Hot Iron #111

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CQ-CQ-CQ

Software...

I have yet to come across anything (in my blatantly biased opinion) as ridiculous as the software "features" built into modern electronic equipment - be it amateur radio, photography, broadcast radio receivers, even fridges and freezers are now among the afflicted. Nobody, but nobody, likes sieving through stacked menus and selection tables, impossible in a rush: a control panel is far more pleasant with simple knobs to twiddle. Stacked menus, in the rush of the moment trying to capture that fleeting moment, that elusive Brocken Spectre of ephemeral fading voice, a dozen menus to navigate is exactly what you **don't** want, need or desire.

Not only is every electronic gizmo set up with umpteen menus and commands, there is no standard structure to the menus - so you have to learn a different system for every gadget you have. How does that help a customer? Answer: it doesn't!

Modern 'software' is verging on the ridiculous. Features you'd never use in a lifetime, added by some "disrupting" motivated irk (I suspect with nothing better to do) who thinks 'more is better, biggest is best': then promptly adds another abstruse function that only a "left handed non-smoking pole vaulting lemon squeezer" could possibly require - in his child-like determination to find yet another menu full of pointless adjustments that only serve to multiply confusion and irritation.

Mind you, that's not to say the knobs on the front of an AR88 didn't need dextrous hand movements to get (and keep) that contact - but get it they did, under the pressure of wartime too, in their original application. Having cut my teeth on electrical / electronic equipment featuring and using some of the most toxic substances this wonderful planet can create to make the twopenny transistors and diodes we happily use by the bucketful - as well as the hundreds of millions in a modern CPU chip - I can say that "simple is best"; robust construction and open, accessible chassis are the ONLY practical means of creating reliability with maintainability.

Many machines I worked on, either routine servicing or breakdown repairs, had computer controls, and mimic displays showing temperatures, set points and the like: one absolute I noted in my 50+ years of "active service" was that machines controlled by industrial PLC's (Programmable Logic Controllers) were more robust, reliable and faster to fix ("mean time to repair" is part of Production statistical process control) than the machines equipped with a PC running control software and interfacing to the real world via opto-isolators and miniature PCB mounted relays. The machines that ran, year in, year out, in the demanding semiconductor processes (I'm thinking of Vapour Phase Epitaxy, deep N layer Arsenic Diffusion Furnaces and Plasma Etch) had big open frame relays (with hefty contacts that could be cleaned up with a file); modular control units that could be interchanged in minutes; and simple interconnects with multipole "Mil-Spec" circular connectors that screwed together and had proper cable clamps - that would hold until the cables themselves parted.

The Test Hall was a mixture of discrete logic control, PLC's and Office PC's. The PC's were cheap, cheerful solutions; the high speed machinery used dedicated industrial PLC's running maths algorithms, but the real stars were the discrete logic controlled test stations. Utilising simple, fast logic - the "RISC" philosophy - these beasts might not have been easily adaptable to every device we made, but by jingo, would crunch a huge amount of throughput in a night shift. The only job in the morning was to empty the product bins to stop them overflowing! The sight of 25 million transistors in a bin is a nice way to start the working day!

The key feature of all this is SIMPLICITY, which gives reliable results. You're paying a hefty price for all the unused Bells and Whistles in modern amateur radio equipment. Oh, sure, it might have an edge on odd occasions - but, as Bruce Vaughan NR5Q comments in his book "Surviving Technology" - his Ultimate Regen receiver will receive at least 95% of the signals your mega-bucks commercial receiver can. We are Amateurs, after all, not professional listening stations, funded by Government money!

Occam's Razor is alive and well at GW6NGR; KISS technology is reliable, fixable, a pleasure to use. I would tactfully request that all manufacturers of electronic gear keep this in mind: the law of parsimony states that "entities should not be multiplied without necessity" in the design of their software. After all, how about thinking of your customer first, or is that a bit too "disruptive" for you?

Small is Beautiful?

E.F. Schumacher went to great pains to explain how technology has debased human creativity and more or less destroyed 'job satisfaction' in his book "Small is Beautiful". Technology diminishes the human appreciation of time well spent; it removes the human element to a great extent and offers convenient, but very limited, mental satisfaction to the user.

