Hot Iron #118

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CQ-CQ-CQ

With both hands?

'Ambidextrous' means capable with both hands; whilst 'ambisinistrous' means unable to use both hands (that's me!). An ideal word therefore for early telegraphers to use, to describe a less than capable keying operator - and hence, taking the first sound - 'am' - is this the origin of terming an amateur telegrapher (assumed to be not much cop with either hand) 'ham'? Just a thought…!

SSB via phasing method

The 'Tucker Tin' by Fred Johnson, ZL2AMJ used AF / RF phasing to make a simple SSB transmitter; before economical crystal filters were available and was a real 'home brew' breakthrough for amateurs. You could put together a functional SSB rig using resistors and capacitors for filtering, add a couple of balanced modulators and you've got a decent job ready to go. Yes, I know the carrier suppression with phasing isn't as good or reliable as the filter method - but - so what? Since, as amateurs, we can use any of our licensed modulation modes - including full carrier A.M. - anywhere in the allocated amateur bands so a minute sniff of carrier, from the 50 dB of suppression achievable with phasing, isn't the end of the World. Nowhere is it written in stone that 'thou shalt not allow less than 60dB carrier suppression'!

The phasing method is a means the impoverished amateur can get on the air with SSB; it's simple, cheap and very (relatively) easy to fabricate. Pat Hawker G3VA gave some excellent 'preferred value' audio phasing networks in his 'Technical Topics' book, that work well for the amateur. What most SSB crystal filter devotees forget is that it's just as much the screening, physical layout and construction that counts, as well as the crystal filter specification to 'eliminate' the carrier; and that's not including the input / output matching of the crystal filter over the bandwidths required.

Yet nowadays you see nothing but the (crystal) filter method. Why? it's cheap(ish), yes; effective, yes; but without very careful construction to avoid carrier leakage at the filter stage and use a mixer that can cancel the carrier perfectly it's almost impossible for an amateur, in an amateur scenario, to create (or perhaps more appropriately, *measure*) anything like the quoted carrier and unwanted sideband attenuation.

The overwhelming drive to create a 'perfect' SSB signal is not really an amateur capability - by sheer definition, 'amateur' indicates a more relaxed specification than 'professional'. Fine if you want to strive for a specification that matches or beats commercial or professional products; but, for the home brewing amateur, on limited budget, with limited fabrication facilities, the the phasing method is a viable and acceptable means of producing SSB.

The 'Way Back Machine'

Kay Savetz, K6KJN, has emailed me asking if Hot Iron can be included in the archives at the Digital Library of Amateur Radio & Communications. Well, my 'gast' was truly 'flabbered' with this request! The library (abbreviated DLARC) is known for holding the 'Wayback Machine' where you can find masses of information archived; it's practical 'time travel'!

In the spirit of Andrew Carnegie, I'm all for the dissemination of information, free for all, open to all - and am myself a member of the magnificent Central Library in Manchester (UK), set up specifically as an open learning resource in the first truly 'modern' city of the World.

Therefore I'm greatly honoured to have Hot Iron included in the DLARC archives. Have a look below and see, you'll find yourself down a proverbial rabbit hole wandering amongst the past - all for free. What a magnificent resource for all radio amateurs - and all the other topics to be found there - see:

http://www.arrl.org/news/amat
https://youtu.be/ZNPtKMoGagg
https://archive.org/details/d

Simplicity? Yes please!

Thank you to all readers who have requested that I continue the 'simple designs' theme in Hot Iron. I accept it's fair to say you're not going to get that delicious gem of Dx with a one transistor receiver; nor are you going to reliably call up our Transatlantic or Antipodean colleagues with an ECL82 one bottle transmitter - but you get a real buzz in building such a transmitter in an evening and calling up local - and not so local - amateurs with it; and a transistor or two to receive the reply.

Our GQRP brethren have proved beyond shadow of doubt you don't need radiated kW's to have a lot of fun, learn new skills and discover fundamental radio truths, so onwards we go - 'simple is as simple does', I'm with you all the way.

I have received emails about reflex and super-regenerative receivers, apparently these receiver techniques aren't too well understood, and even less, appreciated. One of my favourite designs - that fires up reliably with little, if any, faffing about - is a reflexed super-regen, using an NPN transistor of the 2N2222 or 2N3904 variety. The design (shown later in this edition, and in previous Hot Iron editions) is a good example of how one transistor can do several jobs *at the same time* if the surrounding circuitry is set up to enable this; and how altering the operating mode of a transistor from common emitter to common base can result in very different frequency capability from a common-or-garden transistor.

Mains sockets UK…(1)

A YouTube video I saw t'other day sang the praises of our UK mains outlet plugs and sockets (type G), as compared to the common US plugs (types A & B). On the whole, the video considered our chunky UK 3 pin plugs as being very safe, as compared with the smaller US 2 pin plug. As a finale, the video pointed out 3 "problems" with UK 13 amp plugs: the size of a UK 13 amp plug, the installer having to work out current distributions in a 'ring' circuits, and finally, the problem of standing on a UK 13 amp plug in bare feet, saying it was worse than standing on a 'Lego' block!

Here's my response to the "problems" noted by the video, and, as ever, I welcome any comments, one way or t'other.

The size: yes, UK plugs are big - and perfect for gripping with old, arthritic fingers. It was noted that you can't pull a UK 13 amp plug from the wall socket with the cord; the UK plug tilts and locks in place which the video thought a 'good idea'.

The video thought that installing electrician had to work out the load distribution in a ring circuit: no Sir; not at all. Each ring (covering < $25m^2$ floor area) is fed by a 32 amp miniature circuit breaker into which are connected the two ends of the ring, 2 off 'twin and earth' (T&E) $2.5mm^2$ (~12 AWG) cables in parallel, so it doesn't matter where the loads are, with two cables feeding every load point and the floor area limit (with diversity) means the cables in the ring circuits don't have volt drop issues or surge current limitations.

And standing barefoot on a UK plug? Yes! It does hurt!

Mains Sockets UK...(2)

The 'functional earth' terminals behind a 13 amp socket used to be wired in cream coloured wire; the latest UK 'Regs' demand they are wired in pink, and I'll bet you didn't know that, did you?

I can already hear the voices - "earth wire coloured cream, what's he talking about?"

Well, if you look at modern UK electrical outlets, you'll notice the earth terminals - the ones that go to the screw hole bushes to earth a metal back box and connect to appliance cases to protect us from shock - have some others adjacent: unlike the "CPC" (**C**ircuit **P**rotection **C**onductor) earth terminals with their earth symbol in a full surrounding circle, the 'functional' earth terminals are in a semicircle moulding, and are for a 'clean' or 'low noise' earth connection for electronics, IT data cable screens and the like - and are **NOT connected to the mains (CPC) earth** . It won't be long before somebody thinks that they are the CPC safety earth, and finds out the hard way,!

Be sure you earth to the mains earth (the 'CPC' in green//yellow) **all** the 'touchable' metal bits of your gear, and keep your 'functional earth' **completely separate** from the mains earth.

Here's something useful I found, from https://incompliancemag.com/article/the-grounding-symbols/ whom I thank for being accurate and succinct:

"With the various markings available to identify ground terminals, how do you know which specific symbol should be used? The international standards are the right place to go for guidance, and this column will outline these best practices for use of earthing (grounding) symbols and markings.

The Grounding Symbols

Identifying the ground terminal is critical to ensuring the products you design can be properly used and serviced in a safe manner. The actual symbols used to indicate ground terminals are found in IEC 60417 Graphical symbols for use on equipment (Figure 1).

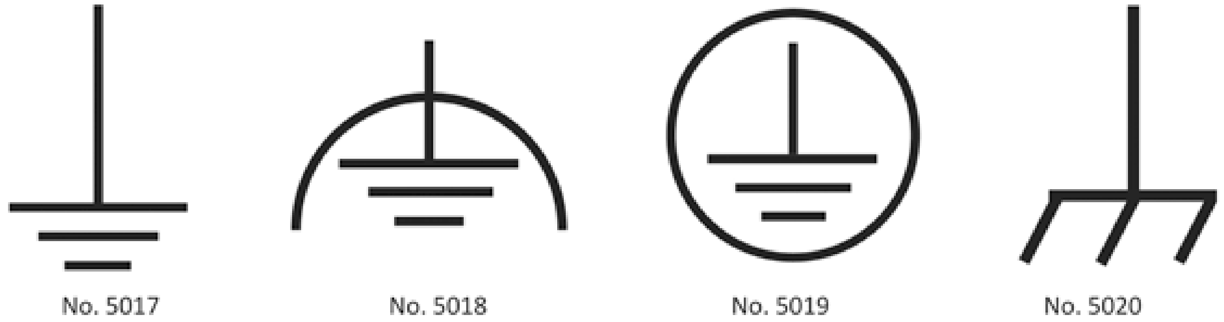


Figure 1: IEC 60417 ground symbols

Here are the IEC definitions for each symbol:

***No. 5017 Earth (ground):** To identify an earth (ground) terminal in cases where neither the symbol 5018 nor 5019 is explicitly stated.*

***No. 5018 Noiseless (clean) earth (ground):** To identify a noiseless (clean) earth (ground) terminal, e.g. of a specially designed earthing (grounding) system to avoid causing malfunction of the equipment.*

***No. 5019 Protective earth (ground):** To identify any terminal which is intended for connection to an external conductor for protection against electrical shock in case of a fault, or the terminal of a protective earth (ground) electrode.*

***No. 5020 Frame or chassis:** To identify a frame or chassis terminal."*

Now you've had a taste of UK Regulations…

I was once sent on a training course, which taught me how to size cables by Prospective Fault Currents and the like. Back at work, I bumped into Stan and told him of my newly acquired knowledge. 'Hmm…' quoth Stan; 'keep to mind the original IEE Regs: volt drop is the most stringent requirement for cables, and has been ever since the Regs were first written. Prospective Fault Current calculation will most likely give a cable size equal to or less than the volt drop requirement: but you MUST keep to volt drop limits above all else'.

He was, of course, right: you size cables to comply with the volt drop limits (that date from 1882!) as copper is still copper, volts is still volts, and I^2R is not a passing whim, nor to be discarded as 'out moded'. I work to 2.5% volt drop at the load; in the USA it's 2% if my memory serves.

So we come to today, with earth leakage circuit breakers, miniature circuit breakers and the like. The Institute of Electrical Engineers (who created the UK 'Regs') are viewed differently by different users: some installing electricians see the IEE Regulations as a license to print money, the public see them as a complete mystery. The IEE Regs authors love abbreviations and terminology that puts the fear of the good Lord into the average reader; solicitors and lawyers love 'Regs' as they profit from ensuing litigation. Now local UK town hall 'jobsworths' have a finger in the pie with 'Part P' electrical regulations - all legally enforceable - and can charge £300 for a house owner notifying them of simple electrical work i*n their own home*. Of course, if you employ a member of one of the Electrician's Unions (NICIEC, the National Inspection Council for Installing Electricians, for example, there are others) then you pays your £300+ to a sparky (this was quoted to me for a minor job recently) and ½ an hour later he gives you a bit of paper with some ticks on it that take care of your legal obligations.

Being a professionally qualified electrical engineer with 55 years or more experience, designing, installing and maintaining electrical machinery (and the factory building they reside in) for the safety of 2,500+ operators counts for nothing: if you're not an 'Installing Electrician' your professional experience and qualifications count for naught. You have to ask an 'Installing Electrician' with an automatic test instrument to look over your work and pronounce it safe.

It's a good job the UK 'Regs' are not retrospective: otherwise every Consumer Unit (incomer distribution panel) in the UK would have to be updated as AFDD's came around (see what I mean about abbreviations?). This is why the IEE Regs writers rapidly issued an errata; now only certain buildings have to have AFDD's, like Care Homes, Houses in Multiple Occupation and a couple of others. AFDD? **A**rc **F**ault **D**isconnect **D**evice, or **A**rc **F**ault **D**etector **D**isconnect, or… perm any 4 words from many!

This reminds me of an earlier 'Regs' fiasco demanding 'extraneous conductor bonding' some years ago, which resulted in irrelevant earth wires all over the place - even floorboard nails had to be earthed to fully comply. I witnessed this manic earth bonding in a bathroom: it was a fibreglass bath, with plastic hot and cold water pipes and a PVC waste trap, all solidly earthed!

Part P Building Regulations and amateur radio wiring

I'm busy reading the Part 'P' Building Regulations which cover domestic Electrical Installations here in the UK. Part P states that it applies to 'all **fixed** electrical installations'. This therefore includes any wires (and co-ax?) we fasten to a wall, shed or outbuilding, in and around our houses. The Part 'P' Regulations say '**ALL fixed**' wiring… it makes no distinction between AC mains, DC or RF wiring; nor does it define '**fixed**'. I'm ploughing through pages of convoluted 'legal' documents and explanatory notes; I've even found explanatory notes for the explanatory notes!

Suffice to say I agree with the safe installation of electricity in houses, but Building Regulations have nothing to do with amateur radio wiring. Watch this space, and if any UK sparkies are amateurs reading Hot Iron, please email me as I want to get to the bottom of this fiasco.

End note: fires caused by faulty electrical installations have dramatically increased in the UK since the introduction of (very costly) Part 'P' regulations. Who'd have thought it?!

Receivers

A remarkably beautiful receiver

From: https://antiqueradios.com/forums/viewtopic.php?t=373629

'*A Google Image search for Direct Conversion receivers using the NE602 (NE612 SA612) double balanced mixer will reveal numerous, perhaps over 100 similar schematics designed for the 80 to 10 meter amateur bands. Kits used to be sold by Vectronics and Ramsey.*

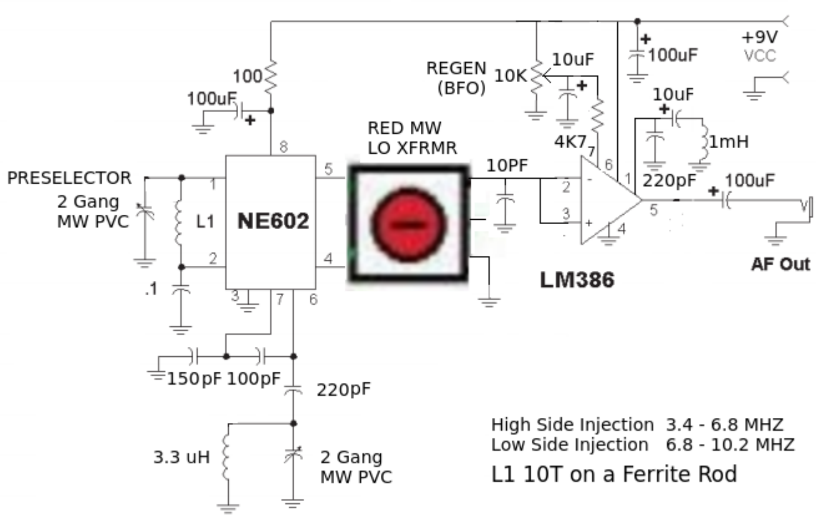
I was never happy with their performance and for this reason I built a simple superhet using an LM386 audio amplifier as a regenerative IF detector-amplifier. Using 10 turns on a ferrite rod as a preselector enables the receiver with the values shown to use both high side and low side injection to tune from 3.4 MHz to 10.2 MHz in 2 bands.

