

Hot Iron 104

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CQ - CQ - CQ

Back issues availability

Back issues of the “electronic” editions, 89 to 103 are available. Please let me know which you would like and I’ll email them to you but please be patient, as I’m a bit pushed for time. This doesn’t include the “paper” editions; I believe they are being scanned and stored as PDF’s for easy emailing by an operator in Australia, but I don’t have any further information as to exactly which issues are available or when the scanning will be complete.

Scanning isn’t a particularly quick job (that’s experience talking....) and it’s very easy to miss or duplicate a page or two, but as soon as I have more information I’ll make sure it’s known to all.

Amateur Radio: relevance today

I had an interesting email recently that prompted me to take a sideways look at amateur radio today, in view of the easy and cheap world-wide communications offered by mobile phones and “voice over Internet protocol” (VOIP) systems.

As some of you might know, my interests lie in several areas: amateur radio, rock climbing, and motorcycling. I contacted a colleague who’s climbing in Spain, simply dialled the number on my mobile phone here in Northern England. Within seconds I was connected, and the call answered: the audio quality was at least equal to calling locally, crystal clear with no particular bandwidth limiting or distortion. It cost just £0.09p per minute! This call was followed by a VOIP call to South Africa, via a VOIP application (I refuse to call them “Apps”) on my mobile phone. Result - clear speech, no obvious bandwidth clipping, low noise. Cost? FREE, as it used my “already-paid-for” Internet connection - which is getting cheaper every year because fibre optic cable connections render

copper cables unfashionable, and so prices are falling - the copper cable typical data rate of 6 - 10 Mb/s is plenty good enough for me.

This raises the question: what does amateur radio mean to me? As the above illustrates, not impromptu long distance communications at any time of day; no - to me, it's the chance to experiment with different circuits; to try old technologies built with modern components; to exercise my "grey matter" in finding optimum designs, fault finding bits of dud gear. I don't find the communications side of amateur radio particularly interesting - once I've tested a circuit, antenna, or whatever, made a contact or two, my interest wanes. If I want to talk with (non radio amateur) climbing friends I keep in touch with them all over the globe via mobile phone or VOIP communications.

That doesn't mean I don't understand or appreciate other interests in amateur radio. I noted recently Peter Parker's (VK3YE) amplitude modulated "OXO" transmitter, the much beloved (quite rightly) midget gem of QRP amateur operators. "Simple is as simple does" is an excellent motto, and producing quality A.M. with just 10 extra components is a triumph on Peter's part. Another fine example of this elegant thinking is Nyle Steiner's (K7NS) "Easy Ten" transmitter: 6 parts gets you onto 80m CW, and his antenna notes in the same article are priceless, in their simplicity and down-to-earth common sense (more on that later in "Antennas"). This illustrates another aspect of amateur radio: doing the most with the least.

The simple beauty of doing the job with the minimum of parts (and expense) is, to me, an "elegant" solution: consider, for instance, Pete Juliano's (N6QW) magnificent Arduino controlled SSB rigs, or the superb RTL / SDR receivers conjured up using very cheap and easily available parts that plug into the USB port on a PC. It's not just the technology; it's not just the complicated designs in the silicon that power these projects; it's the sheer visionary elegance and beauty of the final result, wringing superb results from a few components. That the components might have millions of transistors in them (in some cases) isn't the point: it's the amazing human ingenuity and imagination that makes the design stand out and work so well.

This being the Journal of the Constructor's Club the emphasis is on "construction" of radio equipment and ancillary support items. As you might know from previous Hot Iron editions, I readily accept the ability of CW / Morse to get the long distance "Dx" - but "Dx" communication doesn't particularly interest me, as outlined above. Morse code, generated by hand, cannot (to date) be accurately and reliably machine decoded, yet man has walked on the Moon, and machines are, at this moment, digging holes on the surface of Mars. There is a staggering gap just waiting to be filled here with asynchronous, random, hand made CW signals being interpreted reliably: such technology would have huge opportunities in communications systems for digging digital data signals out of noise and phase error faulted transmissions, or, for blind or deaf amateur radio operators. Yet, to date, nobody has come up with anything nearly as good as a human ear and brain for the job!

It's when simplicity meets ruggedness, the application demanding the utmost from the design, the power efficiency being engineered to give best performance in desperate situations, for a build price shaved down ("Muntzed") to the absolute minimum that impresses me - as a good example of that, I'll close this with a reference to the WW2 clandestine transceivers, "Parasets", "TRD's" and their ilk. To my mind they were perfect examples of amateur radio ingenuity shining through (these

WW2 sets were almost exclusively designed by radio amateurs in the armed services) under the most trying circumstances imaginable, that proved themselves (although the TRD's of the "stay-behind" British resistance groups were never used in anger - as far as we know...!) time after time and saved countless lives, by courageous operators who risked their own lives just turning them on. They had to be battery powered to avoid detection by cutting off the mains electricity, able to be set up, tuned and run into any "bit of wire" - even bedsprings - yet be reliable, simple to fix, small enough to be inconspicuous, yet still able to transmit and receive over path lengths of many hundreds of miles reasonably reliably. An article later in this edition shows some of the amazing engineering and marvellous spirit of the Dutch engineers who developed the EF50 as an illustration.

Puts the modern kilo-bucks all-singing, all-dancing, multiple "bells and whistles" transceivers (now a much promoted "fashion" item in the amateur radio World) in a different light, perhaps? This isn't to decry the amateurs who have no construction desire, nor facilities to construct electronic circuits and associated paraphernalia who buy in the R&D, engineering, manufacturing and testing of RF equipment: amateur radio is whatever you want it to be - so long as you stay within the terms of your license, it's entirely up to you!

George Dobbs, G3RJV

George Dobbs, G3RJV, now a "silent key", steered the G-QRP amateur radio movement for many years in a most professional yet personal manner. By both amateur and professional RF engineers, George was well respected; his designs illustrated elegance in every respect. He will be sadly missed; and I would recommend all Hot Iron readers look out for the future publication(s) of his circuits and articles. They shine like a beacon of common sense and practical application in this World of gimmick marketing, fake, invented "problems" and "snake oil technology" ("SNOT" is an old term for this malevolence). George proved incontrovertibly you don't *need* a professional receiver or transmitter to enjoy amateur radio: you don't *need* every option inside a receiver to be adjustable. To mimic a professional station's standards is a fine aim, but that's all: we are *amateur* radio enthusiasts, and George's work showed how *amateurs* could derive far more pleasure from building and operating home-made radio gear, rather than being merely operators of black boxes. No matter how technically (or otherwise) competent these black boxes are, the pleasure in operating an all "bought in" station soon palls - it's the satisfaction of building your own gear and de-bugging it that "educates, informs and entertains" (as Lord Reith declared) for far more years.

"Community" amateur radio

In the USA "part 15" radio transmitters are allowed, unlicensed, to transmit low power A.M. and F.M. in the broadcast bands, for not only voice (or other "sound" applications) but other useful things like baby monitors, security devices, remote controls, and the like. The Part 15 scheme is - as far as I'm aware - used for "Campus Radio" services and "Carrier Current" distribution, which means RF injected into the mains electricity cables to link into local broadcasting areas, limited to 61 metres around the originating transmitter. There is no specification as to what is transmitted: you can transmit whatever you wish, in any form you wish (but I assume you've got to observe copyright requirements?). USA readers who know different please feel free to tell me if this is truly the case, and how effective "Part 15" local radio services really are.

Perhaps to create a wider community based appreciation for radio amateurs, would a UK version of “part 15” operation suit? Amateur radio would become a useful and cheap radio communication in helping those who are alienated in this progressively uncaring society: the blind, disabled, lonely elderly people could have some personal connection via Part 15’s local radio service. Citizen’s Band in the UK did prompt some operators to become licensed amateurs, to escape the on-air lunatic asylum CB is here in the UK; but CB here was never a properly organised, voluntary radio service - here I’m thinking of voluntary Hospital Radio and the like - which in remote areas could be a very useful system indeed for disseminating community local information.

I confess to an interest myself here: in rock climbing and mountaineering circles in the UK, local conditions can vary a great deal within a few miles: the UK hills and mountains attract bad weather like a magnet, and as a radio amateur, I’d love to “stick it to the man” who profits from mobile phone telecoms (which are not always functional in mountainous regions, anyway) by using MW ground wave and / or VHF mountain top transmitters to give on-the-spot climbing condition reports. But... we don’t have any freedom to do that; and I suspect the low power outputs of “part 15” would need increasing a wee bit to get coverage. So... in true amateur style, why can’t we use “time division multiplexing” - transmit a some watts for a few minutes every hour? The average power (calculated per hour) would then be miniscule, representing no continuous interference threat to anyone?

Added to that, a “carrier current” service could use the existing mains electrical distribution system in a mountain village (where one power transformer feeds the entire community, so all in the village have free access) to alleviate the need for a medium wave antenna, not an insignificant beast, this could bring amateur radio to the attention of many more people, and attract more UK licensed amateurs to the bands?

The whole aspect of truly open, free speech, unlicensed radio operations here in the UK needs a proper dose of looking at!

The marketing of SSB...

I use “SSB” as an example of the commercialisation of amateur radio. I should add I have absolutely no objections or complaints about amateur radio use of SSB; if that’s what “flops your mop”, then so be it! But... there are many alternative modulation methods: to ascribe one as the “be all and end all” phone modulation method is short-sighted and inaccurate in my opinion.

The standard technique to make money is to find something many people find useful that they do for themselves, convince them that they can’t do it “properly” by quoting some imaginary (or semi-genuine) problem: in other words, guilt trip them into thinking they would be pariahs if they built their own gear, substantiated by inventing spurious “problems” - then sell back to them what they used to do for themselves. So, just what IS “sufficient carrier suppression”? If you reduce the carrier by -40dB, who says “that’s not enough”? WHERE did these figures come from, and by what authority were they given? Certainly, the elimination of heterodyne interference from carriers is a good thing: that’s why (I guess?) the A.M. slots - voluntarily I should add - are unique frequencies in each band. Operators therefore know “there be carriers here”, much akin to the dragons marked on Mediaeval maps!

I have a small ICOM HF transceiver; it has more twiddles, multi-function buttons, menus and other switches, display modes, than some of the machines I've repaired that made the silicon chips inside the darn thing! It's akin to a piano with a dozen pedals and five keyboards - you can't possibly use all of them "on the fly". Humans have two hands, two eyes: I'm not counting feet but it won't be long before somebody comes up with foot pedals for yet more functions on a transceiver!

In the heyday of amateur radio, you used CW or AM phone. The crowded bands of those days welcomed SSB; SSB started as a mathematical curiosity until amateurs engineered it and made it "do-able" by amateur constructors. Then the marketing men got wind of it, the hype began, and SSB suddenly became the best thing since sliced bread, but only if you bought it ready engineered in a commercial box. But still some phone operators kept using full carrier A.M.; so the vilification campaigns began, with forceful, overwhelming advertising budgets and marketing which eventually (almost) pushed A.M. into extinction - but not quite, thank goodness. That the bands were full to the brim in those days, yes: but nowadays? For local and not-so-local communications, A.M. is fine: IF you listen first, a good few kc's either side of your carrier that the frequency is clear, and your A.M. signal bandwidth is within the limits (bandwidth **and** band edges) set by your license, then off you go: you're not doing anything wrong; you're not an outcast; just keep to your license terms and everything's hunky dory.

It's a very simple matter for a CW transmitter to be converted to A.M. phone. Use a modulated supply to the driver and final; or the wonderfully simple "cathode modulator" that plugs into the key socket and away you go. A superb example of the simplicity (listen to Peter's joy in describing his design) A.M. affords is Peter Parker's (VK3YE) amplitude modulating an "OXO" QRP CW transmitter - 10 extra components and the job's done. The delight in Peter's voice as he demonstrates his TL431 voltage regulator A.M. transmitter (on U-Choob) says all.

Here's a quote from R.A. Penfold's book, "How to build advanced short wave receivers", published in 1977 by Babani, which neatly sums it up:

"The reason that commercially produced equipment has increased in popularity is probably largely due to the high standard of finish that is achieved. It must be admitted that it is difficult for the home constructor to equal commercial standards in this respect, but if due care and attention is taken, it is possible to obtain a standard which will satisfy even the most critical. As far as performance is concerned, there is absolutely no reason why a home constructed receiver should not have a level of performance which is at least equal to that of a commercially built receiver of similar complexity. Furthermore, the home constructed receiver is likely to cost very much less than its ready made equivalent."

It doesn't *need* to be "state of the art" - but of course it could be! Just your best efforts, in a receiver or transmitter you built, and your "bit of wire" antenna is all you need to sample the true wonder of amateur radio. And that's something the marketing men can't put in a black box and flog back to you!

Hot Iron contributions & ideas

Hot Iron is your journal: I need you to tell me what you want to see, and for you to show me the wonderful gear you've built, or the intriguing antenna you've designed that runs all HF bands at 1:1 up to a kW, 95% efficient and doesn't need an earth plane the size of Wales.

Please send all your ideas, designs, thoughts, pictures, scribbles and questions to me (equieng@gmail.com) for Hot Iron. All are welcome; if you are writing to me “not for publication” please make that clear, otherwise I’ll assume you’re happy with me reproducing it in Hot Iron.

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I cannot accept any liability for any damage or injury to you or any Third Party from any article or description in Hot Iron. It is your responsibility to ensure the safety and safe use of anything you build; I am not responsible for any errors or omissions in Hot Iron, circuits are reproduced assuming the reader has a basic understanding of the safe use and implementation of electrical and electronic equipment and components.

If in doubt, don’t do it: get professional, competent, qualified expert advice and help.

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Tim's Topics

A new project - maybe?

