

# HOT IRON issue 110

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## CQ-CQ-CQ

From Lachlan...

*Hi! Thank you, an excellent read! Could I ask if you have any suggestions on "combining" two articles...soldering stainless steel and 75 ohm co-ax. I use RG-6 a lot, a nice cheap relatively low loss co-ax., 75 ohm, no problem, but it would be nice to be able to solder the multi outside braids. I have soldered normal Al quite well, using some clean engine oil, carefully scraping the oxide layer away under the oil, and using a large hot iron and rosin core solder. Years ago I replaced one of the relays in my first car, a soft top Morris Minor, with a stud diode on a piece of Al, and soldered to the aluminium... but that method does not seem suitable for the thin braid/foil on co-ax. Any suggestions? Thank you again for adding me, and taking the time to reply. You are a true gentleman! Cheers Lach VK3ALM*

OK, Lachlan: no worries, check these references out:

<https://www.harrisproductsgroup.com/en/Products/Alloys/Soldering/Fluxes/Stay-Clean-Aluminum-Flux.aspx>

<https://soldersandfluxes.co.uk/p586/Aluflux-Aluminium-Flux.html>

*This product has is listed as good for soldering co-ax aluminium foil...*

[https://www.amazon.com/Uniweld-P4KD9S-Aluminum-Solder-Applicator/dp/B010UMSB9Y/ref=sr\\_1\\_2?dchild=1&keywords=Aluminum+Soldering+Flux&qid=1603457772&sr=8-2#descriptionAndDetails](https://www.amazon.com/Uniweld-P4KD9S-Aluminum-Solder-Applicator/dp/B010UMSB9Y/ref=sr_1_2?dchild=1&keywords=Aluminum+Soldering+Flux&qid=1603457772&sr=8-2#descriptionAndDetails)

## OFCOM and EMR proposed power limits

OFCOM are moving in their mysterious way with amateur radio - as well as marine radio users, PMR taxi operators and countless others who use RF in their everyday life: they are apparently worried about exposure to RF causing illness, presumably through RF heating, rather than ionising effects you'd see with X-Rays and the shorter wavelengths.

My father (rest his soul) warned me that the most frightening words a person at your door can say are: "I'm from the Government, and I've come to help you..." and he's been proved right time and time again.

The details are here: <https://www.ofcom.org.uk/consultations-and-statements/category-1/limiting-exposure-to-emf> . The penalties for disobeying this are 51 weeks imprisonment, unlimited fines (England & Wales); 6 months prison (Scotland) [*At the time of writing; but things could change.*]

As amateurs we have always been naturally careful about exposure to RF radiation; warnings issued in my apprentice days about not looking into waveguides for fear of damaging eyes, or approaching

too close to RF transmission lines to prevent RF arcs causing deep burns. The first inkling I recall about RF radiation being a health hazard was Pat Hawker's (G3VA) note many years ago about mobile phones running a watt or so of UHF right next to the operator's head and eyes; history has proved that mobile phones, or should I say the RF emanating from them - is more or less benign.

Well, to sum up, ALL UK amateurs of every license class will be required to work out the hazard potential, an OFCOM spreadsheet is available for this purpose.

My advice is "Keep Calm and Carry On". Once the paperwork and associated bumff is completed, as per OFCOM requirements, we can get on with amateur radio as we know it.

### **Oh Dear...**

For some reason, Andrew Woodfield's email address is corrupted in my files. If anybody knows Andrew please ask him to email me at [equieng@gmail.com](mailto:equieng@gmail.com) and I'll correct the problem.

## **Tim's Topics**

### **Transistors and the fakers**

Tim asked me recently about fake transistors, knowing I've been involved with semiconductor production most of my working life. The faking Fakirs manufacture transistors that are not as marked, using much inferior - but still functioning and the right polarity - dies packaged up as exotic and expensive devices. For the average amateur, a quick multimeter test will show a working device, but put into service, sorry chum, no can do!

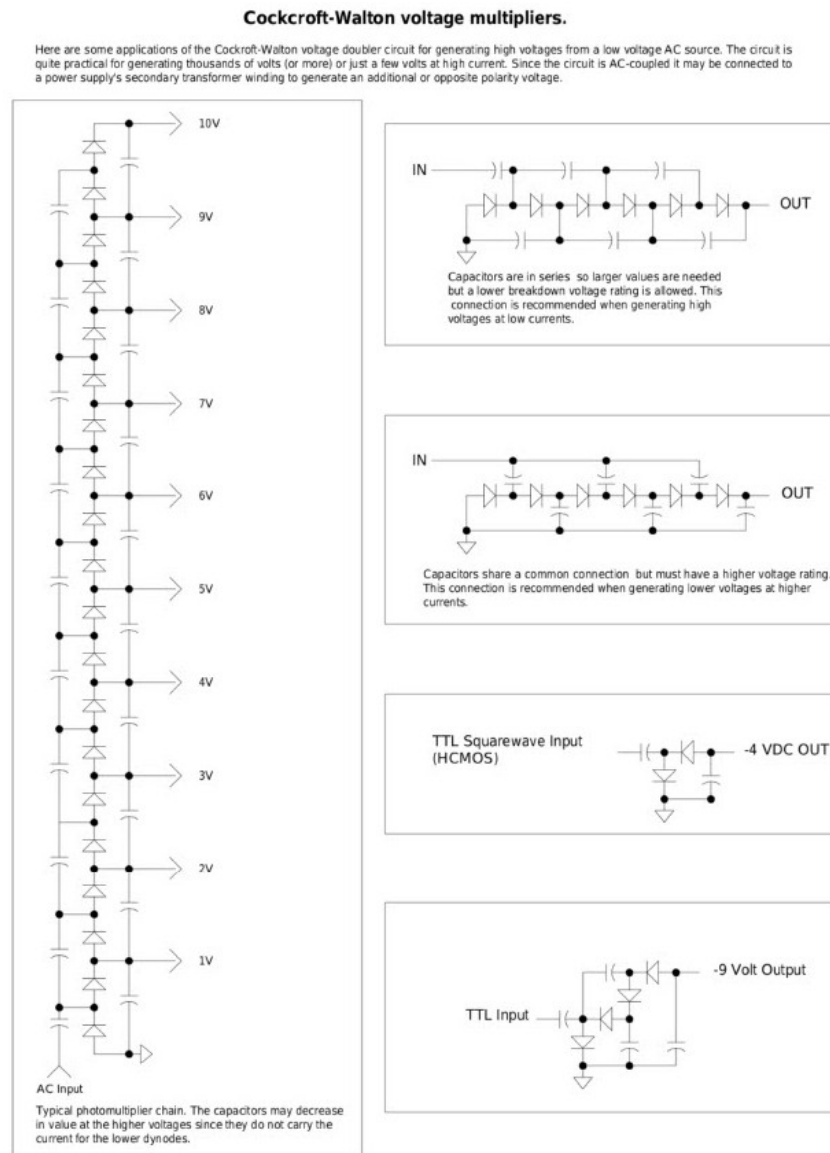
Testing discrete transistors as the genuine manufacturer does requires some hefty test gear; not the sort of thing that an amateur would have readily to hand. I'm thinking of capacitance bridges that can resolve fractions of a pF, electrometer leakage tests to Femto amps, signal generators for Ft test to GHz, that sort of thing. But - as amateurs, can we can cobble something together that will find the fakes?

The simplest approach I think is that fakes are (almost) always smaller, cheap dies, to maximise the faker's profit. Smaller dies = lower power dissipation capability, so a simple high dissipation circuit (i.e. regulator "wrap around" service) will find the fakes by over heating small dies to the maximum junction temperature, usually 150°C. This will work fine with bipolar transistors and power mosfets; though for mosfets you'll have to increase the sense resistor in a wrap around circuit to get enough gate bias. A positive regulator "wrap around" will dissipation test PNP's directly; a negative regulator will test NPN's.

Step up the device dissipation in easy stages; the die inside will heat up faster than the case - especially in fakes, where they rarely (if ever) fit the proper heat spreader pads under the die. The device will most likely go "phutt" at a far lower dissipation than the spec., when the die melts or the bond wires burn open.

Another give-away is the  $V_{ce0}$  /  $V_{ds}$  breakdown tolerance: the smaller, cheaper dies and the uncontrolled home-brew manufacturing process reduces the breakdown voltage, collector to emitter, drain to source. To test breakdown voltage you need a low current, high voltage power

supply: a half wave voltage quadrupler and a simple variable voltage control will do nicely. The available current from the HV power supply only needs to be a few  $\mu\text{A}$ ; more in this case is definitely not better, it's just volts you need for this job. The following image is from Chas. Wenzel's Tech Lib superb web pages, take your pick to suit your test voltage required. I often used the photomultiplier chain, shown delivering  $10\times V_{in}$ , when building leakage Test Gear for bipolar transistors, as you can use lower voltage capacitors in each stage..



IC's pose an altogether different problem; no simple "Kwik-Sorta" test will root out the rogues. Some good approaches can be found at: <https://www.allaboutcircuits.com/news/how-to-spot-counterfeit-electronic-components/>. This topic is *vast*; manufacturers spend large amounts of money devising sure fire test techniques to identify fraudulent copies of their chips.

One technique is to build in functional but redundant bits of circuitry, that go unnoticed in the reverse engineering Fakir's labs ripping off IC's, or an extra via (link from one layer to another in a multi-layer IC chip) that had no function but could be sensed if the right data words appear at

appropriate timing on the data, control and address lines. I used a simpler technique in some of my circuits - I would make a placement on the pcb for a 1N4148 diode, that had no function whatsoever as it would always be back biased (usually on the output of a gate or op-amp to a rail). The counterfeiters would slavishly copy the diode, thinking it must have a purpose - so if this diode was fitted in warranty claims we knew we had a counterfeit board. Gotcha!

Some references that might help you:

<https://www.eevblog.com/forum/beginners/fake-transistors/>

<https://www.eevblog.com/forum/repair/warning-fake-mj16012-transistors-on-ebay/>

OnSemi technical article about breakdown voltage, etc.

<https://www.onsemi.com/pub/Collateral/AN1628-D.PDF>

## Transmitter Topics

### Screening - why it works

Transmitters have to have screened compartments, to keep “near” electromagnetic fields from affecting the more sensitive parts - like oscillators, VFO’s, Synthesizers, DDS’s and PLL’s.

Screening - how does a screen work? Well... the magnum opus is <https://w8ji.com/skindepth.htm> where skin effect is found to be the prime mover (or stopper, in this case).

Of course, here at G6NGR, our old friends still do valiant service: heavy kitchen scissors and steel (baked bean) cans make wonderful screening, custom built and soldered in at almost zero cost. Another approach, especially useful for valve / tube circuits is to use individual boxes (conduit “adaptable” boxes?) for each stage with the power wiring for the stages going to common star points to eliminate earth (and power!) loops. You also have the opportunity to improve a stage without losing your existing design - build the new stage up in it’s box and it’s a one-for-one swap out job.

### The Michigan MONSTER Mite?

From John Kirk, VK4TJ: *“Incidentally, If you'd like to experience the thrill of crystal cracking without the pain, switcher FET's show great promise. I cobbled together a 25 watt 1-FET transmitter around an MTP3055E and an HC-18/U colour burst crystal. The FET eventually expired of unnatural causes, but that little crystal is still singing up a storm.”*

I have always had a fascination for simple one transistor transmitters: arguably the best of the bunch is the Michigan Mighty Mite. I’ve amplitude modulated one and it was pure fun! Made a very good test signal source too, mounted inside a screening box driving an external lamp load, for receiver testing.

If you can blow up a switcher FET in such circuits, without cracking the crystal, your circuit’s a good ‘un, but as often as not that tiny sliver of quartz - especially in bipolar designs - will go pop.

So, adopt John's other plan: get a good few of them, connected in series / parallel, up the supply volts and blast away!

I must admit I've a mind to try a power mosfet Michigan MONSTER Mite on a valve HT supply (with bypassed resistor biasing in the source to set the DC drain current) as modern power mosfets are as near a solid state pentode as you'll get.

## Receiver Topics

### Direct Conversion

An excellent discussion about simple direct conversion receivers can be found here:

<https://www.raynetrepair.us/circuit-design/some-practical-design-approaches.html>

In which you'll find some wonderfully explained fundamentals about the structure of direct conversion receivers, and some useful notes about "diplexers" (sometimes known as "DC to Daylight" bandwidth circuits). I personally hanker after a 50 ohm resistor feeding a virtual earth amplifier input, but that's just me and my curmudgeon.

### A complete radio receiver on a chip

See: <https://www.silabs.com/audio-and-radio/multiband-radios> from Silicon Labs. I'm not going to describe much here about this little chip, having played with ZN414's all those years ago and one transistor super-regenerative broadcast VHF receivers, but I do appreciate how powerful the silicon digital designer's art has become. The sheer fact that all the signal processing can be done digitally, with ne'er an IF transformer in sight, I find nigh on miraculous.

It won't be long before a chip appears in a big square ceramic package with umpteen solder bumps below that is a complete top performing HF / VHF receiver - with a matching transmitter section needing only a power amplifier adding for a complete QRO transceiver. If such a chip can be done for \$100.00 apiece then I reckon the (radio) World will beat a path to the manufacturer's door!

### The Ultimate receiver

A book called "Surviving Technology" might seem somewhat incongruous in this "systems on silicon" era; but there is much the constructor can learn from Bruce Vaughan's (NR5Q) book of that title.

Whilst the bulk of the book contains tales from Bruce's experiences over the years, and how he learned to repair radio sets that had been struck by lightning (!!), he gives the diagrams for his "Ultimate Regen" design. Nothing spectacular; but, like most things in this life, "it's not what you do, it's the way that you do it". He describes a design - a word that syntactically embodies construction - that has evolved over more than 60 builds of the original circuit to include all the improvements that put his regen receiver in a class of it's own: one that can give superb results up to and including 15m operation - and for a simple but well built valve regen that's some going.