No external antenna is necessary for casual listening and selectivity and performance are comparable to my best commercial portable short wave receivers using their built in whip antennas. I use it most evenings to listen to SSB on 80 and 40 meters up and down the East coast of the U.S.

The IF transformer is a 'red' medium wave local oscillator transformer which in my case is tuned to 1.7 MHz. A variable local oscillator frequency of 5.1 to 8.5 MHz permits 2 band coverage using both low side and high side injection by tuning the front end preselector variable capacitor. Image rejection is good and by properly arranging the IF and LO frequency values there is little chance of *overlap. Unlike a pure regenerative receiver, a superhet using a regenerative IF permits tuning across the bands without having to vary the regeneration control.*

The LM386 audio amplifier is set up as a high gain regenerative RF envelope detector which when oscillating allows the reception of CW and SSB signals. Although adding varactor fine tuning would be an asset, the regeneration control varies the receive frequency slightly and is useful to fine tune SSB reception.

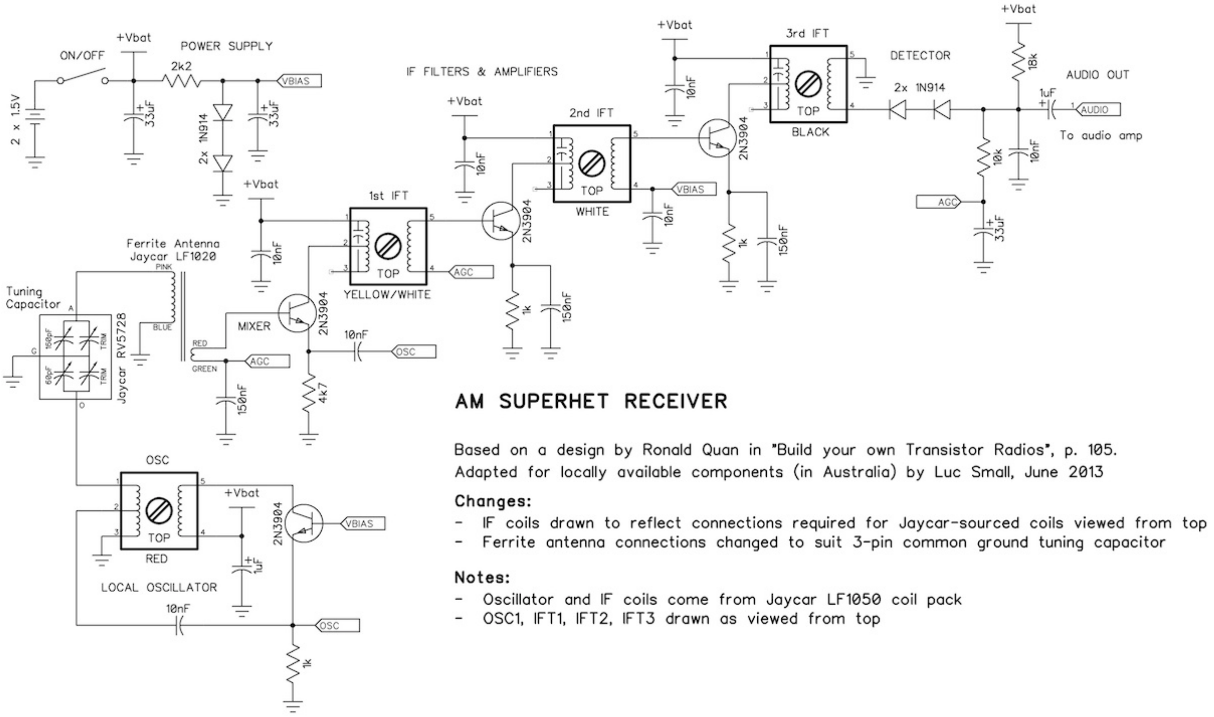
The photo shown below is that of a modified QRP Kits EASY Direct Conversion receiver which has a varactor fine tuning and after modification uses the original audio volume control for regeneration.'



Shortwave Superhet With Regenerative IF

Isn't that a neat way to use an LM386? The 'red' transformer is detailed in another design, from :

https://lucsmall.com/images/2013-05-10-am-superhet-radio-schematic.jpg



The transformer has a centre tapped winding on one side, and a single winding on t'other - thus the windings can be identified in the regenerative IF receiver.

A ZN414 Gallimaufry

As I searched for some data, I came across:

https://cool386.com/zn414/zn414.html

I worked in the Ferranti Semiconductors Test Gear Maintenance workshop, adjacent to the Applications Lab, from whence came 120dB whistles, bangs, flashes and musical interludes as a daily symphony. We were frequent visitors to the 'Apps Lab', to ask about the various circuits we came across in repairing commercial instruments and test gear, and the Apps Lab staff were always interested in seeing circuits inside the commercial test gear we had in for repairs and calibration.

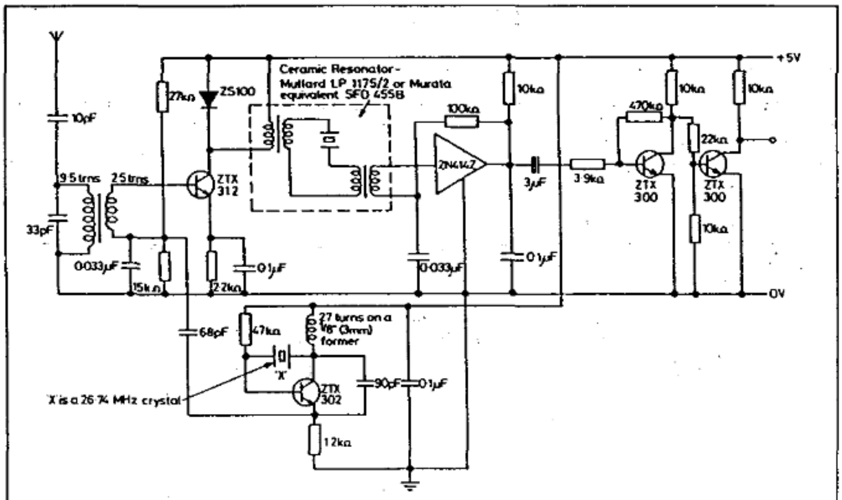
The ZN414 was in many Apps Lab RF experiments, and powered our Maintenance shop radios - since the medium wave broadcasting of the day was limited to a local A.M. music channel, it was a strange effect walking the length of the workshop, hearing the echoes and time delays of the numerous radio outputs, all tuned to the same station! A favourite was the 'Triffid' receiver, a neat design that worked magnificently, see:

https://www.cool386.com/zn414/PE_Triffid.pdf

...though nowadays we'd use a one chip audio output stage, most likely an LM386, and probably a more sophisticated AGC / power feed to the 414, rather than the usual 10k & 100k resistors.

The ZN414 makes a potent superhet too in the IF stages, as below:

The circuit below shows a ZN414Z used as an I.F. amplifier for a 27MHz superhet receiver.



Performance Details:

Sensitivity = 2.5μV for a 5V p.t.p. output measured at f_C = 27.21MHz.
100% modulated with 100Hz square wave.

Selectivity: ±5kHz for <100mV p.t.p. output.

Input Signal Range: 2.5μV to 25mV (i.e. 80dB)

Supply Current: ≈ 4.5mA.

With a little adaptation, this circuit will run 10, 12, 15 metres - or any other HF band you care to try. The weakness of this design is the rudimentary mixer using the ZTX312; not that the ’312 is in any way inferior, but a ‘stronger’ (balanced?) mixer and tuned RF amp. will likely perform far better. The input impedance of the ZN414 is stated as 4 Meg-ohms, so matching the filter is relatively easy. Crystal filters are very good contenders for a superhet with a ZN414.

Here’s a novel take on the ZN414 (a.k.a. MK484) that provides good performance - and can benefit from some of the more esoteric ZN414 drive / AGC enhancement circuits. This looks like an 'Elektor' schematic - my grateful thanks to them - and it will certainly perform on Top Band and 80m; if you try really hard, you’ll get a hot ZN414 / MK484 up to 60m and possibly 40m.

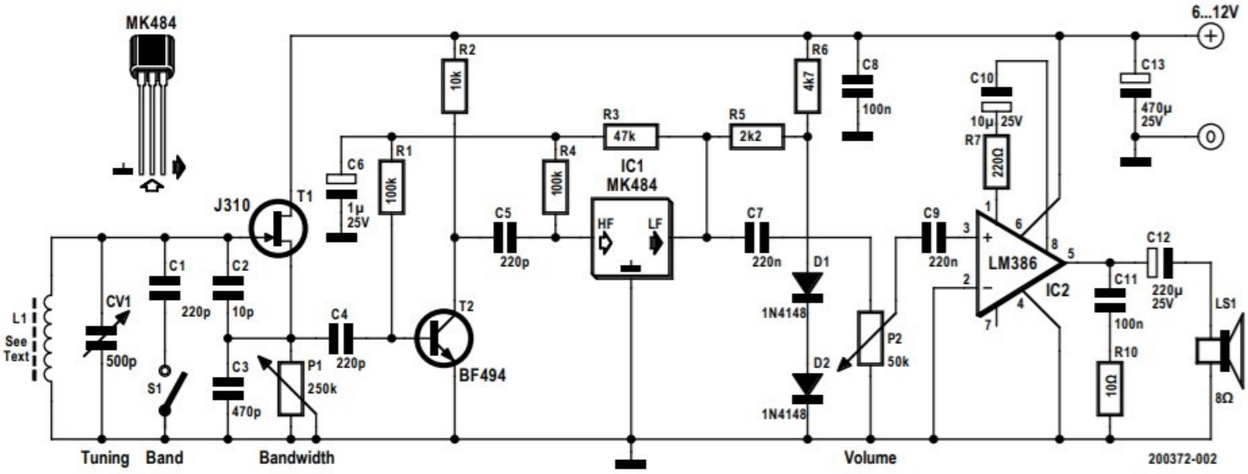
'*Three RF stages permit the reception and detection of AM radio signals in the MW band (usually 500-1600 kHz). T1, a type J310 junction FET,* (try a 2N3819? Ed.) *provides positive feedback for the antenna tuning circuit. The feedback limits coil damping, increases sensitivity, and narrows the overall bandwidth. The antenna, L1, consists of a 120-200 mm long, 10 mm diameter ferrite rod holding a coil with 55 turns of 0.2 mm diameter (~ #24 AWG) enamelled copper wire (ECW), close-wound. CV1 is a mica- or air-spaced 500 pF tuning capacitor providing a frequency range that matches the MW band. The tuning range can be extended down to about 150 kHz by closing the band switch S1.*

The second stage, comprising of a BF494 (T2), increases the receiver sensitivity and amplifies the MW signal for the input of the third stage at IC1, an MK484. This 3-pin integrated circuit, originally launched as the type ZN484 by Ferranti in 1972 contains a complete RF amplifier, a detector, and AGC circuitry, making it one of the most popular solutions for building straightforward AM-receivers. Although the original ZN41 devices are long since obsolete, modern equivalents of the original 3-pin ZN414 are available, such as the MK484.

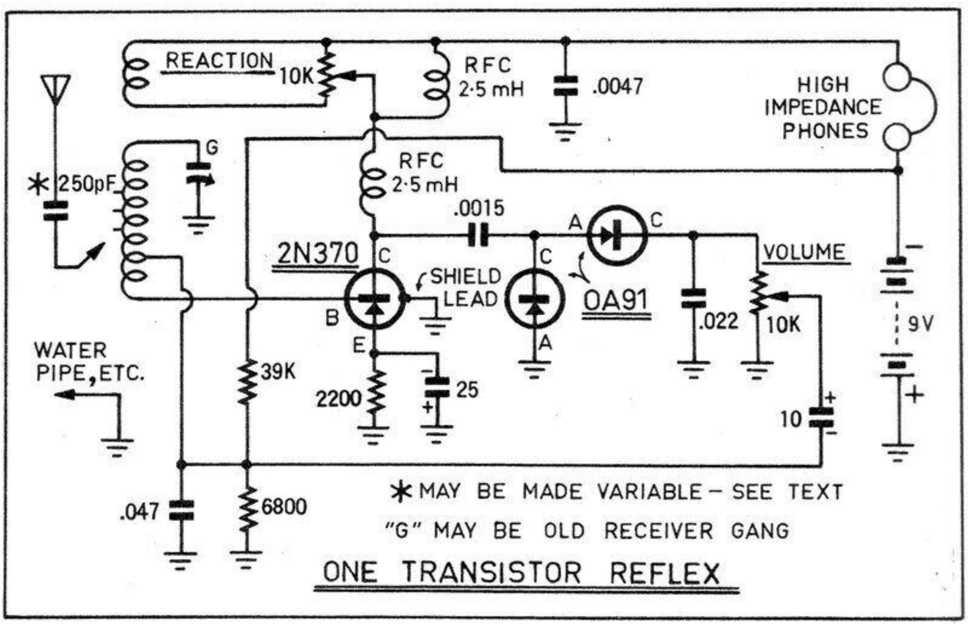
Lastly, we have the good-old LM386 (IC2) acting as an audio amplifier and loudspeaker driver, *complete with the prescribed Boucherot* (Zobel? Ed.) *network formed by C11 and R10. The ‘386 is sure to ring a bell with many readers.*

Reception is optimal with bandwidth control P1 correctly set — simply make the adjustment by ear. The tuning range can be extended down to LW with a fixed capacitor, C1, connected in-circuit by S1. With the additional damping this introduces, the positive feedback at low frequencies may drop excessively. Fortunately, this can be compensated for by using a smaller value for capacitor C3.

Some tuning, tweaking, and experimenting may be required to get it just right for MW and LW. A larger value for C1 can also help to extend the tuning range. At frequencies higher than ‘official MW,’ i.e., above 1.6 MHz or so, you’re unlikely to find any (legal) AM stations. By mounting two ferrite rods side-by-side, the cheap and simple antenna can be improved in both directivity and selectivity.'



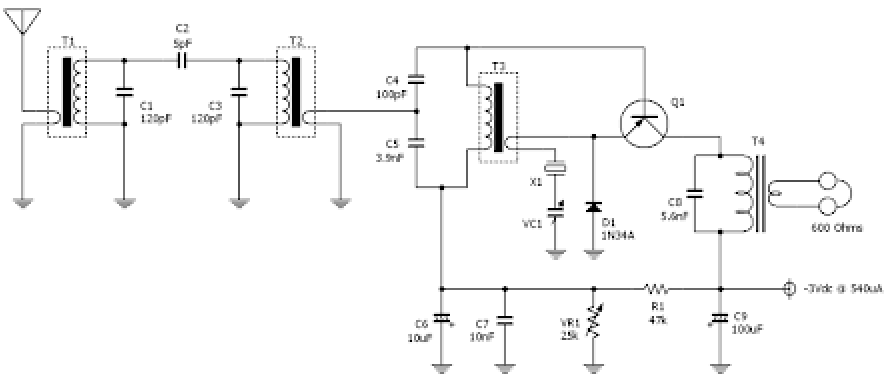
Reflex, Regens and Super-Regens



The circuit above is a *reflex*, you can see the demodulating OA91 diodes, and the audio they develop is fed back to the 6k8 resistor and 47nF RF decoupling capacitor to be amplified by the transistor as audio. The 47nF capacitor is the crux component: it presents a low impedance path to earth for RF, yet doesn't 'leak' too much audio to earth. Such circuits were very popular in the late 1950's and early 60's, when transistors were very expensive (note the odd-for-today transistor symbols!) and of very wide spread characteristics. Reflexed designs tend to distort the audio on large signals as, like a regenerative receiver, they overload easily - the single transistor is dealing with double the signals a single non-reflexed amplifier has to cope with.