Think on this applied to your home constructed radio receiver. It might not have all the features a "bought in" receiver offers; it may well struggle to equal the capabilities, or the diversity of functions. But - and it's a huge 'but' - YOU made it. YOU put it together. YOU can modify it, improve it, try different approaches. It's YOURS, and belongs - in every way - to YOU, not some distant designer who's Muntzed the d*mn thing down to the lowest price, used midget components only a robot can manipulate, and needs a trained microbe that can solder to repair the blasted thing.

If you think surface mount components are a bit tricky, wait a few years hence until they are one tenth the size. Whatever you do, when using a "speck of dust" component, is don't sneeze! It gives an interesting view of the future when, to construct a simple circuit, a lab. standard microscope will be required; and how do the designers of ever shrinking components believe, will a less able, or less financially capable user, be able to work with them? Don't think that SPICE and similar software simulations will rescue you: software can't represent the real world surroundings of your circuit, and all the ill winds they might blow over your design!

Semiconductor manufacturers are looking at solder down dies, and even smaller programmable structures, so pcb manufacturers (that's you and me, in our amateur context) will need semiconductor assembly wire bonders to connect the components. If enough people want "through hole" parts, in sizes that humans can see, handle and rework, semiconductor manufacturers will make and sell them - IF you want 10 million next week, and every week thereafter. They do actively listen to customers and will fill a need if there's money to be made, but keep to mind it's a full production facility that has to be configured - and if the trend is towards smaller scale devices and more integrated construction technologies, the semiconductor manufacturers want their factory space for that, not "ancient technology" like through hole devices. There just isn't the profit in these old technologies with their lead frames, tin plating baths, testing via hard wired connection (not electron scanning) and money stuck in "Work in Progress"!

Take, for instance, the demise of the amateur's best friend, the RCA 40673 dual gate mosfet. It's relatively simple (as shown by Pete Juliano N6QW recently) to stack jfets in cascode to substitute a 40673.The only drawback is the vast spread of characteristics inherent in jfet's: you're almost certain to have to fiddle with the biasing to get the best from a jfet 40673 substitute.

That said, I sounded out a few contacts in the semiconductor industry and was pleasantly surprised to find there is a small manufacturer fitting SMT 3N211 dual gate mosfets on micro-pcb's as pin for pin compatible replacements for 40673 dual gate mosfets. Dual gate mosfets represent major simplification for radio amateurs, delivering excellent performance mixers and easy practicality. They disappeared primarily because semiconductor manufacturers didn't see enough demand for them in tin can through hole packages, which represent (in comparison with SMT devices) a much larger manufacturing cost. Any reasonably priced alternative would be a new opening for radio amateur constructors. I shall be following this up; and would welcome your comments. If the demand is there, I'll see if I can discover more information.

On a similar topic, one of the specialities of the old textile industry in my home county of Lancashire is the specialist manufacture of springs: used by the million in the textile machinery of yesteryear. Spring winding is an art identical to inductor stock manufacture: many varieties were once available to amateurs in years gone by, ("AirDux" for instance) but nowadays rarer than hen's teeth. I asked a leading Rochdale spring manufacturer about winding hard drawn copper or brass wire to make "standard" inductor stock: he thought it eminently "do-able" so long as the wire was of sufficient diameter and hardness. He suggested an internal diameter of 50mm, minimum, a wire diameter of 2.5mm - 3mm, in tight coiled lengths of 100mm. These could be easily manipulated by home constructors, cut, stretched, and supported using epoxy resin "bars" like the old AirDux style. If Hot Iron readers would comment I'd be very grateful - who knows, it might be a new chapter in amateur radio construction?

Bloggety Blog...

Ryan Flowers has asked me to mention his Blog at miscdotgeek.com so I have! Take a look, lots to see, and plenty of useful ideas too.

I had a very kind email from Tom McKee, K4ZAD; he asked if I could mention his pages. I will with pleasure!

http://www.radio.imradioha.org/DIY_Coil_Calculators.html

http://www.radio.imradioha.org/PC_Based_Test_Gear.htm

http://www.radio.imradioha.org/Manual_Sources.htm

These contributors are at the core of modern amateur radio construction and I think should receive the accolades they so richly deserve.

A brief note...

I'm now ensconced in my new home in West Wales, out on the Lleyn Peninsula. I'm surrounded by boxes, bales and bundles, and slowly getting back to civilised habitation. I don't have the facilities or easy access to materials (yet...) I enjoyed at my old house, so I apologise for the somewhat abbreviated Hot Iron presented here, and any typos you might spot. I have vast amounts of work to do on my house: getting the roof watertight and some form of heating, it's -2°C outside as I write! I will be up to speed hopefully within 9 - 12 months; much to do, trees to fell, walls to repair, drains to dig, not to mention the bills and final demands from my old address - all of which require attention. Please bear with me, normal service will be resumed as soon as possible!

