"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

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Editorial

The grass is at least growing now and the cattle are out with the better weather. Time for some antenna work outside soon! To my surprise, nobody has commented (to me at least!) on my quip in the last editorial, that maybe an open-wire fed half wave antenna in the classic Zepp configuration, is not really a 'good' system. Even though the open wire feeder can withstand the resulting poor-match and high voltages, it just does not feel right for one side of the feeder to be unconnected to anything where it meets the half-wave antenna connected to the other feeder wire! I suspect that the performance of the same total length long wire antenna, working with a good RF earth and a capable Antenna Matching Unit, will be comparable. Come on one of you antenna experimenters – explain to me why I am wrong!

Through the good offices of the Radio Society of Great Britain (RSGB), we recently managed to get about 200 simple Rodway radio receiver projects into English schools where the mid-teen pupils were able to build the sets and have an introduction to amateur radio. This exercise was funded by the Radio Communications Forum with much hard work by Steve Hartley G0FUW and the staff of the RSGB. I was tasked with the circuit design – see later for some aspects of that! (The last Hot Iron had a photograph of an early Rodway.) The receiver uses the plain Tuned Radio Frequency approach with just three BS170 MOSFET transistors. It has two bands – the high frequency end of the Medium Wave for the powerful broadcast stations, that should be easily received, and 160m for demonstrating amateur radio techniques. In a few modern school buildings, there was a slight problem with the reinforced concrete construction acting as a Faraday cage barrier for the broadcast signals, but they were at least able to hear a nearby 160m phone transmitter operating into a dummy load instead. The RSGB had the PCBs made and gathered together all the parts for the kits. The excellent kit instructions, which had an introduction section about radio techniques and early radio history, were put together by Steve G0FUW and his Bath Buildathon team. I was particularly pleased to have been involved in the project because I feel very strongly that introducing analogue radio concepts to school children is an essential first step - long before they might get into radio processes executed in the digital domain. Radio communication is fundamentally analogue and they can easily do experiments in the school lab in support such electronic construction activities – not so easy with digital micro-processors! So they should start with the ANALOGUE concepts and techniques, and then most certainly should progress to digital methods if they are interested. The project is more fully written up in the May 2016 issue of Radcom.

Tim G3PCJ

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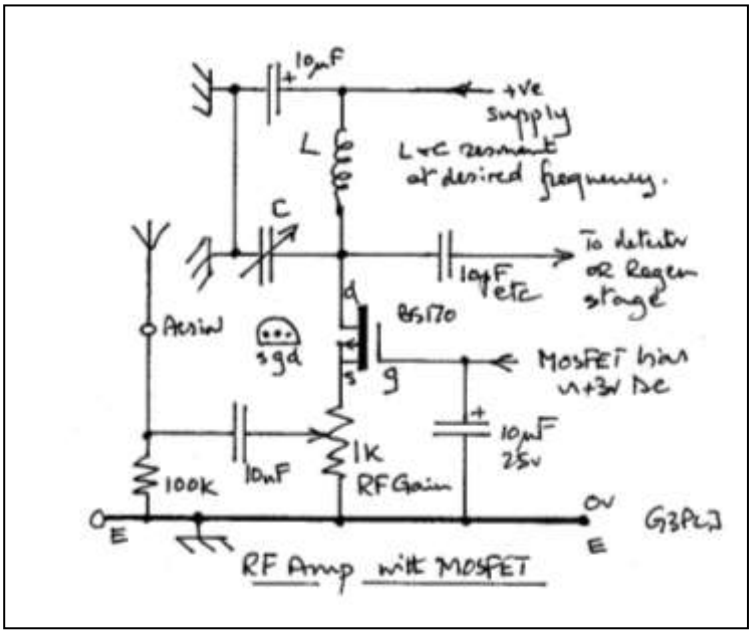
Kit Developments

In the last Hot Iron I mentioned the Redlynch derivative of the Rodway. The former is now available – see website www.walfords.net ; it is a Regen TRF with four bands giving coverage of 40, 80, 160 and MW bands, with much of the in-between frequencies as well owing to the simple tuning schemes. It is intended as an introduction to amateur radio for individuals and radio Clubs.

There is much interest among CW operators about how well simple Regen TRF receivers can perform. With this market in mind, I have laid out the PCB for a further derivative called the Cale (another small river in Somerset) for CW work on the 20, 30 and 40m bands. It intended to be the companion RX for the simple 3 band crystal controlled Isle CW transmitter. It is in the small upright format like the Yeo pictured right – which is now also available. I will be making the Cale prototype soon.