The advent of cheap and capable computer driven DDS style RF oscillators for a receiver, means that analogue multi-band RXs are a thing of the past! Consequently I am always on the look out for other interesting projects to add to my line-up. A good customer in Wales suggested I might consider a small Amplitude Modulated (AM) transceiver for 10m – hence these deliberations! It would need better selectivity than a single plain Tuned RF stage so I first considered a fairly conventional superhet; the usual IF range of up to a few MHz would mean a first tunable local oscillator probably over 20 MHz – not going to be frequency stable! Instead I considered a ‘converter’ ahead of the main tunable RX which would also provide the selectivity. This appeals because the converters could be for ‘any single band’ with different crystals driving its mixer – so allowing for the keen 40m AM fraternity. So what form should the main tunable and selective RX take? It could be a superhet but it then becomes triple conversion overall – complex and with potentially many unwanted spurs! The obvious choice is a Regen RX – simple with much gain and good stability if its frequency range is in the low MHz range. The Regen allows reception of CW or SSB as well as AM which might be an added attraction. Some might say they are fiddlesome and difficult to use – a fair criticism unless specifically addressed; so this needs a restricted tuning range, Regen stage gain control (either side of the critical point at which oscillation starts) without a change in frequency and which is very smooth. These are (normally) addressed by using a low MHz Regen stage frequency and a control pot with added presets on its ‘top’ and ‘bottom’ leads to turn it into a ‘fine’ form Regen control. A tuning offset can also be added just in case that is needed when switching to transmit, this is because the Regen oscillation needs to be quite large for that and this might lead to a small jump in frequency when it is forced to oscillate somewhat more strongly! (I happen to know that our Editor has been investigating Regens with automatic gain control, so maybe he will come up with other solutions, especially for really weak CW that appear challenging for a conventional Regen!) This project’s potential block diagram (Fig 1) looks like this:-

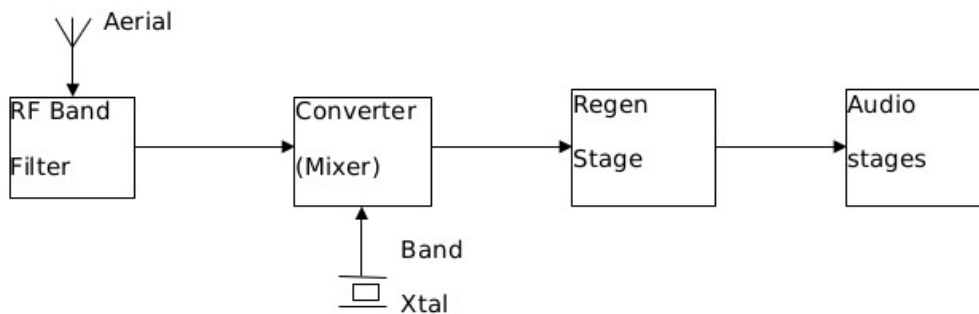


Fig 1 – RX Block Diagram

There are two obvious choices for the modulation method to produce AM – conventional superimposition of the audio onto the RF final’s supply rail (plate modulation) or superimposing the audio onto the gate of a MOSFET RF final stage which is nearly as good at producing AM as plate modulation. The latter is much easier nowadays because suitable audio power transformers are hard to find, and it needs an audio driver stage capable of half the carrier power!

A more interesting design point is how to implement the reversed RF signal flow through the RX converter’s mixer? My initial thought was to use a SA612 mixer with its integral oscillator stage; and to then switch the inputs and outputs using an extra relay controlled by the PTT switch. Not very elegant and the in/out impedances are a bit high for comfort when working on 10m for transmit! How about diode or FET mixers which can be arranged in an inherently bi-directional arrangement to avoid the in/out switching problem? They also usually operate at nearer 50 Ohms in the conventional twin transformer doubly balanced arrangement. Mixers using switches like the fast 74HC4066 don’t need huge driving power and can be driven by an easy crystal oscillator and chain of digital gates for best alignment of the desired complimentary driving waveforms and their sharp edges.

References on such mixers suggest that proper wide band termination of in and out ports is highly desirable to avoid unwanted responses, so maybe one should add small resistive attenuators (or maybe diplexers) on in and out ports; this would normally lead to a noticeable loss of sensitivity, but don’t forget that the RX aerial signal is coming via the transmitter bypass route during reception – so why not give this route a strong wide band RF amplifier which will make up for the loss of gain in subsequent RX stages (RF filter, mixer and possibly two attenuators). This leads to a partial block diagram as in Fig 2. Problem solved! Could this scheme work?! If it does, the RX might be called the Hurst and the TX will be the Heale.

Tim G3PCJ May 4th 2019

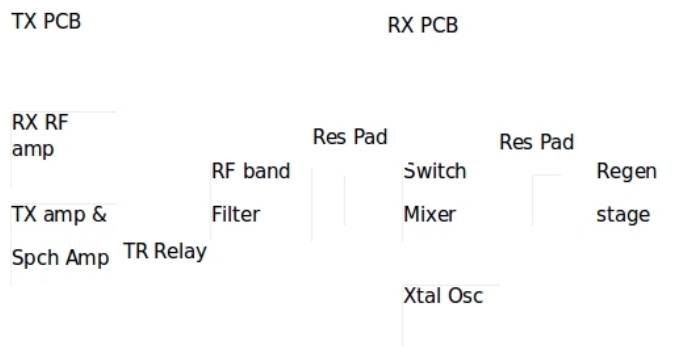


Fig 2 – Partial overall block diagram

Apologies for the diagram - the outline boxes are very feint; conversion from Microsoft “docx” format to “jpeg” was nigh on impossible due to the way Windoze handles graphics, and I didn’t have the time to re-draw the diagram out. You can see Tim’s reasoning of the bi-directional nature of the design; and yes, I’ll be looking at auto-regen detection of weak signal CW in the future.

Audio Topics

Microphones...

For those who like to build their own microphones for commercial equipment, or repair “bargain buys”, an absolute gem of a web page is by G4WPW: <https://www.qsl.net/g4wpw/date.html>

My sincere thanks to G4WPW for his magnificent work and the QSL.net group for presenting the information in the public domain (internet).

You’ll find hundreds of mic schematics, notes and details referring to just about every commercial transceiver - a veritable gold mine of useful information. And for me, this is the core spirit of amateur radio: helping others, do-it-yourself and building a network of co-operation.

Copper Water pipe fittings and sweet sounds

A microphone deliberately designed and engineered to have an “old time” sound is the “Copperphone” from Placid Audio (<https://www.placidaudio.com/products/copperphone/>). If you look closely at the beast, you’ll observe it’s akin to a short length of copper water pipe with “end feed” caps on the ends, the caps held in place by annular screws - no heavy soldering and easy servicing. The holes in the front cap can be marked and drilled with elementary geometry, and a small piece of black speaker cloth glued in place inside the cap makes for a neat finish. Polish the outer metal with some auto chrome polish, then apply some well thinned clear nail varnish to protect the now shiny copper surface.

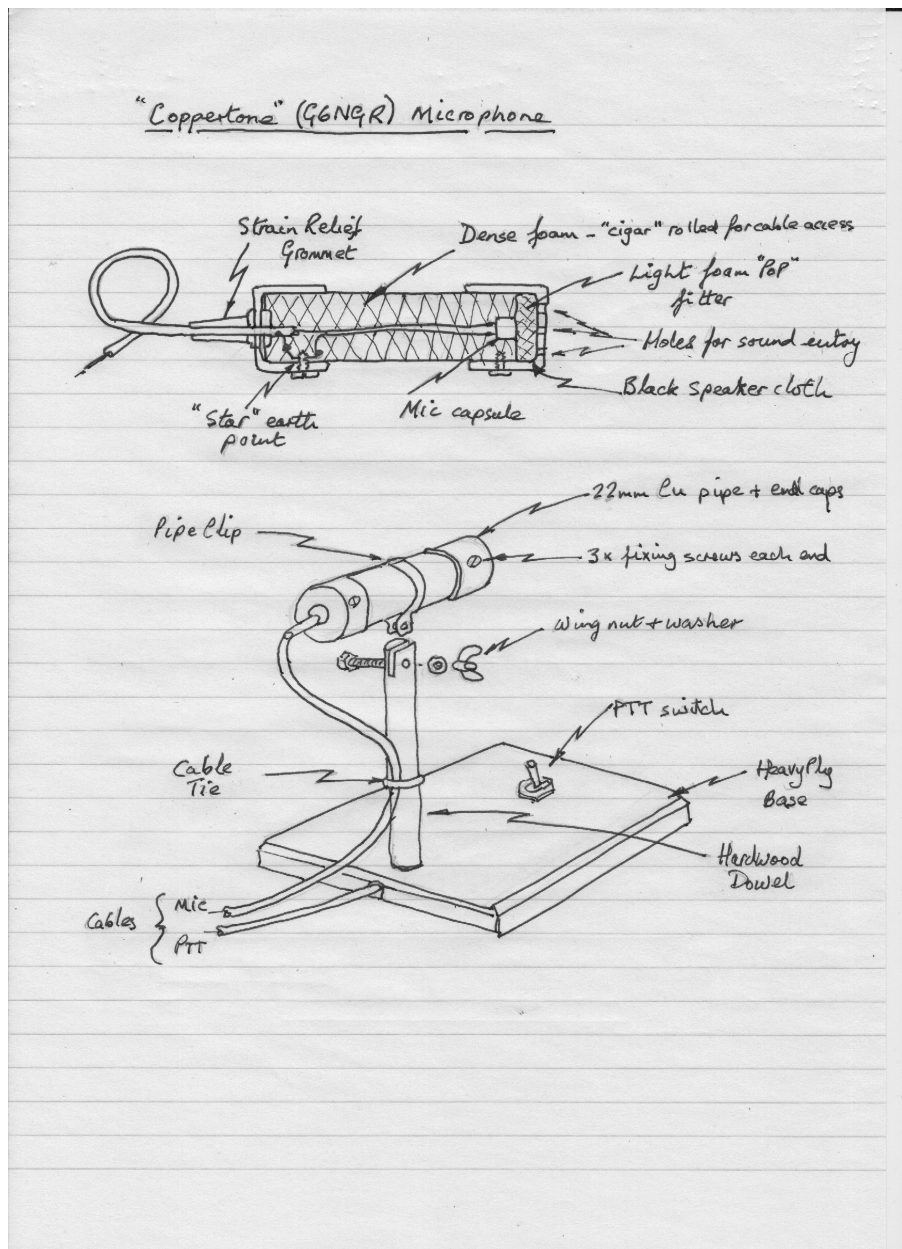
The beauty of this design that caught my attention for radio amateurs isn’t the “old time” engineered sound the Placid Copperphone achieves, it’s the superb “all-over” electrical shielding the construction creates: this solid metal cover gives just about the best Faraday screen money can buy. You are, after all, generating μV to mV audio signals in close proximity to watts of RF; it’s a good idea to make your microphone as “RF proof” as you can. If you build your own version of the “Copperphone” you can experiment with foam damping, positioning and other such variables until you get the quality of audio you want - mics are much like antennas, being a similar “black art”, requiring a fair bit of cut and try, but always a pleasure to build and use.

Internally, an electret microphone capsule is supported with a tight fitting, “cigar rolled” dense foam plug, which damps and centres the electret, provides rear sound absorption yet allows tiny rearward air flow to avoid damping the diaphragm, with consistent yet flexible shock absorbing support. The front face of the electret will need covering with a few millimetres of light foam to create a “windshield”, eliminating the breathy “pops” found on certain letters, “P” and “D” for instance. If you’re prone to s-s-sibilance, then a double layer of front foam and a touch up on the mic gain can help.

For those on the tightest of budgets, an ear bud scrounged from the lightweight earphones now found - literally, often discarded - makes a good dynamic microphone, in place of the electret; but remember that you’ll need a low input impedance input amplifier of about 80 to 350 ohms, pointing to either a common base or High Z input amplifier slugged with an input resistor to get the best results from an “earbud” dynamic mic. The electret has an internal pre-amp and needs “phantom” powering, the ear bud, no; however for ultimate sound quality mic pre-amplifiers look to: <http://sound.whsites.net/index2.html>, and have a wander through some of the finest audio pages

you'll find on the planet. Don't forget too that the microphone amplifier is the best place to apply treble roll off and bass cut with feedback capacitors and coupling capacitors, respectively, and make sure you use single point "star" earthing wherever possible to eliminate earth loops.

A brass "Ring" type pipe clip very neatly supports the copper pipe body, which can be easily set into a slotted piece of dowel using the Ring clip securing screw hole, matching bolt, washers and a wing nut, morticed in a small plywood plinth, nicely sanded, chamfered, painted black, looks the real deal in any amateur shack - and costs but little.



For the most "rigorous" microphone enthusiasts

Don't say I didn't warn you. Acoustic design makes RF antenna analysis look like a Sunday School picnic! The maths is full-on abstruse, things like the "acoustic Ohm" and similar, commonplace. Yes, mechanical objects have resistance, capacitance and inductance, believe it or not - it's the only way you can realistically analyse an acoustic system.

Right, that's the hard bit done: I refer you to a web page where you can download all you'll ever need to know about microphones. It was originally written in the 1950's by that wondrous organisation, the BBC, and, whatever you consider their faults, poor quality sound is NEVER one of them - it is, literally, World Class sound engineering, so is well worth a good dose of looking at.

I've always made my own microphones by thinking of them as loudspeakers in reverse: you're aiming for an infinite baffle, so the sound has no rear reflections, yet anything infinite in this World isn't really a practical proposition so we use damping material behind the loudspeaker and a nice box for it to live in, so the desired sound is squirted out where we want to hear it - a direct transposition into our ears of the original voice, music or whatever.