This next is a regenerative (or 'TRF') from Mike Rainey, AA1TJ, and is an absolute beauty - I've built a few of these and they really do perform. This is magnificent engineering, as are all of Mike's designs. Mike's truly a master of the 'art of RF'.

Using crystal control in a regenerative receiver renders it ideal for CW enthusiasts, as such amateurs use only small sections of the HF bands and crystal control is (almost) mandatory in the UK. A crystal dramatically cuts the receiver's bandwidth, some shunt pF's and / or a resistor across the crystal can help speech quality by opening up the bandwidth a bit. The article below is from Mike Rainey's web pages.



T1, T2: 10mm, shielded "IF can," 16-turn main winding, 3.5 to 6uH; 2-turn coupling
T3: Ditto above, except 1-turn coupling
X1: 40m quartz crystal
VC1: 20-360pF -> 3kHz frequency shift
VR1: bias set/regeneration control; adjust for maximum signal sensitivity
Q1: 2N504 Germanium transistor (AF124, AF125, 2SA71, 2SA121 and 2N966 also worked well)
T4: small ex-power trano (junk box find); primary 11H, secondary 500mH (15k Ohms: 600 Ohms)
C8: Select value to cancel residual T4 inductance at ~ 700Hz

Xtaflex

40m VXO Regenerative Receiver
Based on Sir Douglas Hall's "Spontaflex"

de AA1TJ

6/1/2009

This circuit is based on the Autoflex/Spontaflex receiver designed by Sir Douglas Hall. It turns out that Sir Douglas' clever circuit works well as a one-stage, crystal-controlled (VXO'd) regenerative receiver.

As he explains in his June, 1964 article (thanks Geoff!), the transistor functions as a common-collector radio-frequency (RF) amplifier in which the gain is augmented by regeneration. The high impedance looking into the base helps to reduce the input tank circuit loading. C8 places the collector at RF ground. Demodulation is provided by the Germanium diode at the emitter. The base of Q1 is at ground potential for AF. The parallel combination of C8, T4 and the headphones provide a 15k Ohm collector load resistance (15k + j0 Ohms) at **700Hz**. Q1 operates as a common-base amplifier at AF. The circuit may thus be described as a crystal-controlled, regenerative, reflex receiver; or, Xtaflex, for short!

This crystal-controlled regenerative detector is virtually immune to frequency shifts due to hand-capacitance or antenna "swinging." Neither does the frequency pull when receiving strong signals at a low beat note. Here is an audio snippet sampled at the headphone terminals. Please notice how it's possible to tune through zero-beat with a strong, incoming signal without the slightest hint of synchronization (frequency "pulling"). In operation, this circuit "feels" more like a direct-conversion receiver than a straight-regenerative set (of course, a regenerative set is a direct-conversion receiver "at heart").

The circuit shown in my schematic diagram is built for 40m. I've used it on the 30m band by changing the frequency-sensitive components. In fact, the rock-solid frequency stability of this regenerative receiver will shine progressively brighter as the frequency is raised. What's more, the degree of VXO frequency shift will increase along with the operating frequency. My **40m** prototype exhibited a VXO shift of **3kHz**. On **30m** the shift was **5kHz**.

Under crystal control, a stable regenerative receiver for 15, 10 or even 6m appears to be a practical proposition (an RF amplifier placed ahead of the detector will likely prove useful on these higher bands). On these these higher frequencies it may be possible to eliminate the bandpass filter and connect the signal source directly to the C4/C5 node.

Generally speaking, there are a few tricks for obtaining smooth regeneration using modern, high current-gain, transistors. Wes, W7ZOI, recently mentioned a friend of his that builds smooth-operating regenerative detectors from (modern) bipolar transistors by swapping their collector and emitter in order to reduce the current gain. I've been achieving the same results (without needing to swap the emitter - collector) using early, low current-gain, Germanium transistors. The Xtaflex, for example, uses a Philco, **2N504** MADT (Micro Alloy Diffusion Transistor); date-coded, September of 1959. Another example is my Talking Doll, which uses a **2N107** in the regenerative detector.

Charles, N1TEV's well-known bipolar regenerative detector achieves the same end with a **2N2222A**, running at an unusually low collector voltage.

Lacking such methods the device transconductance will increase dramatically with collector current; as noted on page two of Ian Hickman's Imp (click-on "PW Imp: I. Hickman," third from the top) receiver article. Ian cleverly linearises the regeneration control by using a differential-pair in his bipolar transistor-based detector.
I would like to express thanks to my friend, Jim Kearman, KR1S, for re-planting this idea for crystal-controlled regenerative receivers. I happened to be doodling with a Spontaflex receiver when Jim's message arrived, telling of his experiments with crystal-controlled regenerative detectors. Talk about serendipity!

Links/Reference

http://qrp.kearman.com/html/vxoregen01.html Jim, KR1S's, JFET, VXO regenerative detector

http://home.comcast.net/~phils_radio_designs/ Dee/Mitch-Dyne; the JFET diode is interesting

http://www.io.com/~nielw/3tube_xtal/3tube_xtal.htm Quartz crystal inside regenerative FB loop

"An Ultra Simple W1AW Receiver," QST Magazine, May 1997, by N1TEV and WU2D

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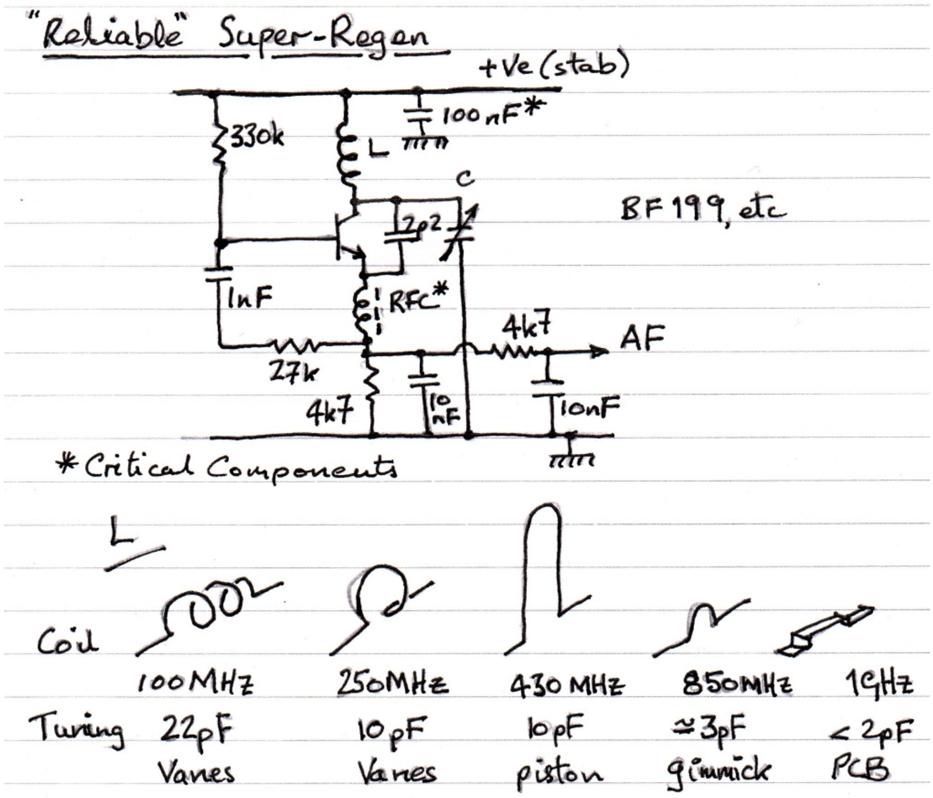
Below is my favourite super-regen receiver. Needless to say, it MUST have an antenna isolating RF stage to prevent unwanted radiation! The key to this circuit are two components: the emitter choke and the decoupling capacitor (100nF). Keep to accepted VHF /UHF practices, minimal lead lengths, heavy *plain* copper wire for coils / hairpins. It just works, unlike a lot of the j-fet super-regens I've tried; I think the wide spread of j-fet parameters are a problem, but don't quote me!



Critical components:

RFC = 6 turns on ferrite bead (100MHz), reducing proportionally to wire straight through for 1GHz

100nF capacitor = mounted in a through slot in double sided pcb (FR4) material; earth on top side, +ve on underside. Component leads are via chamfered holes (to prevent shorting on top side earth plane). MUST be fitted immediately adjacent to cold end of 'L'.

Tuning capacitor = piston trimmers are good but for 850MHz and 1GHz, a small piece of earthed pcb board material can be moved near the hairpin / bridge or cut and try a small square adjacent to L and filed down until frequency is set. Manhattan pads make ideal low-pF capacitors!

Apply the RF input to any of the transistor leads with a gimmick capacitor or proximity coupling; see which gives best results.

The super-regen above has worked faithfully for me at GHz frequencies, by using as near zero component lead lengths, or preferably, chip components soldered through slots in the pcb or on earthy top side as appropriate. Try several BF199's, they can be quite different in performance at these frequencies, and the 2p2 collector to emitter capacitor isn't often required above 250MHz unless you've got a BF199 of exceptionally low internal capacitance.

The 27k and 1nF to the base is a reflex circuit: the BF199 is in common base for RF (hence very high frequency capability) and common emitter for audio. You can hear the difference!

LF and VLF thoughts…

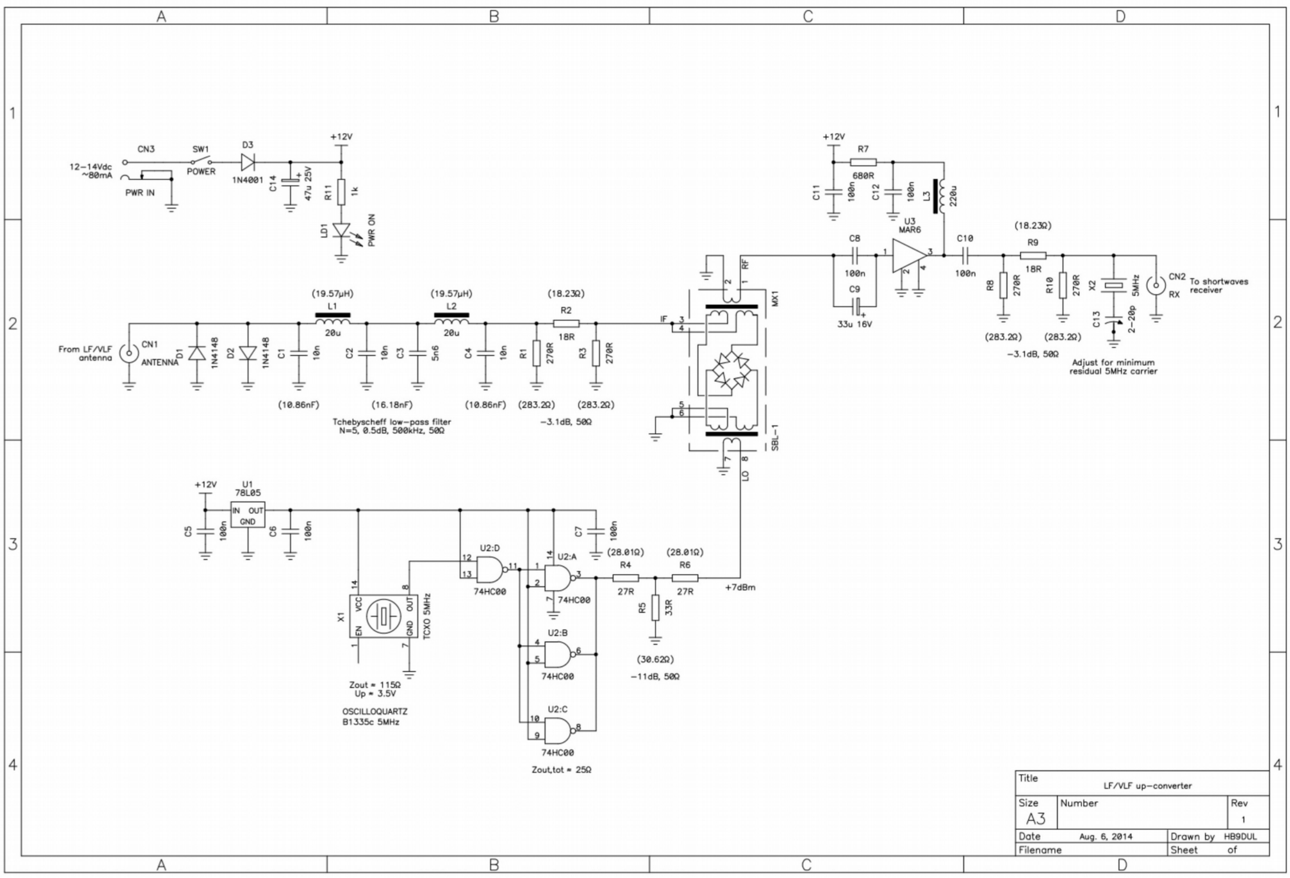
I've always had an interest in the lower end of the RF spectrum; simple receivers and loop receiving antennas make the listening comparatively simple. There's lots of fascinating work to be done down there towards DC; Schumann resonances, earth signals and all sorts of weird and wonderful

phenomena that are little understood, even nowadays. See:
https://en.wikipedia.org/wiki/Schumann_resonances

There are simple methods that make your HF gear able to investigate these signals, an ‘upconverter’ will do the job very nicely, meaning all your HF technology - Software Defined Radio, digital signal processing and the like - can be brought to bear. This being amateur radio, though, you’ll know that simple ideas can soon become very complicated! The design of the upconverter is critical, just as much as in HF Rx. You need to consider very carefully things like mixers, input filters and all the rest of good receiver design, and one such design is:

https://www.giangrandi.org/electronics/lwupconv/lwupconv.shtml

The circuit is reproduced below to give you an idea of the thoroughness Iacopo Giangrandi HB9DUL has applied to this job; take a look around his web pages and you’ll be in no doubt as to why Swiss precision engineering is the best in the World, bar none. Iacopo’s workshop (read ‘laboratory’) is far better than most of the workshops I’ve worked in professionally!



Note the crystal filter in the output section to remove the local oscillator signal - very simple and effective, as is the input signal conditioning. That’s quality engineering and design - Swiss style.

Oscillators

Simplicity and Crystal power (1)

Crystal current is a topic relatively unexplored - until now? I can find few, if any, really definitive articles to explain what is really happening inside a quartz crystal, for my deeper understanding of what can - and can't - be done with our little geodesic gems.

To replace an 'FT' brick crystal in an old valve design, it came to me to consider the *paralleling or series connecting* crystals. If my fundamental electrical theory still applies (you never know in this day and age!) then two *identical* crystals in parallel or series would dissipate 2x the power allowable in a single crystal.

I put this question to a crystal supplier here in the UK, with this reply:

'*The answer is not that simple I am afraid, firstly, in general, as soon as you over-drive a crystal the output distortion and spurious responses increase, too much power and the crystal will shear from its mounts. However, it will be frequency dependent and the higher the frequency the thinner the blank leading to more risk of damage.*

The old low frequency crystals were larger, thicker blanks which could handle more power depending on the mounting system.