RedlynchCircuits

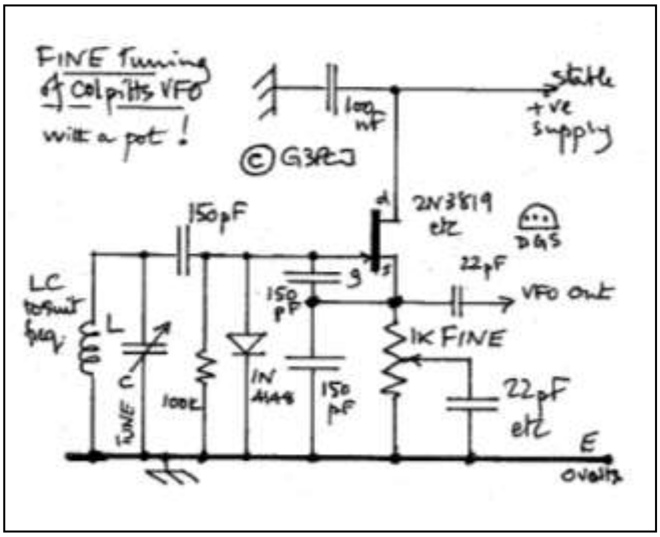
The desire to use a single type of active device in these simple lower cost circuits – preferably a MOSFET – has led to several interesting ideas:-



RF Amplifier

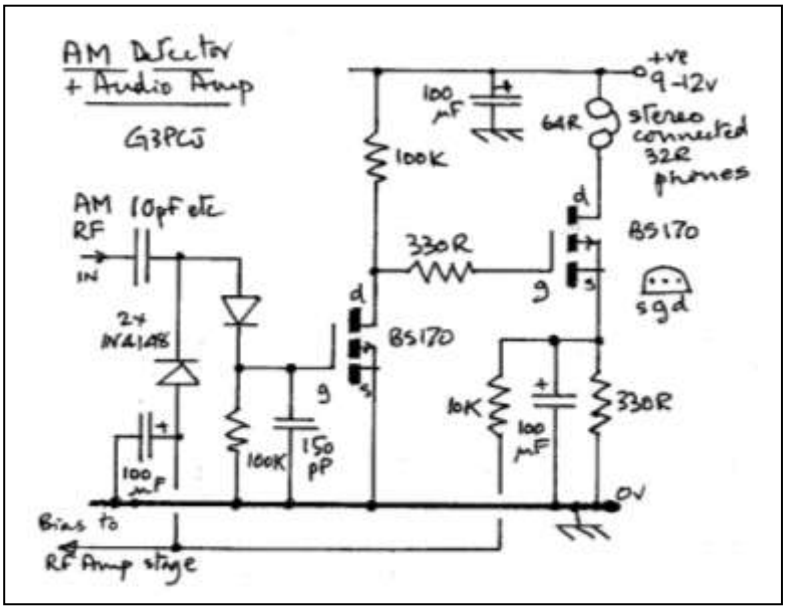
Youngsters especially - but many older people also - don't like winding inductors or toroids; so in these simple designs, the tuning inductors had to be ready wound and without any small or low impedance primary windings that are classically used for the 50 Ohm aerial input! Enter FETs with their high dynamic drain impedance that would not cause any problems for succeeding stages – especially if that stage is regenerative for high Q and good selectivity! An RF amp will also reduce aerial radiation if a following Regen stage is actually oscillating. Thus a parallel resonant tuned circuit can form the drain load of the FET. If the FET works in the grounded gate mode, feeding the signal into the source (with its low impedance), it will have a reasonable match for a 50R aerial feeder. This makes for a very easy input stage and can easily incorporate an RF gain control as shown above. A MOSFET can be used in this role where low cost is essential but is a bit more prone to unwelcome high voltage static on the aerial lead (hence back to back input diodes or a discharge resistor). A junction FET is more robust, and its capacitances are less variable, so is better where performance is more important.

Fine Tuning



Air variable capacitors and slow motion reduction gears are now lovely items of the past! Coarse and Fine tuning controls are the next best alternative but even small variable capacitors are impossibly expensive! One approach is to use some form of varactor diode whose capacitance changes with applied voltage derived from a Fine tuning potentiometer. Often these diodes are connected across the Colpitts capacitors of the rig's variable frequency oscillator. If you connect a small capacitor across the lower Colpitts capacitor it will shift the frequency down but if instead it connects to the lower end of the Colpitts stage source resistor it will have no effect! What control can do this? A potentiometer! So replace the source resistor with a pot whose slider has the small capacitor to ground! The relationship between slider position and capacitance change may not be linear (nor well defined), but the end conditions are well defined and it is low cost! The incremental frequency range of the control is adjusted just by just changing the slider capacitor.