You want the full experience of microphone design? You want to know the real engineering "ins and outs" of the acoustic / electromechanical interface device? Here:-

[https://www.bbceng.info/additions/2016/BBC%20Engineering%20Training%20Manual%20-%20Microphones%20\(Robertson\).pdf](https://www.bbceng.info/additions/2016/BBC%20Engineering%20Training%20Manual%20-%20Microphones%20(Robertson).pdf)

This is an openly available public document on the web; and is truly a *magnum opus*. Doubt ye not; this is THE full story of microphones. Well, I did warn you...!

Receivers

RF amps and my memory

The simple transistor RF amplifier shown in Hot Iron #103 has some shortcomings: Tim Walford nudged my grey cells and remarked on the choice of a resistor as collector load as not able to give an adequate output swing. When I wrote the piece I had a picture in my mind of a test rig I used to measure the ft of RF power transistors: this was the circuit given in Hot Iron #103, but with a subtle difference - which I was reminded about whilst chatting with a colleague from those halcyon days.

Those of you who have had the (somewhat dubious) luxury of running 807 tetrodes at full whack will recall the anode cap often had a low value resistor with a few turns of wire wound over it to suppress parasitic oscillations - 807's were particularly prone to "taking off". The resistor / inductor put a VHF lossy element right on the anode connection, to kill any VHF oscillation - and the same technique was used to stop power transistors in a test rig from "hooting". Only this was done by using a *wire wound resistor* rather than a winding over a resistor body, the wire wound resistor features inbuilt inductance and resistance: so I got two components for the price of one.

This was the resistor I remembered - it was in fact the collector choke load and parasitic stopper for the common base RF amplifier. The moral of this tale is that the common base RF amplifier shown in Hot Iron #103 must have an inductive collector load, be it a choke or a transformer!

CW trainer for the blind

The reliable and low cost pin drive printers of a year or two ago prompted me to think of Braille patterns: surely the pin drive mechanism could be used to present Braille characters to the blind amateur radio operator? The reasoning is this: that some amateurs become progressively deaf to a certain extent in their later years; and a pin drive Braille mechanism would mean more years of amateur radio for those blind operators who's hearing is failing, to whom amateur radio is a lifeline.

Of course, this all points at that favourite hobby-horse of mine: the accurate decoding of hand sent Morse. I'm not of the generation who happily talk of modern microcontroller technology and the like; I find the manufacturer's programming suites so convoluted, inaccessible and assuming the user has full understanding of the terms and features of the software to be unusable by the amateur radio enthusiast. Some of the real experts (hiya, Terry...) find the programming software so far "over the top" as to be a real pain in the arse; combine that with the design of "AI" (artificial intelligence) to decode hand Morse in real time, well, it just isn't my field of interest or expertise.

Samuel Morse didn't design his telegraphy system to be a hand driven system, he had electro-mechanical designs to create the code's dits, dahs, and spaces; at the receiving end, to decode them and print the decrypted letters on paper tape. But, humans being what they are, Morse's operators soon learned the sound that represented particular letters - and the rest is history. Admitted the problem of decoding in real time sounds simple enough until you actually start considering how to differentiate between slower sending, atmospheric / ionospheric distortions, but it *must* be possible somehow?

More exciting perhaps...

I heard on a BBC Radio 4 programme about speech synthesis directly from brain neuron signals in the cortex, from a research team in California (where else?). This really is an amazing breakthrough: with simple skin electrodes picking up the appropriate signals from the brain - already an established technology in medicine - they can reproduce in words what is being thought about! I assume you must "think" the words (I dread to think what it would make of some of my thoughts...!) and it uses successive approximation to "learn" the pattern of your individual brain waves. The programme illustrated the unit working: it's first translation sounded muddled: like a drunk with a heavy cold trying to order an Italian meal. The second iteration was far clearer: it just sounded a bit muffled. The third iteration was spot on, perfectly readable. Between each iteration, the researchers tweaked the settings, but the comment was that once the pattern had been learned for one individual, it got it right 90% of the time.

What an achievement! And how useful for people paralysed from the neck down, trapped in a body they can't use? Those without full speech capabilities (for whatever reason) being able to communicate clearly and reliably? The mind literally boggles: this is a wonderful advance for humanity. Until the Government gets hold of it and uses it in Police cells, that is... shades of Huxley's "Brave New World" and Orwellian "Thought-Crime" perhaps?

But what a superb auto Morse keyer - just think the words and there they go! I wonder if it can be engineered in reverse? The dits, dahs and spaces translated into electrical impulses and fed into the brain to make letters sound inside your head? Wow!! You heard it in Hot Iron #104 first!

SSB and all that... the DDS VFO strikes again

Reproduced from an article in QST, November, 1952 - and how the IF carrier insertion oscillator is considered NOT the best way to do the job! The article concludes that SSB and full carrier AM can be used in "round table" on-air discussions with little, if any, problems.

More to the point perhaps, is the ready availability and use of DDS / microcontroller VFO's - which could very easily provide signal frequency carrier re-insertion at the receiver. One neatly packaged (die cast box is a good idea) VFO would cover the needs of dozens of receivers in an amateur

context, thus relieving the need for individual carrier reinsertion oscillators in every receiver, and give a good indication of the stability of the receiver's local oscillator, too.

Here is the article as presented on the archive web page, and many thanks to QST for this:

“Practical Pointers on Two Methods of Operation

By Paul N. Wright, W9 OHM

Reinserting the Carrier:

In a superheterodyne receiver, the carrier may be replaced by injecting the carrier from a local oscillator at the i.f. frequency into the i.f. section of the receiver, or by injecting the carrier from an oscillator at the signal frequency at the antenna terminals of the receiver.

If carrier injection from the b.f.o. in the receiver is used, the receiver should be adjusted as follows: First, with the receiver set up in the regular a.m. position, tune the bandsread dial for maximum deflection of the S-meter from the s.s.b. signal. Do not touch the bandsread dial after this. Next, reduce the r.f. gain to zero and increase the audio gain to maximum. Bring up the r.f. gain until the signal is heard at a comfortable level; then turn on the b.f.o. and carefully adjust the frequency of the b.f.o. until the voice sounds natural. If this procedure is followed closely, little difficulty should be experienced tuning the signal, regardless of which sideband is being transmitted.

In using the b.f.o. method of carrier insertion, it should be pointed out that practical reception of s.s.b. signals depend upon the stability of the h.f. oscillator in the front end of the receiver, as well as the stability of the beat oscillator that supplies the carrier. Any frequency change in the h.f. oscillator produces the same effect as changing the frequency of the transmitter on the other end. The h.f. oscillator in most receivers is fairly stable on the lower frequencies. However, at frequencies above 5 Mc. the stability of many h.f. oscillators leaves much to be desired, when thinking in terms of the stability required from these oscillators when using i.f. carrier insertion.

In using carrier insertion at the signal frequency from an external oscillator, the procedure is as follows: With the receiver set up in regular a.m. position, first tune the bandsread dial for maximum indication of the S-meter from the signal. Then adjust the frequency of the external oscillator to the approximate frequency of the incoming signal, and increase the amplitude of carrier injection to a point that approximates the amplitude of the s.s.b. signal. When this point is reached, the S-meter will no longer swing with modulation. Carefully adjust the frequency of the external oscillator until the voice sounds natural. Rock the receiver bandsread dial back and forth across the carrier. You will easily be able to tell which sideband is being transmitted. As you leave the carrier, on one side the audio will drop off; as you swing on the other side, the audio will come up. The more selective the receiver, the more pronounced this effect.

An s.s.b. signal suffers a certain amount of nonlinear distortion when demodulated by a linear rectifier. The amount of distortion produced is relative to the modulation depth of the injected carrier by the s.s.b. signal. Increasing the carrier injection above the 100 per cent modulation point will reduce the nonlinear distortion in the detector to a negligible amount. Increased carrier also helps swamp out adjacent channel QRM and generally to improve the signal-to-noise figure.

The advantages of front-end carrier insertion are:

- 1) Stability of the received signal.
- 2) S-meter reports may be given on s.s.b.
- 3) It makes round tables including s.s.b. and a.m. stations practical, since the receiver remains in the a.m. position at all times.
- 4) Oscillators in the s.s.b. exciter may be used to furnish the stable carrier to the receiver, providing consistent "on frequency" operation of the transmitted signal.

Point 4 is very important from the standpoint of pleasurable operation and good operating practice of a s.s.b. station. Since the oscillators in the s.s.b. exciter furnish the carrier to the receiver, the transmitted signal is automatically on the same frequency as the received signal. This means that only one oscillator has to be adjusted to get both the receiver and the transmitter on the same frequency. Of course, any large frequency shift would require resetting of the receiver bandspread dial. This method, if universally adopted, would make practical operation of single sideband as simple as operating an a.m. transmitter, by eliminating the extra tuning procedure. With amateur s.s.b. operation still in its infancy, elimination of a tuning operation may not seem of much importance. However, as new s.s.b. stations come on the air and spread out on the bands, the elimination of a tuning operation becomes more important. If all s.s.b. stations involved in a voice-controlled round table were using their exciter VFO for carrier insertion to the receiver, they would remain on the same relative frequency. Using this system, any drift occurring in the local VFO, or drift occurring in a VFO on the other end, is compensated for while listening. It would not be necessary to halt the entire round table QSO every so often and realign on somebody's frequency. Proof of the need for the adoption of this operational method can be obtained by listening to any large s.s.b. round-table QSO on 75 meters. Note the confusion and the lost time caused by off-frequency operation. Then, too, it is rather difficult to impress anyone that single sideband has come of age and can step in the same ring with a.m. after they listen to that sort of operation.

There is another advantage to VFO carrier insertion. Those who have used it have found that when they are in QSO using voice-control break-in operation, they can control the QRM situation very nicely. If they hear QRM come in on the low side, they merely move the VFO higher until the QRM disappears. If the QRM comes in on the high side, they move the VFO down until the interference disappears. With the tuning ease afforded by this system, rapid QSY is practical, providing a most effective way to dodge QRM."

A valve that has saved lives

The following article is presented with great thanks to Henk Zwier, Robert van der Zaal, and Tim Walford. It was translated from the original in QRP Newsbrief # 169 by Robert van der Zaal.