Particular thanks go to the contributors who sent me articles for inclusion. It really is refreshing to hear from you constructors: no matter how simple or (apparently) old fashioned, every item for inclusion is valued and appreciated. More, please!

Rx Topics

The Audio Cube, by Alan Victor W4AMV

As most of you know, I favour a modular approach to radio equipment construction. It offers the opportunity to “cut and try” in a known environments and structure, so improvements (or otherwise) can be readily assessed. I had a very interesting email from Alan Victor, W4AMV, about his modular approach - and it ticked the “keep big signals away from the little ‘uns” approach I like too. Alan has split, in old fashioned (i.e. proven) valve style, the audio output and power supply from the low level RF sections of his projects. I particularly like the twin op-amp filter of adjustable centre frequency and “Q” - it’s a very neat circuit indeed. His article is below:

The AUDIO CUBE, Alan Victor, W4AMV

The AUDIO CUBE is an integrated assembly consisting of a high current power supply, audio power amplifier, active band pass filter and speaker. There is sufficient room in the chassis layout which is made up of left over bits and pieces of wood to add options. The filter targets narrow band pass applications for CW and has adjustable center frequency and Q. Their settings are independent and they do not interact, a nice feature. Filter details are discussed in Williams text [1] and simple equations are presented here. The filter structure is referenced in the literature as the Dual-Amplifier Bandpass or DABP structure for short. A single op-amp featuring dual amplifiers like the LM358 makes this filter an easy one to duplicate.

The goal of the assembly is to dedicate the audio processing chain in one package which could be used with any receiver on hand. The electrical assembly of the cards prompted the AUDIO CUBE name, as the final assembly takes on a 3-dimension cube form. The power supply card serves as the mother board and the audio filter and power amplifier cards are mounted vertically at right angles on the supply card. This makes a nice compact assembly, measuring 4x4x4 (10.2 cm) inches on a side. A picture of the electrical-mechanical assembly is shown in figure 1 while the finished front view of the housed unit is seen in figure 2.

Figure 1: Inside top down view of the AUDIO CUBE

The speaker enclosure houses a 3 ½ inch (8.9 cm) 4 ohm Infinity ™ speaker capable of 25 W rms power. The card nearest the speaker front panel is the filter card, to the left the audio power amplifier, a TDA2040 operating at 15 V. This amplifier is capable of 30 W audio output but limited to 5 W peak at 15 V supply. The amplifier heat sink is the center horizontal finned unit. The power supply card and main supply filter capacitor are just to the right of the amplifier heat sink. The line fuse is mounted on the left side wall. The power transformer is in the rear. The enclosure is made from ¾ inch (2 cm) thick MBF wood, quite dense and makes an excellent speaker housing. Because the front panel is thick, mechanical

Figure 2: Front view of the AUDIO CUBE.

The controls bottom are ON/OFF, filter bypass and external internal speaker switch while the top row provide control for filter Q, center frequency and volume.

mounting of control shafts is difficult. Hardware provided for mounting controls such as toggle switches and potentiometers will not work. You can counter sink the rear panel, cut out an area to mount a plate on the front or attach the controls from the rear with a mounting plate. This is the method I used and I fashioned a plate from some scrapes of PC board material. I thick this provides a cleaner look to the unit.

The enclosure outside dimensions are 8” x10” x11” (20 x 25.4 x 28 cm) inches and has a spacious bottom chassis area below for added circuits such as wider band filters if desired for SSB and AM audio enhancements. The DABP filter is capable of a wide range of Q and center frequency adjustments. The current design is set for approximately 400-to-1000 Hz center frequency with an ajustable Q of 3 to 50. Q values in excess of 100 are easily achieved as well as cascading multiple sections. The power supply is capable of high output load current without affecting audio distortion via power supply voltage clipping. The audio amplifier is built around a TDA2040, however discrete or other integrated circuit designs are quite capable. The main feature they should provide is low distortion and hum rejection. In operation, the AUDIO CUBE provides the enhanced Q multiplication audio effect of a narrow bandwidth filter. That chacteristic of low level hollow band limited noise power, reminiscent of high Q filters is apparent. However, there is no ringing. Schematics are shown in figures 3-through-5 and simulations provided by Spice are very helpful in finalizing the design. Shown are power supply, power amplifier and DABP schematics from Spice.