I am afraid I am not aware of a 'wrap around' circuit such as you describe.'

Best wishes, &c., &c.'

So, it would seem, that the basic principle of parallel or series connected components sharing the applied voltage *is not applicable* to crystals: the reason (to my limited thinking...) being - that even if the crystals are nominally of identical frequencies - the crystals are NOT exactly electrically identical and can't be assumed as such. But see this article:-

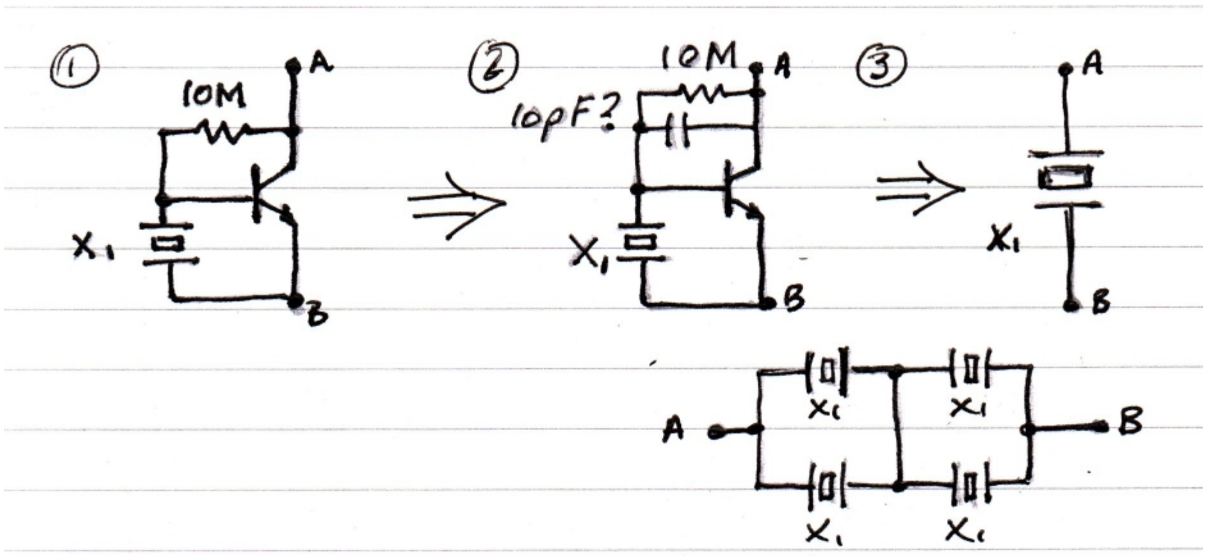
https://electronics.stackexchange.com/questions/413054/confusing-quartz-crystal-impedance-graphs

...illustrates, in the responses to the article, a whole host of different thoughts and interpretations regarding the 'simple' crystal's electrical characteristics.

I was thinking about the old 'FT' crystals - the 'brick in a box' type, *tour de force* pre 1960 and how they could possibly be mimicked by modern crystals, the 'speck of dust' SMT types arranged in a series // parallel matrix to get a watt or two dissipation: the idea being to replicate old valve designs that gave crystals a real shellacking in terms of current.

It seems from the crystal supplier's reply you can't just shunt together a host of crystals; but my thinking is along these lines, that in this Universe it's a fact that if several objects are sharing a load, the energy will be shared amongst them according to their resistance - or in crystal terms their internal friction - and in any crystal you care to name, a Watt's a Watt; a Joule's a Joule, and never the twain shall be anything but.

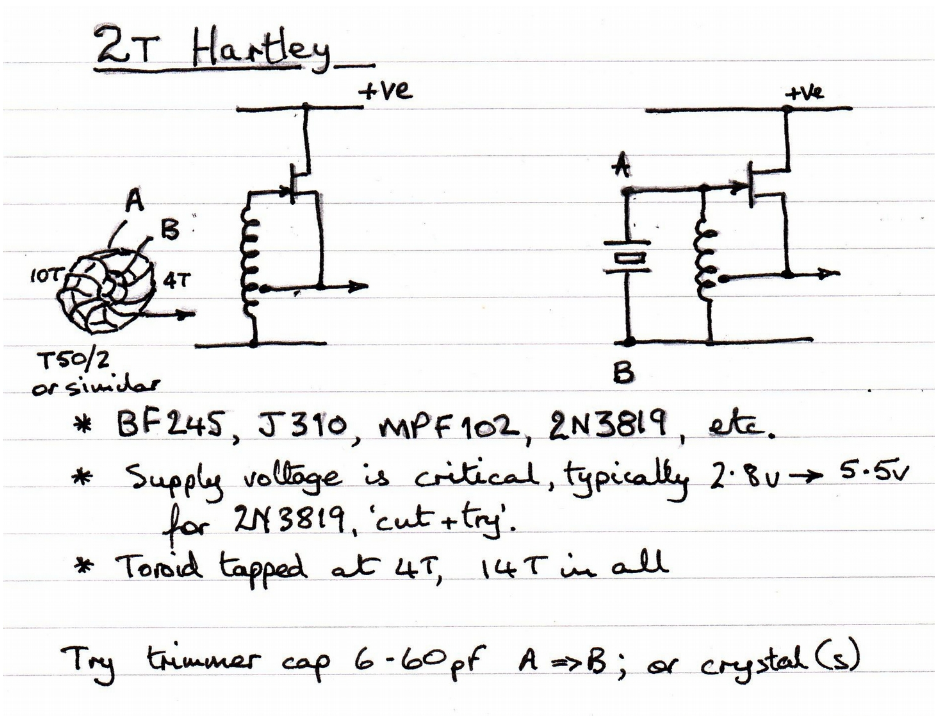
I thought about 'wrap-around' schemes - as you would 'wrap' a PNP transistor around a 78L05 regulator to gain extra 'wattage' - from a mini crystal, series and parallel (below). A and B are the connections for an 'FT' crystal in the original valve circuit.



The idea in (1) is that the 10M resistor feeds a sniff of forward DC bias (not enough to allow self oscillation) and signal to the base and X1; thus X1 controls the base of the transistor and modulates the collector current. (2) is similar, in that a small value capacitor feeds some RF signal to the base; the 10M resistor adds a sniff of DC base bias to put the transistor in to conduction at a low collector current until the crystal, at resonance, creates Q factor mV's in the base circuit so the transistor mimics the crystal. (3) is a series - parallel matrix of crystals, all nominally the same frequency; the energy applied A to B is shared between all the crystals. Well, that's the theory, anyway!

The series connection of crystals is common in amateur designs: think of the crystal filters in an IF strip. Thus we deduce crystals CAN be operated in series, albeit in a filter at very low dissipation; so who's going to try a handful of nominally identical crystals in series // parallel and see how many watts can be safely run through the assembly? Over to you!

A 'minimalist' 2T Hartley



Minimalist oscillators, ideal for quick Rx tests, are a useful bit of kit: here's a down and dirty solution, a very simple j-fet Hartley (from Elektor via http://qrp.gr/2cosc/index.htm). The basic circuit (above, left) relies on self capacitance in the coil; try a trimmer A to B, or a crystal and see what happens.

Simple circuits can be extremely frustrating: they either sing like a bird or refuse point blank to do anything, and with so few components, you're left little choice as to what to change! In this case it's the +ve supply volts, tap point and j-fet type. I tend to go for 2N3819's; they are pleasant little beasties, happy to give their all, and not at all fussy, but please try whatever you have to hand. A variable power supply (current limited) is a God-send!

Taming a VFO… (1)

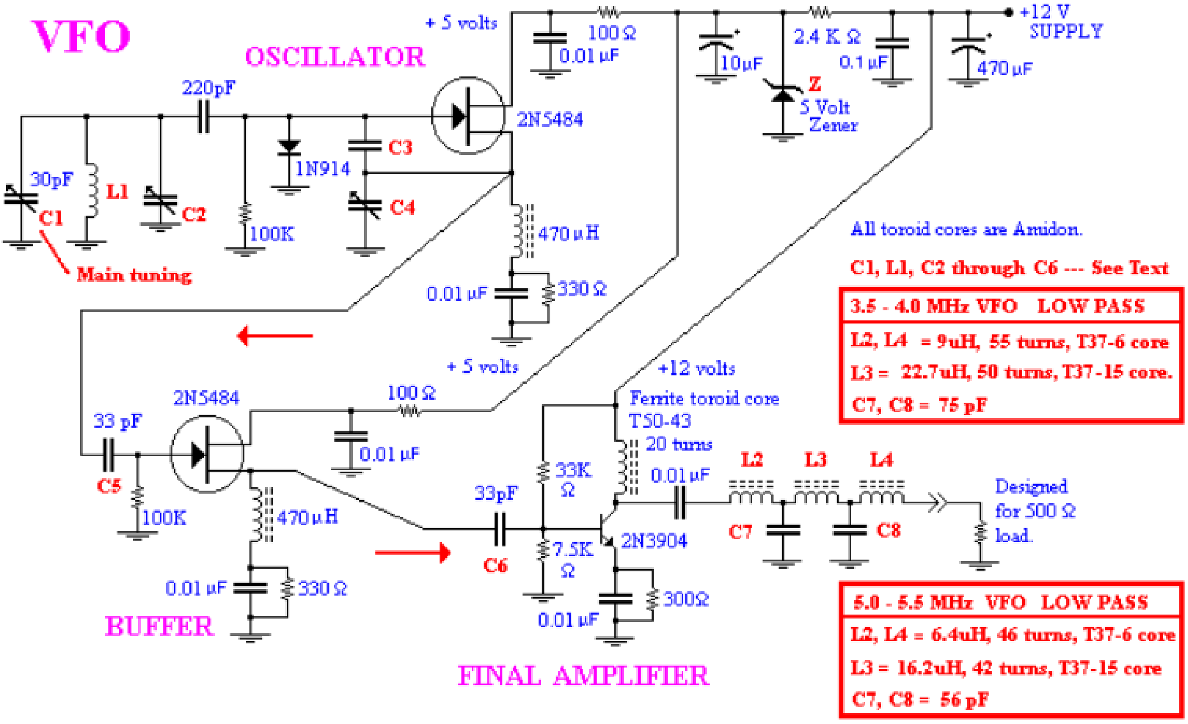
If you would wind your VFO coil with chunky copper wire, you might choose a threaded former, like a 15mm or 18mm (¾' UNC?) steel bolt, then once sure the coil is of satisfactory turns, the coil is 'unscrewed' and a similarly threaded rod made of tufnol or other insulating material can be 'screwed' in and out of the coil to vary the self capacitance of the coil - thus giving you a capacitive 'fine tune' function, not 'permeability' tuning. This however, relies on the coil turns being very rigidly fixed which is not easy in such an assembly! Any insulating material, moving into the centre of the coil, will give fine tuning (as mentioned previously in Hot Iron) so how's this for an idea?

A tufnol former, having threads die cut round the outside, is an ideal former; leave it in the centre of the coil, varnished with 'Q-Dope'. If you drill and tap the centre of the former, thread a brass bolt into the former, you've got much more mechanical stability and a fine tune option on your coil.

Taming a VFO… (2)

There are many ways to make a VFO; very few to make a stable VFO! I have had queries from amateurs wanting to build an 'analogue' VFO, after using a 'digital' VFO; why, they didn't say, but below is just about the best article I've seen on the subject. It's from "Crystal Sets to Sideband" by Frank W. Harris, a most valuable reference: look it up, the entire book is available online and is a gem in every respect. You can rely on it!

Once you have built a stable(ish) analogue VFO you certainly feel you've accomplished something and indeed you have - and you've trodden a well worn path. If you can get to ±10Hz you deserve hearty congratulations!



'Suppose you were to build the above VFO without reading the details in the following paragraphs: When you first turn it on, you will be disappointed to find that it drifts a hundred Hz per minute or more. The drift is caused by temperature change. The components expand and contract with temperature change and this causes small changes in the capacitance and inductance of the components. Air wafting across the board doesn't allow the temperature to stabilize. Drift is prevented by preventing temperature change and by choosing components that change as little as possible with temperature.

VFO building is an art form as arcane as Grandma's secret pie crust recipe or the fine points of building Cub Scout Derby racers. As you'll see, there must be 50 ways to improve the drift problem. I have never built a VFO that was a completely "stable" and probably never will. But perhaps that's because I only know the 14 secrets listed below. If you apply as many of these as possible, you should get within the 20 Hz target - and maybe even under 5 Hz.

Secret # 1.
Junction Field Effect Transistors (JFETs) The first secret of a stable VFO is using a JFET instead of a bipolar transistor. As described earlier, a field effect transistor is better because it is less sensitive to temperature. I have used 2N3823, 2N5484 and 2N4416 N-channel JFET's for VFO oscillators. My impression is that any small N-channel FET works well.

Secret # 2.
Seal the VFO in a cast metal box. Simply protecting the VFO from air currents makes a huge improvement. Use a heavy, cast metal box so that the temperature will at least change slowly. In contrast, a flimsy, sheet-metal aluminum box will heat and cool relatively rapidly. On the other hand, ANY box is a huge improvement over not having the circuit sealed from air currents.

Secret # 3.
Use single-sided PC board. A double-sided PC board is constructed like a capacitor. That is, thin metal sheets are bonded to a layer of insulator. Unfortunately, the resulting capacitor has a significant temperature coefficient. As temperature increases, the board material expands (thickens)

and the capacitance across the board drops. If the VFO is built on traces and islands that have changing capacitance to ground, the frequency of the oscillator will drift slightly.

Secret #4.
Mount the oscillator PC board away from the metal case on stand-offs. Using the same principle as above, do not mount the single-sided PC board flush against the metal case. By standing the board up and away from the case, the capacitance between the traces and the metal case can be minimized.

Secret #5.
Choose and mount all components affecting the oscillator LC circuit carefully. All the L and C components in the oscillator should be designed for minimum temperature drift. Referring to the diagram, it is not just capacitors C1 and C2 that affect the frequency. Capacitors in series with the 220 pF capacitor, C3, C4 and even C5 affect the frequency. To at least a tiny degree, ALL components in contact with these capacitances can affect frequency drift. These include the diode, the RF choke, the transistor and the 100 K resistor.

Secret # 6.
Mechanical variable capacitors should be chosen carefully. Although good mechanical variable capacitors are hard to find, they may be the best solution for you. Pick a capacitor of about 30 to 60 PF, not larger. High capacitance variable capacitors are too sensitive to temperature change. Smaller ones don't tune far enough. Don't use a capacitor with aluminum plates – they warp too much with temperature. Brass is the best metal. Try to find a capacitor with thick, widely spaced plates. Paper-thin plates are compact, but warp readily with temperature change. If the capacitor tuning is linear with degrees of rotation, the frequency it produces will be somewhat non-linear. Ideally, the capacitor plates should have a non-linear shape that allows it to tune an LC resonant circuit so that the frequency will be linear. Rotate the capacitor through its range and you'll see that a compensated capacitor has rotor plates that are not simple half circles. As they rotate, they do not mesh with the stator plates at the same point. The non-linear correction isn't a big deal, but it is something to be aware of.