Superb results from a simple regen design indeed: most home built regens, because they haven't evolved over this number of iterations, can't hope to compete with commercial black boxes on

today's bands, but Bruce has stuck to his circuit over the years and the overall design has been developed so that every component's position, mounting and orientation has been tried, tested and adopted or discarded. The result is a sweet, capable and elegant design that is so simple and economical it's within the reach of even the most thrifty amateur (and that sums up G6NGR quite nicely).

For instance, the mounting of the detector valve in a shock absorbing sub-chassis gave a major improvement, the antenna coil coupling to the detector tuned circuit is a simple mechanical variometer that gives superb control of the input signal thus avoiding the regen's curse: overload blocking. A practical demonstration of mutual inductance.

Bruce followed the effective expedient of separating the audio output stages, where large signal volts and mechanical / acoustic vibration exist that wreaks havoc with sensitive detector stages, by fitting the 6V6 output pentode (for a fair 'switch hitter', try the more available B9a EL84) inside the PSU module and linking the sensitive RF chassis to the PSU / audio chassis with an umbilical cable. This keeps the "hefty" PSU and audio power section well away from the "sensitive" RF section.

Cost? A few \$\$'s for some screw terminals and a some PVC wire to run power and screened cable for the low level audio. If you really want to push the receiver's boat out, there is an easy option to slot in a "Select-O-Ject" circuit giving a receiver bandwidth of a few tens of Hz or to "notch out" nearby interfering signals.

Bruce's years in a radio shop showed him how manufacturers got superior performance with minimal - but ingenious - design, something all constructors should keep to mind; the technique of "Muntzing" is very applicable. "Radio construction can be divided into three parts: mechanical construction, circuit design and wiring, and the cosmetics of the finished radio" and in that order, too. Heavy and solid RF sections, vibration mounting of detector valves, sensible component placement with well thought out wiring harnesses all mounted in a properly finished straight, square, ergonomic layout that graces the quality of the design and build are just as important as the electronic wizardry within.

As Bruce comments: "*a well constructed regenerative receiver can receive almost any signal you can receive on your \$2,000 solid state rig*". And that's why I like building them!

Bruce's book, "Surviving Technology" is published by Farmhouse Books, and I strongly recommend you buy yourself a copy or borrow one from your local library. The circuit schematics, chassis layouts and coil details can be copied with pencil and paper in minutes, they are that simple; but the real knowledge that makes the "Ultimate" receiver are in Bruce's words.

### **A note from Harry Lythall, SM0VPO**

I asked that amazing gentleman, Harry Lythall, about using his "pipe" resonators as a basic regenerative receiver, the idea being to open up 23cms band for simple A.M. / C.W. using cheap and easily available parts. The transmitter could be a simple 48MHz crystal oscillator and a diode multiplier (a-la a 23cms test signal source) feeding the resonator for basic spectral purity - just



about acceptable if the power is under a  $\mu\text{W}$  or two - and feeding a decent home made Yagi this would give some interesting “pre-booked” contacts from a local high point.

Below is Harry’s reply:

*“Hello Peter,  
I have been thinking about your request "how about fitting a BF199 to your tin can resonator Rx for a regen... or dare I suggest a super-regen... for 23 cms?" and I have a suggestion.  
I created a simple resonator that has the same properties as a cavity. This I used to make an oscillator in the article: [http://sm0vpo.altervista.org/use/resonator\\_1.htm](http://sm0vpo.altervista.org/use/resonator_1.htm) .*

*It would not take much "fiddling" to build the oscillator inside a cavity, then reduce the supply voltage to the point of oscillation. The output loop can be connected to ground by a feedthrough capacitor so you can stuff some power into the oscillator. With this arrangement it should be possible to make a regenerative receiver, or a self-oscillating mixer/down-converter. The TDA7000 will make a good NBFM receiver by changing capacitors. AN193*

*(<http://www.electroscheme.ru/datasheet/TDA/TDA7000%20for%20narrowband%20fm-recieving.pdf>) has been written specifically for the TDA7000 and NBFM operation.*

*A little caveat would be the possibility of unwanted radiation from the input port.*

*Unfortunately I do not have the time to work on this, but this could be an idea for further experimenting?*

*Very best regards from Harry Lythall - SM0VPO”*

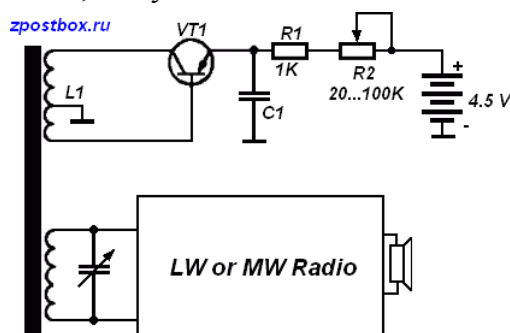
Unfortunately, neither do I have any time or construction opportunities, I’m moving house soon (hopefully....) so I pass it on to Hot Iron readers for experimentation. Please let me know if you build one!

### The simplest Q multiplier?

This is a design from Viktor Polyakov (if not Viktor, please let me know!) that shows how minimal a Q Multiplier can be; and how simply it can be added to a tuned circuit to peak up the “Q”.

What struck me was that the Q multiplier doesn’t have to be employed (as it usually is, in simple regenerative receivers) in the detector stage; it will work wonders in any of the signal path tuned circuits, from the pre-selector , RF amp input or RF amp output tank. All that’s needed is to link couple the Q Multiplier coil to the signal path tuned circuit - a single turn link at either end will probably suffice for 40m and above; below that you’ll probably need more turns at either end of the link, at a guess 3 turns for 60m, 5 turns for 80m and 10 turns for 160m.

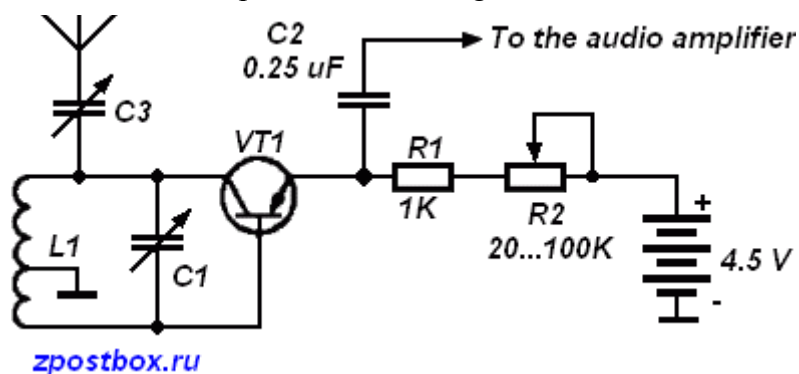
The tap on L1 is  $\sim 10\%$  up from the base connection, and you’ll need to cut and try the turns on L1 for coupling to an outboard tank. For Q multiplier service, remove C1. The audio appears across R1 (substitute your Hi-Z phones for R, or try a miniature audio transformer, 2k to 8 ohms.)



Viktor notes:

*“This regenerative circuit can increase the quality factor  $Q$  in any frequency range, from Long Waves (LW) to Very High Waves (VHF). It is not necessary for the coil  $L1$  to be a resonant tank - it can be used as a coupling coil [or try an old fashioned valve ‘coupling link’ or even close proximity to the antenna lead? Or a perhaps a toroid with the antenna wire running through it? Ed.], it will provide coupling with any other resonant tank (in this case remove the capacitor  $C1$  from the circuit). This coil can be wound on a ferrite rod of a magnetic loop antenna of any LW or MW radio, the number of turns needs to be only 10...20% of number of turns of the magnetic loop antenna. So we get a  $Q$ -multiplier for any LW or MW radio, this  $Q$ -multiplier circuit, based on a bipolar transistor is much simpler than any other  $Q$ -multiplier ... based on a FET transistor.”*

Viktor shows how the circuit adapts to become a regenerative receiver:



*“A regenerative receiver suitable for short wave reception, it takes an antenna, connected to the resonant tank  $L1C1$  through a coupling coil or through a capacitor with small value (less than 1 pF) [or toroid link coupling / antenna lead in close proximity? Ed.]. An audio signal can be taken from the emitter of the transistor  $VT1$  and applied to an audio amplifier using a capacitor of 0.1...0.5  $\mu\text{F}$ . Sensitivity of this regenerative receiver is high enough - for AM radio stations it is 10...30  $\mu\text{V}$  (adjust the feedback just below the point of oscillation), for SSB, CW radio stations some  $\mu\text{V}$  (adjust the feedback above the point of oscillation).”*

This is surely the dinkiest regenerative receiver! A 2N3906 with careful construction and supply decoupling this would make a neat “/ P” or “/ M” receiver?

## Audio Topics

### A simple question that's rarely answered

This item could well be part of Antenna Topics, as I've been investigating “active” antennas recently and the amplifier requirement for which are either of high input impedance for the “E” field, or low input impedance for “Mag” loops. J-fets or mosfets (both discrete and op-amp type) cope admirably with the high impedance side of the job; common base connection bipolar transistor amplifiers, including noise cancelling types, or “virtual earth” op-amps, deliver the low input impedance loop antenna amplifiers demand.

The question here is how to estimate the AC signal input impedance of an amplifier, be it common emitter or common base - and this is the connection with audio topics, as many amateur audio

amplifiers don't perform properly when the input impedance of a stage isn't taken properly into account.

Many web pages and text books I've seen over the years fudge this calculation; or gloss over it by implying the DC bias resistors form a parallel loading, and completely ignore the base - emitter shunt path the AC input signal takes for the stage to work. The concept is the dynamic base region resistance ("re"); this is the slope of the base emitter diode forward bias curve, and is an easy value to estimate if you have a few basic facts to hand.

If you imagine an AC signal (AF or RF) flowing into the base terminal lead and out the emitter lead, the internal base resistance ("re") boils down in practical terms to a simple approximation: it's  $\beta$  (the transistor's current gain at that particular collector current) multiplied by 26 then divided by the emitter current in mA's - this equals "re" in ohms. There is an argument that  $\beta \times 25$  is a more accurate estimate, but since  $\beta$  is given plus or minus a country mile, I'm not too fussed either way, and  $\beta$  is different for varying emitter currents anyway. The point is that you put this value of "re" in parallel with the base bias chain to get an idea of the loading the previous stage has to drive (common emitter connection) or in parallel with the emitter resistor (common base connection).

Thus estimating the actual AC input impedance allows us to build amplifiers with an input termination of 50 or 75 ohms - give or take - or really low impedances for loop antennas and similar jobs.

An excellent reference describing this far better than I can is at:

<https://www.electronics-tutorials.ws/amplifier/input-impedance-of-an-amplifier.html>

...which shows clearly and simply how these calculations can be done to get a circuit running to expected specifications.

## **Power Supply Topics**

### **Adaptable boxes for all?**

Conduit "adaptable boxes" are the power supply builder's friend: good weight steel, easy knock-outs that eliminate a lot of drilling (and take a B9a valve base nicely), galvanised or black finished, they are absolutely ideal for the job - and at a price which makes diecast box manufacturers weep. I've used hundreds of adaptable boxes over the years, with good result, the steel is a superb electromagnetic screen. They are commonly available at most electrical trade suppliers, DIY outlets and other similar suppliers.

A simple but very effective piece of advice came to my attention recently about low noise linear power supplies and earthing. It commented about where the earth stud should be placed for best performance - and considering how we as amateurs try to keep RF out of where it shouldn't be and maximise it where it should be, it was an interesting read. Now I know why those superb linear power supplies by our beloved manufacturers like HP, Advance, and the like, have those complicated earthing arrangements, internal screening and solidly clamped wiring looms!

No doubt you'll be aware of "skin effect" where RF currents travel on the outer skin of a conductor, and - by the magic of RF - stay there, even on a good conductor like copper. The proposal was that the station RF "earth" should be connected to a stud, connected electrically only to the **outer** of the power supply case, or a tag connecting on the outside by scraping the paint off and using a (power transistor) stepped insulating washer to stop the retaining bolt contacting the **inner** of the power supply case - see <https://www.youtube.com/watch?v=SvSP3kQQYMg>; from <https://www.pa0nhc.nl/cobra80/index.htm> .

The transformer inside the case should be similarly fixed; the core and winding screen should be earthed **only** to the mains earth OUTSIDE the metal box, **NOT** to the inner of the power supply, as a "screen" winding or capacitance primary to secondary will reverse couple noise from the mains earth. Similarly, the output terminals should be well isolated from the case. Fitting "delta" 0.1 $\mu$ F capacitors, plus to minus, plus to earth and minus to earth, usually a good idea, and should be done with similar due diligence: only earthing to the **outer** of the power supply case. Thus we keep our RF earth **inside** the enclosure clean and clear of all the noise and rubbish on the mains earth **outside** the power supply enclosure.

Your "shack" RF earth should be based on a hefty earth spike walloped deep into the ground near your antenna feed point, and connected to your shack RF earth buss with some hefty copper cable (16mm<sup>2</sup> welding cable from welding consumables is a good idea).

It's good practice for safety to have your local "sparky" test the earth loop impedance of the antenna ground spike to the incoming TNC-S / P.E.N. earth bar at your electricity meter (temporarily disconnect the spike from ANY gear in your shack). You should be able to achieve a loop impedance of a few ohms or less, but it does depend on your local ground conditions and moisture levels. It's not unknown for some "salty liquid" (ahemm...) to be applied to ground spikes to get a low impedance reading once it's soaked in a bit.

The earth spike is the cleanest earth you'll have; not perfect though as the mains distribution system does run earth currents back to the star point in your local supply sub-station, but usually far better than the mains earth in your house.