I also thank the Dutch Philips engineers, WW2 clandestine radio operators and all others involved in the Allied radio communications during WW2. Every time I have visited the Netherlands I have always been mightily impressed by the industry, ingenuity and determination of the Dutch nation, who make the absolute most of their compact country - and in technical engineering and artistic appreciation, are truly superb.

~~~~~  
**"THE SECRET RADIO VALVE EF50**

## ***“the valve that made the war got won”***

**By Henk PA3CLL**

*Each radio amateur that got active after the Second World War no doubt has come across famous transmitting valves like the 807 and 813. These, then, modern valves could be found in virtually all British and American built transmitters. Without these valves the Allies would never have been able to win the war. Less known but possibly even more important was the development of the EF50, also known as VR91, CV1091 or ARP35. Later versions are the EF54, EF55 and EF90.*

*Officially, Philips developed the EF50 as to be used in the 45MHz IF of television receivers. This was however a disguise as the valve was developed for use in English radar equipment, like the “ground mapping radar” H2S. In an earlier talk I mentioned the importance of the H2S radar, a system considered to be the first “airborne” radar. H2S was of crucial importance in combating the German “U- boats” and allowed the RAF and USAAF to “blind” bomb targets in poor visibility.*

*In the 1930’s, before WW II that is, most radio communication took place below 30MHz but due to a low amplification factor and a high noise level the then available valves were poor performers in the higher range of the spectrum. The two main reasons for these shortcomings were capacitance and auto induction caused by the construction of the valves. Another important reason turned out to be the speed of electrons which appeared to be lower on higher frequencies. On, say, 3MHz an electron moves between cathode and the grids in about 1 nanosecond. Around 100MHz this “leg time” becomes an important factor resulting in a lower impedance and amplification factor of the valve. If the impedance on, say, 10MHz is 4k $\Omega$ , on 40MHz it has dropped to 1k $\Omega$  and on 80MHz to only 250 $\Omega$ .*

### ***Research in VHF valve techniques***

*In the 1930’s a lot of research was done by Philips Netherlands and her English branch Mullard aiming at improving the performance of valves on higher frequencies. Before WW II Philips also cooperated with Siemens and Telefunken when developing valves for VHF. This all resulted in valves of the EF series like the EF11, EF12 and EF15. Philips solved the problem of the internal capacitance by mounting the anode sideways, leading to shorter internal wires to their pins.*

### ***TV and the secret radar valve***

*In 1936 England was well on its way in developing “modern” television by using electronically scanned images. The sound carrier was at 41.5MHz, the picture carrier at 45MHz. The then available valves lacked in performance, especially in amplification, this leading to the need for valves with a higher amplification above 30MHz. This was obviously not just for TV as the development of RADAR had become of utmost importance.*

*In those years the English already had quite some experience with, what was then called, “Radio Direction Finding” (RDF) and later called “Radar”. Radar research took place at Bawdsey Manor in Essex, mainly in cooperation with Mullard (Philips!) Valve Company and the British government. Mullard approached the Philips HQ in Eindhoven asking whether there was a valve available with the required amplification in the VHF area. To disguise the actual application in Radar technology Mullard referred to the valve as to be used in TV equipment. A special valve, developed for that purpose in the late 1930’s, was introduced in 1939 and was: the EF50!*

*The EF50 was developed by Professor Jonkers of Philips Eindhoven and by PYE Electronics in England suggesting a full metal shielding around the glass. The EF50 was the first glass valve with all pins at the bottom, matching the socket. This way the use of a top connection for the anode was avoided. Teething problems occurred however in making the valve “gas tight”.*



### **The secret RADAR receiver**

*In the end the EF50 was used in a number of systems. In 1939, the first “airborne” radars were equipped with an IF strip of EMI. By sheer coincidence one of the project managers involved in the Radar project discovered the 45MHz TV receiver strip of PYE. This strip showed a much better sensitivity with a much lower noise figure. With six EF50’s in a row the strip could serve as an off-the-shelf fixed IF receiver for Radar. Other advantages were the lower price and lower weight. Next to the poorer performance, amplification and noise wise, the low production capacity of EMI did not allow the production of sufficient IF strips. PYE (Philips) had a sufficient production capacity but....*

### **Philips helps PYE and the English:**

*Early 1940 the British authorities were worried about the availability of the EF50, after all, that valve was crucial in the development of Radar systems. But Mullard in England had difficulties producing the valve. As although the print on the valves read “Mullard”, the EF50’s were produced in Eindhoven, soon to be occupied by Germany. The English leader of the Radar project (Watson Watt) realised that when the occupation was there, the production in Eindhoven would fall in German hands. Early 1940 he arranged a meeting with Theo Tromp, head development of Philips, urgently asking Tromp to produce as many EF50’s and send them to England as soon as possible.*

*Philips Eindhoven started to work day and night producing loads of EF50’s. Just before the German invasion on the 10<sup>th</sup> of May, on the 9<sup>th</sup> of May a lorry with production machines, 25,000 EF50’s and 250,000 basic EF50 parts was driven from Eindhoven to Flushing and shipped to England on an English ship leaving Flushing on the 10<sup>th</sup> of May, at 05:00AM, a few hours before the German invasion started. Although the ship was shot at during the crossing of the Channel, its cargo including the EF50’s safely made it to London. Later, Sylvania, USA produced loads of EF50’s.*

*Amazingly, the EF50 made the victory of the Allies in WW II have a touch of Dutch!”*

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## **Transmitters**

### **Pink Brazilian**

I decided to build a valve project because of the simplicity that “hollow state” design gives, and rugged robust performance under extreme SWR that valves tolerate. Sure, the job could be done with solid state devices, but for sheer elegance, ease of use, and bombproof survival ability of a valve in the event of short / open circuit antennas made a valve the component of choice.

Valves are like steam locomotives: they engender respect and appreciation, and besides that, look great, and are warm, living things that glow a healthy red. And... they keep your tea warm on top of the cabinet!

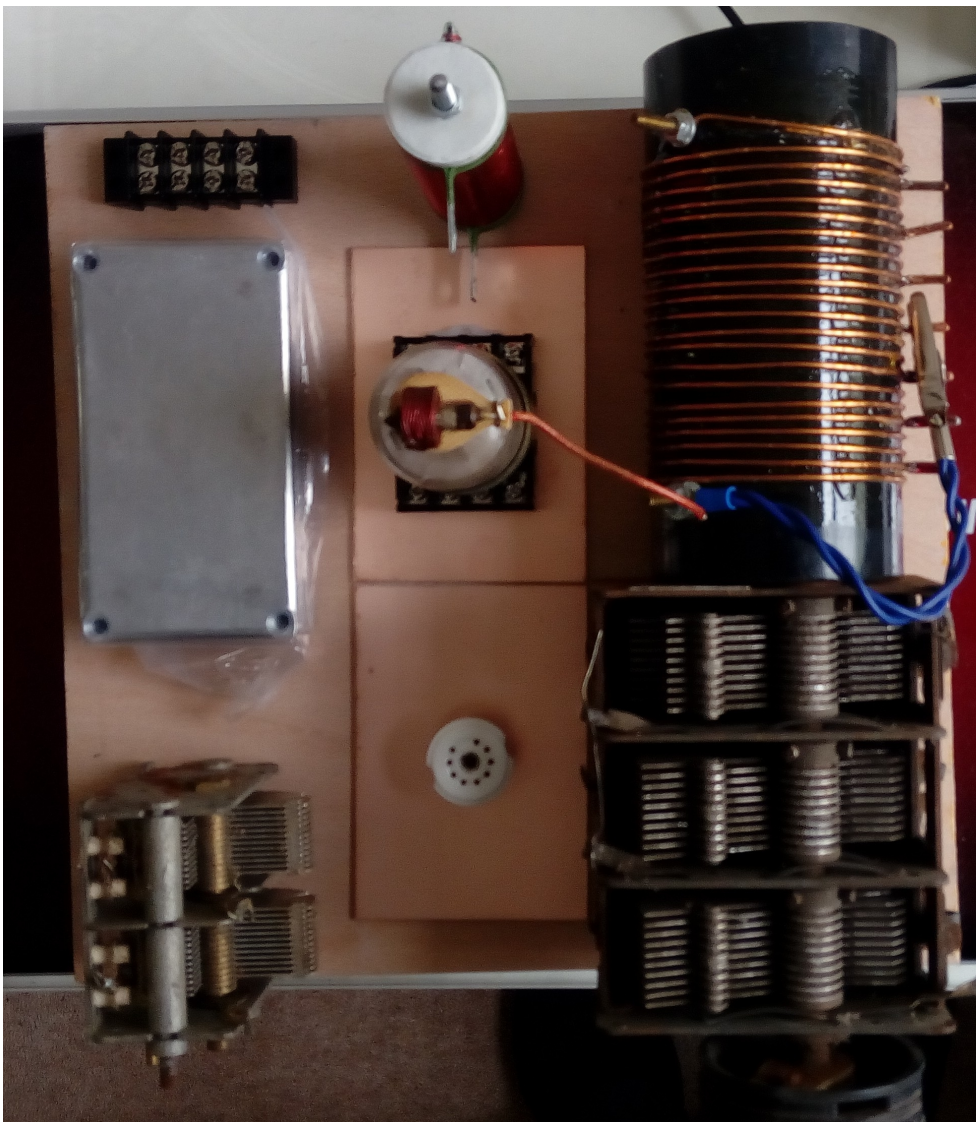
Mind you, I do have a soft spot for valves; I earned my living for many years working with high power RF generators using Siemens RS3150CJ triodes (and others of similar capabilities - the 3150CJ is certainly NOT an amateur valve!), so I have much respect for these beasties. They deliver reliably under the most extreme circumstances, and give ample warning of failure: something solid state devices - the fastest three-legged fuses ever invented - never do, despite complex current and voltage limiting power supplies. Valves just take overload in their stride, then return to the fray

ne'er a watt lost, once the fault's been found and fettled. Let's see a power mosfet survive after a 10kV DC HT supply flashover!

Here's a picture of my proposed layout for the Pink Brazilian A.M. transmitter, on the plywood "breadboard" I'm using. Starting top left, you see the 4 way screw terminals for power input; centre top is the RF choke, made from a 50 watt power resistor. I stripped off the resistance wire by finding the ends - they were wrapped around the lugs you see sticking out, pointing "South". The vitreous covering green paint-on ceramic just flaked away, leaving me a perfect ceramic cylinder, with terminal lugs already fixed at each end and a mounting steel bolt (which secured the right angle bent tin legs on the resistor) now used as a vertical support and gives the extra bonus of a thin steel core to my RFC, increasing the inductance a tad.

Top right is my matching coil: the Pink Brazilian uses an "L" network to match the anode impedance to 50 ohms. You can see my tap selector mechanism, since amateur A.M. operation is on spot frequencies, I don't need a fully variable matching coil, simple taps will be fine. The coil is wound with 14 SWG enamelled copper wire on a 75mm / 3" diameter piece of PVC - I did the microwave oven test (bung it in the microwave with a glass of water, blast on full power for a minute and see if the PVC gets warm) to see if it would absorb any RF, it didn't, so it got used.

Left hand side centre is the diecast box for the cathode modulator. Good screening is an absolute "must" - it's a quality box, with deep flanges, and will have a heatsink bolted to the top so the power mosfet (mounted inside) can be cooled properly.



It's important to ensure the mosfet mounting bolt is earthed to the diecast box: otherwise this would be a path for stray RF to enter the modulator AF section. I had considered a suppressor grid modulator, but since the 6146 is a tetrode, it doesn't have a suppressor grid! The cathode modulator works just fine with any triode, tetrode or pentode, so it's a flexible and simple choice.

More or less dead centre is the 6146, in an Octal relay socket, mounted over a piece of FR4 copper-clad board which will have components mounted Manhattan style on super-glued pads. I've set the relay socket 1/2" / 13mm above the copper clad board, to allow wires, components and such to be easily fitted beneath. You'll notice the 6146 has a commercial VHF parasitic stopper on the anode cap. This came with the valves (salvaged from a 500W "fish-phone" trawler Tx), and it saves me making one. The 6146 is a powerful beast and can run a full 50 Watts output / 30W anode dissipation (and a fair bit more if you push it) at 175MHz. This is one serious bit of Hollow State technology! I'll be running on 80m / 60m / 40m A.M. slots, so the 6146 won't be suffering transit time effects (and have plenty of gain) running well under it's limit frequency.

To the right is the bottom of the anode tuning coil: the croc clip tap selector is perfectly adequate - and I want to check how the beast runs with shorted turns (as in the photo) as opposed to open circuit turns (if the blue twisted pair go straight to the anode connector). Tim Walford prefers open circuit turns, though I've seen many circuits running just fine with shorted turns. The difference is this: with open circuit turns, you've a potential Tesla Coil - those open turns induce some hefty voltages at the open end. With shorted turns, you put a damped element on the inductor, but the damping is very small - it depends on the coupling co-efficient of the coil turns. Above 200kHz or so it seems to make little difference, but on industrial eddy current RF heater units (used to fire "getters" inside vacuum devices) running at 10 - 80kHz, the Tesla Coil effect is terrific - if the shorted turns become open ended, i.e. if the wire breaks with vibration from the cooling fans or pumps - then you get some fearsome blue flashes from a few inches to a foot long!

Lower left is the VXCO frequency adjust capacitor. It's way too big for the job! I'm going to change it for a 10 - 70pF variable I have. The crystals I have are all 30pF parallel calibrated; so with circuit strays I guess I'll only need less than half what I've available in the 10 - 70pF variable. A.M. operation is very simple in being on specific spot frequencies: saves the need for precision wide range VFO's / DDS / VXCO's.