Secret # 7.
Varactors (Varicaps) are the most stable tuning element. It's hard to buy mechanical variable capacitors that are mechanically and thermally stable. Collins Radio formerly tuned their VFOs with special powdered iron slug tuned coils, but I've never seen any for sale. A varactor capacitor controlled by a quality pot is a good solution to these problems. Varactors are a kind of silicon diode biased with DC voltage. In my experience varactors are an order of magnitude more thermally stable than mechanical capacitors. They are at least two orders of magnitude more mechanically stable. You can slap the VFO with your hand and, although other components may vibrate, the varactor doesn't change its capacitance. Unfortunately, varactors produce a non-linear scale on the frequency tuning knob. This means that the high frequency end of the VFO range will be extremely detailed while the low end may be compressed into a few degrees of rotation. For this to be usable, the potentiometer should be non-linear to compensate.

Secret # 8.
Use NPO fixed capacitors. When selecting capacitors, look for type NPO. These are supposed to have minimum temperature change. Use these for ALL fixed capacitors affecting the LC circuit.

Secret # 9.
Use multiple NPO capacitors in parallel to achieve a given value. If you must use fixed capacitors in parallel with C1 or C2, it is better to use several small ones in parallel than one large capacitor.

The temperature of a small capacitor stabilizes quickly, whereas heat builds up more slowly in a larger capacitor.

Secret # 10.
Temperature compensation for the LC circuit is essential. It took me four prototypes to accept this, but temperature compensation is as important as putting the VFO in a box. Lots of guys claim to have succeeded without it, but I never have. Not using temperature compensation implies that every capacitor and inductance in the VFO must have a zero temperature coefficient. Alternatively, all negative coefficients must be balanced precisely with components that have positive temperature coefficients. Good luck doing that!

Secret # 11.
Use an air core inductor. As usual, it is most convenient to use a powdered iron toroid core. Unfortunately, powdered iron changes its permeability (magnetism factor) with temperature. Therefore, by not using iron, another variable is eliminated. I have successfully used old plastic pen caps as little coil forms for air-core inductors. I bore little holes in the plastic to accept tiny pieces of stiff copper wires to serve as wiring terminals.

If you do use powdered iron, among the CWS (Amidon) cores, type 7 is supposed to have the best thermal stability. Amidon #6 cores have worked reasonably well for me but maybe #7 would be a few percent better. If you make a coil out of turns of copper wire on a plastic form, the copper will change its dimensions slightly with temperature too. And because an air core inductor requires more turns of wire, there is more opportunity for the copper to change its dimensions, its inter-winding capacitance and also its resistance. Finally, an air-core coil will couple like a transformer to nearby parts whereas a powdered iron toroid couples far less.
After you have your coil wound and working over the right frequency range, epoxy or clamp it to the board. Without the epoxy, the frequency will warble with the slightest vibration. I once tried to use slug-tuned coils. They were convenient to adjust, but were mechanically and thermally unstable.

Secret # 12.
Precision voltage regulation for the VFO supply is vital for precision frequency stability. The 12 volt supply for the VFO as whole must be regulated. Ordinary voltage regulators like the LM317 or LM7812 gave me regulation within 0.1 volt. This was OK for frequency stability down to about 20 Hz drift. But to get down to less than 5 Hz, I needed to regulate my VFO power supply to a few millivolts. To achieve this, I built a precision supply that just powers the VFO. The less current the supply has to deliver, the more constant its output voltage will be. The supply is discussed in detail below.

Secret # 13.
The VFO should draw as little power as possible. The less power drawn, the less heating that occurs inside the VFO box. Also, the less power drawn, the easier it is to build a precision voltage supply to drive the VFO. That is why the VFO was designed for a 500 load rather than 50 ohms like most ham RF circuits. The VFO as a whole should draw less 20 mA DC. 10 mA would be even better.

Secret # 14.
Forget tube oscillators. You old timers may be tempted to use a tube oscillator. I first tried to update an old tube VFO, but tubes get hot and make temperature compensation too difficult. You'll have plenty of trouble without this extra burden. You may use bipolar transistors for the final amplifier in your VFO, but not for the oscillator. For good measure you may as well use a JFET for the buffer as well'

From experience, the ideas presented above are solid and reliable: they will make a very good VFO if you follow Frank’s advice. Here are some thoughts:

- “6” material toroids (air cored preferred IF you can make them very robust);
- Multiple NP0/C0G capacitors for under 120pF and styroflex (polystyrene) over that value
- Design for less than 10MHz;
- Short, wide pcb tracks; a minimal pcb etch layout is best - in other words, remove the minimum copper (a 0.5mm radius tip pcb router is ideal for isolating islands of copper);
- Single sided glass fibre pcb material; if you have only double sided, make topside ground, underside power and liberally sprinkle decoupling capacitors around the assembly using slots or countersunk holes to guide leads through the pcb without causing short circuits;
- A better stabilised power supply than a raw 7805 or similar can provide.

Complexity and crystal power (2)

Kosta, SV3ORA, has described a crystal oscillator with THREE crystals, that oscillates on all three frequencies! Just how useful this is not immediately clear to me, but it’s yet another of those good ideas looking for somewhere to happen. See:

http://qrp.gr/multiosc/index.htm

Hans Summer has looked at this too; see:

http://www.hanssummers.com/multiosc.html

Any ideas gladly accepted!

Transmitters

ONE component transmitter

Let’s get this established before we go on: spark transmitters are, for most purposes, not allowed: they’ve been (voluntarily) banished since 1929. Of course, radio amateurs being what they are, ‘certain’ amateurs just couldn’t resist and rebuilt ancient radio gear, especially airborne spark transmitters from WW1. In those days reliable communications needed enormous ‘flat top’ antennas and loading coils to resonate antennas in the VLF and LF bands so the ‘short wave’ sets carried aloft in Vickers biplanes (a.k.a. ‘string bags’) were a prime target for investigation, and what I discovered in the reference below was an eye opener to say the least. Not only did the pilot of a ‘string bag’ have to fly a rickety collection of canvas, wood spars and leather straps whilst sat on gallons of petrol, being shot at from all directions, whilst running a spark transmitter to guide artillery and report reconnaissance to those on the ground. Intrigued thus, W5JGV obtained permission to test an airborne transmitter from the FCC and the result is in the web page below:

Legal spark transmitter: http://w5jgv.com/375%20Meter%20Spark%20Transmitter/

I first came across spark transmitters as a nipper, reading an old book at my grandparent’s house, called ‘How it Works’, that described spark transmitters. To me, this represented a wonderful experiment: I made a spark transmitter with a 6 volt ignition coil, a 6 volt ‘lantern’ battery and a file as a mechanical circuit breaker to buzz the primary of the coil - all mounted on a bit of plywood with brass screw terminals. I strung out a wire from my bedroom window to back garden fence, connected an earth lead to a water pipe, and proceeded to make some ‘Hertzian Waves’.

I knew I’d transmitted, no doubt about that: how could I be so sure, since I didn’t have a receiver? My parents, that’s how, who soon told me to ‘give over doing whatever it is you’re doing!’ (in NO uncertain terms) as I’d wiped out the VHF TV they were watching, with screens full of white flashes and sound laced with crunching crackles. I was most proud of my success, but couldn’t repeat it without getting a four-penny one from irate parents; so, advised by my uncle who served as a ‘sparks’ in Atlantic Convoy Royal Navy Destroyers in WW2, I began to look at amateur radio.

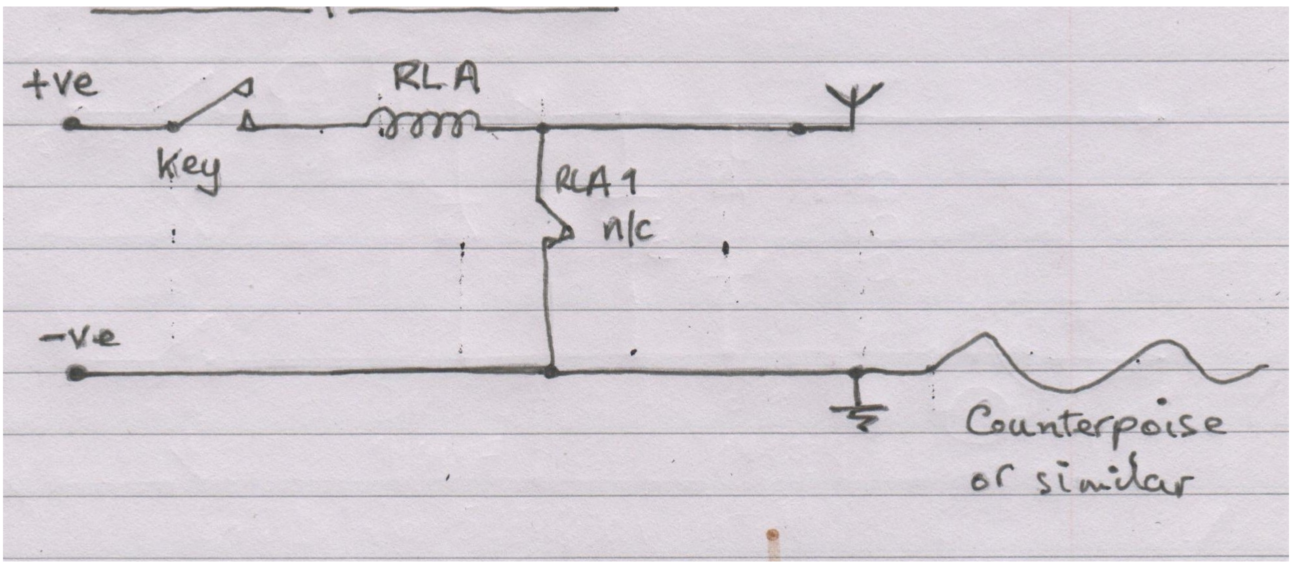
And the rest is history! I was launched headlong into an electronic age where valves ruled the serious stuff, and transistors were just beginning to poke their noses in (early 1960’s) and I soon began playing with all sorts of circuits, made from bits scrounged here, there, and everywhere.

It was during my apprentice days a few years later I met spark transmitters again: in high voltage, high vacuum glass work you test for air leaks with a ‘Tesvac’: a Tesla coil with a hand-held EHT probe. A pinhole leak drew a spark (2” long mind you) and showed a discharge inside the evacuated glass vessel - be it an 807 on burn in or a Royal Navy cathode ray tube.

Anyway, below is the schematic of a ONE component radio transmitter. It’s primary purpose is to test the noise immunity of receivers, logic circuits, and any other gear we have around our radio room. An old open frame Arrow relay - the type with ⅜” // 10mm diameter silver contacts and a huge coil - is the one to go for. 3Φ contactors with a low voltage DC coil culled from a scrap control cabinet are good, too. Note the use of the operating coil as both an actuator for the relay, and as an RF choke. Neat!

The unit makes an excellent test set with a few metres of wire for an antenna plus counterpoise for checking how well your gear rejects broadband noise, its earthing and screening capabilities and logic noise immunity. Admitted, it’s a shotgun approach, but it don’t half find problems!

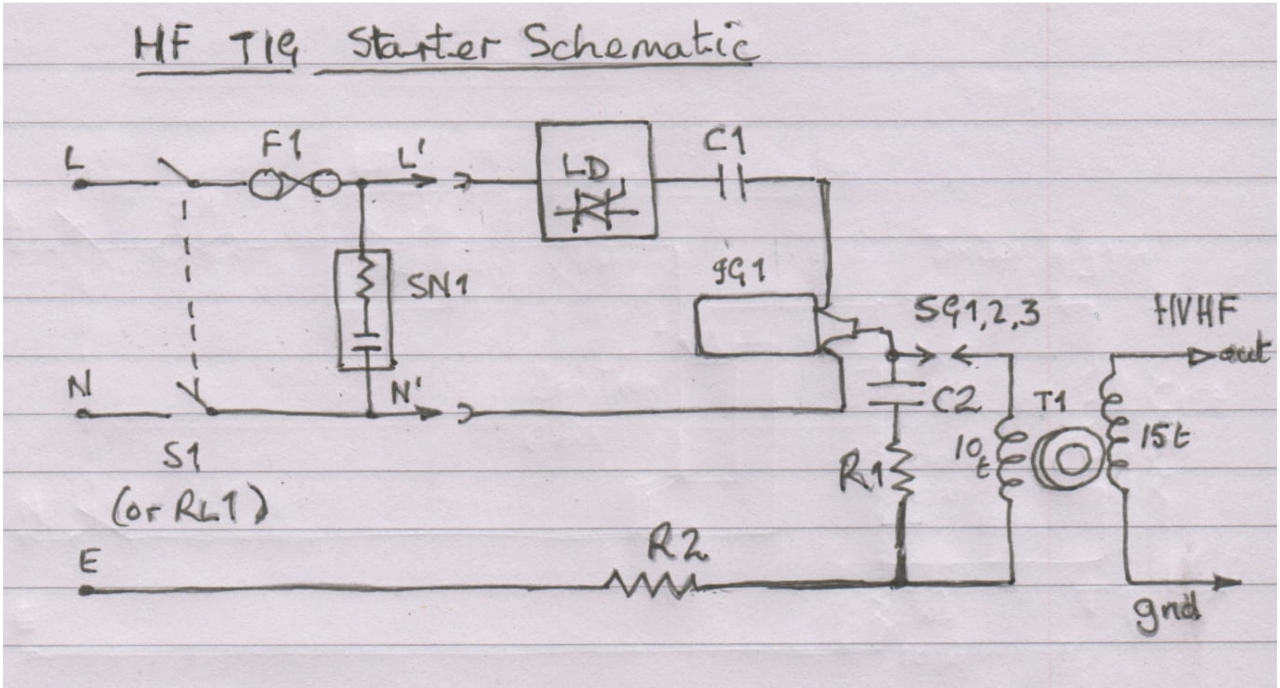
To stop the loonies out there from blattering the aether, no details given re. antenna or counterpoise - capable amateurs will soon sort these out.



Should you need a more potent wideband HF noise signal, the circuit below is useful. Normally used in TIG / MIG welding, it's a hefty source of wideband HF.

WARNING: this circuit generates high energies powered directly from the mains (*use an isolating transformer! Ed.*) Unless you're familiar, experienced and aware of the precautions needed to build and run such a circuit then DON'T BUILD IT IF YOU'RE NOT EXPERIENCED WITH HIGH VOLTAGE AND RF SAFETY. I was trained by experienced engineers who taught me to respect beasts like this to ensure my continuing to draw breath.

I'm not responsible for any injuries or damage units like this CAN and WILL cause if mistreated or mishandled. The component values are deliberately left off the schematic to deter the uninitiated.



Down at DC...

Are you still playing 'down near the DC' at 10 GHz? Take a look at:
http://www.modulatedlight.org/optical_comms/optical_index.html

...and be ready to be amazed. Marvellous stuff, and exactly what amateur radio (optics?!) is all about - and easily reproduced too. Amateur radio is a very broad Church; Nature has given a magnificent playground to those who would strike out into the wide blue yonder and experiment.

Driver level shifting

In designing bridge type switching circuits for RF induction heating and much beloved by our LF brethren - before chips were available for this job, or weren't up to more than a few kHz - designing your own is the only answer. The trick that is simple and very effective is to drive the 'top side' power device(s) is an HV PNP silicon bipolar transistor 'level shifter'. With suitable drive from a totem pole logic output (74HCXX types) the circuit below gives a good solution and can achieve nS edges if set up properly.