### **Transformers - take two...**

I recently made a comment about an "unknown" transformer, in this case a hefty 6.3v AC filament transformer that had an unknown or ambiguous reference number on it, on how to assess the current it could comfortably drive. In Hot Iron 109 I mentioned a rule of thumb, "20VA per lb., or 45 VA per kg"; this gets you close to the rating, however if this transformer is a valuable or rare item, then a more engineered approach might be preferred.

The clue is - as almost always in basic physics - to be found in *heat*. Discuss with any physicist "The Laws of Thermodynamics" and you'll soon see what makes this Universe behave as it does, and gain a glimpse of the inner working of Quantum mechanics!

If the unknown transformer is set to driving a dummy load, be it lamps, resistors, tanks of acidified or salty water, or whatever else you can dream up to absorb some watts, with a temperature sensing

element attached to the winding cover insulation (to get the quickest report of rising temperature) then you have all you need to find a reasonable estimate of working current. This is taken from:

<https://www.electrical4u.com/transformer-oil-and-winding-temperature-rise-test/>

and:

<https://www.ecmweb.com/content/article/20885885/the-basics-of-transformers-part-2>

which refer to windings withstanding a 55°C rise over ambient - which, from experience, is not an untypical figure. DC testing is another option on power transformer windings; you could probably adapt the scheme to smaller transformers, as per:

<https://www.hightest.co.uk/temperature-rise-heat-run-test/>

...the general idea being to run DC amps through a winding, and note the consequent temperature rise; but this of course identifies just the winding under test's heat contribution, not the whole gallimaufry. This might be just what you're looking for; I don't know. Who am I to say?

### **Transformers - take three...**

ON NO ACCOUNT USE WHAT FOLLOWS ON ANY VOLTAGE ABOVE 50 VOLTS AC. SERIOUSLY, DON'T DO IT! USE THIS FOR LOW VOLTAGE AC ONLY AND ALWAYS USE A "DULL LAMP" TO LIMIT THE CURRENT FROM THE MAINS WHEN TESTING HOME ADAPTED TRANSFORMERS.

Sometimes, it really helps if you know the "turns per volt" of the secondary winding of a transformer. Maybe you've a 4.5 volt transformer you'd like to use for the 6.3 volt heaters of a valve Rx, and don't know how to get those extra few volts... 4.5 volts just doesn't cut it for you.\*

(\*see the end of this article for more on this subject).

What can sometimes be done is squeeze some extra windings through the core apertures and connected in series with the existing secondary, to get your desired 6.3 volts. That's if you've guessed the "phasing" right: if you connect your added winding the wrong way round it will reduce the total volts out! Reversing your extra coil's connections resolves this. Known in the trade as "bucking" or "boosting" this is a good way to get the volts you want without the expense of a custom transformer.

The question is, though - how many turns will you need, to get that extra 1.8 volts from your under volt tranny? Well, here's a handy rule of thumb.

Most transformers cores are made of alternate "E" and "I" laminations, stacked together alternately with the winding bobbin on the middle limb of the "E"s and it's the magnetic flux induced in this centre limb that does the transforming magic (thank you, Mr. Faraday). You need to measure this centre limb. If you're stuck and can't measure the centre limb any which way, don't panic: the outer limbs are usually about 60% of the larger centre limb, so measure them to estimate the cross sectional area of the centre limb, even though you can't get at it.

Now the hard bit: calculate the cross sectional area of the centre limb IN SQUARE INCHES.

Suppose the centre limb is 3/4" by 7/8" then the cross sectional area (CSA) = 3/4" x 7/8" = 0.75" x 0.875" = 0.65625 square inches. OK, here's the whizz-bang moment: **divide 9 by the CSA in square inches: this estimates the turns per volt of the transformer.** In our case it's  $9/0.65625 = 13.7143$  turns / volt. We were 1.8 volts short at 4.5; so we need to add  $1.8v \times 13.7143 \text{ turns / v} = 24.6857$  turns. Make that 25 turns and I bet you'll be within spitting distance of 6.3 volts when your extra turns add to the existing 4.5 volt output. This will have professional transformer designers curling a lip; as it's not the most efficient or accurate method - it works near enough.

Adding a few turns is a doddle with toroidal transformers, but watch you don't draw too much extra juice and saturate the core. You'll soon know; the transformer will get stonking hot rather quickly!

OK, so you can't get any more turns through the core apertures? Another solution is possible. Have you a similar sized (equal or a touch bigger) burned out or otherwise scrap transformer to hand?

Strip off the existing windings, keeping the winding bobbin intact as best you can, and dismantle the "E" and "I" laminations. It's a sticky job, but reasonably easy provided the whole thing's not been drowned in varnish or pitch - but in dire emergencies, a hot oven will soften the varnish (but they don't half smoke at 120°C!) or a carefully applied blowtorch will do the job. Don't burn the winding bobbin, but, if times are really hard, and you can't resurrect the bobbin, or you can't strip the laminations, you can cover the core limbs with insulating tape and wind directly onto that, without a bobbin - but you'd have to be a masochist to do this as you'll need to load up a shuttle with wire and pass it through the core windows without kinking or damaging the enamel coating - never easy and very time consuming.

Work out for your extra transformer the turns per volt as above - we'll assume it's about 25 turns / volt. Calculate how many turns you need for a 6.3 volt winding by multiplying the turns / volt by 6.3 = 157 (rounded up to 160 for good measure). Work out how many turns represent 4.5 volts similarly:  $4.5 \times 25 \text{ turns / volt} = 112.5$ , round up to 115 for good measure.

Now with some enamelled copper wire of appropriate ampacity (use the wire tables in the Hot Iron Data section at [www.W4NPN.net](http://www.W4NPN.net)), solder a PVC insulated flying lead to the end of the copper wire which is to be the start of the winding, then wind on 115 turns and tap the winding by looping up a bit of the enamelled copper wire, twisting it with pliers, and tinning and soldering another flying lead. Then continue the winding (in the same direction as before!) until you've 160 turns on, and solder a lead to the end. Tape up the windings to secure them, and re-stack the core. You should have three wires: start, tap and finish. Write down the start, tap & finish wire colours!

You've just made an **autotransformer**. Connect 4.5 volts AC from your original transformer to the start and tap wires. Test the voltage when powered up (via a dull lamp!) between the "start" and "finish" wires: it should be 6.3 volts (or most likely a bit more) if all's well. You should have two wires connected to the "start" (one for the input 4.5 volts "cold" and one for the output 6.3 volts "cold") and one wire to the "tap" (4.5 volt drive) and one to the "finish" (6.3 "hot" volts output). Check it on load to your heater / filament and I'll bet it will be just fine. If needs be, if the voltage is

too high, you can strip off a turn or two or use a dropper resistor - whatever is easiest for you. Job done!

**SAFETY NOTE: always check that ALL windings are not shorting to the core or other windings before powering up. A 500 volt insulation tester is the minimum; a multimeter on “ohms” just isn’t adequate!**

\* Running a regenerative detector valve on low filament volts can turn a *temperamental* Rx into a silky smooth delight. The valve, running at rated heater / filament volts will have full  $\mu$  and Gm; running the heaters / filament a bit low can “soften” the gain and makes the regeneration control smoother and less sensitive. The onset of oscillation is sometimes accompanied by a hysteresis effect as the impedances around the circuit change with the loop gain approaching infinity; low heater / filament volts can help reduce this malady. No guarantees, mind, and don’t reduce the cathode heat too much; running cathodes too cold can poison them.

Another good way to drop heater volts is to insert a pair of inverse parallel connected silicon diodes in the 6.3 volt AC heater line to the detector valve, with a shunt switch to short them out if needs be. The 0.6 volt drop in each diode will soften the detector valve’s heaters only leaving full volts on the other valves in the circuit.

#### **An e-Mail from Alan Gale, G4TMV...**

*Hi Peter,*

*Since the EU in its wisdom decided that all small power supplies should be of the Switched Mode variety to protect the environment (I'm not sure how polluting the airwaves with them achieves that aim), it's now almost impossible to buy the smaller clean 'wallwart' types, which are something that was always very useful in shacks, so something like a design for some of them might be useful.*

*I've always referred to my very old Babani book called 'Power Supply Projects' by good old R.A. Penfold, that was always a good source of 3 and 4 terminal regulator designs, but something along the lines of a 'Build your own clean Wallwart' might be something that would be useful to a lot of people. Hams are often far too concerned with big PSUs like the 20 or 30 Amp types for use with their transmitters, but it's still easy to get those, it's the smaller ones that are more of a problem.*

No problem, Alan: here’s how you design power supplies that are cheap, functional and effective - using junk transformers too, that will save bits of electronics going to land fill. You can buy empty wall wart cases or build in a separate enclosure - it’s up to you. Ex-PC psu cases are useful too.

You have a choice between the “classic” approach and what I term the “modern”.

The classic approach is to find a suitable 50/60Hz transformer with sufficient volts and amps to run the regulation circuit - regulators need headroom volts for them to perform properly. For instance, if I were to be designing a 13.5v DC supply, I’d be looking for a transformer of at least 15 volts RMS secondary; but no more than 20 volts, as too high a secondary voltage can lead to dissipation problems in the regulator. Then I’d look at the amps I wanted: for general bench work, an amp or two is adequate.

The LM317 is ideal for this job, so the transformer I'd need is 15v rms x 2 amps = 30VA rated. If we wanted more amps from a bench supply, a PNP "wrap-around" (as previously discussed in Hot Iron) can be used to drive almost any current you want - limited only by your transformer, rectifier, power transistor(s) and heatsinks.

Below is a diagram showing in blocks a reliable LM317 regulator circuit used in a "classic" power supply. I've not indicated any particular devices or construction; the design is very tolerant and will work with almost anything, providing the components can withstand the volts and amps.

Note the "slump" diode (D1 below) around the LM317 for protection if the input voltage fails. D2 is another protection diode: it provides a discharge path for  $C_{adj}$  if the output is shorted, otherwise  $C_{adj}$  forces short circuit current through the "Adjust" pin, and, like so many solid state devices, "they don't like it up 'em"!

"Extralytic" very low ESR and high temperature electrolytics are useful in any power supply; look out for these specs when choosing your smoothing and decoupling capacitors in any power supply application.

The "Classic" LM 317 regulator circuit:

$R_1$  is typically 220R or 240R

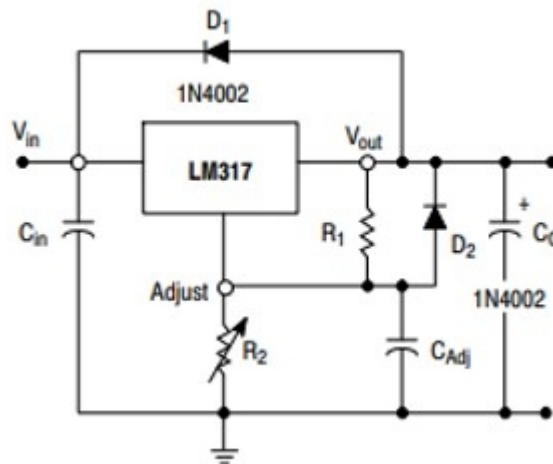
$R_2$  is typically 5k

$C_{adj}$  is 10 to 100  $\mu$ F, 25 vDC

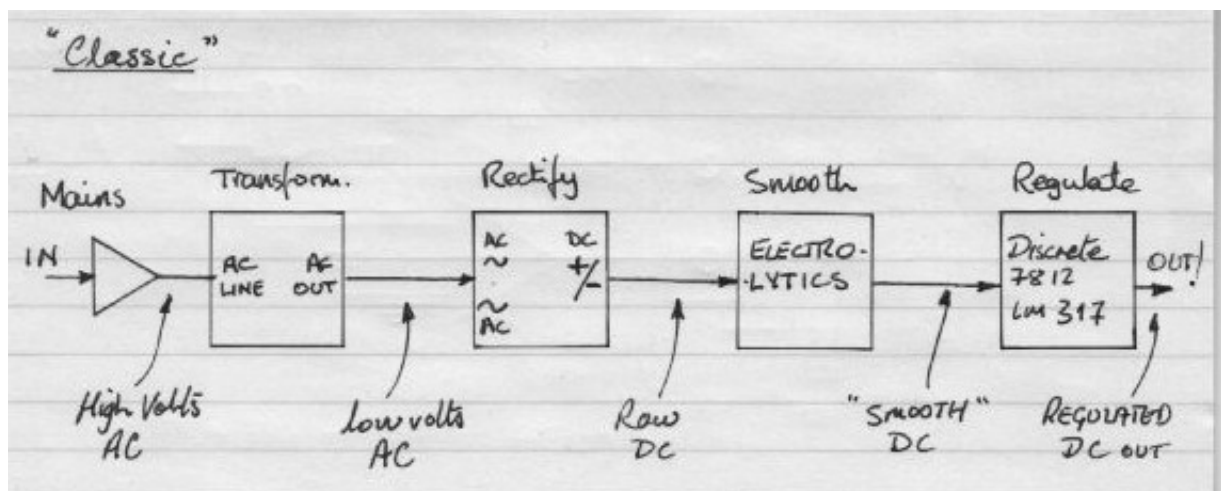
$C_{in}$  &  $C_{out}$  = 1000 - 4700 $\mu$ F 50vDC

$C_{in}$  is the main smoothing,

$C_{out}$  is the output reservoir



The "Classic" approach... if you can get a decent mains transformer at the right price!