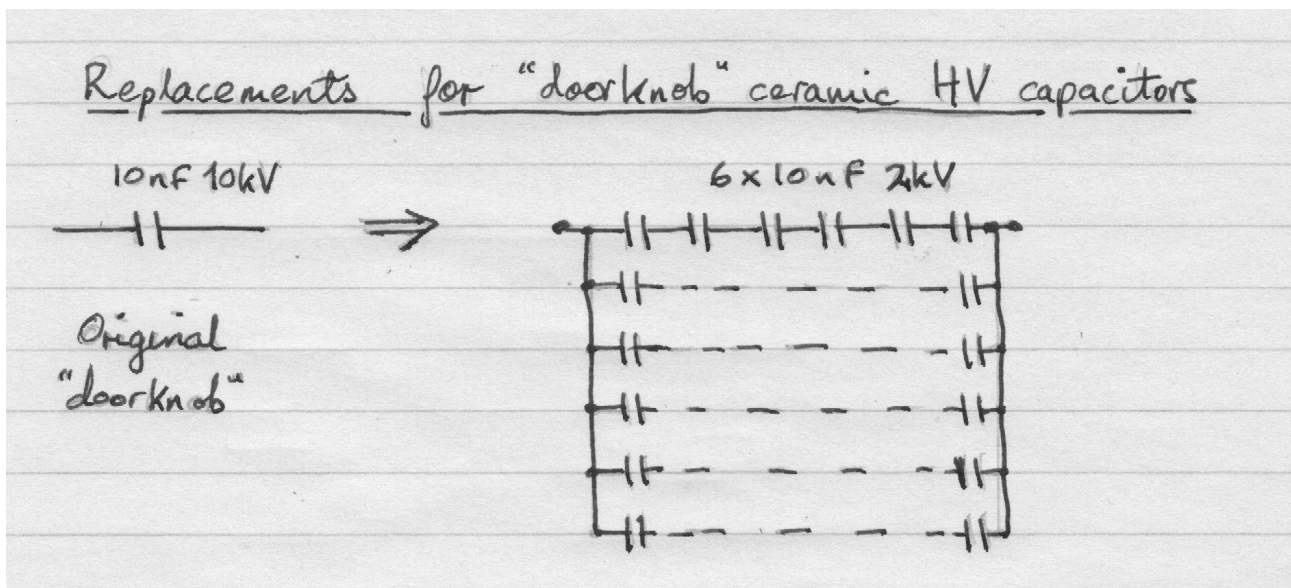
In the lower centre is the FR4 copper clad board for the VXCO. It will be "stitched" to the 6146 FR4 board with a zig-zag 18SWG wire, bent like a concertina, laid across the butt joint, then soldered to each side right across. Simple and easy, that makes a substantial earth plane; I'll probably fit an M5 brass bolt somewhere on one of the FR4 boards as the "star" earth point, but I haven't decided just where yet. I like to get stuck into building each module up and then see where the shortest run to a star point is - and that's where the bolt goes. The VXCO will be a twin triode Butler VXCO, running on the fundamental. The reasoning for this is modern crystals are but babes in arms compared to the paving slabs inside the old FT style crystals, and do not like more than the lightest sniff of RF up 'em! The Butler puts the crystal under very low voltage and current stress as it's a two stage amplifier oscillator, so doesn't wallop the crystal as a Pierce or Colpitts would. The noval valve holder will be mounted with some 25mm long 3mm diameter screws and spacers, to elevate the valve holder allowing components and wires (if necessary) to run beneath, as per the 6146.

Bottom right is a whacking big three section variable capacitor, that needs a full refurbish and clean. I don't know how old this is, or what total capacitance; but I do know that it withstood a 4kV flash test for 1 hour after a quick blow clean with compressed air at a "local friendly electronics manufacturing company" (ahemm). This old girl will be fine in the role, as I'll be fitting a double section anode coupling capacitor which gives "double indemnity" in stopping of anode DC supply reaching the tuning capacitor or the antenna.

I'll be using an in-line 50 ohm 5 pole Butterworth low pass filter in the antenna co-ax line to clean up the output further; I might alter the output matching to a "Pi" network if the harmonic suppression isn't adequate as I suspect my antenna, being very short on 80m, might need the extra capabilities a Pi network gives. We'll just have to see!

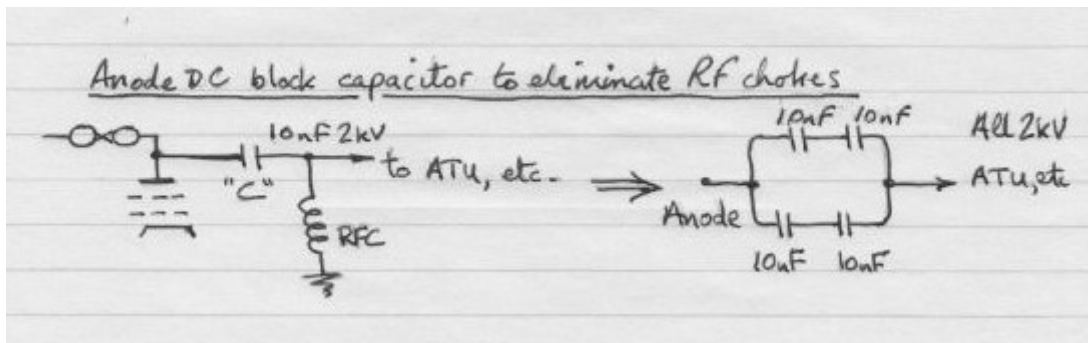
### ***HV "door knob" output capacitor substitutes***

The large ceramic high RF power "door knob" capacitors are not commonly found nowadays on the used market or from manufacturers at prices to suit amateur budgets; but a useful substitute can be made from 2kV rated 10nF ceramic disc capacitors, available for very reasonable prices and of very small size. But... that's the snag, the size indicates that these little beasties won't take the oomph from a hefty transmitter for very long. The answer is to assemble an array of these capacitors, following the "series / parallel" method, which is two capacitors in series to get 4kV rating, but of only 5nF; add an identical pair in parallel and you're back to 10nF. This divides the RF power between four capacitors so each capacitor has a much less stressful life. It's a good idea to always add an extra margin... but to add more capacitors, you need more assemblies like this, again arranged capacitors in series with an identical series capacitors in parallel - this gets you good kV rating, at 10nF, and the RF power is divided equally between many capacitors. Now you're talking! Make sure air flow can get to each capacitor: space 'em out and mount 'em securely!



An added advantage of these series / parallel arrays is that if one capacitor weakens, sags at the knees and gives up the ghost, the remaining capacitors in the array keep running safely, feeding RF until you can repair the damage - which will be obvious! Note too that if used for DC blocking from an anode, to prevent the DC HT appearing on the antenna, series / parallel arrays more or less

obviate the need for “safety” earthing chokes as the DC anode supply is safely blocked by the other capacitors: at least two capacitors must fail. Not unknown, but very, very, rare - and you’ll certainly not be left in any doubt when a capacitor goes down, and can make repairs as and when safely.



## Power Supplies

### Safety & EMO systems

The safety of amateur constructed equipment is just as important as any other application: it’s got to be safe, especially high voltage power supplies, or high current supplies. The HV aspect is (I hope!) obvious: it is a blatant danger, but the high current supply is a serious contender. Modern rechargeable batteries pack a lot of amps into a very small package - witness the small “booster boxes” now available to jump start cars, able to deliver 350 - 400 Amps for 60 seconds, certainly enough to throw a cold engine over sufficiently briskly to start it. Whilst this is only 12 volts, the “ampacity” is enough, if accidentally shorted by, for instance, a wedding ring on a finger, will burn through flesh and bone in no short order. I learned the danger of high current power supplies in an electroplating shop: the DC bus bars, accidentally shorted by a dropped spanner (no, not by me!), blew one end clean off the spanner, and the other end spun skyward in the magnetic force generated by the kilo-amps current.

In industry, special relays have to be used for “emergency OFF” circuits: a simple latching relay circuit - where a relay coil is energised by it’s own normally open contacts, temporarily bridged by a “start” push button, is not accepted as safe. The reason is that if the “start” button is jammed in (for whatever reason or circumstance) then the power is applied. A momentary “start” must be a *pulse* so it cannot be applied more than a moment. The other problem with a latching relay circuit is “contact welding”. The spring blade that carries the moving contact is designed to slightly “wipe” the moving contact over the static contact to break through any oxide or other contaminant on the contact faces: thus we have metal-to-metal with current flowing through it. Over time, electro-migration carries atoms of one contact onto the other, hence the pitting of one contact, and spiking of the other. These can easily lock the two contacts together, so releasing the coil volts doesn’t open the circuit. A similar effect can be seen is the load current is very “spiky” - of low average value, but very high peak currents (when powering up a transformer feeding a large reservoir capacitor, for example). Or - the ultimate disaster - a short circuit load, inappropriately fused, so the full supply ampacity flows through the contacts. The contact resistance, combined with the high amps flowing, yields  $i^2R$  watts, enough to weld the contacts together.

The answer for the amateur “shack” is a clearly labelled and accessible AC mains power switch right next to the door / entrance / access, that mechanically forces open the main power contacts -

DON'T RELY ON SPRING OPERATED SWITCHES OR RELAYS. You should include appropriate fuses or circuit breakers to protect the supply cables as well as the load fed by the switch / fuses; if in doubt as to what rating, cable sizes, installation requirements, consult a qualified electrician for your local area. An auxiliary "Consumer Unit", with isolator switch with combined earth leakage trip module and individual circuit breakers for each load; you could have individual benches, or outlets, fed separately so you can be absolutely certain you can isolate mains power to that section. You *can* use latching relay "start / stop" circuits on AC supplies, with emergency OFF buttons (EMO's) placed around the shack that can be reached from any operating or test bench. These should be tested regularly, usually every time the shack power is turned on, to avoid the relay contacts spiking and pitting over a long period. Industrial equipments commonly use "Pilz" relays for safety circuits: these employ mechanically forced return contacts, pulse start and lock-out facilities. For amateur service these are overkill; they also cost a great deal of money, but they are worth studying to see how it's done to the latest safety requirements.

ALWAYS turn the shack power OFF when you leave or finish your radio session. For obvious reasons, the shack lighting should NOT be fed by the shack "power" switch - the last thing you want in an emergency OFF situation is the lights blacking out the moment you push an EMO!

Keep in mind too that AC power drops to zero at every half cycle; switches and relays can open far easier on AC than DC for this reason. DC power controls must be considerably heftier than AC types (as Mr. "DC" Edison found out in competition with Mr. "AC" Westinghouse many years ago). Don't hesitate to rate DC controls very conservatively: observe the manufacturer's rating for contacts, AC vs. DC ampacities, and then add plenty extra.

This doesn't address the accidental contact with high value, high voltage electrolytic capacitors. These beasts can deliver hundreds, nay, thousands of amps; and are commonly used in high current low voltage power supplies, now common for hefty solid state linear amplifiers. Keep in mind the basic safety rules: NO rings or metal jewellery, NO metal tools anywhere near whilst energised / charged; take special care with 'scope probes having an earthed collar close to the probe needle tip. I've seen the probe tip blown clean off by an accidental touch on a DC power bus, running  $47,000\mu\text{F} \times 10$  at 450 volts (no, not me; but I saw the flash from some yards away). The major injuries were the flash temporarily blinding the operator, and reflex action to pull back with untold possibilities for injury. In this case it was a deep gash below the elbow from a metal cabinet corner that bled profusely.

The voltage levels to be considered as "safe to touch" in my day was 50v AC or 70.7v DC; you need to be aware of what your local electricity regulations dictate. As responsible amateurs, if you have any equipment that has open (or touchable by a small finger...?) it must be protected, covered by appropriate barriers, covers, insulation - and ALL unaware people kept strictly well away.

Whilst power RF won't enter the body on an accidental contact - it is a "skin effect" current - where the RF then flashes over to earth from the body, it will cause very deep and painful burns that go septic very readily. The "no touch" rule also applies to open wire feeders and the like, where high RF voltages, even from a 12v supply transmitter, can exist, so make sure they are set well out of reach or otherwise protected.

## **USA vs. European Mains transformers**

This question has cropped up occasionally for as long as I can remember: “can a USA manufactured 60Hz transformer be used on European 50Hz mains electricity”? Since the supply of HV valve style transformers in UK / Europe has dried up completely, it’s a good question to ask if the more commonly available (but at what scandalous shipping costs!) USA transformers could be used.

If it’s anything to do with transformers or power chokes, I ask the UK guru on such topics: Martin Boardman, of Boardman Transformers, Ulverston, Cumbria.

He gave me the following advice:

*“There are a couple of issues that would concern me, both around the core magnetisation.*

*In my experience, American Transformer Companies tend to run their Transformers quite hard, both in terms of core magnetisation and current density in the conductor. You rightly point out that the UK voltage is likely to be somewhat higher than 220V, pushing the iron circuit harder. The second and probably more significant factor is the 50Hz here as opposed to 60Hz in the USA.*

*If it has been designed with only 60Hz in mind, then it won’t be so happy running at 50Hz in the UK, particularly in view of my previous comment about companies pushing the core hard anyway.*

*Running a 50Hz Transformer on 60Hz is fine, but running a 60Hz Transformer on 50Hz is not so good, 20% higher in flux density. It may or may not push it into saturation but it will certainly run a lot hotter. Perhaps you could ask your USA radio man if it is marked 50/60Hz, or just 60Hz.*