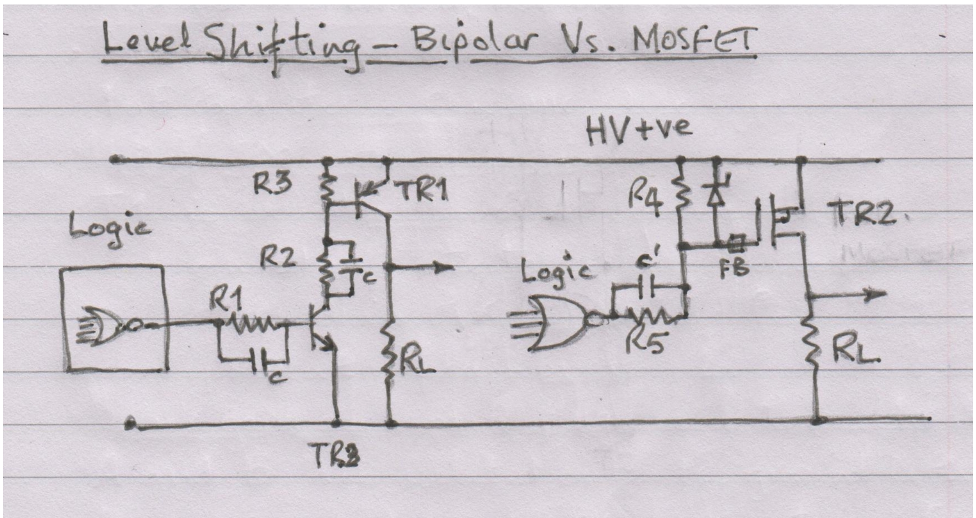
The trick is the capacitor ‘C’: this is chosen to be equal to the stored charge in the PNP base / emitter junction, so on the rising edge drive from the logic, the capacitor instantly transfers charge into the empty base / emitter, resulting in very fast TR1 switch on. The exact opposite on the logic output going low occurs: the stored baser charge is removed as fast as the surrounding circuitry and wiring allows. R3 (and R4) remove any false switching due to noise; not always required.

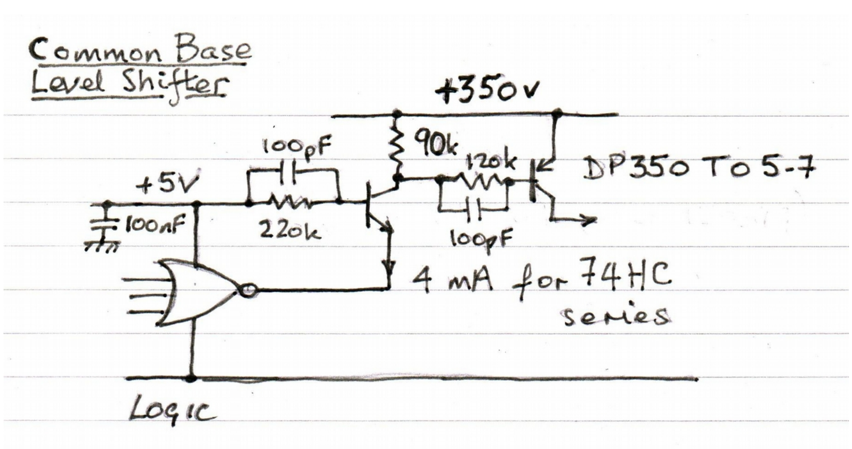
A similar drive technique is used with a P-Channel MOSFET, shown right. Note however the need for a zener to stop the gate / source insulation (normally good for ~15 volts) being broken down by the much higher voltages available in this circuit. Whilst a MOSFET is by it’s very nature a very fast little beastie, the stored charge in the gate / source is generally larger than in a bipolar device; and adding the zener (9V1 to 12v. or so) adds to the charge the logic has to switch.

In the bipolar PNP drive, a transistor, TR2, is used to remove the amps of charge very quickly; far more effectively than the logic 10mA capability. The same trick can be done with a MOSFET by adding a driver transistor to shift the stored charge as fast as possible.

We used these techniques with multiple HV line output transistors to bridge drive an inductive heater coil wound around quartz reactor tubes containing a graphite susceptor for vapour phase epitaxy on gallium arsenide wafers at 1000°C+. We ran an HT supply of 600 volts, at ~10 amps to give just shy of 5kW of heat; the efficiency of the drive circuits relied on very fast switching edges and exact timing, otherwise the power transistors very quickly shuffled off their mortal coil.

We did suggest trying a 4CX1000 tetrode, but since we were a semiconductor manufacturing plant, the ‘powers that be’ frowned upon us buying and running such esoteric beasts!



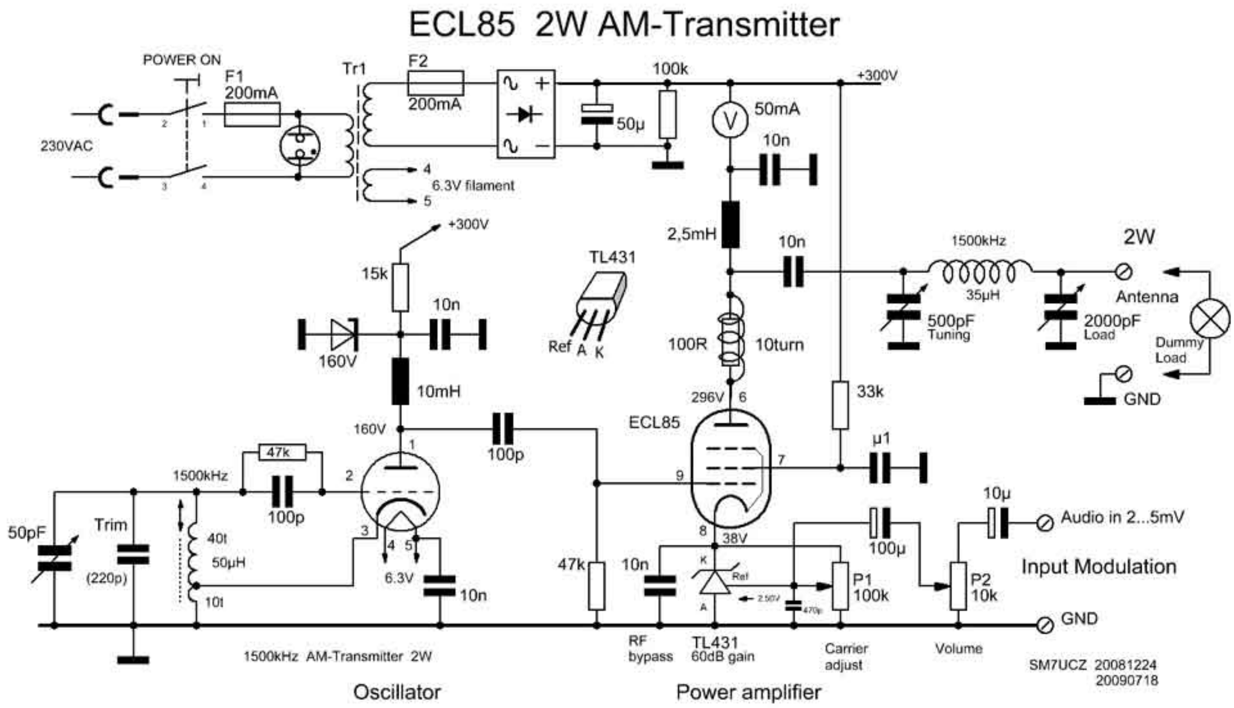


This is a very canny way to drive the PNP level shifter; admittedly the base drive is limited to the logic low 'sink' current but despite that it ain't half fast! Try it and see; be ready to cut-n-try the base drive C // R networks to get the best switching times.

How simple can it be?

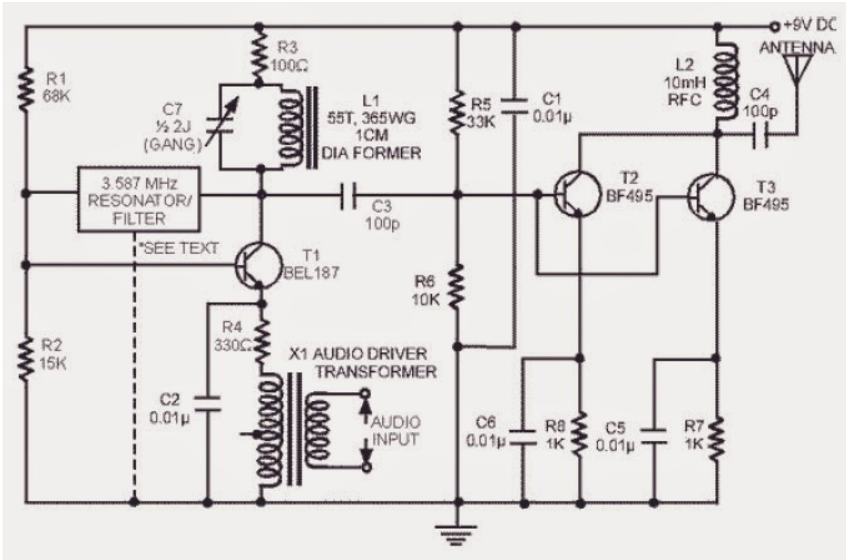
Here is a neat transmitter, which use a TL431 regulator as a cathode modulator. You could easily use a crystal rather than a VFO if you wished. The circuit round the cathode will need adjusting to get 50% carrier on zero modulation, but it shows just how simple A.M. phone can be!

The use of a TL431 is an excellent idea, simple and direct to get grid and plate modulation. For Top Band try an L/C VFO - well built as per this edition of Hot Iron - and if it's an excellent performer you could get A.M. on 80m too. If you prefer to be spot on every time, substitute a crystal for the L/C oscillator and you're sure of frequency.



http://www.sm7ucz.se/AM_Transmitter/AM_transmitter.html

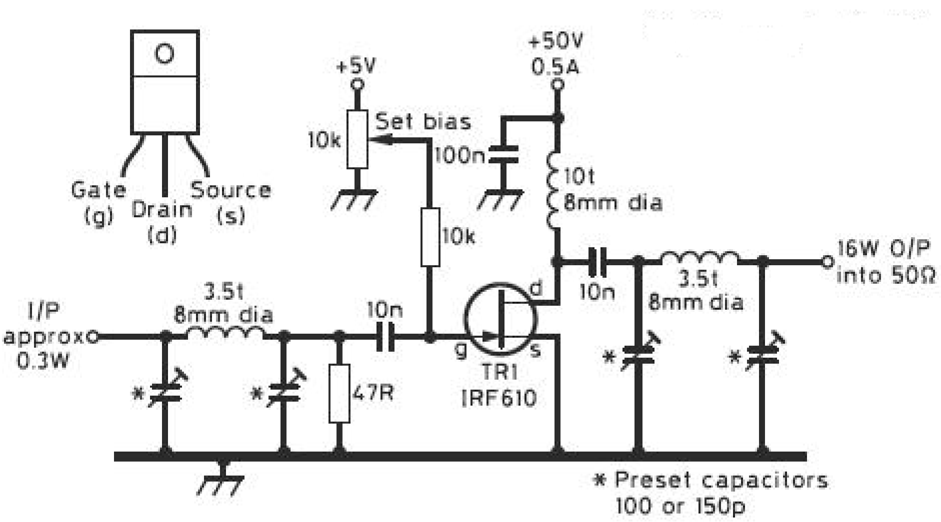
Here's a neat little transistor A.M. transmitter; simple and straightforward, of the 'JABOT' approach ('Just A Bunch Of Transistors') for a very nice linear PA.



Power Supplies

A review of 12 v. power supplies

12v was nominally chosen as it was commonly used in automotive engineering, but nowadays it's easier (and cheaper!) to find 19 volts in laptop power supplies. I checked on our favourite auction site and 65 watt 19v 3.5 amp supplies are a couple of ££'s, far cheaper than if you tried to make one from parts, and it's in a safe and neat small case. You've got the issue of SMPS noise, but mounting the unit inside a steel conduit 'knock-out' box (or diecast box if you're rich) kills a lot of that, as does AC common mode input chokes. The low cost of such SMPS's allows stringing 3 of them in series (the outputs are usually isolated, but CHECK!) and you've got ~ 50v at 3.5 amps: use that to power a single (low cost) mosfet HF linear amplifier, the higher drain volts gives far better linearity and gain, as below:



Mysterious 'hash' from Switch Mode Power Supplies?

Watch for noise being spread in the earth wiring in your house! High frequency 'hash' has to run to ground somewhere, and it's most likely your mains incomer panel where, under 'PEN' or TNS/C wiring, the earth is joined to the neutral - and thence to the Earth point on the sub-station transformer winding. The whole point is that screening picks up the radiated noise signal and runs the noise current to ground - somewhere. That’s how it works! Current running through a wire is exactly what’s needed for radiation: current in a wire is the definition of an antenna!

The principle of screening is that a charge on the inner surface of a sphere cannot be detected on the exterior; and vice versa (Gauss’s Law, Faraday Cages). But… practical screening isn’t a sphere, nor does it completely enclose the inner surface - we have to get signals in and out of our gear somehow, so that’s where the noise currents travel, either on cable screens or power wiring. Our knowledge of screened cables tells us that the earthed screen stops external noise getting to the core, but that’s a problem: the noise can propagate on the **outer** surface of the screen.

The way to reduce any radiation from such earthing is to use as near enclosed screens as you can, earth through short, fat copper strips to a ‘solid’ earth plane. Enclose your gear in steel or diecast alloy boxes: the magnetic property of steel absorbs the magnetic component of radiated noise and diecast boxes have very low resistivity, making a path to earth easier - IF you can solidly earth!

Refurbishing ‘sulphated’ batteries

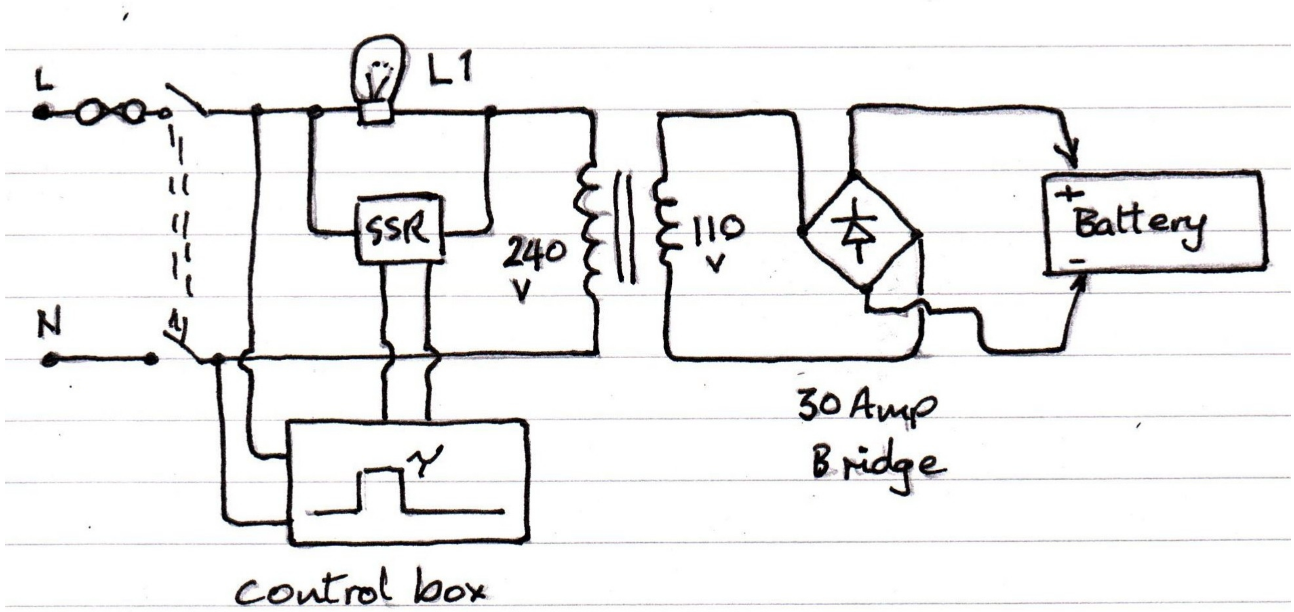
It’s a common question, especially by those stood by an old lead acid battery, automotive or ‘leisure’ type, saying… ‘it won’t hold / take charge any more, what can I do?’

