he said 'it really comes into its own at speeds greater than 40 wpm, and is probably not worth doing at speeds less than 25 wpm.' I rest my case.

I would go so far as to ask why use an electronic keyer? Again it is fun to learn a new skill and for some people who suffer from arthritis etc a keyer is a boon. However if you don't send much faster than say the mid teens then do you really need to use a keyer? The good old straight key can make superb morse and even scruffy morse is more readable than perfectly formed errors that so often come from those using keyers. With the straight key you can show that you are a true master of the art of sending by slightly accentuating the last dash of characters such as Y and J. This greatly reduces the possibility of them being read as C or P. With the fully adaptive manual manipulator you can more easily change speed on a letter by letter basis if conditions so dictate. If you want to listen to excellent hand sent morse you know as well as I do who to listen to in the Yeovil Club.

Gerald Stancey G3MCK

More Power for the rails!

This story came from Power Systems Design Europe June 2004. It refers to regenerative braking on electric trains such as used by London Underground. When accelerating the train, the motors draw power from the DC supply (often in the range 500 to 1000 volts) in the conventional manner. However under braking conditions, the control circuits make the motors behave as generators putting the power back into the supply network. This is fine but does need another train wanting power at that moment! In practice much of the surplus kinetic energy of trains has to be dissipated as heat, either in conventional brakes or in special resistive loads. A means of temporally storing the surplus energy is needed. Could this be a capacitor? Studies have shown that, with suitable capacitors, London Underground could reduce total demand by about 30% and so save 300 tonnes annually of CO_2 emission! Very large low voltage capacitors are now available with several thousand Farads in the size of a beer can! They feature a power density of about 25 kW/Kg with an energy density of 5 Wh/Kg. One such system has 1300 units of special capacitors each having 2600 Farads operating at up to just 2.5 volts! Clearly clever devices are also needed to convert the excess power on the main supply into such low storage voltages! Tim G3PCJ

Crystals!

I still have loads of crystals. One savvy member had a load of 6.0177 MHz ones - he didn't tell me the use but I bet it was for an IF filter!! The offer is still open! Send a stamped address envelope, and they wont cost you anything more! Just tell me what and how many you want.
Parallel Resonant – 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
I have some TTL oscillators (sq wave output) which need padded bags so £2 in stamps please for P & P for these - MHz 24.0, 30.0, 32.0
I also keep a largish range of integer value MHz crystals and an increasing number of X.5 MHz ones. These are all fundamental 30 pF parallel load types. Let me know what you want. G3PCJ

Happy Christmas to you all!