*Best Regards,  
Martin Boardman”*

## **Test Equipment**

### ***Pock-Pock\* RF test oscillator***

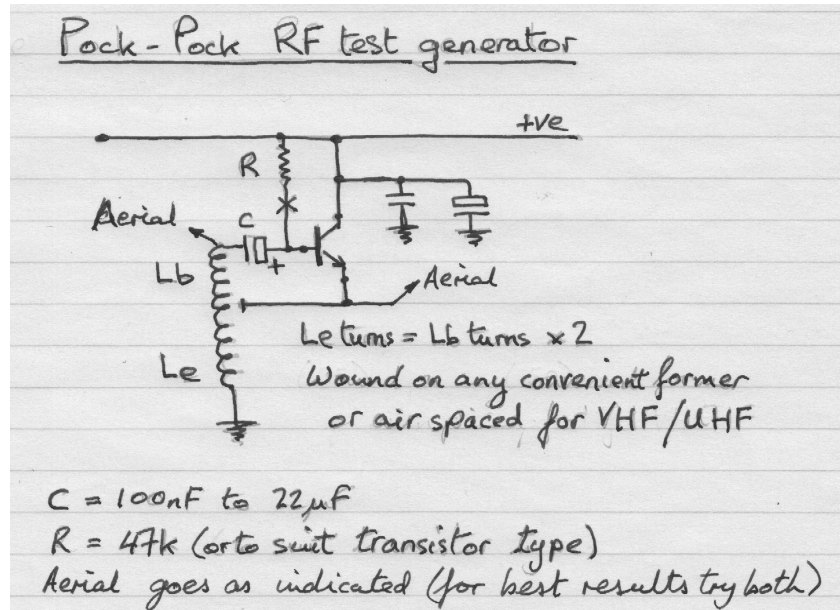
The Pock-Pock is a strange, unruly beast from the deep dark corners of the RF jungle: it has a remote cousin in the super-regen receiver, in that it is deliberately designed to be a “squegging” oscillator. But there the similarity ends: the Pock-Pock runs on many frequencies all at once, rather than being tuned with an LC resonator. “Why on Earth would anybody want such a beast?” is a fair question; but consider this: you’ve just set up your new microphone and want to see if it is adequately screened, earthed, and RF-proof: you can either chance it, or get the Pock-Pock out and hold it close to your mic and cable all the way to the Transmitter mic socket whilst listening on a local receiver for the very distinct “Pock-Pock” note in the transmitter’s output. Any sign of “Pock-Pock” tone means the mic or mic cable is allowing RF to penetrate.

This broadband squegging oscillator is very useful for testing anywhere you want RF proof screening or similar: shielding, IF cans, audio amplifiers / pre-amplifiers, active headphones.... well, just about anything you don’t want RF to sneak into. You can make the coil as small as you need to get into tight corners, but of course a 6 turn coil will run very different frequencies than a 60 turn coil!

Holding a Pock-Pock close to an Rx antenna input will show how your receiver copes with off-frequency signals of significant power; a good test for mixers too as the Pock-Pock creates many frequencies, which some mixers (single ended unbalanced, for instance) do **not** like it up 'em!

You are invited to send in any Pock-Pock tests you find useful: you will get a special mention!

\* *Because this is the noise it makes in a receiver!*



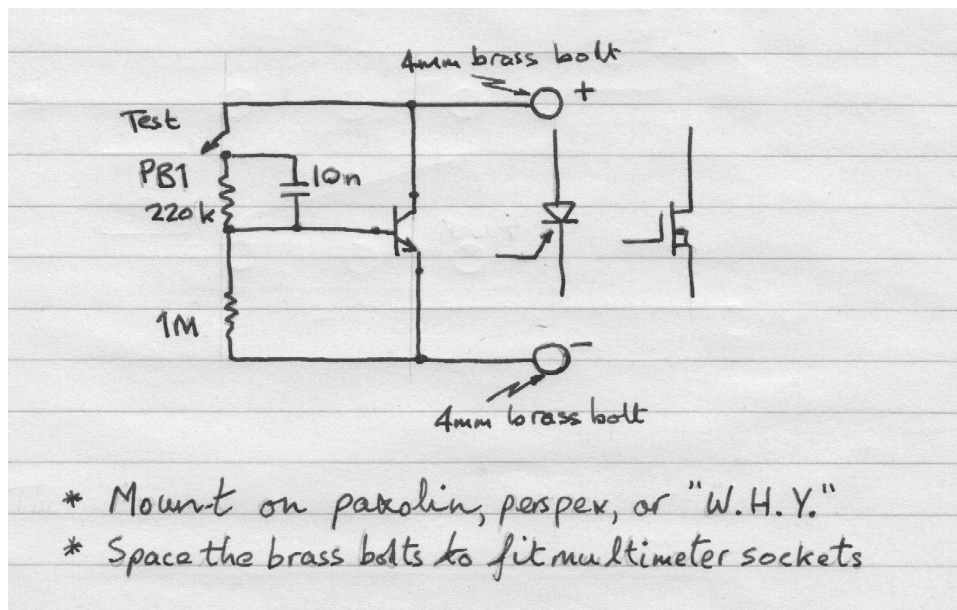
### **Transistor tester**

Most (“cheap”) multimeters have an “ohms” test facility that can be switched between “diode” test and “ohms” - the difference being that “diode” uses a voltage sufficient to turn on a silicon junction, whereas the “ohms” range tests with less than (usually) 0.5 volts or so. Normally, “diode” test reads out the forward volt drop of the diode on test, whereas the ohms test computes the volt drop and applied current to give ohms readout. If your multimeter has a “diode” test setting that uses more than a volt or two, but no transistor test feature, then this might be just the job for you.

Fit into some insulating board (no copper FR4 material?) two 4mm brass bolts long enough to connect into your multimeter 4mm input jack sockets and add the components shown in the diagram; turning the multimeter to “diode” then applies a voltage to power the device. Fit a transistor, mosfet, scr, whatever, and note the meter reading: it should be “over-range”, “O/C” or something similar if the device on test doesn’t leak, collector to emitter / drain to source / anode to cathode. Push the test button: the reading should drop to the expected collector - emitter “on” voltage, typical for a bipolar transistor < 0.2v; for a mosfet, a very low reading; an SCR will show about 1.2 volts or so as it’s a four layer device (2 P-N junctions). Thus you now know several values: the off state leakage current; the on state volt drop and the device functionality.

Not bad for three components, a couple of brass bolts and a switch?





### **Finding SMT short circuit IC's**

Got a pcb with a short circuit somewhere on it? Want to know which IC has gone down? Years ago using DTL / TTL logic, you'd soon find the dud package by looking for the cracked open IC package, or smoke coming from the plastic burning - but modern low current LSI chips just don't suck the amps (or the PSU limits and shuts down) that show the offending chip. How do you find the dud? Dead easy. Get some methylated spirits (or pcb cleaning solvent) and a paint brush - power up until the fault kicks in, and quickly "paint" all the IC's with methylated spirits.

The "bad" chip sucking the amps will evaporate the methylated spirit faster than the cooler "good" chips. You *could* use your finger tip... but leave a fair bit of skin behind and possibly blow static sensitive chips. Job done, and far cheaper than a "FLIR" heat camera! Oh, and observe strict "no smoking" whilst vapourising inflammable solvents!

### **"Volt Sticks" for Ham use**

The volt sticks (non-contact voltage detectors) now commonly available are the LED version of an old and trusted friend, the neon bulb, and can be used in somewhat similar circumstances. Take note however, that they are only a relative indication: the lack of LED illumination might NOT mean a conductor is safe to touch as some volt sticks only illuminate on AC power; DC high voltages might not energise the volt stick's jfet. Generally speaking, the cheaper models from our favourite on-line auction house respond to almost anything, including rubbing the sensing tip on a shirt sleeve, generating some static charge - but don't rely on that if you're testing for live cables or terminals, check it on a known voltage to establish the capability of the beast before attacking under battle conditions.

But, all said, a volt stick does make a dinky CW monitor, when set close to an RF hot spot - the flashing LED following every press of the key. If you have no easily accessible RF hot spot, run the volt stick tip along the antenna co-ax and (with luck) you will find a point on the cable or connector(s) where there is a sniff of RF, enough to energise the volt stick. Wrapping stiff copper wire round the tip to make an "antenna" can make some volt sticks far more sensitive to RF. Once the best place is located, a few cable ties, blu-tack, or adhesive PVC tape (of harmonious colour, please) and the visual CW / transmission monitor is complete.

# Construction Notes

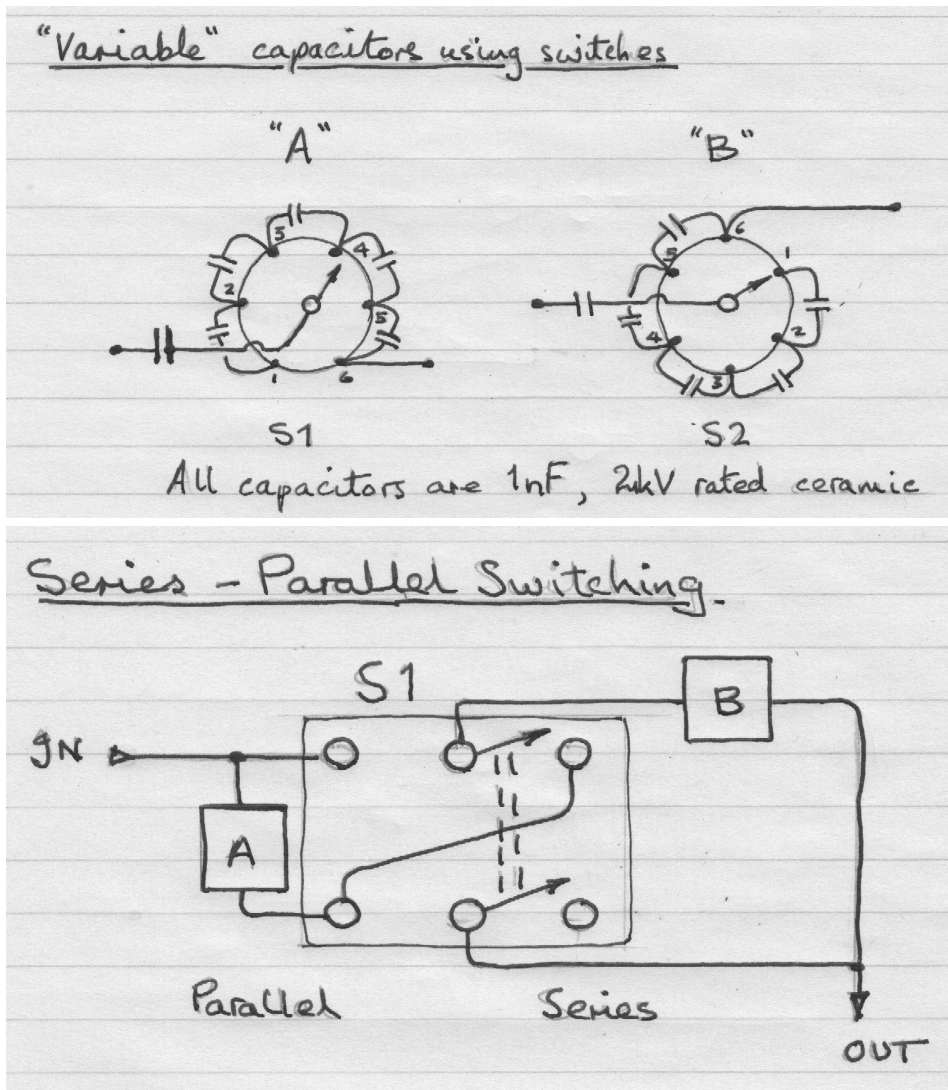
## Elevated pcb bus rails

When using “Manhattan” or similar stick-down pad construction techniques, a simple trick that really helps keep construction neat and tidy, both mechanically and electrically, is elevating the power bus rail(s) above the earth plane copper to space the supply bus rail up about 6mm. Offcuts of perspex, FR4 etc. are ideal for this job. In the space below you can run wires, components, and the like, and solder 100nF disc ceramics / electrolytics at intervals along the bus; achieving more “distributed” decoupling. What’s not to like?

## Antennas

### Variable High Voltage Capacitors - using switches

It’s possible to use fixed capacitors as the “loading” element in a Pi Coupler ATU; the adjustment is nowhere near as critical as the input “Tune” capacitor. A useful replacement for the increasingly rare high voltage variable capacitor is a couple of rotary switches, and a change-over switch to effect a “series” or “parallel” connection - I saw this many years ago and have used it many times since in many different situations. Strongly recommended!



I have 12 way switches to hand (from our favourite on-line auction source), so the range of capacitances available augmented by series / parallel switching should cover just about every eventuality for me.

You'll notice a series capacitor feeds the wiper contact . This prevents a direct DC path through the system: no DC short circuits! For other jobs, you can rearrange the capacitors to be a direct through path, should you need a "zero" capacitance setting.

### ***Getting feeder wires through a brick wall***

The usual practice when running cable in and out of buildings is to use a long masonry bit to drill from the inside, of a diameter a mm or two bigger diameter than the protective pipe that you should always use (don't you?). Once the drill is through to outside, remove the power tool, and push the drill bit back into the room with the protective pipe. That stops any bits of broken brick or rubble falling and blocking the hole. So far, so good.... but what about modern, airtight houses, with super cavity insulation, and vertical DPC membranes in twin leaf brick walls?

A good idea is to use plastic conduit to line the hole, and smear silicone sealer around the outer diameter as you push the drill bit back inside. If you bore the hole in the masonry a good few mm's bigger than the conduit diameter, enough sealer is carried into the cavity to seal on the membrane and insulation. To avoid problems later, make sure the protective pipe is longer than the wall thickness. Then you can repeat the "sealer smearing" on the inside piece of pipe, and push it partially back out again, repeating the push operation inside and out until the sealer is well and truly spread right through the hole, thus making sure both leaves of the wall are sealed up tight. Push the protective pipe reasonably close up to the inside wall - you only have to trim off the outside excess length, thus not damaging the decorative finish on the inside of the house.

One note of caution: if you use a *metal* protective pipe, for instance copper water pipe - be aware that most Electricity Regulations insist that "all extraneous conductors be bonded to Earth", and you'll need to bond the metal pipe section to a solid mains earth point.

### ***Notes from W9SCH, K7NS and VK5YE about "random" wire antennas***

Chas. Rockey, W9SCH, Nyle Steiner, K7NS, and Peter Parker, VK3YE have all described on their web pages a simple fact that many amateurs forget, or just plain don't know: there is nothing, *nothing*, magical about a piece of wire a quarter of a wavelength long for a transmitting antenna - it just makes a direct connection to 50 ohm co-ax (sometimes!) possible. ANY length of wire, if matched to the transmitter output impedance, then brought to resonance, will radiate. In simplistic terms, if you can get the RF volts and amps in phase, in as large an amount you can, in the longest wire elevated in the open as best you can, you'll radiate a good strong signal.

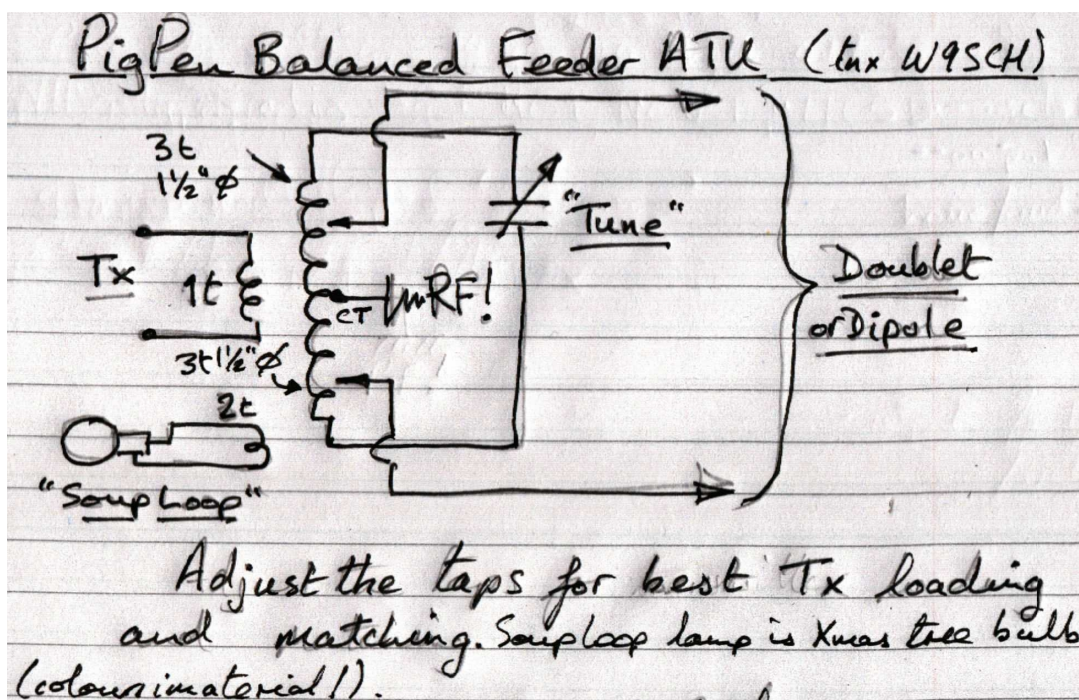
It is a common misconception that a dipole is good Dx radiator. A dipole has significant upward radiation if it's less than ONE wavelength above ground: for Dx you want low angle radiation. Imagine a 30m band dipole in your yard: it's roughly 15 metres / 49'2½" long - and it needs to be HIGHER than that too! You're in for some serious tower engineering on bands 10MHz and down if you want the ultimate Dx dipole.

Why bother on the lower bands, you'll radiate a signal that's only a dB or two down from a full dipole from a length of wire you've got high, wide and handsome, with a vertical run down to your

matching unit as an “inverted L” antenna - with as much of a counterpoise / ground as you can fit around your flower beds, fences, and yard walls? Feed the beast with a decent antenna tuner - and none finer than Chas. Rockey’s “Pig Pen” Tuner (below), and it will get good results.

The Pig Pen works quite simply by transformer feeding the transmitter signal into a parallel resonant circuit; the antenna wires having capacitance and inductance add to the ATU coil and capacitor and the whole shebang is brought into resonance. A coil for an “inverted L” on the low bands (10MHz and under) will need more turns - feel free to adapt the design, it’s based on a unit first used in 1914, so has proved itself over some considerable time! For a single wire radiator, you only need the top half of the coil shown: simply connect the coil and tuning capacitor in parallel, earth the frame of the capacitor and bottom of the coil - connect the “inverted L” to the coil “hot” end (or tap down), the counterpoise to the RF earth point, then tune to resonance as indicated by the “soup lamp”, held near the coil temporarily, glowing brightly whilst running a few watts of carrier. Move the lamp away for operation at full power. One valuable feature is the coupling loop that feeds the transmitter power into the tuning coil: this keeps RF off the outer of the co-ax from the transmitter to the ATU.