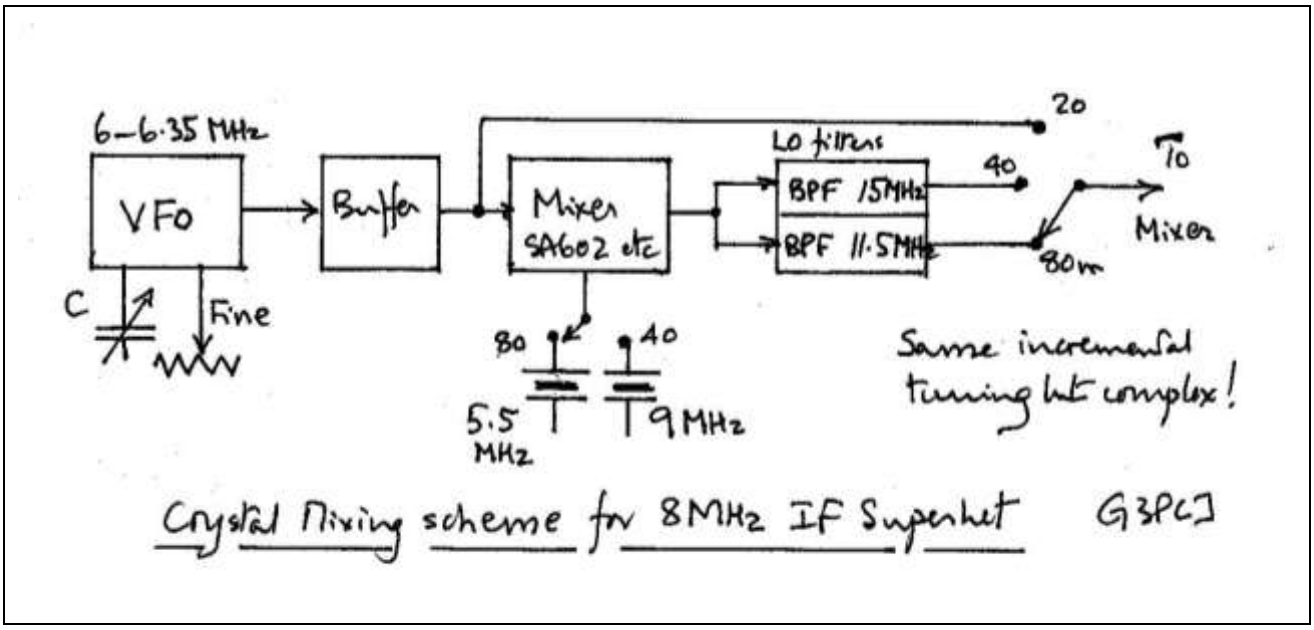
Biasing



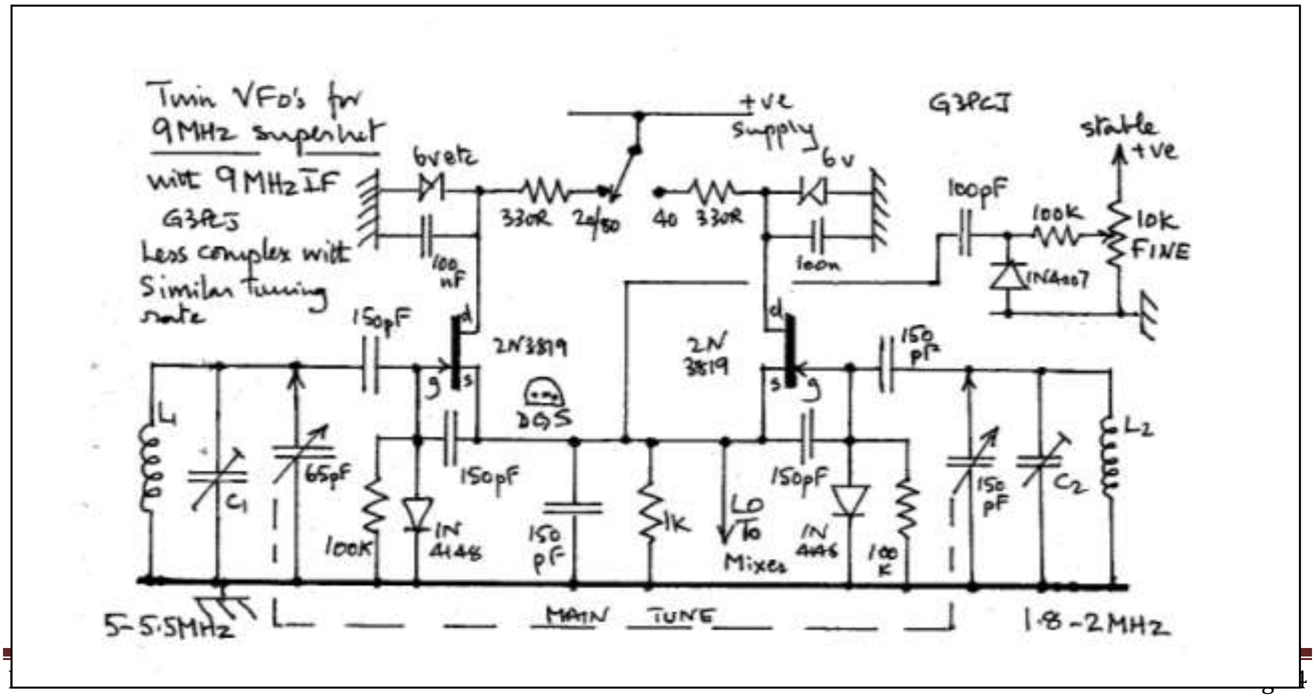
These simple TRF receivers need an amplitude detector instead of the product detector more commonly found in DC RXs. An amplitude detector is a rectifier by another name. Historically germanium diodes would have been used but they are like hens teeth now so we have to use silicon ones – they are fine for low signal work provided they have some form of forward bias. This is easily arranged if two diodes are used and they can directly feed the high input impedance first stage of a MOSFET audio amplifier. The design above has a second MOSFET output stage for driving series connected modern 32R phones. So with the feedback arrangement shown, the output stage source voltage settles at just over three volts - made up from the two volts needed to turn on the first audio MOSFET plus two diode drops. The diodes are only passing a very low current so together have about a volt across them. To boost the builder's electronic construction confidence, the source 'resistor' can incorporate a LED but it is not an essential part of the loop design – it is the diode drops and MOSFET gate turn on voltage that control the DC conditions. This bias arrangement is fairly 'stiff' because the MOSFET has very high DC gain and so can be used conveniently to bias the receiver's RF amp stage if that is also a MOSFET! G3PCJ

More Local Oscillator Schemes for Superhets!