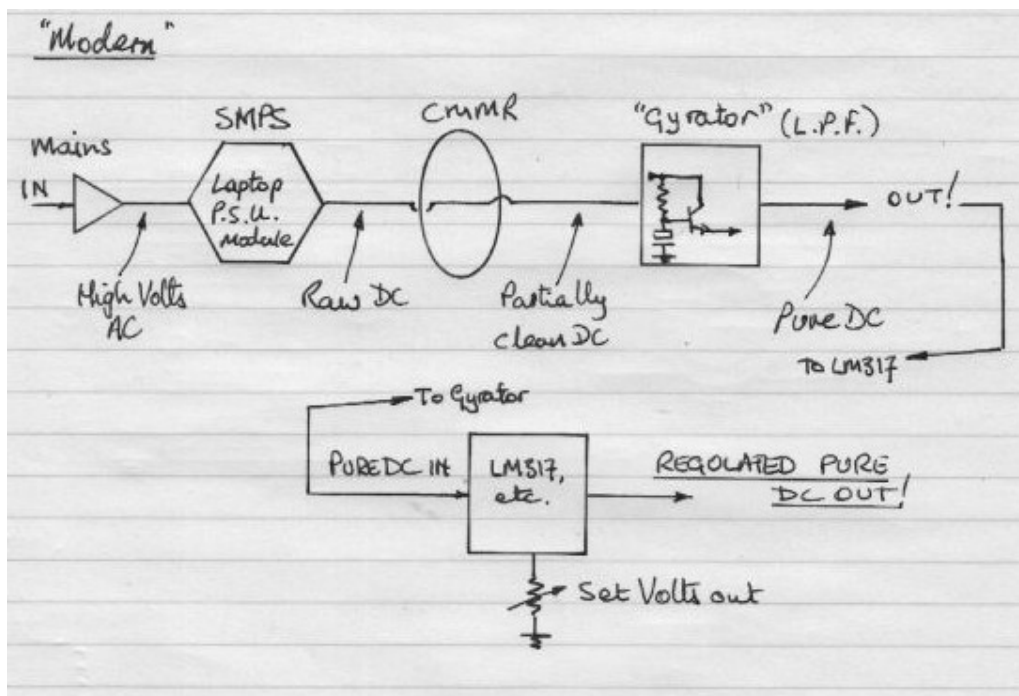
This is the basis of every linear power supply - time tested, reliable and quiet. Fit 10nF / 350v ceramic capacitors in parallel with the diodes in the Rectifier section if RF pick-up is a problem.



There is one major snag with the classic power supply: the transformer. Unless you have one in your junk supply, they are expensive, heavy and getting a bit rare in amateur terms. This prompted the “modern” approach: it’s cheaper, smaller and has easily obtained parts: but you have to pay attention to the noise reduction techniques this approach demands. They aren’t always required; modern switch mode (laptop) power packs are very much quieter than the more elderly, and the definite ones to avoid are the switch selectable output types.

You’re looking for a 15 to 19 volt DC output, at 90 watts or thereabouts (the power’s not too important) and our friendly online auction house can oblige nicely: I found a fixed output 96 watt / 19 volts laptop power supply - complete with IEC mains inlet and lead with moulded UK plug - for £6.99. Compare that to a 100 VA transformer from a reputable component supplier at £48.99!

The block diagram is below:



The “Raw DC” is described in our radio terms: it ideally needs processing and regulating to polish it up a bit before letting it loose on pet projects. I’ll run through the blocks:

The mains in and PSU module are a given - that’s what you get for your £6.99. The first de-noising is by mounting the PSU module in a steel box (mains plug wall socket boxes are ideal) then a Common Mode Choke (CMC), labelled CMMR in the diagram. I wound this with an offcut of heavy (2.5mm<sup>2</sup>) twin “figure of eight” speaker cable wrapped on a scrap 50/60Hz toroid transformer core, I got 36 turns on. You could use a scrap transformer, a ferrite ring core, or even (yes, it works!) a thick handfull of iron nails bound together as a rough cylinder with PVC insulating tape. Just wind the twin cable round and round, secure the ends, job done. It’s not critical; the DC current going one way is balanced by the returning current so the core never saturates, but common mode noise is rejected (i.e. noise equally present on both wires). Virtually anything magnetic will do the job.

The next block is often called a gyrator but in reality it's a capacitance multiplier configured as a Low Pass Filter. It's three components: R, C and a pass transistor. You'll need a hefty darlington power transistor here, but feel free to substitute. Just keep in mind it has to carry a fair number of amps, the output current divided by the  $H_{fe}$  (guess around 500 - 1500). The resistor feeds the base current to the darlington; if it's too high a value, the output current will be cut - hey, that's automatic current limiting! - but you want it low enough to start up the output in a reasonable time. Cut and try 1k, 10k, what have you and see what suits. And... it slows the output volts rate of rise on switch on, a "soft start"... we'll keep that idea, three jobs for the price of one is fine by me!

The capacitor is the highest value electrolytic you have; 1000 $\mu$ F / 50 volts is fine here, the more  $\mu$ F's the better. Feel free to try whatever you have to hand, just stack 'em up in parallel.

The final polish is put on by the LM317, as in the classic design. Modern LM317's have good ripple and noise rejection - so you might not need the CMC or the gyrator. If it works fine for you, job done; if you detect a sniff of noise, then in with the extra bits.

You *could* make a useful power supply by just using a 12 volt / 5 amp laptop supply, with the output via a hefty CMC; but this approach doesn't give you a variable output and 12 volts is a bit low for amateur use, 13.8 to 14.3v is more typical for a lead / acid battery for mobile operation.

You can get small digital readouts for voltage and current from our favourite online auction house, very useful and only a few ££'s, that add functionality to the basic design - go ahead, it's your project, but be warned: some of these readouts are electrically noisy little beggars.

Note earthing from mains side should only be to OUTSIDE of the METAL (steel) case as discussed elsewhere in this issue: plastic cases offer no screening whatsoever. See:

<https://www.youtube.com/watch?v=SvSP3kQQYMg> from  
<https://www.pa0nhc.nl/cobra80/index.htm> .

Some laptop power supplies have the mains input Earth pin bonded internally to the negative pole of the output: most of the time this isn't a problem as the CMC and gyrator will eliminate noise coming from the mains Earth. One thing I have noticed though with laptop power supplies: they need to feed a minimum current to run quietly. A bleed resistor - a filament lamp with series resistor (they don't make 19 volt bulbs!) indicating power "on" right at the raw DC output can reduce noise.

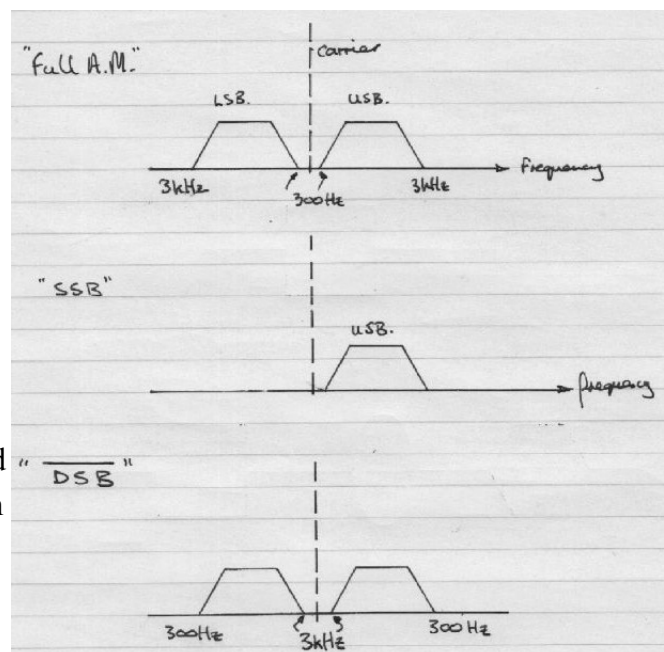
## R&D Topics

### Peter Parker VK3YE DSB to DSB transceivers

I've recently had some fascinating dialogue with that Antipodean Human Dynamo of RF Design, Peter Parker VK3YE, about Double Sideband (DSB) transmitters and receivers. He's dug out some references from the 1950's, from the dawn of SSB replacing full carrier A.M. as the amateur telephony mode of choice. It wasn't always SSB as first choice: DSB Suppressed Carrier transmitters were much easier than SSB to build in the technology of the day but they couldn't be received on an ordinary (A.M. receiver with a BFO) as the speech comes out garbled.

The apparent downfall of the DSB system is that a DSB transmitter can't be received on an existing receiver as the re-inserted carrier has to be not only the correct frequency, but also the exact phase of the original carrier that created the double sidebands. The Costas Loop receiver overcame this but was mighty complicated and difficult to capture stable lock when tuning. What was required was a standard A.M. receiver with BFO (or Product Detector), that could demodulate DSB sidebands and present clear speech with no kerfuffle. And that's exactly what they did in the 1950's! Studying the frequency plane diagrams of an A.M. signal yields the clue: for an unmodified A.M. receiver, the DSB sidebands are the wrong way round, as the receiver tunes up the band, the 3kHz end of the spectrum is where the 300Hz end should be; and moreover, tuning down the band from a higher frequency presents the same problem! Where the receiver is expecting low audio frequencies (close in to the carrier), DSB presents high audio frequencies; and vice versa, so the speech comes out "the wrong way round". So... how to "invert" the sidebands in frequency terms?

The whole idea - which can be used either at the DSB transmitter or receiver - relies on "inverting" the sidebands in the frequency plane using an audio frequency carrier and a mixer. If you imagine a standard A.M. signal frequency spectrum with each sideband 300 Hz to 3kHz wide, centred around the carrier that created them, then to invert the sideband in frequency means exchanging the 300Hz and 3kHz points around the (re-inserted) carrier. In the diagrams I've labelled the inverted sidebands with a logic "NOT" bar to indicate the "inversion".



If we imagine a receiver with a BFO making a re-inserted carrier tuning up scale from a lower frequency, the inverted lower sideband now presents itself in the correct orientation to the receiver's bandwidth: 300Hz is now close to the (re-inserted) carrier and the 3kHz point is at the upper frequency relative to the (re-inserted) carrier. Thus the receiver demodulates the lower sideband exactly as an SSB signal would be demodulated! Similar reasoning also demodulates the upper sideband, the receiver tuned down scale from above finds the 300Hz and 3kHz points in exactly the right place in the frequency plane, and demodulates it as an SSB signal.

### Frequency spectrum inversion using an SA612 mixer and LPF's

Unlike the 1950's, the frequency inversion can be done with a couple of common silicon IC's: an SA612 double balanced mixer followed by a switched capacitor low pass filter (or op-amps if you prefer analogue filters). The trick is to mix the incoming audio (from the microphone in the transmitter or recovered audio in the receiver) with a local audio carrier of 3.3kHz, then filter out the "sum" and accept the "difference" frequencies. If the incoming audio is 3kHz, mixed with 3.3kHz local carrier, the LPF delivers a 300Hz audio signal; if the incoming audio is 300Hz, the

LPF delivers a 3kHz audio signal. The sideband is inverted, and thus rendered, the sideband is receivable as an SSB signal. All that's required for signal processing in the receiver is a reasonably good RC oscillator (even a 555!) running at 3.3Khz - no demand for super stability or phase - driving an SA612 double balanced mixer followed by a switched capacitor Low Pass Filter (SCF), with suitable input and output coupling capacitors to establish the 300Hz lower cut off and appropriate clocking the SCF to give 3kHz top cut off (a MAX 7409 perhaps?).

There you have it: build the simplest DSB transmitter of your choice, and with it a simple receiver with audio inversion circuit after the detector / product detector and you have a full DSB transceiver. A stable Direct Conversion receiver will demodulate the inverted sideband as an SSB signal - this makes for ultra simple DSB transceivers. Not quite Costas Loop 6dB gain over SSB, but a superb and simple way to get DSB to DSB compatibility with simplicity.

Not content with solving a 70 year old problem with modern technology, Peter Parker has found a novel, ready made sideband inversion gizmo that can be used: a "Dr. Who" Dalek Voice Modulator kit that has the mixer and oscillator built in: just change one capacitor to get the 3.3kHz local audio carrier, and the job's a good 'un. See (and hear!) Peter's results at <https://www.youtube.com/watch?v=Y7DQa2kTx9w> and <https://www.youtube.com/watch?v=J-QmZOrL-lA>

As they say in Rock-N-Roll, "follow that if you can!"

### Diplexers...

<https://www.qsl.net/g3oou/mixerterminations.html> gives an explanation of the need for diplexers, but discards the 50 ohm resistor termination as "inefficient". But, asks G6NGR, just what **does** "inefficient" mean in our amateur reality? We can apply a little audio gain after the mixer at the cost of adding a sniff of noise, but a resistor and amplifier stage is considerably less bother than most of the diplexer designs I've seen. 88mH inductors, commonly mentioned in USA diplexer designs, are as rare as Hen's teeth in the UK & Europe!

A simple common base stage, of ~ 50 ohm input impedance, with LF and HF roll-off applied to define the audio bandwidth, will do nicely for a simple Direct Conversion receiver. Gain is available to make up for any "inefficiency" and give - if the LF and HF roll off characteristics are well designed - champion performance.

I note too the addition of a "gyrator" in some instances, where the supply to the stage following the diplexer is fed from a transistor emitter follower whose base is heavily "slugged" with an electrolytic to eliminate any rail noise. This creates a noise elimination stage; a real gyrator, simulating a giant inductor, might prove a better bet - see

<https://www.epanorama.net/documents/telecom/gyrator.html>

for the schematic. It needs a current flowing through it to be effective - so a suitable load needs connecting below the diagram, like the 50 ohm Zin common base amplifier mentioned above.

### A single transistor bistable?

Yes! This was a challenge issued many years ago, and caused many hours of soldering and fizz-buzz effects on the G6NGR bench (ahemm). It can be done! A better question, perhaps, would be “why?!”

See: <https://hackaday.io/project/112126-one-transistor-flipflop>

### The one transistor twin lamp dimmer - with a twist!

Here’s a neat conundrum from many years ago, when an ancient HP signal generator was to be refurbished as a standby for some production equipment. The beast had an illuminated horizontal “slide rule” frequency scale, and it was suggested I modify the twin lamp supply so that when the frequency was set low (to the left hand side of the scale), the left hand scale lamp lit brightly and the right hand scale lamp was (almost) extinguished. As the frequency was adjusted upscale, at mid frequency both left and right lamps were lit at ~ 50% brilliance. At maximum frequency, the right hand lamp was lit brightly and the left hand lamp (almost) extinguished to give clear visual indication of where the pointer was positioned. The lamps, by the bye, were 6v / 120mA rated, originally connected in series across the 12 volt supply rails.