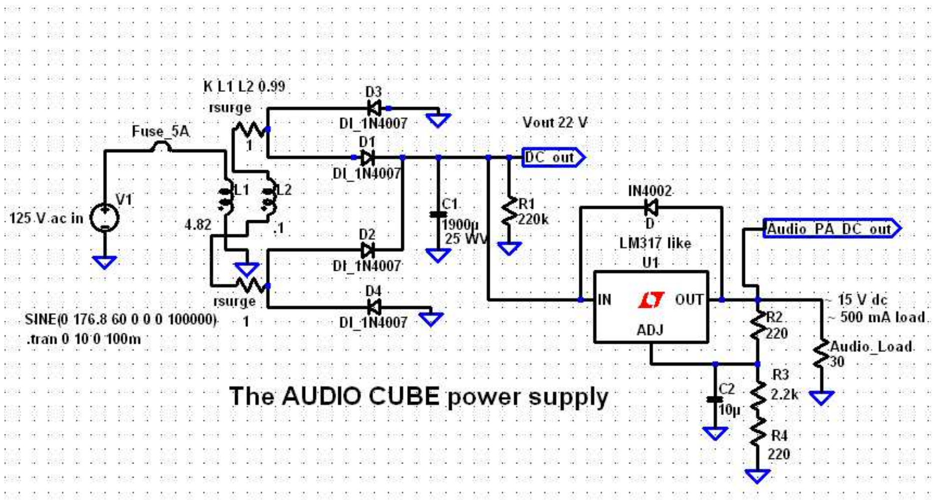


Figure 3: Power supply 15 V over 1 A capability

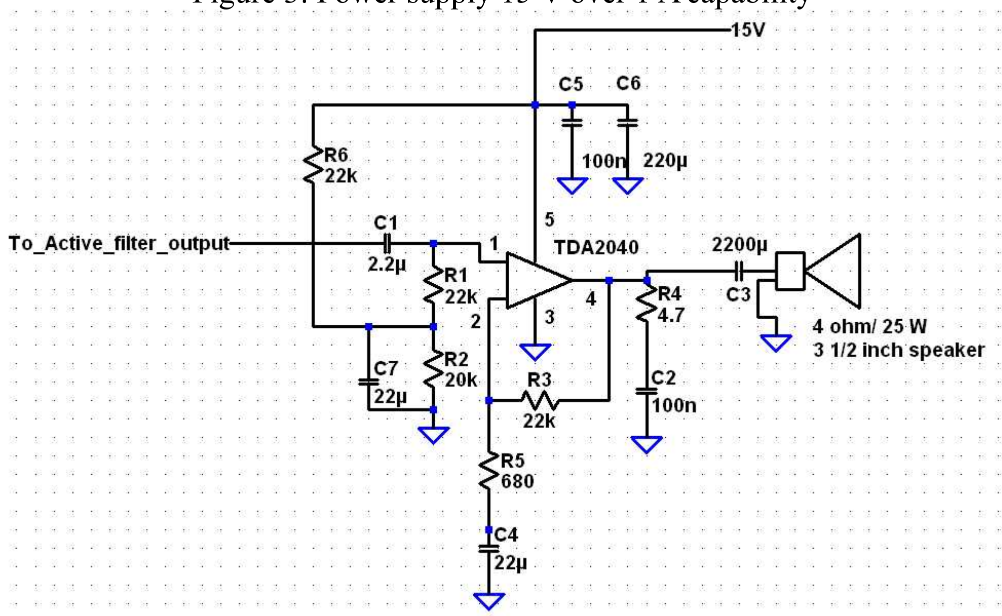


Figure 4: AUDIO CUBE Audio power amplifier, TDA2040