I outlined an approach for a multi-band superhet with an IF of 6 MHz in the last Hot Iron but it did have at least one major drawback – the tuning rate was significantly different for all bands! Although a user could quickly get used to the rate for any particular band, it is not good for a top end rig - so think again! The scheme below is better but does have the drawback of needing 'tender' and complex extra bandpass filters etc – it still uses the crystal mixing approach, to avoid chirp/FMing and give stability on the higher bands:-



I think this could be improved for a three band rig doing 20, 40 and 80m by changing to a 9 MHz IF with a VFO at 5 – 5.5 MHz (in the classic 'image' scheme) for 20 and 80m. This needs to work on both sidebands but that is relatively easy! How do 40m? Use another complete VFO working 1.8 – 2 MHz! This is less complex than another set of filters and crystal mixing so is a good solution for the Somerton RX and Dorchester TX to replace the Minster & Lydford. G3PCJ



Variable Capacitors and all that… by Peter Thornton G6NGR

Many folk in the electronics World think the tiny bit of silicon inside is the "clever bit". Well, a "pie without a crust is no pie", and most people don't see the "crust" on a device! I'm talking about the "encapsulation" - the covering that keeps fingers off the silicon, be it plastic, or the metal cans of yore. The encapsulation is as important as the silicon: without both, that's no pie!