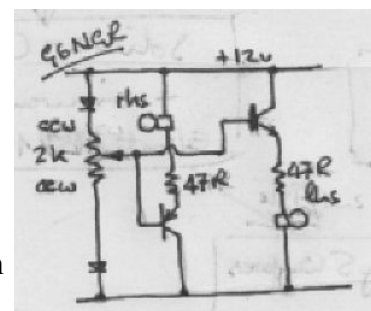
A pot was fitted to the end of the frequency control shaft - the question was how to do the “moving” illumination job? I reckoned I could do it neatly with an NPN and a PNP transistor, running as emitter followers: with the pot at the low frequency end of scale, the PNP would be “on” and the NPN “off”; mid way both would be half conducting, and at maximum frequency the NPN would be “on” and the PNP “off”. Job done... until Brian G., the demon designer of CRT scan coil amplifiers, sayeth unto me: “I can do that with ONE transistor...!”

After pondering this in between doing my routine jobs, I composed a way with one transistor; but it didn’t perform as well as Brian’s, and, just to stick it to the man, Brian had potted his circuit in black resin with ONE transistor poking out the top, so I never saw his circuit.

Of course, all this kerfuffle inevitably came to my mentor Stan’s ears: he promptly said: “you don’t need transistors. You always jump to the transistor solution, before considering the simpler options. I’ll do it with NO transistors, just one pot., and I’ll bet you’ll never see a blown bulb in that rig ever again!” And, beggar me, he was dead right.

Can you figure out how Brian and Stan did it? Below is my two transistor design, which I thought rather nifty, nay, dare I say, elegant, at the time... and it’s a great way to make your tuning dial scale illumination “move” in sync with the knob movement.

It’s complementary emitter followers, buffering the voltage on the pot. wiper. When the pot. is set fully counter clockwise (at the top of the track) the NPN emitter follower puts the pot. voltage on the “lhs” lamp - fed via a 47R resistor so as not to blow the 6.0v lamp. Similarly, when the pot is at the bottom of the track (fully clockwise) the PNP applies 12 volts to the rhs lamp. Job done! The two diodes in



the pot. chain are to compensate the base - emitter volt drops, so the pot. has no “dead” zones on the track at the top or bottom.

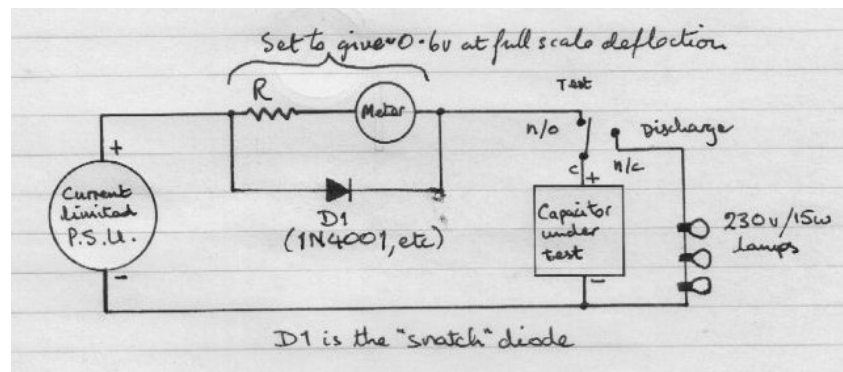
### Identifying the polarity of unmarked Electrolytic Capacitors

Why these beasts ever survive I don't really know; but more than once in my working life I've been asked to identify the polarity of unmarked electrolytic capacitors - typically  $47,000\mu\text{F}$ , at 450 volts was one recent candidate. NO polarity marking visible anywhere on the thing; but it promised (so sayeth its owner) “good smoothing for my latest power supply... and it was very cheap...”. Nuff said! But how to identify the correct polarity?

There are a couple of measurements that will help - but with a potential bomb like  $47\mu\text{F}$  charged up to 450 volts it's for you to ensure yours (and anybody else's) safety! Put the electrolytic in a steel box, or other robust enclosure with secure lid, and run wires out to a safe place. Remember the energy stored in Joules is  $\frac{1}{2}CV^2$ , so do the sums first before turning on the power. Calculate the explosive power from watts = Joules per second; a 'lytic explodes in under 0.1 seconds, so multiply the Joules by 10 and you have watts. So  $\frac{1}{2} \times 450 \times 450 \times 0.047 \text{ Farads} = 4758.75 \text{ Joules} = 47.58 \text{ kWatts}$  if the charge is dumped in 0.1 seconds! You have been warned!

First, remember the fundamental principles of an electrolytic: if it's biased with correct polarity, the chemistry inside the thing creates a very thin insulation layer between the capacitor plates, and it's this insulating layer that creates the capacitor. Bias it the wrong way round, and it leaks like a proverbial colander - but the snag is so does an old electrolytic, it has to re-form the oxide insulating layer, so apply some test volts and monitor the current. If it's wrong road round, it will leak, and carry on leaking at an ever increasing rate - and get HOT. This gives you two weapons in your armoury: leakage current and temperature rise.

So... attach a thermocouple, or infra-red thermometer (so beloved in these COVID-19 days!) or other means of measuring temperature onto the beast under test; then measure the leakage as you S-L-O-W-L-Y charge the thing up, from a current limited (a series connected “dull lamp” feeding a rectifier is a **very good idea**) DC supply, and using a very well protected  $\mu\text{A}$  meter (not your very best expensive multimeter). Use an old VU meter or similar with a series resistor of a few ohms to get a full scale deflection of  $\sim 0.6$  volts, and wrap around the whole shebang a snatch diode, so if the 'lytic goes short, the meter doesn't explode.



Don't forget that every time you raise the voltage, a current will flow to charge the capacitor, as the plate oxide layer re-forms. Wait a minute or two and let the current settle back to indicate the

leakage. The function of the “test” and “discharge” switch is self explanatory; tungsten lamps are excellent self indicating discharge devices. Series them up to match the expected voltage, or use a dropper resistor. 6k8 at 20 watts in series with a 5 watt pygmy lamp is good for 600v or so.

If the leakage rises on charge, towards 10 - 20  $\mu\text{A}$  or so, all's fairly reasonable; but any sudden rises of current, with a corresponding rise in temperature, you've got a banger biased with that polarity. STOP IMMEDIATELY, switch off all power and let the 'lytic calm down for an hour or two.

Once you have the polarity fairly certain, re-form the plates by charging up to rated voltage - in gradual steps - via a current limited DC supply (“dull lamp” as above) and hold the full rated voltage for a few hours, keeping an eye on the leakage current. It should drop to a few 10's of  $\mu\text{A}$  fairly quickly; and drop eventually to a lower settled value.

Here's a note from Stack Exchange which is useful for all you low voltage electrolytic wallahs:

From: <https://electronics.stackexchange.com/questions/35480/polarity-of-unmarked-smt-electrolytic-capacitor>

*“If they really are unmarked polarised (extremely unlikely) then a possibly destructive method of testing for polarity is to gradually apply a current limited voltage (e.g slowly up to ~25% of rated voltage, limited to ~10mA) in both directions across the cap whilst measuring current - if polarised and the wrong way round you should start to see a steadily rising current flow. Can be done with a bench power supply, and put a shield of some sort over the cap just in case it decides to detonate ;-)*

*I tested with the bench supply, above ~7V across reverse polarity with a 100uF/35V aluminium electrolytic, the leakage current rises above 1mA (measured using bench display) and quickly starts to accelerate upwards.*

*I also just tested this with a multimeter in series with the bench supply (more sensitive than the bench supply measure) measuring current across the same capacitor:*

- *Using 5V with correct polarity produced ~1uA leakage.*
- *With 5V and reverse polarity the leakage started at around 25uA and gradually got higher, after around 30 seconds it was at 50uA.*
- *Even at 3V it was reasonably obvious which way round it was - the reverse leakage was at least twice that of the correct polarity.”*

The *magnum opus* of all this is at: <https://tadiranbatteries.de/pdf/applications/leakage-current-properties-of-modern-electrolytic-capacitors.pdf>

A useful end note: 'lytics that have been accidentally back biased usually recover if biased forward for a period of time at low voltages; build the voltage up S-L-O-W-L-Y, watch the leakage current with your bomb proof leakage meter and all - if you're lucky - will likely be fine.

## **A link**

Here's an article about audio amplifiers (and much, much, more) you might like. I really enjoy trawling round these darker corners of electrical, electronic and radio engineering - I keep the motto “don't knock it till you've tried it”!

[https://www.aes.org/aeshc/pdf/how.the.aes.began/vincent\\_magnetic-audio-fundamentals.pdf](https://www.aes.org/aeshc/pdf/how.the.aes.began/vincent_magnetic-audio-fundamentals.pdf)

## Mag Amps

I first came across magnetic amplifiers when repairing the 15kV, 3.5 Amp DC power supply in a Perkin-Elmer high vacuum evaporator. The design engineers had used a 24v DC control signal feeding this monster lump of iron and copper, which in turn controlled the 3 $\Phi$  input power to the main HV transformer. I'd never met one of these beasts before, so was unsure of how they functioned: it was obvious the control signal could be anywhere between 0 volts and +24 volts - but did +24 volts equal zero power or full? I didn't want to energise this dangerous old beast at full bore; I wanted to ramp the thing up slowly to see where the flashover was, and hopefully prevent a lot more damage. 15kV with amps behind it can go places and do things that just aren't sociable before the over-current trips can open the main HV 3 $\Phi$  input contactor!

A trip to see my mentor, Stan, soon brought an answer. "No volts = no output; +24 volts = full output". Job sorted: control card removed, a bench PSU rigged up and wired in, and off we go. Yes, one of the HV feedthroughs was flashing over, deep inside the ceramic insulating sleeve. The thing lit up like a miniature lightning display, and I very quickly knew the problem. The solution was, however, another story... but the fact that the magnetic amplifier (commonly known as a "mag amp") had survived multiple short circuits with ne'er a quibble, full power flashovers, which impressed me mightily. As Stan mentioned in the canteen at lunch time, he'd never known a mag amp turn up it's toes - they were "nigh on indestructible" quoth he, "just like this pie crust on my plate").

So, me being an A.M. nut, when I was trawling through my notes about mag amps, VLF transmitters, Alexanderson alternators and the like I came across the references below:

([https://en.wikipedia.org/wiki/Magnetic\\_amplifier#Applications](https://en.wikipedia.org/wiki/Magnetic_amplifier#Applications))

*"Magnetic amplifiers were important as modulation and control amplifiers in the early development of voice transmission by radio. [2] A magnetic amplifier was used as voice modulator for a 2 kilowatt Alexanderson alternator, and magnetic amplifiers were used in the keying circuits of large high-frequency alternators used for radio communications. Magnetic amplifiers were also used to regulate the speed of Alexanderson alternators to maintain the accuracy of the transmitted radio frequency. [2] Magnetic amplifiers were used to control large high-power alternators by turning them on and off for telegraphy or to vary the signal for voice modulation. The alternator's frequency limits were rather low to where a frequency multiplier had to be utilized to generate higher radio frequencies than the alternator was capable of producing. Even so, early magnetic amplifiers incorporating powdered-iron cores were incapable of producing radio frequencies above approximately 200 kHz. Other core materials, such as ferrite cores and oil-filled transformers, would have to be developed to allow the amplifier to produce higher frequencies."*

From:

<https://ham.stackexchange.com/questions/14674/is-it-practical-to-use-a-magnetic-amplifier-as-an-am-modulator-in-a-transmitter>



## **Magnetic Amplifiers**

From

[https://www.nutsvolts.com/magazine/article/the\\_magnetic\\_amplifier](https://www.nutsvolts.com/magazine/article/the_magnetic_amplifier),

with many thanks.