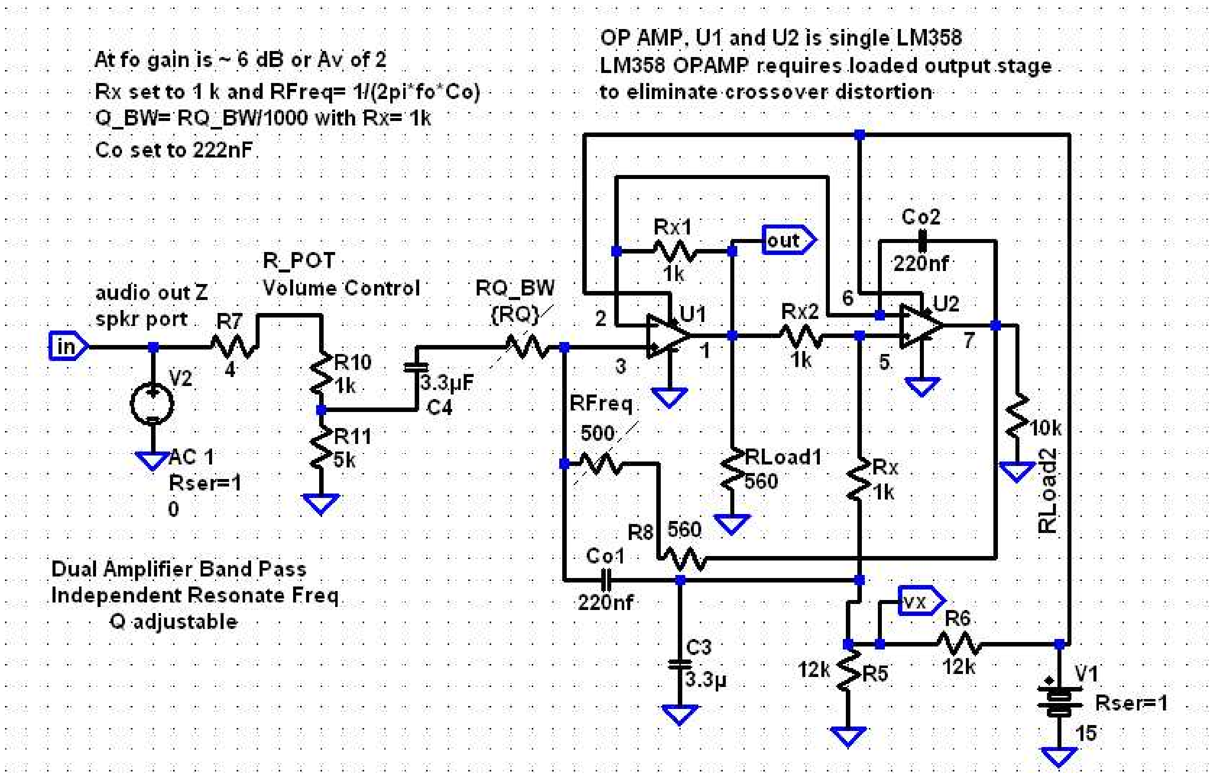


Figure 5: AUDIO CUBE DABP filter structure

The simulations for the filter response are collected herein and compare very well with bench test operation.