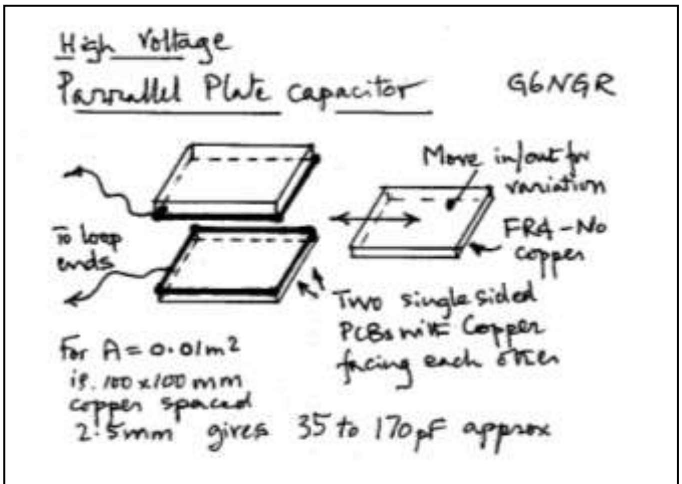
I used to maintain machinery at Ferranti Electronics and one of the jobs was to repair a pellet heater machine, this heated the plastic pellet of moulding material that was injection moulded around the silicon devices. The plastic pellets had to be stored at 2C to prevent deterioration; not good for pressing through the channels of a moulding tool with tiny galleries and runnels - so the plastic pellet had to be heated up to 110C immediately prior to being forced into the mould tool. A pellet that was cold would result in a split inject barrel (and me in the gaffer's office).

How to heat up a plastic pellet quickly enough for production? An oven was too slow; and unused pellets would be ruined, it is a thermo-setting plastic and once it starts polymerising, it quickly becomes an un-meltable lump! The answer was RF power - lots of it. As the cold pellet dropped into the inject barrel, a coil around the barrel was energised with 15kW at 80MHz. The pellets became the dielectric in a capacitor: every dielectric has losses - no dielectric is perfect, the current leads the applied voltage by just under the "perfect" 90 degrees. That few degrees off 90 represents the losses, and they appear as.... heat. Thus - one hot pellet, heating as it drops through the injection barrel into the mould tool, immediately prior to moulding. Perfect!

Which leads nicely to a problem I had at my house recently. New neighbours installed a plethora of electronic gizmo's. Reception of amateur signals was impossible: on HF, I'm S9 noise top to bottom! I decided to try a loop antenna, and yes, on 15-12-10m a loop helps, I can turn it to reduce the noise on RX. The design is from W9SCH, the "Rockloop". Make it with the thickest copper you can get your hands on, to keep those losses low. A Rockloop design is at: http://www.qsl.net/dl1gsj/html/rockloop.html and many more are on the Internet.

How about transmitting? Loops for a TX need a **very** good variable capacitor for high power: some loop designs demand split stators, others vacuum variables. Neither available here! Answer: use dielectrics. I set up two pieces of 2.5mm thick single sided FR4 copper clad board (copper facing copper) with insulators spacing them 2.5mm apart. The formula: Capacitance in pF = E x 8.85 x A/D (where E = Relative Permittivity of the insulator, A = plate area in m^2, D= spacing in m) and that's my variable capacitor. "How do you vary the capacitor?"

Easy. Slide a piece of plain (no copper) FR4 material in the gap - it has relative permittivity (E) of ~5 (air is 1) so the inserted dielectric, as in the formula, varies the capacitance. It's fully insulated, so it's safe to touch, has no "earthy hand" issues and FR4 is one of the lowest loss dielectrics available to amateurs. A few HV capacitors add some shunt pFs to the "variable" pFs to set the band. You can use any insulator to adjust: I happened to have FR4 to hand. Good luck!



Some common materials' Dielectric constants

The actual value will be somewhere between the "low" and "high" values below.

Material	E value (low)	E value (high)
Air (clean & dry)	1	1
Epoxy Resin	3.3	3.5
Formica laminate	3.6	6.6
FR4 PCB material, no copper	4.8	5.3
Glass	3.8	14.5
Mica sheet, no internal voids	3	9
Neoprene Rubber	4.1	6.7
Nylon	3.4	22.4
Paper	1.5	3.3
Plexiglass (USA) / Perspex (UK)	2.6	3.6
Polycarbonate (Plas-Glas)	2.9	3.2
Porcelain	5	6.5
Slate	7	7.1
Styrofoam	1.05	1.1
Teflon	2.1	2.1
Vinyl	2.5	8
Wood, dry and split-free	1.4	2.95
Water, de-ionised 18M-ohm	34	80

The breakdown strength, kV / mm varies greatly with moisture and atmospheric pressure; but some materials are relatively un-affected by moisture and pressure. FR4 PCB material is the best choice overall in this regard - proven by its use as the material of choice for best quality PCBs.

The Dielectric strength of FR4 is given as 20MV/ m which corresponds to 200kV / cm: whereas clean dry air has a breakdown of ~30kV / cm, and is an industry accepted value. Unfortunately you can't scale this relationship down much below mm's - the geometry of the gap plays a much more important part as the dimensions shrink. Eventually as you shrink the scale you end up studying Paschen curves, gas dynamics and Quantum effects.