*“A magnetic amplifier uses the change in inductance that occurs when an inductor's core is magnetically saturated (with a relatively small DC current through a high number of turns on the same core) to control an AC current.*

*This works because the inductor (L1) is designed to have high impedance at the frequency of the current that it is required to control when no control current is flowing, and low impedance if sufficient DC control current is flowing.*

*Due to the use of a core material with the right saturation characteristics it is possible to reduce or remove the magnetic effect of the core by passing a DC control current through a second winding and progressively saturating the core, so that the core contributes less and less to the inductance of L1. This lowers the inductance of L1 and therefore the impedance to the controlled ac. The resistance of L1 to DC is not changed.*

*There are several ways to stop induced emf from the (controlled) ac current from feeding back into the control circuit, all involving 2 magnetic fields or 2 emfs cancelling each other e.g. 2 identical magnetically separate saturable core inductors with the control windings in series and oppositely phased.*

### **Simplicity**

*The mag amp, like the vacuum tube and transistor, is an electrical control valve. When a smaller circuit controls another circuit's larger flow, that's the definition of an “amplifier.”*

*A mag amp can be put in series with any circuit carrying an alternating current and control that flow. No external power supply is required to run the device. The simple mag amp is just a core of iron or ferrite with some coils of wire wound around it.*

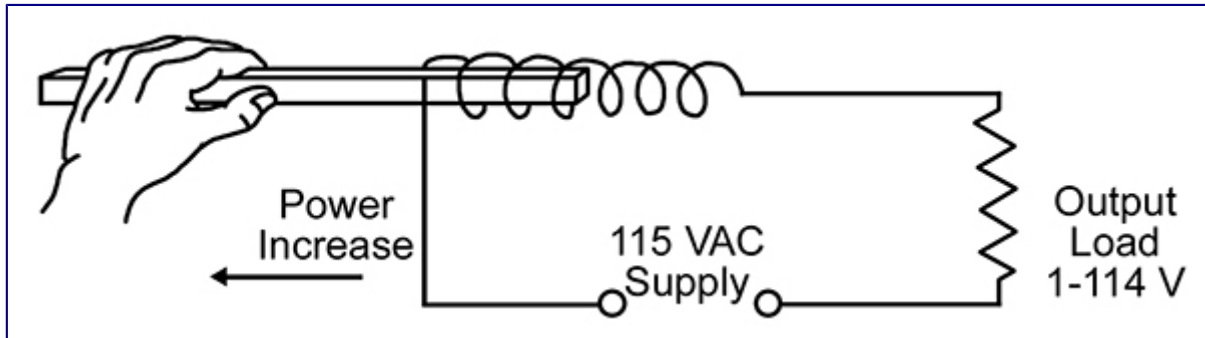
*One other basic component is the rectifier. Today, rectifying diodes are compact, easily available, and cheap. The old selenium rectifiers used back in the 1950s were large, cumbersome, and expensive. A variety of ferrite core materials are also available to today's builders. With some spools of wire, a ferrite rod, and a couple of diodes, you can throw together a little high-frequency mag amp on a Sunday afternoon. Compare the construction challenge of a vacuum tube or transistor. And the mag amp can handle voltages and currents that you would never put into the average transistor or tube.*

### **How it Works**

*The mag amp is a ... variable choke. It controls the impedance (opposition) to alternating current in a coil by controlling the magnetic condition of the core on which the coil is wound. This is done by energizing another winding on the core called a control coil. Depending on the energy in the*

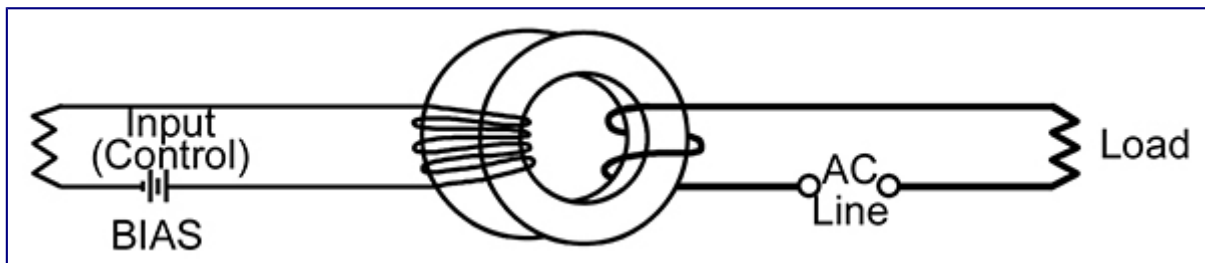
control coil, the core's permeability (its receptivity to magnetism) can be varied by degrees, thus controlling a larger AC flow.

Fully energized, the control coil can reduce the permeability of the core to zero, in which case the core is said to be saturated. Then it becomes so magnetically unresponsive it's like the core has been removed.



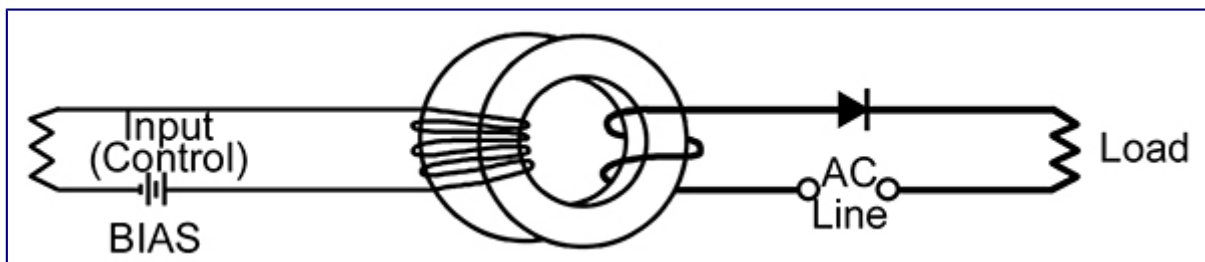
**FIGURE 1.** Principle of Operation.

**Figure 1** is a way of showing the principle. With the core completely within the coil, the impedance to the flow is high, permitting perhaps only a fraction of a volt to appear across the load. Pulling the core out causes the load voltage to rise progressively to 115. Since it took only a few watts of muscular energy to move the iron core within the coil, which may, in turn, control several horsepower, the device is an amplifier.



**FIGURE 2.** Saturable Reactor

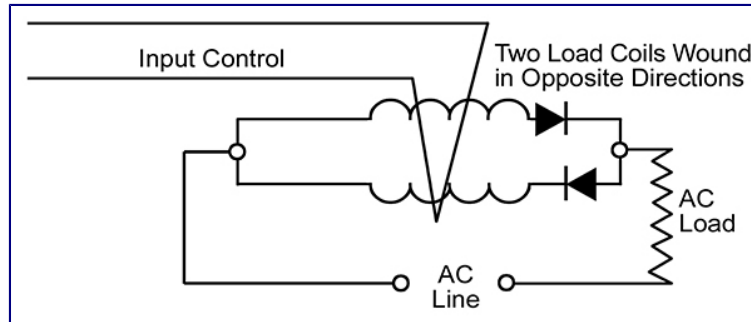
**Figure 2** is another demonstration. This qualifies as a saturable reactor. This circuit could be for a dimmer for theatre stage lighting. Add a diode, and you have a basic mag amp (see **Figure 3**). The larger coil is the control coil. The smaller is called the loading coil.



**FIGURE 3.** Mag Amp.

The diode rectifier makes the load current unidirectional, which assists the control winding in saturation. Considerably less power is now required, making it a more potent amplifier.

This mag amp, however, will function as a step-up transformer, which would be undesirable since it would send energy back into the control circuit. This effect is cleverly cancelled by running the AC through a pair of parallel loading coils which are wound in opposite directions.



**FIGURE 4.** Functional Mag Amp.

**Figure 4** is your basic functional mag amp represented by the appropriate schematic symbols. The control coil symbol is a single sharp angle-line, but the control coil actually has many more turns than the loading coil.

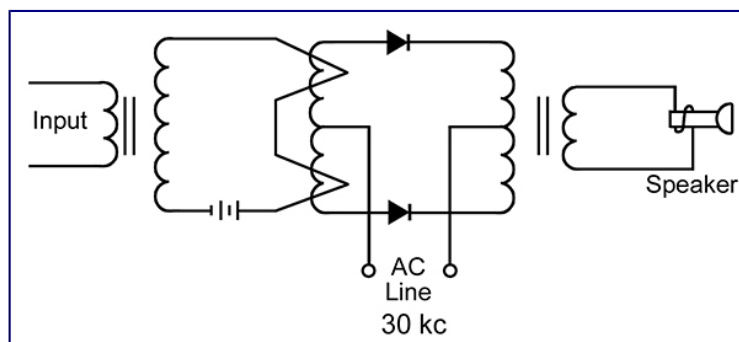
How many turns? The rule of thumb is control-coil ampere-turns equals loading-coil ampere-turns plus sufficient extra turns to saturate the core. (Much of the how-it-works above is from *Magnetic Amplifiers* by the US Navy, 1951, recently republished.)

### Uses

The mag amp still has industrial uses in the control and regulation of power utilities and big electric motors, as in locomotives, but its most fascinating applications — mostly forgotten — are in electronics.

The mag amp can modulate, switch, invert, convert, multivibrate, audio-amplify, radio-amplify, frequency-shift, phase-shift, and multiply. Stages can be cascaded. Simple feedback techniques enable gains in the millions.

The mag amp can even compute. Trouble-proof magnetic binaries replaced the less reliable vacuum tubes used in some early digital computers.

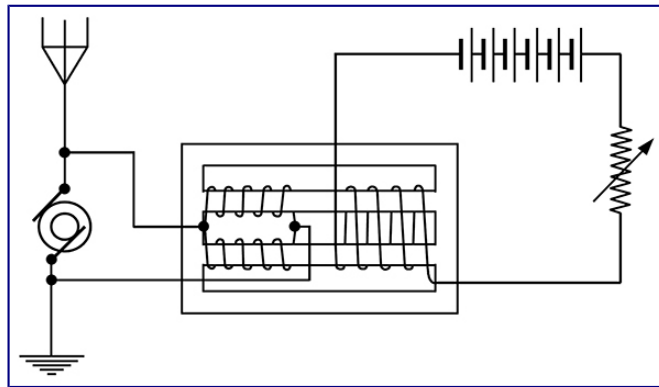


**FIGURE 5.** Mag-amp Audio Amplifier (push-pull).

**Figure 5** shows the incredibly simple circuit for a mag amp audio amplifier. Mag-amp audio would be a challenging pursuit for some adventurous audiophile.

### **Mag Amps in Radio**

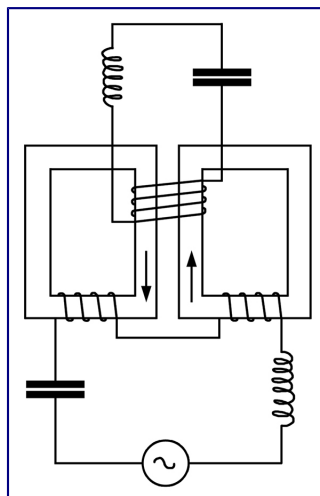
The first patent for a mag amp was in 1903, but little attention was paid until 1916 when radio pioneer E.F.W. Alexanderson seized on the idea as a means of controlling the giant rotary alternators he was using for high-power radio transmitting (at 10,000 to 100,000 cycles). The *Magnetic Amplifier Bibliography* (by the US Navy, 1951) lists three Alexanderson patents in 1916 and three more in 1920, the last titled “Transoceanic Radio Communication.”



**FIGURE 6.** GE Mag-amp Modulator by Alexanderson.

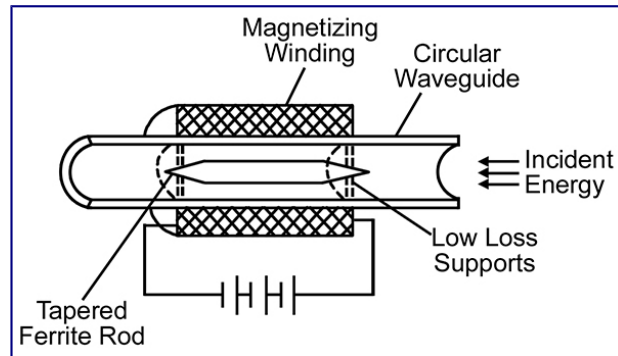
The mag amp can turn the alternator on and off for telegraphy and vary the signal for speech modulation (see **Figure 6**).

The frequency limits of an alternator are low, so the mag-amp was reinvented in that era as a frequency multiplier (doubler, tripler), as seen in **Figure 7**. The Bibliography cites many radio-transmitter frequency-multiplier patents up through the 1920s. These are simple circuits compared to those of vacuum-tube frequency changers that came later.



**FIGURE 7.** Frequency Multiplier.

Early mag amps with solid iron cores never got above a few hundred kilocycles. Powdered-iron cores, the ceramic-iron-oxide composition known as ferrite, and later the ultra-thin magnetic tapes liberated the mag amp, so by the 1950s the limit was up to a megacycle and switching rates were in microseconds, suitable then for computer applications. Techniques for the modulation even of microwave frequencies were also developed in the 1950s (see **Figure 8**)."



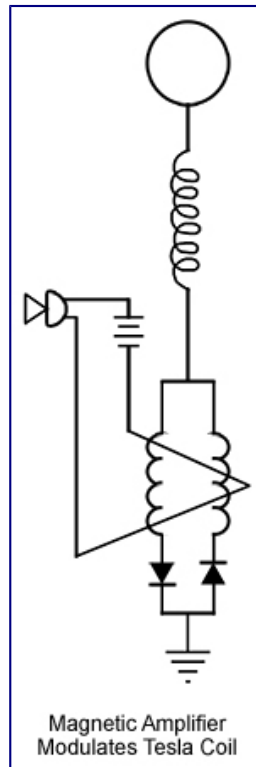
**FIGURE 8.** Microwave Mag Amp.

Here's an article by that very practical gentleman, of "Easy Ten" transmitter fame, Nyle Steiner K7NS. Nyle lists two mag amps, one built with common 12 volt transformers and another using "junk box" toroid cores at: <http://www.sparkbangbuzz.com/index.html>

### My Home-built Mag Amp by K7NS

By Nyle Steiner, K7NS

"I wanted to see if a mag amp could modulate a Tesla coil (see **Figure 9**), as Alexanderson modulated his big alternator-transmitter. I used the schematic in **Figure 4**. The Navy booklet, *Magnetic Amplifiers* served as a reference.



**FIGURE 9.** In Tesla Coil Circuit.

*I first obtained a ferrite rod (material #33), six inches by just under 1/2-inch diameter. I got it surplus from Alltronics, for about \$5, but it's no longer available, though they do carry a four-inch for \$5 ([www.alltronics.com](http://www.alltronics.com).) Another source for rods is Surplus Sales of Nebraska ([www.surplussales.com](http://www.surplussales.com)). From Alltronics I also got spools of magnet wire — #26 for the two loading coils and #30 for the control coil.*

*I wound my coils, not directly on the ferrite, but on acrylic tubing, 1/2 inch inside diameter (from Tap Plastics), which I could slip over the rod. A section of the tubing and a couple of nylon fender washers from the local hardware store made a well insulated spool or coil form on which to wind the coils on my winding jig. The loading-coil spools were 1-1/8 inch wide, the control coil two inches wide. For the loading coils, I wound 13 layers, 860 turns of the #26 wire, laying on some electrical tape for extra insulation between each layer. I wound the two loading coils in opposite directions. The control coil took 400 feet of the #30 wire.*

*A mag amp is frequency specific according to the size of its loading coils. (Thus, an audio amp would be quite large.) I wanted 180 kilocycles, and I determined the number of turns experimentally.*

*For the rectifiers, I used eight 1,000-volt, three-amp 1N4008 diodes, four in each leg (three for a \$1.00, from All Electronics, [www.allelectronics.com](http://www.allelectronics.com)). The mag amp was now safe to 4,000 volts and could handle the output of my solid-state Tesla coil.”*

### **Performance**

*So that I could observe the mag amp's performance with my signal generator and oscilloscope, I replaced the 1N4008s with two low-power signal diodes. In series with the control coil, I put a 12-*

volt battery and a telegraph key, as a convenient switch. The mag amp is frequency-specific; you design it for a particular range. Keyed on and off, the mag amp showed response from 155 to 200 kilocycles (a range that happens to fall within the license-free experimental radio band called LowFER).