Well this question is about as old as the invention of lead - acid batteries! The short answer is ‘get a new one’ but it’s always worth a shot to try rejuvenating dud batteries - and plenty of ideas abound on the internet, some sensible, some away with the Fairies and Cosmic Earth Energy. Here’s one I built many years ago to Stan’s design, and it works providing the battery hasn’t been left for weeks flat as a pancake, frozen, drained of electrolyte, or otherwise ill-treated.

The basic principle is to use pulses of current at high applied voltage to break down the high resistance of the plates, then slowly return the sulphated plates back to lead; if there’s a chance, this method will do some good. The real problem is to remove the coating of ‘clagg’ from the plates, which drops as sludge to the bottom of the cells. The sludge is conductive and shorts out the plates. It can be swilled out with water (once the electrolyte has been drained and sieved), and the electrolyte replaced into the now clean(er) cells.

Here’s the gist of the Battery Bumper. The points to note are the use of a current limiter in the primary circuit, bridged by a solid state relay which featured zero crossing switching - the SSR will only trigger if the control voltage is present within a mS or two from zero volts. Stan set the output pulse (T) to a touch under 10 mS (for 50Hz) thus ensuring that whenever the input trigger pulse arrives in the 50Hz sine wave, it will catch a single zero crossing and statistically, catch as many positive as negative half cycles to avoid DC bias flux in the transformer. The timing was about a minute per pulse from a 555 astable timer; the 25 watt current limiter lamp briefly flickered off as the battery (or more likely, the transformer… Ed.) gave a pronounced “BMPP!” which could be heard across the workshop. The current limited rectified pulses in between the BMPP! pulses made a low buzzing from the battery. The clagg typically dropped off the plates in about 15 minutes; Stan turned the BMPP! pulse circuit off, allowing trickle charging via the lamp current limiter overnight.

The following day, the battery went back on the stacker truck and proved serviceable for another 2 months, then died again. No amount of BMPP! treatment did anything; Stan reckoned the plates were just plain wore out (‘like my dodgy knee…’ sayeth the Stan) , so it went for lead scrap.



Stan reckoned the high voltage with limited current plus the BMPP! pulse was the trick; it certainly gave some more life to the battery, but you can't restore brand new performance. Lead acid batteries have consumable materials in the plates; when it's gone, it's gone - no amount of messing will put it back. It's in that sludge you swilled out down the drain - oops, I meant 'ecologically recycled into the appropriate waste stream'!

One other thing: those gel cells and similar - the usual problem is the electrolyte eventually evaporates out through the vents. You can try introducing some distilled water into the cells (if you can get the top cover off and get to the vents); not always possible, and don't try drilling holes in the top. Not recommended!

Arc Fault Detection (or 'Disconnect') Devices (AFDD's) and neighbours

The IEE, that collection of venerable experts who publish the 'wiring regs' for UK electrical wiring, have heard about some remarkable devices much beloved by our pals across the pond, who (for interesting historical reasons involving carbon filament light bulbs and Thomas Edison) use more amps per kW than we do here, as we have 230v AC supplies, they 110v AC.

'More amps' is the key: to make true arcs you need amps, and lots of 'em: think of an arc welder. Arcs ain't Sparks; no sir: an arc needs enough heat to vapourise the metals involved, thus creating a plasma, an electrical conductor. The volt drop across the arc of a manual metal arc ('MMA' or 'Stick') welder is in the region of 20 -70 volts peak after the arc is struck by running 60 - 130 amps through an electrode, depending on dimensions and material. It is almost impossible to strike a true arc with a copper to copper contact; copper to brass (as in a terminal block, for instance) is touch easier, as the metals shunt heat away so effectively. If - and it's a big 'if' - a true arc strikes, then you've got a very dangerous heat source and fire hazard, so AFDD's are generally *a good idea*.

In the USA (and other 110 volt regions) cables are far thicker than our Euro / UK cables to carry enough amps to for the kW's; thus a poor connection, creating I^2R heat, has plenty of 'ampacity' (isn't that an magnificent word the USA has given us!) behind it causing a very real fire hazard and possibly an arc.

Thus was the ‘AFDD’ designed; it detects the characteristics of an arc - namely the HF components of the plasma, apparently around 18 - 32MHz. I don’t know the exact means an AFDD uses to sense the HF, but suffice to say those caring people at the IEE, ever vigilant in looking after our interests (whether we want them to or not..!) have insisted that AFDD’s are fitted in various special locations, as noted earlier in this edition.

What I don’t see is how somebody transmitting on 14m, 17m,15m, 12m or 10m can avoid tripping nearby AFDD’s with RF picked up on nearby cable runs: or how somebody down the street on the same phase running an arc welder avoids false tripping nearby AFDD’s. Any readers with experience of AFDD’s please let me know how you get on with them, and false trips please!

Incidentally, there is a formula for converting AWG to mm²: $0.012668\ mm^2\ (92^{(36-n)/19.5})$

where ‘n’ is the AWG number. I can feel you cringing at that formula, so check the table in the Hot Iron Data section at W4NPN.net!

You need the right connections…

Whilst we’re on the subject of electricians, Regs, and all that malarkey, I note with interest the popularity amongst our “T&E” fraternity of electricians of ‘push fit’ and cage clamp quick connectors. It seems like every 20 years or so some ‘bright spark’ decides to have another go with these devices: I recall years ago Klippon (I think?) trying to flog these as the next best thing to sliced bread, which, of course, they aren’t. “Why?” asketh thou; and lo! I shall tell!

Many years past, around the time of Tesla, Edison, Westinghouse, Steinmetz and a plethora of others of similar electrical bent, discovered that if you wanted reliable electrical connections then the beat method way ‘copper to copper’. Any intermediate material **always** degrades reliability and increases volt drop - as true today as it was then, believe me. I learned the hard way; in an electroplating shop, tin plating transistor lead frames prior to having the transistor chips bonded.

These tin plating baths consumed tin anodes at a rate of knotts; the finished anodes had to be removed and sent for reclaim (tin anodes aren’t cheap!), a new anode connected to the DC with hefty stainless steel (to resist the acid environment) ‘choc-bloc’ connectors. Stan normally did this job; he was busy elsewhere, so I had a go. I stripped the insulation off a new anode wire, shoved the exposed copper into the new choc-bloc, and nipped up. Power up, 50+ Amps, no bother, and off I went to my next job, happy as Larry.

30 minutes later, Stan arrives and drags me out from under the diffusion pump I was rewiring. ‘what’s the matter, Stan?’ uttered self: ‘That anode replacement has failed, and burned the wiring back to the bus bar, that’s what!’ quoth a somewhat effervescent Stan. I followed, looking suitably sheepish, behind Stan to the offending scene in the plating shop.

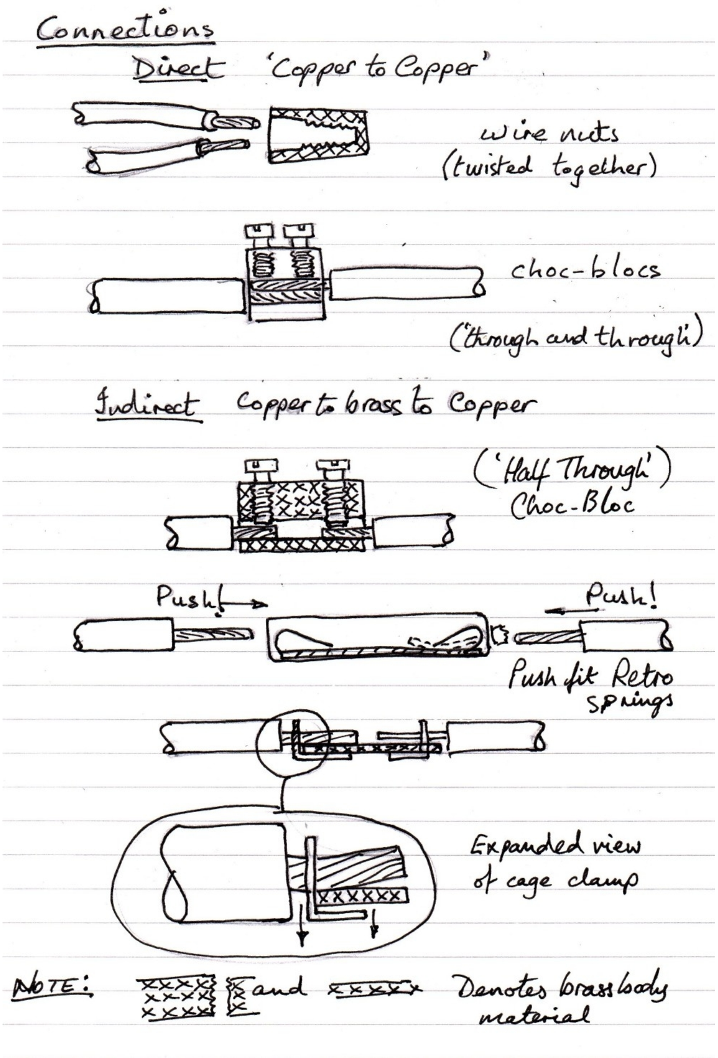
Derek L., the Plating Shop manager, waited with steam coming out of his ears - that tin plating line was numero uno in work, and the line had stopped because of the burn up. Stan, investigating for a few seconds, simply said ‘I’ve told you to connect these ‘through and through’ haven’t I? Why have you done it only half through?’ No excuses, I had rushed the job, and told Stan so. ‘Right, you get another 100 Amp choc-bloc, I’ll clean up here - and bring 10 yards of 100 Amp TRS welding cable, a few 100 Amp lugs and the crimp tool’.

Thus I learned about making a ‘copper to copper’ connection by stripping enough copper for the cable core to go **right through** the choc-bloc from both sides; **not** halfway in from either side.

New cables installed, choc-bloc tightened to full four white knuckles, current running a steady 50 to 60 Amps and the choc-bloc no warmer than the cable. ‘job’s a good ‘un, Peter - d’you not wonder how I knew exactly what you’d done?’ I had to admit Stan had sussed the fault within a second of knowing the line was down. How? ‘Easy,’ sayeth Stan, looking a bit smug… ‘I did exactly the same years ago meself…!’

Below are some diagrams showing some connections and the consequent reliability - knowing this has stood me in good stead for 55+ years. Some here in the UK think that wire nuts are illegal; no, they are perfectly acceptable, as long as they have the steel spiral thread insert in them. Choc-blocs - always use ‘through and through’ if possible. Far more reliable, and far lower volt drop than any other choc-bloc method.

The whole point is to maximise the copper-to-copper contact area - and how the ‘push fit’ connectors often don’t. OK, they work for a while - but I don’t like them on any circuit with more than an amp or two flowing.



Note the area of contact! Look carefully at these ‘quick’ connectors; they might be well rated but I’ll bet you’ll be revisiting them not too many years hence.

Audio Topics

Tap Codes

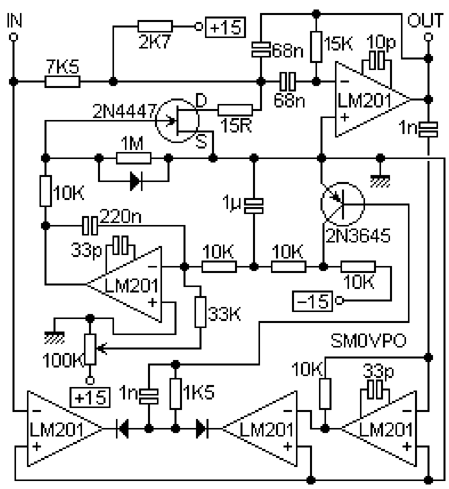
An ideal way to start learning a CW mode that the unskilled can use, on the simplest of transmitters. Easier, simpler and more readily digestible to ‘non Morse’ amateurs is the ‘Tap’ code. This uses a Polybius square, (lots of articles on t’internet) and has a history far deeper than Morse, Semaphore and the like. It’s not quite as efficient as the more complex codes like Morse, but is vastly simpler and easier to learn, and lends itself to simple telegraphy; mental decoding comes within minutes, unlike Morse. A typical ‘Polybius Square’ is shown below, the outer number squares indicate the number of dits:

	1	2	3	4	5	6
1	A	B	C	D	E	F
2	G	H	I	J	K	L
3	M	N	O	P	Q	R
4	S	T	U	V	W	X
5	Y	Z	0	1	2	3
6	4	5	6	7	8	9

Thus, a sequence of 1 ‘dit’ followed by 3 ‘dits’ indicates ‘C’; 3 dits (space) then 5 dits gives ‘Q’. Yes, slower than Morse; but vastly simpler, easier to ingest and mentally decode - and capable of more Dx miles (it’s simpler and slower). Such telegraphy gives dexterity training, so useful for the transition to Morse in the future. Automatic generation and decoding of Tap codes is a doddle compared to Morse coding / decoding, as you’ve eliminated the ‘dah’ and consequent spaces so less to worry about. Keep it simple!

CW tracking filter (SM0VPO)

This is a cracking good circuit that automatically tracks the audio frequency of an incoming signal and subjects it to band pass filtering, so no more losing fading CW signals as often occurs with a tight fixed frequency band pass filter. Keep that weak signal without having to continually adjust!



As Harry says...

'*The Op-Amp with the 10p compensation capacitor is the filter which is tuned by the 2N4447* (try a 2N3819…Ed.) *FET acting as a variable resistor. The remaining OP-Amps form comparators (no compensation capacitors) an integrator (the middle one) and a differentiator (bottom right). These adjust the frequency of the filter so that there is 180 degree phase difference between the IN and OUT signals to the filter. This only occurs when the filter is tuned to the incoming audio frequency. With the values given the filter will track an incoming tone from 330Hz to 3KHz.*'

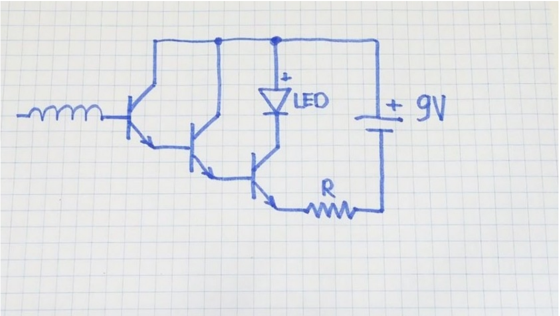
You can, with some impunity, substitute other op-amps and get the beast to fly. The original article can be found on Harry's web pages should you want further information (and a whole lot more!).