Suffice to say, two capacitor plates separated by 2.5mm of plain FR4, will - *if kept clean, dry, and dust free* – will withstand 20kV (peak) forever and a day; and has done so in many a Glasman, Brandenburg and Wallis HV power supply.

Avoiding Heavy Iron in Valve Circuits by Robert - DL3RR

Transformers for valve circuits are unquestionably the most expensive part. Sadly, gone are the days of picking up heavy iron for reasonable prices at the surplus stores. A few years ago, I was looking at ways to experiment with valves relatively cheaply and what was possible in order to eliminate the need for expensive transformers. Tim's comments in Hot Iron E89 persuaded me to put pen to paper.

Mains Transformer

At this point, I should make clear that the mains transformer should **never** be left out. I realise this is common sense, but nevertheless there are various circuits available on the Internet which connect HT straight to the mains. This is extremely dangerous! Admittedly some appliances "back in the old days" did this, but it is unacceptable in this day and age.

Tim's circuit in Hot Iron for generating HT is extremely elegant. As an alternative, I have reverse fed a small mains step down transformer. A 230v:16v transformer can be fed with 12v and this will generate a high enough HT voltage to adequately run (at least) a small regenerative receiver. It needs to be borne in mind that the transformer core is not optimised for this and core losses will be higher than in the "correct" direction but it will work. However, don't make the mistake of thinking that you can try and drive the secondary above 230v – even with a transformer of suitable power rating! The core will saturate and the transformer will burn out. Of course, I found this out in a weak moment when the result of common sense breakdown filled the workshop with smoke!

Low HT Voltages

It is possible to use small-signal valves at surprisingly low HT voltages. When I was doing my degree, voltages of above 30v were frowned upon (looking back, and remembering "us lot" - for good reason!) I got around this by building a headphone amplifier with an "HT" voltage of 30v. The output stage was MOSFET based to reduce the output impedance of the valve stage, but it still had a valve as the amplification stage. Of course, you are clearly not going to be able to run a power pentode at this sort of voltage, but it is surprisingly effective if high power isn't needed.

Such a low HT voltage is going to have the valve working way outside of its linear region, but by carefully choosing the valve we can, to a greater or lesser degree, get around this problem. An ECC88, for example, is a very good bet, as are space charge valves which were designed to run on low HT – but these are getting hard to obtain.

Output Transformers

Output transformers are often the most expensive – even more so than mains transformers for the simple reason that they are not mass produced any more and demand is small.

In my search for an alternative, my first choice was a 100v public address line transformer. These are designed to transform the high impedance output of a public address amplifier down to the 4, 8 or 16 ohm needed for a speaker. I had some success with this method, and it is certainly significantly cheaper than using a true valve output transformer, as these transformers can be bought for a few pounds. They obviously won't be Hi-Fi quality – but in amateur radio applications this isn't a problem.

I also experimented with valve stages to get the output impedance down. A cathode follower output stage was designed on paper using a 6AS7. This valve was originally designed as a series stabiliser for power supplies, and has a very low anode resistance and amplification factor and thus a high transconductance. As the output impedance of the cathode follower is given by the approximate relationship:

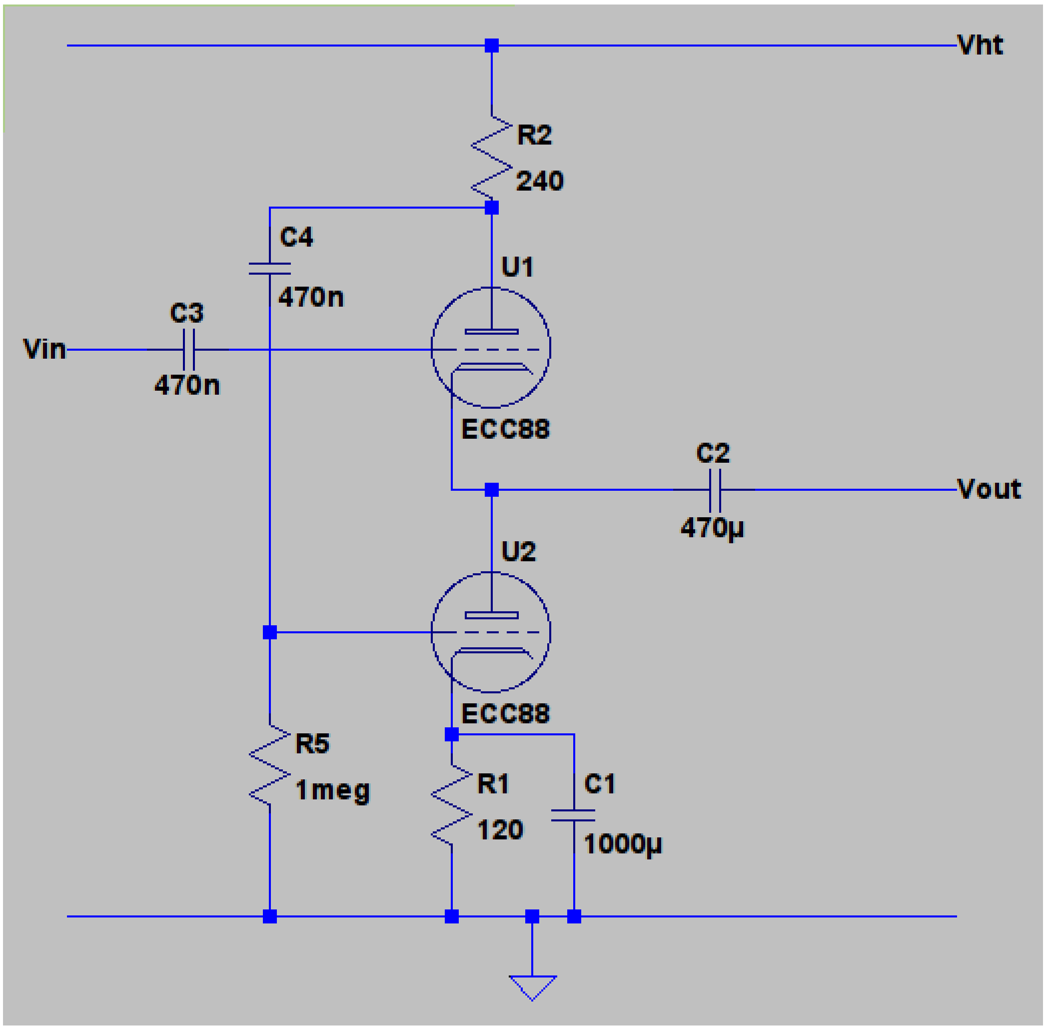
$$Zo = \frac{1}{gm}$$

For the 6AS7 we get approximately:

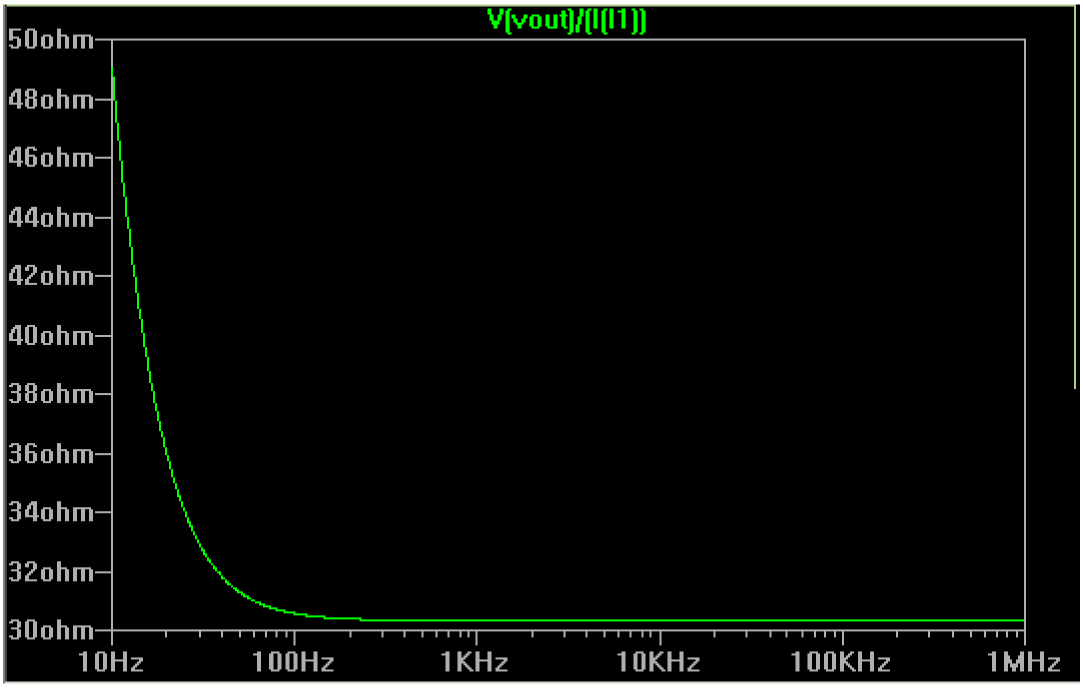
$$Zo = \frac{1}{7 \times 10^{-3}} = 142\Omega$$

Although this value of output impedance is much lower, it still not ideal for low impedance headphones; and no use at all for a speaker. Plus, coupled with the 6AS7 needing a heater current of 2.5A the costs we save with the output transformer will need to be invested in the mains transformer!