*What a versatile device! At a particular frequency, operating the key would increase or decrease the amplitude of the wave as traced on the scope. At another frequency, the keying would shift the frequency back and forth, and at another it would shift the phase. So this one little device, depending on how it was tuned, could do on-off keying (CW), amplitude modulation (AM), frequency-shift keying (FSK), frequency modulation (FM), or phase-shift keying (PSK), including bi-phase-shift keying (BPSK), which is a common mode of digital transmission. Placed in the ground circuit of my solid-state Tesla-coil, the little mag amp showed that it could do all of the above with more than 3,000 oscillating volts running through it. This would be quite a task for a vacuum tube and probably beyond any transistor.”*

### **Keying a transmitter**

This should really be in the “transmitter” section, but since we’re playing with big boy’s electronics here - mag amps and all that - a thought came to my mind that could be used for keying a transmitter without back wave issues or chirp and the like. My thoughts ran thus:

Why switch off the P.A., or driver or oscillator at all? Why not build a mag amp change-over switch, and divert the transmitter output into a well screened and matched dummy load for the spaces? Sure it isn’t energy efficient, but it would mean the P.A. runs continuously into a matched load. No back wave (if the switch is a good ‘un) and no chirp from stop / starting sections of the transmitter. This sounds perfect for a complementary mag amp switch pair?

## **Construction**

### **Building using separate “modules”**

When cheap aluminium boxes were available from Maplin (now sadly defunct) UK constructors had the luxury of building in “modules”. You built each stage in it’s own little screening box, and used a common power supply philosophy: screw terminal blocks on each box, which allowed easy testing, and coupled the stages together with signal cables on plugs and sockets (phono plugs / sockets were great on 7MHz and under; BNC above). Though a bit more costly, it provided a superb way to make individual stages improvements / alterations and allowed easy performance comparisons.

Nowadays finding cheap aluminium boxes for projects like this is not easy - they are rarer than hen’s teeth. Why not try the 4” square steel boxes available from electrician’s suppliers? Galvanised or black painted, they are meant for housing terminal blocks and the like, and are as cheap as chips. The steel backing boxes used to mount UK mains wall sockets make for ideal “cover” style screening (as in Alan Gale’s PSU previously in this issue) and you get screw mounting tabs thrown in for free, but beware: they are an odd thread, 3.5mm.

Electrician's suppliers sell 3.5mm taps mounted in a plastic handle to clear mshed threads in wall boxes. Used with gentle care, these will cut neat 3.5mm threaded holes, ideal for all those screws that you religiously save from scrapped boxes and (UK) electrical equipment, don't you?

### Hook up wire reclamation by Frank Barnes, W4NPN

*"If you can obtain a junked PC, it will have a great deal of multi-colored wire in the various harnesses inside it. The only drawback, for some uses, is that it is stranded wire. Even though a PC uses low voltage, this wire is quite satisfactory for use in a receiver. I've used it to carry well over 600 volts with no problem - I do not know the wire's technical specs but so far no problems have occurred. I like the fact that many colours are available."*

1/8" bore aquarium PVC pipe, is ideal for a "second skin" sleeving over much cheaper thin insulation (or doubtful spec.) wire, culled from scrap PC's, washing machines, microwave ovens and the like. Cheap as chips, too! For hot environments, glass fibre sleeving slipped over PVC insulated wires is excellent: it doesn't matter if the PVC melts, the sleeving insulates (to 2.5 kV) at 200°C continuous, 600°C for a few minutes. For deep freeze duty, silicone rubber sleeving will get you from -60°C to +180°C; for the real hot stuff, to upwards of 1000°C, it's "fish spine" beads - Steatite ceramic beads with interlocking concave and convex ends, so that wires can run round curves without the bare inner conductor being exposed.

Keep in mind though that copper wire will be of much higher resistance per foot at these elevated temperatures, so scale up the cross section adequately and remember copper melts at 1083°C!

Below is a calculation showing how copper wire can change with temperatures not uncommon in valve chassis:

From: [https://www.engineeringtoolbox.com/resistivity-conductivity-d\\_418.html](https://www.engineeringtoolbox.com/resistivity-conductivity-d_418.html) with many thanks.

Change in resistance with heat can be expressed as:

$$dR / R_s = \alpha \cdot dT$$

where

dR = change in resistance (ohm)

R<sub>s</sub> = standard resistance according reference tables (ohm)

α = temperature coefficient of resistance ( °C<sup>-1</sup>)

dT = change in temperature from reference temperature ( °C)

rearranging:

$$dR = \alpha \cdot dT \cdot R_s$$

The "temperature coefficient of resistance" - α - of a material is the increase in resistance of a 1Ω sample of that material when the temperature is increased 1°C.



### Example - Resistance of a copper wire in a hot chassis

A copper wire coil with resistance  $500\Omega$  at normal operating temperature  $20^\circ\text{C}$  is in a hot chassis at  $80^\circ\text{C}$ . The temperature coefficient for copper is  $4.29 \times 10^{-3}$  (per  $^\circ\text{C}$ ) and the change in resistance can be calculated as:

$$\begin{aligned} dR &= (4.29 \times 10^{-3} \text{ per } ^\circ\text{C}) \times ((80^\circ\text{C}) - (20^\circ\text{C})) \times (500\Omega) \\ &= (4.29 \times 10^{-3}) \times 60 \times 500\Omega \\ &= \underline{128.7} (\Omega) \end{aligned}$$

The resulting resistance for the wire will be:

$$\begin{aligned} R &= (500\Omega) + (128.7\Omega) \\ &= \underline{628.7} (\Omega) \\ &\sim \underline{630} (\Omega) \end{aligned}$$

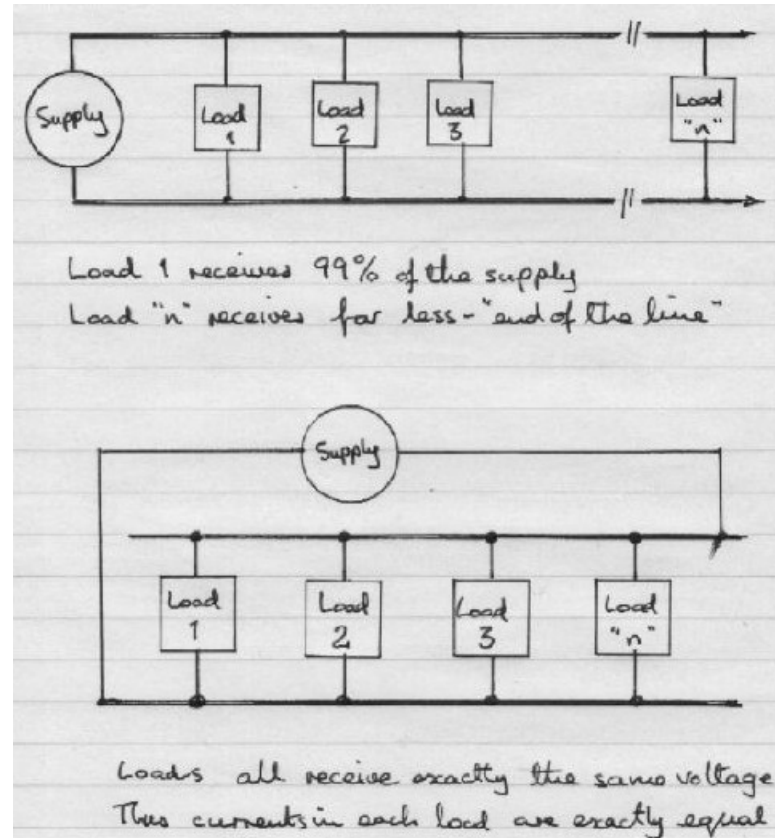
The point to note is that this copper wire could well be a transformer winding; on heavy load the efficiency drops due to the higher resistance of the winding, and the output voltage drops. This reflects the *regulation capability* of the transformer.

### Electrolytics (or loads) in parallel

It's often required to run loads in parallel to absorb the power, similarly to feed power from multiple paralleled electrolytic capacitors, cells, what-have-you. But how do you guarantee that each and every one of the loads or electrolytics contribute exactly the same energy?

This is a very real problem in places like electro-plating shops or power inverters where multiple loads or electrolytics are banked up that must have contribute or absorb exactly equal voltages and currents. In the electro-plating shop every cathode station must plate exactly the same thickness of metal; in a power inverter (or a solid state QRO power amplifier?) every electrolytic must contribute to the load equally to prolong the working life of the electrolytics.

The diagram below shows two scenarios: the top drawing shows a supply feeding two buss bars with loads strung in parallel between them. Load 1 gets virtually the full supply volts, but Load "n" at the end of the line suffers considerable volt drops - the sum of both the feed buss bar drop and the return buss bar drop. If, instead of loads, these were electrolytics feeding a high current system, then the electrolytic nearest the "power supply" (in this case the "supply" would really be the high current load) would be doing the bulk of the current delivery; those down the line would contribute less and less to the load. Odds on the first electrolytic to fail would be that in position "load 1".

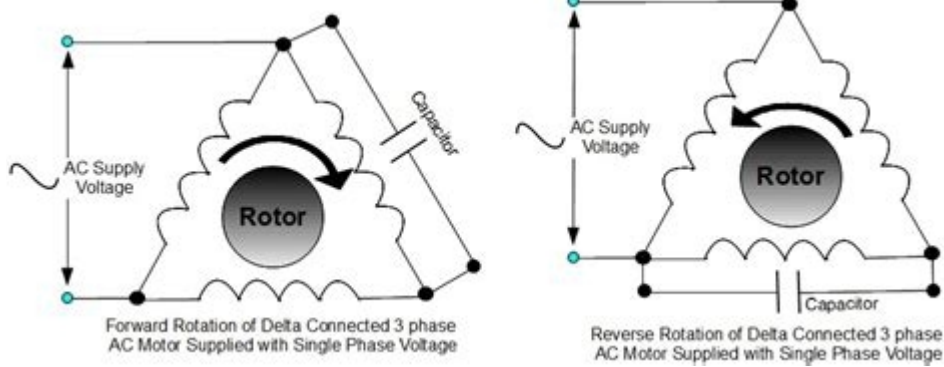


Now consider the lower drawing. The supply is feeding opposite ends of the buss bars; whilst this involves heavy current flowing in the wires from the supply to the buss bars, heavy cable is cheaper (and more reliable) than a repair. If cable volt drop really is a concern then Kelvin ("sense") leads can be run to the buss bar ends to nullify feeder cable volt drops, but I doubt if any amateur jobs - except perhaps legal limit full carrier service modes - would need such sophistication. Look at the volt drops in the lower drawing: they cancel each other along the length of the buss bars so each load or electrolytic absorbs or contributes exactly equal energy. Nett effect: you get much longer life from your electrolytics. Whilst it might not be possible to do this in your latest QRO solid state PA power supply, it's worth bearing in mind if you're doing a PCB copper layout.

I won't labour the point too much, but in a bank of paralleled electrolytics, the one that will fail first, is the one that runs hottest - because that's the poor struggler who is working hardest to deliver the amps. If you have the luxury of an infra-red thermometer (a.k.a. "finger tip" at G6NGR) you can check this yourself whilst the electrolytics are running into a full load. You'll soon spot the future likely dud.

### Running a three phase motor on single phase

A  $3\Phi$  motor can be successfully run on single phase if it can be wired in Delta - sometimes referred to as "Low Voltage" connection - and a suitable capacitor is added to phase shift the current in the phases as per the diagram below (from [ijyam.blogspot.com](http://ijyam.blogspot.com) with my thanks):

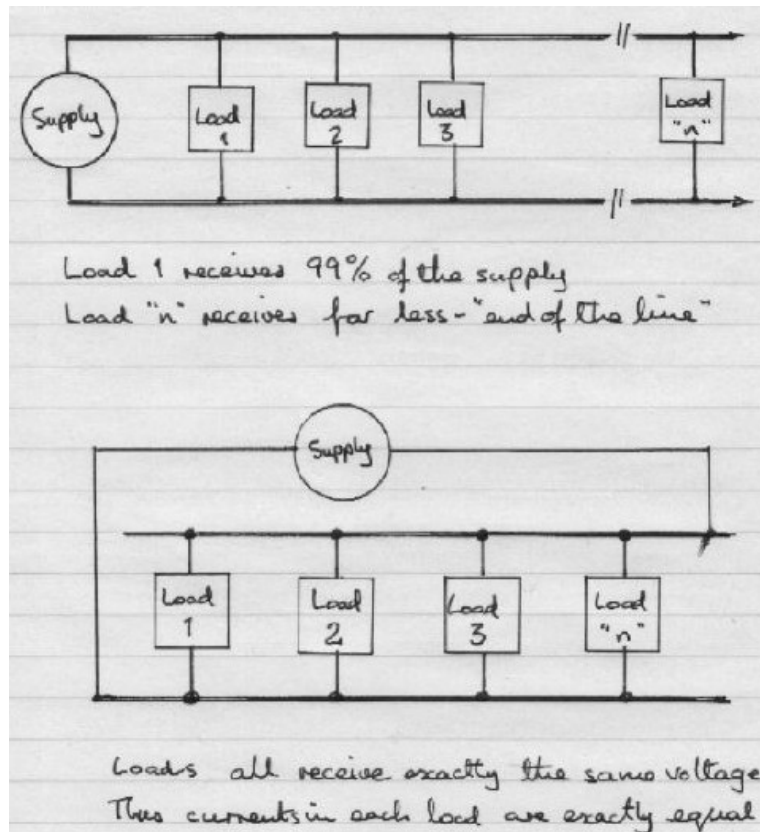


The capacitor is connected between one of the single phase wires to the third phase winding; if the motor runs the wrong way round, change the capacitor connection to the other single phase wire.