For a Doublet, fed by open wire feeders, use the centre tapped coil as shown, and MAKE SURE you have a long insulated control shaft on your variable capacitor, or use the “wafer switch capacitor” shown previously in this edition, which has fully insulated control shafts.



## Conundrum Corner...

### Transmission lines

Transmission lines are a conundrum: they are merely bits of wire, but oh boy, do they do some weird things! Take a look at <https://www3.nd.edu/~wzech/CoaxialTransmissionLine.pdf> and have a browse! Keep in mind, whilst reading, this is insulated copper wire, inside a screen: or a pair of wires spaced apart (open feeder). What could possibly be complicated about that? Hah!

You may recall that short lengths of co-ax can be used as high voltage capacitors for tuning antennas, etc., and so they can. They actually do the job, in the real World, with real amps and volts. Now recall the link above which showed shunt capacitors and series inductances modelling a co-ax line, exactly as you would expect - that's how they work as antenna tuning capacitors, surely?

Here's the crunch: whilst the model of shunt capacitors with series inductors is what we imagine is happening, and co-ax HV tuning "capacitors" *prove* this, surely? Don't they? I mean these things work in real life, don't they? Well, yes they do: but this is a classic example of Nature kicking sand in the engineer's eyes! Because, my dear Moriarty, those capacitors are not individual pieces; nor are the inductors, No, Sir. They are that mathematician's nightmare, an infinite series of components, all inside a few short cm's of wire!

How so? Let's consider the capacitance element. A capacitor is an electric field set up between two "plates", is it not? And a transmission line has zillions of these little capacitors every metre, yes? Each little capacitor forms a transmission line (recall that a metal conductor near another conductor = transmission line); and since a capacitor is a transmission line, each of these tiny capacitors is really a micro transmission line - that is made up of zillions of nano capacitors, all of which are a nano transmission line... and... and.... "little fleas have lesser fleas upon their backs to bite 'em"!

The whole thing becomes a Carrollian White Rabbit disappearing down the rabbit hole: a never ending sequence of diminishing, but real and functional, capacitors, inductors (the logic runs true for the series elements too) and was studied by Oliver Heaviside in the 1880's. A useful reference is [https://en.wikipedia.org/wiki/Telegrapher%27s\\_equations](https://en.wikipedia.org/wiki/Telegrapher%27s_equations)

Heaviside was a mathematical genius who derived the Laplace transform - the analysis of infinitely fast voltage steps, ramps, sine and other repetitive waveforms applied to complex circuits and in later years, control theory and partial differential equations. The Maxwell equations are distinctly similar; and Telegrapher's Equations (coupled linear partial differential equations) pop up in Quantum Field Theory and Relativity amongst many other of the apparently "simple" things observed in Nature.

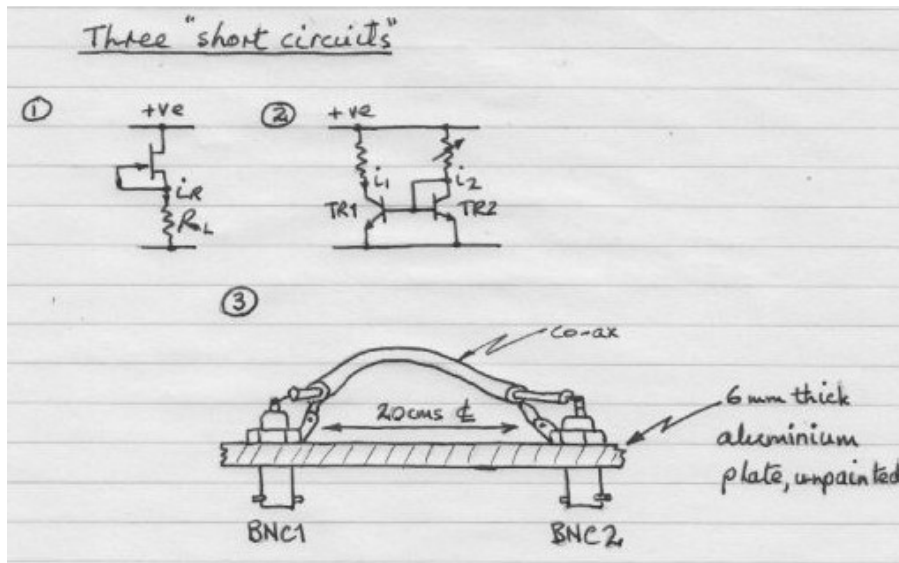
To handle "infinities" in maths as used by electrical engineers requires some fairly hefty sleight of hand maths: the idea being to cancel them out or otherwise "get rid" of them. Infinities caused profound trouble when Quantum Physicist Richard Feynman was forced to use similar maths tricks to shift infinities in his calculations using "normalising" procedures. Just to compound the frustration, just how many *different* infinities are there? Georg Cantor - see [https://en.wikipedia.org/wiki/Georg\\_Cantor](https://en.wikipedia.org/wiki/Georg_Cantor) - discovered there are an *infinity* of infinities! All of them with different characteristics(?!).

Suffice to say: if it's good enough for Mr. Feynman, it will do very nicely for my home-made (twisted pair) feeder at G6NGR! All this from a bit of copper wire alongside / inside another bit of copper wire. That's because the copper wire doesn't carry the energy: it guides the energy through the insulating space between each conductor. Energy is a transverse electromagnetic field running between two waveguides - even at DC. And, as radio amateurs, we know the magic is delivered by electromagnetic fields every time we turn on our transmitters.

Or, I wonder, is the original model of shunt capacitors and series inductors as a transmission line is just plain wrong....? Is the model needing a thorough re-engineering to find a more rational and simpler electrical theory description?

## Three short circuits

A challenge for our readers, with a special mention for the best responses (frivolous or otherwise) in Hot Iron # 105! Let's hear your answers! Just what are the "short circuits" in the following drawing for? How do they work, and why?



## Data and Information

**This information is for guidance only – you MUST comply with your local Safety Regulations. I have included information about AC power systems and conventions, as equipment can often be sourced from overseas nowadays and it's important that we know exactly how to connect it to our "home" supplies - but suffice to say, if there's any doubt - - - GET PROFESSIONAL, COMPETENT HELP BEFORE YOU CONNECT TO ANY ELECTRICAL SUPPLY!**

## Wire Information...

AWG Table

1 AWG is 289.3 thousandths of an inch  
2 AWG is 257.6 thousandths of an inch  
5 AWG is 181.9 thousandths of an inch  
10 AWG is 101.9 thousandths of an inch  
20 AWG is 32.0 thousandths of an inch  
30 AWG is 10.0 thousandths of an inch  
40 AWG is 3.1 thousandths of an inch

The table in ARRL handbook warns that the figures are approximate and may vary dependent on the manufacturing tolerances. If you don't have a chart handy, you don't really need a formula.

There's several handy tricks:

Solid wire diameters increases/decreases by a factor of 2 every 6 gauges,

" " " " 3 every 10 gauges,

" " " " 4 every 12 gauges,

" " " " 5 every 14 gauges,

" " " " 10 every 20 gauges,

" " " " 100 every 40 gauges,

With these, you can get around a lot of different AWGs and they cross check against one another. Start with solid 50 AWG having a 1 mil diameter.

So, 30 AWG should have a diameter of ~ 10 mils.

|                                              |                  |
|----------------------------------------------|------------------|
| 36 AWG should have a diameter of ~ 5 mils.   | Dead on.         |
| 24 AWG should have a diameter of ~ 20 mils.  | Actually ~ 20.1  |
| 16 AWG should have a diameter of ~ 50 mils.  | Actually ~ 50.8  |
| 10 AWG should have a diameter of ~ 100 mils. | Actually ~ 101.9 |

If you are more interested in current carrying ability than physical size, then also remember that a change of 3 AWG numbers equals a doubling or halving of the circular mils (the cross sectional area). Thus, if 10 AWG is safe for 30 amps, then 13 AWG (hard to find) is ok for 15 amps and 16 AWG is good for 7.5 amps.

The wire gauge is a logarithmic scale base on the cross sectional area of the wire. Each 3-gauge step in size corresponds to a doubling or halving of the cross sectional area. For example, going from 20 gauge to 17 gauge doubles the cross sectional area (which, by the way, halves the DC resistance).

So, one simple result of this is that if you take two strands the same gauge, it's the equivalent of a single wire that's 3 gauges lower. So two 20 gauge strands is equivalent to 1 17 gauge.

### Wire Gauge Resistance per foot

|    |         |
|----|---------|
| 4  | .000292 |
| 6  | .000465 |
| 8  | .000739 |
| 10 | .00118  |
| 12 | .00187  |
| 14 | .00297  |
| 16 | .00473  |
| 18 | .00751  |
| 20 | .0119   |
| 22 | .0190   |
| 24 | .0302   |
| 26 | .0480   |
| 28 | .0764   |

### Current ratings

Most current ratings for wires (except magnet wires) are based on permissible voltage drop, not temperature rise. For example, 0.5 mm<sup>2</sup> wire is rated at 3A in some applications but will carry over 8 A in free air without overheating. You will find tables of permitted maximum current in national electrical codes, but these are based on voltage drop. Here is a current and AWG table.

| AWG | dia<br>mils | circ<br>mils | open<br>air Amp | cable<br>Amp | ft/lb<br>bare | ohms/1000' |
|-----|-------------|--------------|-----------------|--------------|---------------|------------|
| 10  | 101.9       | 10380        | 55              | 33           | 31.82         | 1.018      |
| 12  | 80.8        | 6530         | 41              | 23           | 50.59         | 1.619      |
| 14  | 64.1        | 4107         | 32              | 17           | 80.44         | 2.575      |

Mils are .001". "open air A" is a continuous rating for a single conductor with insulation in open air. "cable amp" is for in multiple conductor cables. Disregard the amperage ratings for household use.

To calculate voltage drop, plug in the values:

$$V = DIR/1000$$

Where I is the amperage, R is from the ohms/1000' column above, and D is the total distance the current travels (don't forget to add the length of the neutral and live together - i.e.: usually double the cable length). Design rules call for a maximum voltage drop of 6% (7V on 120V circuit).

Note: it's 5% max, volt drop in UK / Europe.

### Resistivities at room temp:

| Element   | Electrical resistivity (micro-ohm-cm) |
|-----------|---------------------------------------|
| Aluminium | 2.655                                 |
| Copper    | 1.678                                 |
| Gold      | 2.24                                  |
| Silver    | 1.586                                 |
| Platinum  | 10.5                                  |

This clearly puts silver as the number one conductor and gold has higher resistance than silver or copper. It's desirable in connectors because it does not oxidise so remains clean at the surface. It also has the capability to adhere to itself (touch pure gold to pure gold and it sticks) which makes for very reliable connections.

### Thermal conductivity at room temperature

|          | W/cm <sup>2</sup> /°C |
|----------|-----------------------|
| silver   | 4.08                  |
| copper   | 3.94                  |
| gold     | 2.96                  |
| platinum | 0.69                  |
| diamond  | 0.24                  |
| bismuth  | 0.084                 |
| iodine   | 43.5E-4               |

This explains why diamonds are being used for high power substrates now. That's man-made diamonds. Natural diamonds contain sufficient flaws in the lattice that the phonons (heat conductors) get scattered and substantially reduce the ability to transport the heat.

### Copper wire resistance table

| AWG | Feet/Ohm | Ohms/100ft | Ampacity | mm <sup>2</sup> | Meters/Ohm | Ohms/100M |
|-----|----------|------------|----------|-----------------|------------|-----------|
| 10  | 490.2    | .204       | 30       | 2.588           | 149.5      | .669      |
| 12  | 308.7    | .324       | 20       | 2.053           | 94.1       | 1.06      |
| 14  | 193.8    | .516       | 15       | 1.628           | 59.1       | 1.69      |
| 16  | 122.3    | .818       | 10       | 1.291           | 37.3       | 2.68      |
| 18  | 76.8     | 1.30       | 5        | 1.024           | 23.4       | 4.27      |
| 20  | 48.1     | 2.08       | 3.3      | 0.812           | 14.7       | 6.82      |
| 22  | 30.3     | 3.30       | 2.1      | 0.644           | 9.24       | 10.8      |
| 24  | 19.1     | 5.24       | 1.3      | 0.511           | 5.82       | 17.2      |
| 26  | 12.0     | 8.32       | 0.8      | 0.405           | 3.66       | 27.3      |
| 28  | 7.55     | 13.2       | 0.5      | 0.321           | 2.30       | 43.4      |

These Ohms / Distance figures are for a round trip circuit. Specifications are for copper wire at 77 degrees Fahrenheit or 25 degrees Celsius.



## Wire current handling capacity values

| mm <sup>2</sup> | R/m-ohm/m | I/A |
|-----------------|-----------|-----|
| 6               | 3.0       | 55  |
| 10              | 1.8       | 76  |
| 16              | 1.1       | 105 |