What turned out to be useful was a topology known as the White Cathode Follower, which I believe was originally patented for driving 75Ω transmission lines. Here, the trade-off is the need for two valves, but as a small double triode will suffice this isn't too much of a problem. The White Cathode Follower is essentially a cascode amplifier which uses feedback to reduce the output impedance. One valve is used as the amplifier, and the second as a regulator. The circuit diagram is shown below:



As can be seen from the AC analysis plot below, the output impedance of this circuit is extremely low – certainly low enough to drive a pair of headphones and probably even a small speaker (although I haven't tried this). The only thing to bear in mind here is that the capacitor C2 should be a good quality device rated to at least 1.5 times the HT voltage (220 volts in this example). If the device were to fail short circuit, then a significant portion of the HT voltage would appear on the headphones.



Summary

To cut a long story short, there are various ways of getting around using heavy iron – some of which are more useful than others. Like many things in life, it is a trade off. You cannot expect miracles but there are various ways to avoid having to spend big money on large transformers. I welcome comments and suggestions, and can be contacted at robert@dl3rr.net.

Comment by G3PCJ – Most interesting Robert – thank you! I think there is a similar semi-conductor equivalent of your White Cathode follower concept. I know that you were aiming to use an all valve method but when doodling audio output circuits (for 32R phones) recently, I wanted to do it all with a single type of active device to reduce the part picking time when making up kits! I concluded this could be done with an emitter or source follower in the upper 'leg' (as above) and some sort of common emitter (or source) stage in the lower leg. Lack of time prevented me thinking out how to control the gain of the lower leg to make them balance but the White follower is the valve equivalent! Hopefully some Hot Iron reader will be able to tell me its name so I can look it all up on the web from somebody who has solved it already!

Snippets

Beware the Chinese are reclaiming components!! I am sure that most of you at sometime or another have been tempted by the cheap Radio related items that have become available from China. Most of these items can be had on EBay for very cheap prices and some are genuine bargains. I have bought many of these items and have never had any problems other than the wait! I have on a number of occasions, purchased BaoFeng Hand Held radio's and for the money, you cannot go wrong. A few years ago a dual band hand held would have cost over £300 but now we can buy them for as little as £20! The same goes for kits and very cheap test equipment kits can be bought for a fraction of their real value…But.. Now it would appear that the Chinese have gone into the reclaim market!! For those who don't understand how this works, you build a circuit, it works and then after a few years you salvage parts from it to build a new circuit hence the term 'reclaim' and trust me, it is big business in the UK, in particular house building materials, as some of this material can be used again and save fortunes on new items. Well the Chinese are reclaiming electronic components as well and selling them as new!!! I have just taken delivery of a 45Watt Linear kit that was ordered from Banggood and it contains a reclaimed 2SC1971. However it is stated in the advert that this component is used!! I have also bought some of these 50R 100W resistors that keep popping up on eBay cheap,

The idea was to make a 200W dummy load with 4 of them in a series parallel configuration for less than £10!! I ordered two lots from different sellers and they both came in and to my amazement, both lots are also second hand and have been cut out of equipment…you can tell this by the fact that they have very short leads and have screw marks on there mounting tabs. They all are made by Florida RF and are all in pretty cellophane bags but sadly second hand. They all test ok but as these are advertised as new, it does make you wonder. The moral of the story is simple you get what you pay for……… (It is also true of kits too! G3PCJ)

Ray Koster G7BHQ

Here are a couple of photos of various projects. Sig Gen with counter and a 'FiveFET bling' – both by Giles G0AJC

Thanks and New Material!

I am delighted to welcome two new contributors this time – it makes it so much more interesting to have a variety of styles – circuits, construction or the English – thank you all! If any reader can write me any sort of radio related article please do let me know. Almost any radio topic is of interest to us all so please do not hold back. Similarly, if you have any question or topic that you think needs a bit of an airing, please tell me because others are likely to share your interest. Don't worry about diagrams, I can do them! Tim G3PCJ