How big to make the capacitor? Reckon on roughly  $75\mu\text{F}$  per kW of motor power, rated at at least 500 volts and specifically designed for motor applications. You'll need a few in parallel to get the capacity required. Don't be tempted to skimp: the capacitors have to carry fair amounts of reactive current, and have to be designed to do this for long periods without overheating. Small plastic capacitors just won't do, get those big oil and paper jobs that come in steel cases!

### Amps and electrolytics

Need lots of  $\mu\text{F}$ 's in parallel for a high current supply? Use the old electroplating shop trick of feeding buss bars from opposite ends - every capacitor then contributes equal current.



### Manhattan Construction the easy way

This is a simple process, none of which involve spending any money (a G6NGR "must have"...).

Oh, alright, yes, I blew a single solitary spondulick in the ££shop for the Super Glue; but it was "officially" to repair a busted rubber "O" ring in our swivel tap in the kitchen, so I'm counting it as gratis.

1. Contact your local PCB manufacturer (web search, Yellow Pages, I have a choice of three in Rochdale; Oldham and Manchester have many more) and beg, cajole, wheedle the following:
2. Some scrap 0.1mm thick FR4 single or double side copper pcb laminate from the scrap bin - the stuff you can cut with scissors
3. Ditto 2mm thick scrap FR4 pieces - the stuff you can't cut with scissors
4. On the way home, call in the ££shop and buy a tube of super glue
5. Once home, get the kitchen scissors from the drawer
6. Cut strips of the 0.1mm thick FR4 5mm wide (or whatever width you want your pads to be) with the kitchen scissors
7. Cut little squares or rectangles off this strip with the kitchen scissors
8. Cut the 2mm FR4 to size as a "baseboard" for your project with a hacksaw, sand the edges smooth and clean the copper with damp pan scrub, then dry it with a paper towel

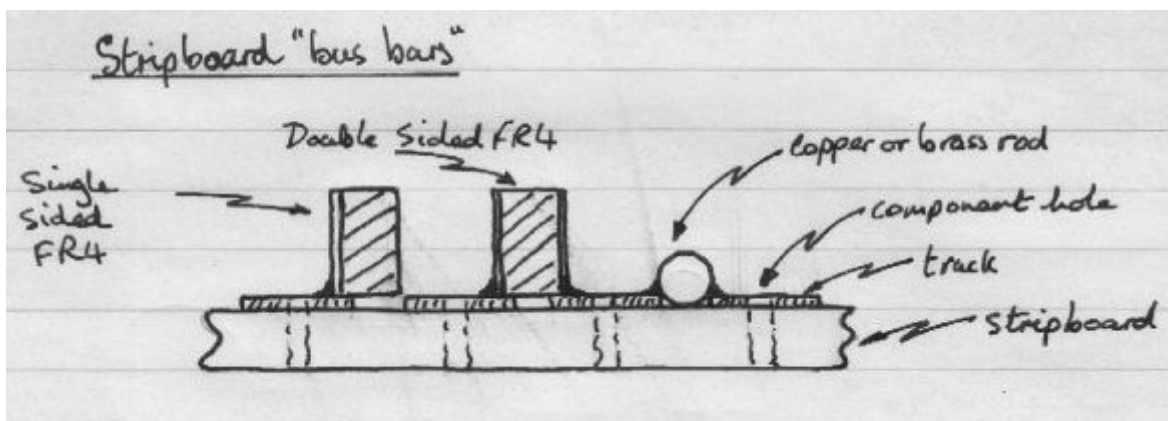
9. Stick the little squares down with super glue in the pattern of the circuit, with power rails made from the initial 5mm wide strips
10. Solder up your circuit & test it. Job done...!

Total cost: £1.00 for super glue (and keep some ££'s for replacing kitchen scissors after her indoors sees you chopping laminate with her finest). Easy-peasy!

### Stripboard ideas...

The biggest problem with stripboard (“Veroboard” in UK) is that you don’t have low impedance power or ground plane “ampacity” for those demanding sections of your RF circuit or audio amplifier output stages. Since we’re already in FR4 bashing territory, here’s some tips.

Beef up stripboard supply rails with narrow offcut strips of FR4 pcb material soldered edge on to stripboard tracks, as shown below, left and centre. Single or double sided FR4 is fine, if the double sided strip (shown centre) is mounted between + and - supply rails, it offers easy decoupling capacitor possibilities that don’t use up any stripboard holes. If you can get hold of some thick single strand copper wire, brazing or silver solder rods, the drawing on the right below will help. It uses two copper strips but is low profile and very neat.



The single sided FR4 sits on one edge of a copper strip; the double sided straddles two strips for plus and minus rails (and gives excellent mounting for 01.µF decouplers without using any stripboard holes); the rod sits in the insulating gap and solders to either side strip for a parallel pair.

If any “holes” get bunged up with solder during the previous operation, a deft touch with de-solder braid or a spring plunger sucker will clear them. The surface tension of the solder will maintain a thin bridge into the reinforcing FR4 copper you’re adding. Cut component leads (you do save them in a little screw top jar, don’t you?) can be used to support the FR4 too if needs be.

I’m not going to tell you how I found these tips; but it might have had something to do with taming a 100 watt stripboard audio (modulator) amplifier which thought it it was a power oscillator...!

## Antenna Topics

### Loopy Loops and all that...

[https://w8ji.com/magnetic\\_receiving\\_loops.htm](https://w8ji.com/magnetic_receiving_loops.htm)

W8JI's web pages are where the myths, superstitions and downright rubbish talked about Mag loops are stuffed where the sun don't shine by someone who really knows what he's talking about... and don't forget the idea proposed by one bright spark about the angle to tilt his loop to catch a wave coming down from the ionosphere - the wave comes down at any angle, polarisation, direction: just turn the loop to get best null of noise and highest desired signal. We live and learn!

Note too Chas. Wenzel's superb loop antennas / amplifiers at:

<http://techlib.com/electronics/antennas.html>

As Chas. shows, no real need for excessive technology unless you absolutely have to, so try much simpler and cheaper designs first! Occam and his Razor - "entities should not be multiplied without necessity" certainly helps stretch a tight (i.e. "zero less 10%") G6NGR budget!

### **Wave Traps (again)**

Are very useful if you're (for instance) near a powerful broadcast transmitter which is drowning out your "wanted" witterings. Even the best receivers won't find fractions of a micro-volt right next to milli-volts of Wah-Wah-Boom-Boom signals from your local broadcaster. Give it a hand... use a wave trap to dump the unwanted (a common theme at G6NGR, as you'll have probably noticed) signals, and you'll soon see the improvement. In fact, a pre-selector can work wonders in many other ways too: it allows your £kilo-bucks black box techno-marvel gizmo to perform in a much "cleaner" environment, letting the real technology inside shine.

### **Mast Eye Bolts - think twice...**

Eye bolts for antenna mast guy fixings are not often the best choice. Why? Because they need holes drilling through the mast that not only weaken the mast considerably, they allow the weather and consequent rot and corrosion to gain a foothold. Far better is a (preferably stainless steel) "U" bolt & saddle car exhaust clamp, as they inevitably have a portion of the U-bolt threaded ends available when clamped tight to fit (M6) tapped lifting eyes on - thus you get two lifting eyes at each clamp position for two guy ropes.

I gained this knowledge from repairing (for the umpteenth time) a roof mounted toxic gas discharge pipe for a semiconductor process; the existing pipe fractured regularly at an eye bolt hole. Even doubling the pipe's wall thickness didn't help; it just made the job heavier and more expensive.

I asked an aeronautics whiz (thanks, Simon) at a factory in North Manchester about the problem and he explained: "it's not just the pipe's brute strength. The whole mast will vibrate in the wind and has nodes of zero and maximum amplitude at various places: in an exposed roof top situation, it will sing like a harp, even though you may well not see or hear a thing - it could well be ultrasonic or infra-sonic. Guying will definitely help, but the weak points are the stress maxima around the eye bolt holes. You'll have no more bother if you use external clamp collars, and attach the guys to the clamp bolts. Use stainless steel thimbles in the guy rope eyes, in "figure eight" knotted loops and at your ground anchors where a clove hitch knot allows easy adjustment yet is reliable on load. You might also try attaching some thin sheet rubber or similar small flexible "flags" to the mast with UV proof cable ties to act as shock absorbers. They help damp out the vibration nodes".

And he was quite right. The only thing I added as extra insurance was bonding the clamps to the mast with bearing securing agent (thank you, Mr. Loctite) because I had some, but epoxy adhesive would be fine for most situations.

Thus the pipe is supported, without any drilling or other weakening, and you get free anchor points for the guys. Stainless exhaust saddle & U bolt clamps are available from our favourite auction web pages at fairly reasonable prices.

### Common Mode Chokes?

This topic has been touched on many times; here's some real genuine antenna common sense from the man who knows:

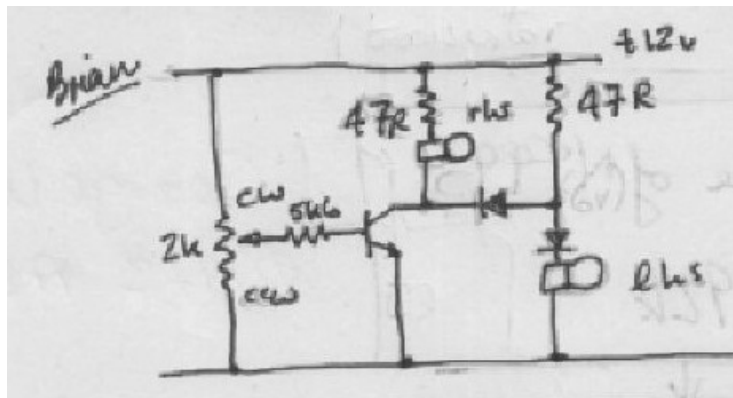
<https://www.pa0nhc.nl/CommonModeChokes/indexE.htm>

The use of looped counterpoises gives a useful reduction in noise: just as a "loop on the ground" antenna cancels common mode noise, then a "loop" counterpoise(s) has been proposed as doing the same. I haven't tried this, but it's a neat idea that has good reasoning behind it and might be a useful adjunct to common mode chokes and the like.

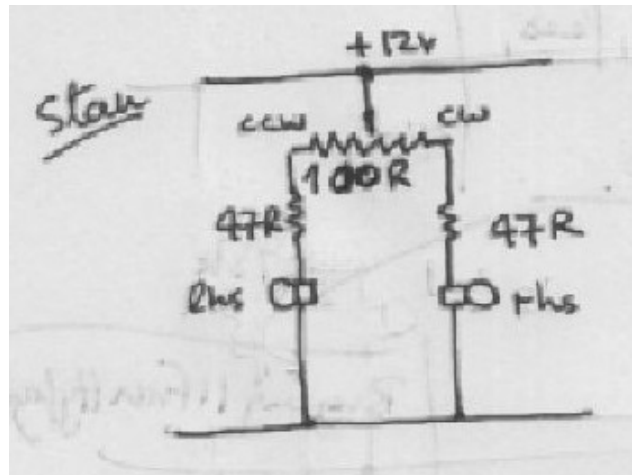
### Finis 2020 and Welcome 2021!

#### Dial Lights...

Here are the circuits for the HP signal generator dial light, from Brian and Stan, as best I can recall them:



Brian built a sort of "OR" gate; as the control pot. rotated clock wise, the NPN transistor "robbed" more and more current from the 47R supplying the rhs lamp. The diode between the rhs and lhs lamp stopped both lamps being half lit when the pot. was fully counter clockwise, and the diode in series with the rhs lamp cancelled the forward volt drop of the other diode when the pot. was fully clockwise. You'll need to experiment with the base resistor (nominally 5k6 with a ZTX300 / BCW10 transistor); it will probably need to be a fair bit higher as you're asking the ZTX300 to perform in a "linear" fashion, not as a switch. 47K wouldn't surprise me!



Stan's circuit is self explanatory; the only comment is that the lamps were a bit dim at the halfway point on the pot. It took a bit of experimentation to get the right value pot., I recall it being 100R but my memory might be wonky!

## Endpiece

All that remains for me to say now is I wish you all a very Merry Christmas and a Happy, peaceful New Year - as far as COVID-19 will allow - in this tumultuous World. Enjoy your amateur radio, remember we do this for enjoyment and self learning, so don't get too seriously involved - leave that to the professionals! But... try your ideas, experiment with circuits, **keep notes of everything** - including why and how it didn't work as well as the amazing results you never expected.

Don't decry historical research, we have in silicon technology more electronic capability today than our predecessors could dream of; though you can bet somebody, somewhere dreamt up your bright idea years ago, but didn't have the technology, opportunity or resources to fulfil it. You DO!

Keep asking "why" on every topic of amateur radio and the Universe you use it in, until you've found the definitive reason. More than anything else, whatever you build or try, keep it simple, robust, and fun: you learn by trying and try by learning.

If it's a nice day, unplug that soldering iron and go climb a mountain, or ponder on what an electron *really* is, but most of all, marvel at the wonders of Nature.

Good luck for 2021!

Peter Thornton, G6NGR