Test Gear, Fault-Finding & Repair

AC / RF field sensor

Here's a lovely little circuit for detecting E-fields, as from buried mains wiring, LF-RF signals. It's worth a shot for detecting RF in a co-ax feeder, too.

Yes, it's a triple Darlington, and yes, you can add another stage if 3 stages aren't sensitive enough for your application. 'R' would be 2k2 to 8k2 or so, depending on your LED. I used ZTX300's as I had a few to hand. It will detect RF fields quite well; might make a neat side tone trigger? The pick-up is ANY 30cm bit of wire, cut & try, the coil is just a bit of decoration.



From the Maestro… Harry Lythall

Hello Peter,
Thank you for the latest Hot iron. I usually read every word in all your articles. I do have a couple of comments about de-soldering. Perhaps your readers may be interested in the info? (You bet! Ed.)

<u>**Desoldering ICs**</u>
As always I find Hot Iron really interesting and I look forward to receiving them. In #117 I read the article on de-soldering components. There were some very good tips. But when desoldering components it is usually because something is defective so you normally have two choices:
1 - Sacrifice the chip and preserve the board
2 - Preserve the chip and sacrifice the board

Sacrificing the chip is a no-brainer. The important component is the board and so one needs to avoid any damage to the PCB. I normally clip off the legs of the IC then de-solder the legs one-at-a-time with the soldering iron set to about 260°C and use lead-based solder on the iron tip after thoroughly cleaning it. I also stagger the pin-removal sequence eg. 1, 3, 5, 7 etc. so that I do not bathe the board with heat. Never de-solder adjacent pins. SMD chips can be difficult to cut with a standard pair of wire cutters. The Dremel drill with a circular cutter can be carefully used to cut the legs where they enter the chip.

I also have a stock of silicone rubber tube that I put over the nozzle of my solder sucker. Solder suckers have a powerful recoil that can lift the tracks of some boards, especially the cheaper bonded paper boards as was commonly used in older equipment. These boards are characterised by the deep brown colour. The silicon rubber tube forms a good seal over the hole and gives a good suck to remove solder from the hole. The rubber prevents the recoil from gouging up the PCB tracks.

Did you know that you can dilute solder with mercury to lower the melting point? Clean the iron, put a small amount of lead-based solder on a bit of wood with a couple of drops of mercury. Clean the iron tip well and use the colder/mercury mix to tin the bit, and carry a blob of it to the board. Some audio chips, eg TDA810, have a wide tag for heat sinking. This can be a problem to desolder if it is soldered in a slot in the board. Adding a little low melting-point solder can make it a lot easier to desolder without destroying the board.

Incidentally, you can mix mercury and solder to make a solder that will melt in your hand, and this was common in older antique radios to make a spring/solder switch to break the circuit if the transformer became too hot. It is difficult to get mercury these days, but I have a small jar of it I got from a priest when they renovated the church clock. It was used for temperature compensation of the pendulum due to its high expansion coefficient.

Sacrificing the board can be a bit more difficult. I once removed a Z80 (40-pin) microprocessor from a board and it worked perfectly after removal. I clamped the PCB to the edge of the workbench with the Z80 underneath. I put a huge car-battery charger crocodile clip (modified a little) across the chip, lengthwise, and hung a 1.5kg weight on it. I then heated the track-side of the board using a blowtorch and the chip just fell out in about 4 seconds. I figured that if I am going to use heat, then let's make it fast. This technique works well to de-solder board-mounted power connectors, battery holders and switches that use plastic.

One tip with large DIL ICs is to use a Dremel with a circular model cutter and cut around the chip. Then gently make a cut of the board lengthwise so that the 2 rows of legs of the IC are separated. This halves the number of legs that are to be de-soldered. Be careful when you cut the board, it is only too easy to cut too deep and mark the plastic case of the chip. I also did some modification to an old worn-out bit for my Weller TCP soldering iron. I cut it in half, tapped it with a 3mm thread and fitted a triangular piece of brass plate, 3mm thick, so that I have a soldering bit that is about 25mm wide. That can be used to de-solder all the legs on one side of a chip simultaneously. Just be sure to file and tin the brass spade really well, regularly.

Larger SMD components are really easy to de-solder with a little practice. If you play with SMDs then you probably already have a heat gun. You can put a small length of fibreglass PCB on top of the chip to help buffer it from the heat. After removal then the board can be cleaned using the heat gun and wiping the solder off the tracks with a slightly moist cloth. I also put painters masking tape around the chip to help protect the rest of the board. The tape should be the more expensive blue tape. The cheap yellow tape can decompose and leave a sticky residue on the board after heating.

Occasionally you just have to forget about desoldering SMD components. Even the small diodes can be difficult to remove, even with the two soldering irons technique. I recently received a Christmas present of an Icom IC-7300. I wanted to remove a couple of the programming diodes to extend the TX range to include 27MHz. (*That sounds interesting…?! Ed.*)The diode panel is fitted with diodes only about 1mm long and about 0.5mm wide. They are also spaced about 0.5mm apart in a large matrix. The last thing I want to do is to destroy the control card in a £1300.00 rig. Sometimes you just have to know your limitations as well as the limitations of your chunky tools.

Having written all this, I find that almost every situation needs a different solution. I have recovered 100s of IF transformers and re-wound them for home brew projects. With these I find that it is best to de-solder the two tabs securing the can. Then dismantle the can and ferrite screw. The coil assembly can then be de-soldered very gently. The pins are mounted in plastic and they are very easy to break. It is better to clean off all the solder then wiggle the pins to be sure they are all free, then push the pins through the board from the component side.

I hope that this has given you a bit of food for thought. If you have any unusual desoldering solutions then I am sure Peter would welcome them.
Very best regards from Harry - SM0VPO (http://www.sm0vpo.com (note that there is no S in HTTP))

Making Manhattan pads

Use .020' thick double sided pcb material - cut with scissors, and can be soldered down for a more permanent fix than Super Glue; or use discarded 2mm thick double sided FR4 material from your local PCB manufacturer, and scribe deep cut lines guided by a steel rule, with:

- A tungsten carbide tipped tile cutter
- A triangular or semi-circular Swiss file
- A short length of hacksaw blade in a home-made holder
- A Stanley craft knife
- A small jeweller’s screwdriver, held at an angle so the corner of the blade tip cuts a line

Then use pliers to shear off the scribed squares / shapes. You get hundreds for free…!

Antenna Topics

Turnbuckle tensioners

These are the tensioners sometimes seen on commercial antenna poles, masts and the like, and on some amateur radio antenna masts. I came across them supporting the upright exhaust ducts from semiconductor clean room machinery, on the factory roof and gantry walkways.

Yes, those things! After a week or two in UK weather, the waterproofing spray used to keep them rust free has washed off; stainless steel types are much better (and far more expensive) so how to keep these things serviceable?

Neat trick Stan taught me: mix a few teaspoons of 'petroleum jelly' (or any other 'grease' that takes your fancy) into half a pint of boiler juice (kerosene, or paraffin in the UK), Turps Substitute or White Spirit, and paint your turnbuckles (or any other steel bits you want rust free) with the mix. The kerosene evaporates, leaving the thinnest smear of grease behind on the surfaces - and, more importantly - inside all the nooks and crannies. Costs pennies, lasts for months (depending on weather, of course - don’t expect miracles in more extreme places).

Hot Wire ammeter - measure REAL RF Amps!

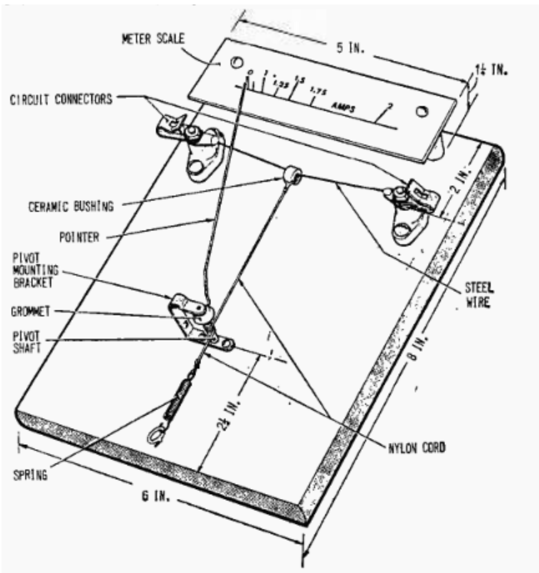
Here’s a design that can easily be reproduced in modern materials, as the principle is a universal truth: heat is proportional to RMS amps. Not peak amps; not average amps; not scaled for sine waves only - no, this is your genuine, no nonsense real antenna amps, them as what does the business!

Of course, nothing under the sun is new, this design mimics old ‘hot wire’ designs - not often seen nowadays, but if you find one (very likely dud) at a flea market, on eBay, radio rally, car boot sale, whatever - then grab it, pay pennies, and take it home with a sly grin, never looking backwards. The operating principle is so simple most likely it can be repaired with some fine work with tweezers, watch-maker’s screwdrivers and the like. Don’t confuse these with ‘thermocouple meters’ though, which are unfixable (more or less).

The original came from https://worldradiohistory.com/Archive-Radio-Logbooks/Science-and-Electronics/Science-and-Electronics-1969-08-09.pdf and the diagram is below. Obviously you won’t get this home-made design to run properly oNorth of 40 metres, but by using sensible RF principles, like putting the steel (or brass, copper, what-have-you) sense wire down the centre of a copper tube to make it (more or less) a co-axial assembly, and taking the motion nylon cord drive out through a hole in the tube wall, will make a useful TRUE RMS RF amps indicator.

It won’t instantly respond to RF amps, but it WILL tell you the truth, nothing but; for tuning up an antenna for maximum amps a hot wire ammeter will need a second or two to respond but will indicate without any doubt the ‘sweet spot’.

Anyway, enough waffle: here’s the design:



You might like to look at the nearby articles in the magazine, all ‘reet good stuff’!

Ionisation test for antennas finds hidden problems

WARNING: this test uses very high voltages. If you’re not familiar with ‘one hand tucked behind your back’ and other standard HV safety techniques, DON’T DO IT. I’m not

responsible for explosions, fires, electrocutions, or anything else however remotely connected to this test method, the circuit or it's use in any way.

Make an earth hook and keep it on the kV output at all times you're not running the test rig, and earth out the antenna connection AND kV output from Cockroft-Walton multipliers when finished testing - capacitance in cables, antennas and the like can hold hefty charges. The earth hook can be made from the hook from a wooden coat hanger - they are threaded where it was attached to the wooden hangar. The insulating rod can be tufnol, perspex or polycarbonate - NOT WOOD - and should be 400mm long or more. The cable to the earth clip is copper extra-flex wire inside 6mm i/d flexible clear wall PVC tubing and all joints are firmly soldered and braced / re-enforced with heavy plastic tie-wraps.

Ceramic seals, klystrons, 4CX250's and the like are tested this way; a REAL test of your antenna insulation, and that includes the co-ax feeder, tuner and low-pass filter, as well as insulators. Nearby trees can alter the air insulation dramatically by increasing the relative humidity; as can next door's boiler exhaust or tumble drier vent. All these and many more can affect your 'Wonder-Whiz-Blaster' 10kHz to 10GHz antenna!

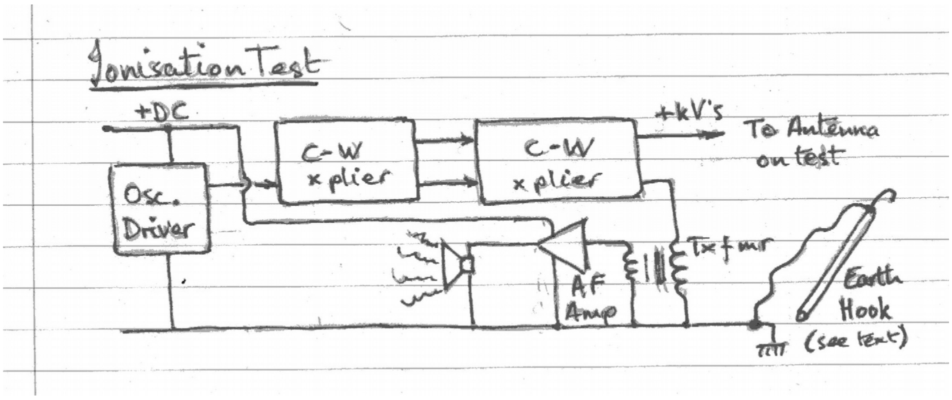
The idea is to use an audio oscillator and power audio amplifier (or a 555 driving a power mosfet?) to feed a Cockroft-Walton multiplier chain (chosen because the output impedance is very high, and thus current is limited) and sense the HV current in the earthy return side (with multiple signal diode clamps) in an audio amplifier, thus any leakage is indicated by sound. Ionisation leakage causes an abrupt rise in volume with a hissing, warbling, wandering note; flash-over breakdown is announced by a loud 'crack'.

Rather than go through the whole construction of such an HV generator, I advise you look at:

https://hackaday.io/project/176220-diy-cockroft-walton-voltage-multiplayer-100000v

...where you'll find construction described far better than I can. I'd recommend using 15 - 20kHz drive ('cos you can't hear it, and it's vastly more efficient than 50Hz) and good HV diodes, like the types sold for microwave ovens, or 1N4007's in series. The multiplier in the article is driven from 5-10kV AC transformer; I'd recommend you build several multiplier modules, then you can string them together to get the multiplication you need to get to the magical 10kV or more output.

You can drive this circuit with an valve transmitter HT transformer; 350-0-350 will yield 700 volts which fed into 20 stage multiplier gives 11kV as you get losses in every stage, it's not a perfect multiplication. You're looking for 10kV; you'll certainly get ionisation results with that, just keep stacking up the multiplier modules. Neon sign transformers are another good driver; search our favourite online auction house for lots of low cost HF output choice. Go for the highest kV's you can justify.



It’s wise to fit an inverse parallel diode clamp to the transformer secondary to limit the surge voltage. This clips the loud crashes on flash-overs but you’ll need to experiment to find out the best number of diodes; or fit the diodes directly on the audio amp input. The transformer is any you have to hand, it’s job is to safely isolate the earth line pulses from you!

Stop Press

Being born many years ago in Rochdale, Lancashire, it was impressed on me that a significant historical and humanitarian feature of the town was that it was where ‘co-operation’ (the Co-oP), a movement that created a wholesale and retail system whereby customers shared the profits of the enterprise, once all the bills had been paid. This spurred to action luminaries like John Bright, who, with Richard Owen, got the Corn Laws overturned which put bread into millions of hungry mouths in Victorian Britain. ‘Co-op’ shops are still a feature of modern Britain, and the principle of ‘Divi’ (the sharing of the shop’s profits with the customers) still exists and is to be valued, in my opinion.

The principle of helping others is very much in the amateur radio spirit. I was asked to put a link in Hot Iron by G6XMO as he’s set up shop to make 3D printed parts on ‘cost plus upkeep’ terms, true to the spirit of co-operation.

Hot Iron is non-commercial, and doesn’t carry advertisements: G6XMO’s enterprise, on ‘cost plus upkeep’ basis, is welcome (as are any others) in the true co-operative ilk. You’ll find his web pages at:

https://www.whizz3dparts.co.uk/

...and I wish Toni the very best in his co-operative enterprise.