| 25              | 0.73      | 140 |
| 35              | 0.52      | 173 |
| 50              | 0.38      | 205 |
| 70              | 0.27      | 265 |

## Mains wiring current ratings

In mains wiring there are two considerations, voltage drop and heat build up. The smaller the wire is, the higher the resistance is. When the resistance is higher, the wire heats up more, and there is more voltage drop in the wiring. The former is why you need higher-temperature insulation and/or bigger wires for use in conduit; the latter is why you should use larger wire for long runs. Neither effect is very significant over very short distances. There are some very specific exceptions, where use of smaller wire is allowed. The obvious one is the line cord on most lamps. Don't try this unless you're certain that your use fits one of those exceptions; you can never go wrong by using larger wire. This is a table apparently from BS6500, reproduced in the IEE Wiring Regs which describes the maximum fuse sizes for different conductor sizes:

| Cross-section       | Overload current |
|---------------------|------------------|
| CSA / area          | rating           |
| 0.5mm <sup>2</sup>  | 3A               |
| 0.75mm <sup>2</sup> | 6A               |
| 1mm <sup>2</sup>    | 10A              |
| 1.25mm <sup>2</sup> | 13A              |
| 1.5mm <sup>2</sup>  | 16A              |

## Typical current ratings for mains wiring

### Inside wall

| mm <sup>2</sup> | Amps |
|-----------------|------|
| 1.5             | 10   |
| 2.5             | 16   |

### Equipment wires

| mm <sup>2</sup> | A  |
|-----------------|----|
| 0.5             | 3  |
| 0.75            | 6  |
| 1.0             | 10 |
| 1.5             | 16 |
| 2.5             | 25 |

## Wire sizes used in USA inside wall

For a 20 amp circuit, use 12 gauge wire. For a 15 amp circuit, you can use 14 gauge wire (in most locales). For a long run, though, you should use the next larger size wire, to avoid voltage drops. Here's a quick table for normal situations. Go up a size for more than 100 foot runs, when the cable is in conduit, or ganged with other wires in a place where they can't dissipate heat easily:

| Gauge | Amps |
|-------|------|
| 14    | 15   |
| 12    | 20   |
| 10    | 30   |
| 8     | 40   |
| 6     | 65   |

## PCB track widths

For a 10 degree C temp rise, minimum track widths are:

| Current | width in inches |
|---------|-----------------|
| 0.5A    | 0.008"          |
| 0.75A   | 0.012"          |
| 1.25A   | 0.020"          |
| 2.5A    | 0.050"          |
| 4.0A    | 0.100"          |
| 7.0A    | 0.200"          |
| 10.0A   | 0.325"          |

## Equipment wires in Europe

3 core equipment mains cable

| Current                        | 3A     | 6A     | 10A    | 13A    | 16A    |
|--------------------------------|--------|--------|--------|--------|--------|
| Conductor size (mm)            | 16*0.2 | 24*0.2 | 32*0.2 | 40*0.2 | 48*0.2 |
| Copper area (mm <sup>2</sup> ) | 0.5    | 0.75   | 1.0    | 1.25   | 1.5    |

Cable ratings for 3A, 6A and 13A are based on BS6500 1995 specifications and are for stranded thick PVC insulated cables.

Insulated hook-up wire in circuits (DEF61-12)

| Max. current                      | 1.4A  | 3A     | 6A     |
|-----------------------------------|-------|--------|--------|
| Max. working voltage (V)          | 1000  | 1000   | 1000   |
| PVC sheat thickness (mm)          | 0.3   | 0.3    | 0.45   |
| Conductor size (mm)               | 7*0.2 | 16*0.2 | 24*0.2 |
| Conductor area (mm <sup>2</sup> ) | 0.22  | 0.5    | 0.75   |
| Overall diameter (mm)             | 1.2   | 1.6    | 2.05   |

## Common Cable colour Codes

American electrical contractors and electricians are required to follow the National Electrical Code (“NEC”) with regard to wiring colours. NEC imposes the following electrical wiring colour standards:

- Ground wires:** green, green with a yellow stripe, or bare copper

•**Neutral wires:** white or grey

In theory, wiring conducting live current in the U.S. is permitted to be any other colour, although in practice, electrical contractors and electricians follow these local conventions:

•**Single phase live wires:** black (or red for a second “hot” wire)

•**3-phase live wires:** black, red and blue for 208 VAC; brown, yellow, purple for 480 VAC

Most countries in Europe, including the U.K., now follow the colour conventions established by the International Electrotechnical Commission (“IEC”). These colour conventions are as follows:

•**Earth wires** (called ground wires in the U.S. and Canada): green with a yellow stripe

•**Neutral wires:** blue

•**Single phase live wires:** brown

•**3-phase live wires:** brown, black and grey

Electrical wiring in Canada is governed by the Canadian Electric Code (“CEC”). The following wiring colour requirements apply in Canada:

•**Ground wires:** green, or green with a yellow stripe

•**Neutral wires:** white

•**Single phase live wires:** black (or red for a second live wire)

•**3-phase live wires:** red, black and blue

It’s important to remember that the above colour information applies only to AC circuits. You are strongly advised to stick to convention as regards DC power wiring:

**RED = POSITIVE; BLACK = NEGATIVES**

## **A.M. Frequency slots in Amateur HF Bands**

All Frequencies in MHz

160 Metres: 1.885, 1.900, 1.945, 1.985 (USA)

1.850 (W. Europe)

1.933, 1.963 (UK)

1.843 (Australia)

80 Metres: 3.530, 3650 (South America)

3615, 3625 (in the UK)

3705 (W. Europe)

3.690 (AM Calling Frequency, Australia)

75 Metres: 3.825, 3.870 (West Coast), 3.880, 3.885 (USA)

60 Metres : 5.317

40 Metres: 7.070 (Southern Europe)

7.120, 7.300 (South America)

7.175, 7.290, 7.295 (USA)

7.143, 7.159 (UK)

7.146 (AM Calling, Australia)

20 Metres: 14.286

17 Metres: 18.150

15 Metres: 21.285, 21.425

10 Metres: 29.000-29.200

6 Metres: 50.4 (generally), 50.250 Northern CO

2 Metres: 144.4 (Northwest)

144.425 (Massachusetts)

144.28 (NYC-Long Island)

144.45 (California)

144.265 (Los Angeles, CA)

### ***Other AM Activity Frequencies***

AM activity is increasingly found on a number of other bands, in particular: 5317KHz, 7143KHz, 14286KHz, 21425KHz and 29000 - 29150KHz.

There are several local AM nets in the UK on top band.

### ***FM Frequencies***

For mobiles working into VMARS events, 2m calling in on 145.500MHz (S20) is usual, before moving to a working frequency. At event locations where military equipment is in use, suggested FM "Centres of Activity" on VHF are 51.700Mhz, 70.425MHz (70.450MHz calling).

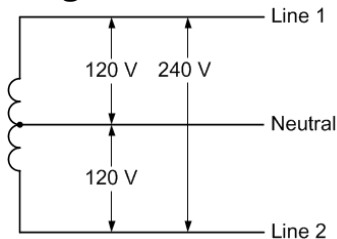
### ***VMARS RECOMMENDED FREQUENCIES***

|            |                                                          |
|------------|----------------------------------------------------------|
| 3615 Khz   | Saturday AM net 08:30 – 10:30                            |
| 3615 Khz   | Wednesday USB net for military equipment 20:00 – 21:00   |
| 3615 Khz   | Friday LSB net 19:30 – 20:30                             |
| 3615 Khz   | Regular informal net from around 07:30 - 08:30           |
| 3577 Khz   | Regular Sunday CW net 09:00                              |
| 5317 Khz   | Regular AM QSO's, usually late afternoon                 |
| 7073 Khz   | Wednesday LSB 13:30; Collins 618T special interest group |
| 7143 Khz   | VMARS AM operating frequency                             |
| 51.700 MHz | VMARS FM operating frequency, also rallies and events    |
| 70.425 MHz | VMARS FM operating frequency, also rallies and events    |

## Electrical Supplies - Courtesy LEGRAND equipment

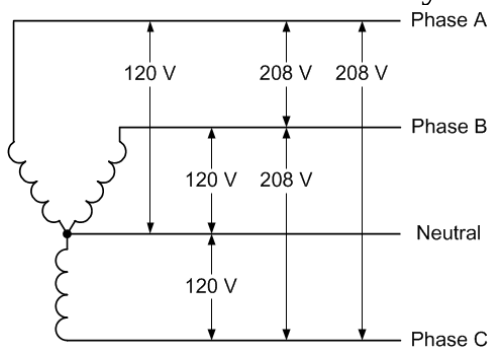
In the following drawings, the coil symbols represent the secondary winding of a utility service transformer or other step down transformer. Electrical code regulations in most jurisdictions require that the neutral conductor be bonded (connected) to the earth safety ground at the electrical service entrance. Note: regional variations may exist: if in ANY doubt, consult your Electrical Supply Authority.

### Single Phase Three Wire



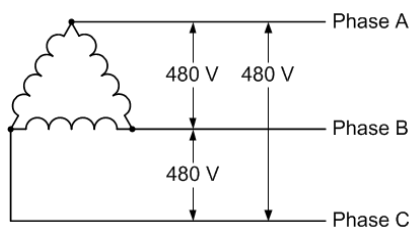
Also known as an Edison system, split-phase or centre-tapped neutral. This is the most common residential service in North America. Line 1 to neutral and Line 2 to neutral are used to power 120 volt lighting and plug loads. Line 1 to Line 2 is used to power 240 volt single phase loads such as a water heater, electric range, or air conditioner.

### Three Phase Four Wire Wye



The most common commercial building electric service in North America is 120/208 volt wye, which is used to power 120 volt plug loads, lighting, and smaller HVAC systems. In larger facilities the voltage is 277/480 volt and used to power single phase 277 volt lighting and larger HVAC loads. In western Canada 347/600V is common.

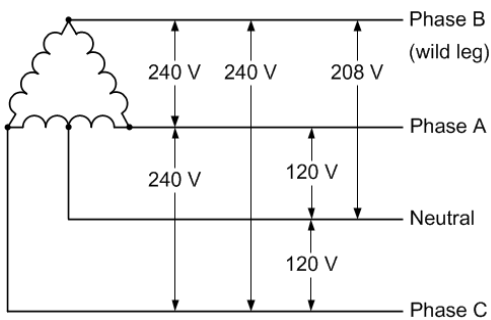
### Three Phase Three Wire Delta



Used primarily in industrial facilities to provide power for three-phase motor loads, and in utility power distribution applications. Nominal service voltages of 240, 400, 480, 600, and higher are typical.

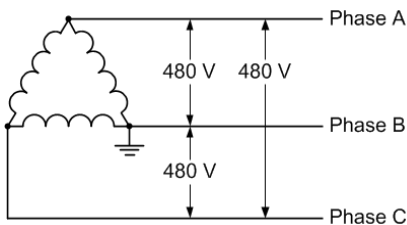
# Uncommon Electrical Services

## Three Phase Four Wire Delta



Also known as a high-leg or wild-leg delta system. Used in older manufacturing facilities with mostly three-phase motor loads and some 120 volt single-phase lighting and plug loads. Similar to the Three Phase Three Wire Delta discussed above but with a centre-tap on one of the transformer winding to create neutral for 120 volt single-phase loads. Motors are connected to phase A, B, and C, while single-phase loads are connected to either phase A or C and to neutral. Phase B, the high or wild leg, is not used as the voltage to neutral is 208 volt.

## Three Phase Two Wire Corner-Grounded Delta



Used to reduce wiring costs by using a service cable with only two insulated conductors rather than the three insulated conductors used in a convention three phase service entrance.

## International Electrical Distribution Systems

| Description                                        | L-N Vac  | L-L Vac | Countries           |
|----------------------------------------------------|----------|---------|---------------------|
| 1-Phase, 2-Wire 120 V with neutral                 | 120      | –       | US                  |
| 1-Phase, 2-Wire 230 V with neutral                 | 230      | –       | EU, UK, Scandinavia |
| 1-Phase, 2-Wire 208 V (No neutral)                 | –        | 208     | US                  |
| 1-Phase, 2-Wire 240 V (No neutral)                 | –        | 240     | US                  |
| 1-Phase, 3-Wire 120/240 V                          | 120      | 240     | US                  |
| 3-Phase, 3-Wire 208 V Delta (No neutral)           | –        | 208     | US                  |
| 3-Phase, 3-Wire 230 V Delta (No neutral)           | –        | 230     | Norway              |
| 3-Phase, 3-Wire 400 V Delta (No neutral)           | –        | 400     | EU, UK, Scandinavia |
| 3-Phase, 3-Wire 480 V Delta (No neutral)           | –        | 480     | US                  |
| 3-Phase, 3-Wire 600 V Delta (No neutral)           | –        | 600     | US, Canada          |
| 3-Phase, 4-Wire 208Y/120 V                         | 120      | 208     | US                  |
| 3-Phase, 4-Wire 400Y/230 V                         | 230      | 400     | EU, UK, Scandinavia |
| 3-Phase, 4-Wire 415Y/240 V                         | 240      | 415     | Australia           |
| 3-Phase, 4-Wire 480Y/277 V                         | 277      | 480     | US                  |
| 3-Phase, 4-Wire 600Y/347 V                         | 347      | 600     | US, Canada          |
| 3-Phase <u>4-Wire Delta</u> 120/208/240 Wild Phase | 120, 208 | 240     | US                  |
| 3-Phase <u>4-Wire Delta</u> 240/415/480 Wild Phase | 240, 415 | 480     | US                  |
| 3-Phase <u>Corner-Grounded Delta</u> 208/240       | –        | 240     | US                  |
| 3-Phase <u>Corner-Grounded Delta</u> 415/480       | –        | 480     | US                  |