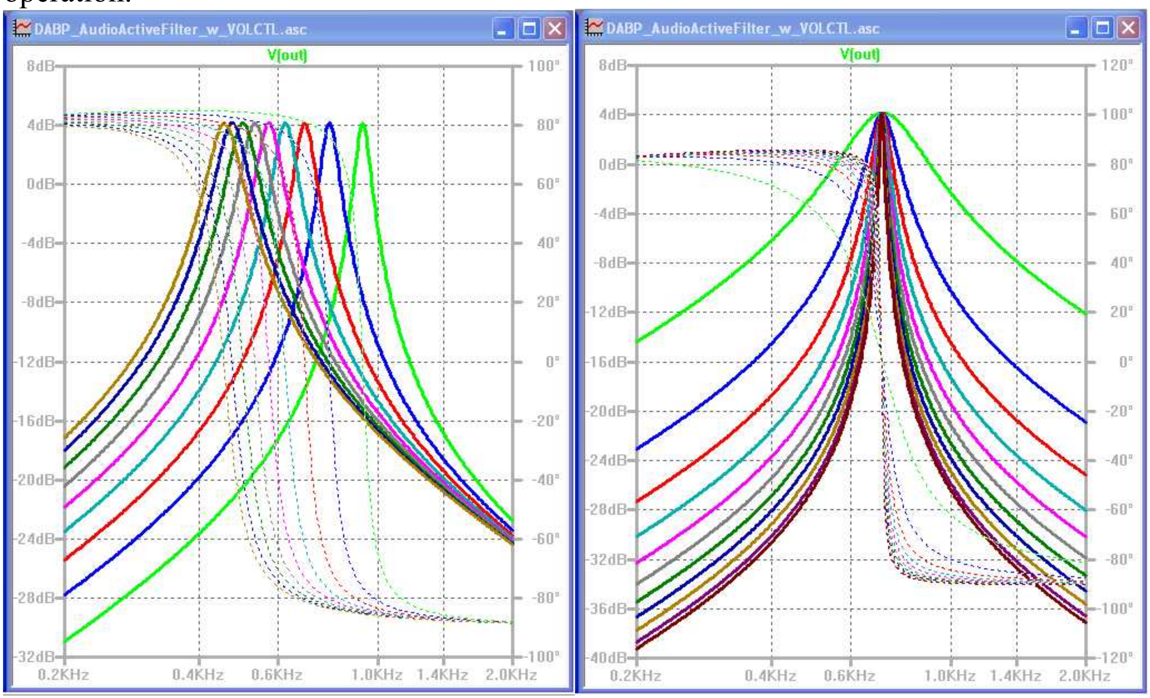


Figure 6: Filter center frequency sweeps and Q, bandwidth variation at 750 Hz.

DABP Design Equations:

Reference to the DABP schematic of figure 5, resistors Rx, Rx1 and Rx2 are conveniently selected to be the same value, all 1k. If (RFreq+R8)(Rx1) = R^2, the following design equations can be obtained:

(RFreq+R8) = $1/(2\pi * f_r C_{01})$ where f_r is the center frequency and again for convienience, the capacitors are chosen to be equal; $C_{01} = C_{02}$ = 220nF in my case.

The R8 value is selected so as to limit the min and max center frequency range.

And **RQ/Rx1 = Q** and with RQ varying up to 50 k and Rx1 set to 1k, Q max limit is 50.

This filter center frequency is variable from an approximate frequency of 1200 Hz down to 300 Hz if RFreq potentiometer varies from 0 to 2k ohm and $C_{o1,2}$ are 220nF.
Meanwhile the Q is adjustable to a maximum value of 50 with the RQ_BW potentiometer set to a maximum value of 50 k. This is implemented with a 10 turn helipot.
Note, if a single supply operation is desired, than the filter grounded nodal components, Rx and C_{o1}, must be returned to an AC bypassed node, schematic reference point Vx. At this node, half supply voltage is provided.

References: Arthur B. Williams, *Electronic Filter Design Handbook*, McGraw Hill, 1981, pp. 5-46,5-48.

An updated Spontaflex receiver
Can be viewed at:

https://www.transkommunikation.ch/dateien/schaltungen/diverse_schaltungen/radio_circuits/Spontaflex%20550khz-30MHZ%20Receiver.pdf

The designs of Sir Douglas Hall - regenerative and reflexed receivers - is the interesting topic outlined in: http://theradioboard.com/rb/viewtopic.php?t=7906

(with many thanks to "Radioboard").

These designs are perfectly capable of excellent results, not only on A.M., but SSB and CW by virtue of homodyne oscillation set by the regeneration control.

They are, in essence, frequency selective shunt feedback amplifiers, with RF feedback to create the regenerative function, and AF feedback (which uses RF and AF stages) to selectively amplify the audio. Only the vast difference between the RF and AF frequencies allows the signals to be simultaneously passed through each stage; however, if the RF was much lower then the two signals would need some very nimble "footwork" to separate the frequencies, nullifying any advantages - but reflexing a low bands regenerative receiver would make a very interesting and simple receiver for local and middle distance amateur communications.

A different approach to 2m FM?
(NOT a Super-regen, a superhet using ONE transistor!)

I was talking with an old friend who was waxing lyrical about the days of "Top Band and 2m A.M. nattering" and the ultra simple ways it could be done. Roger Lapthorn's (G3XBM) "6-Box", his version of the 2m cross town "Fred Box" of yesteryear, is a beautiful example of the art. Every radio rally or junk sale used to have a Top Band (and / or 2m) "talk in" service for out-of-town guests, and why not?

We have bands available, which allow different modes, so why not Top Band NBFM / Phase Modulation, for instance? I've always had it impressed on me by old established amateurs that to preserve amateur bands they need *using*; neglecting them is an open invitation to losing them. So long as we stick to our licence conditions, don't cause unnecessary interference, then off you go!

One transistor superhet? Take a look here:

https://www.google.com/search?q=Superheterodyne+receiver+with+one+transistor&newwindow=1&sa=X&rlz=1C1SQJL_roRO82

9RO829&biw=1280&bih=625&tbm=isch&source=iu&ictx=1&fir=fGv6UWzXKdfCOM%253A%252CgwXJCKeUoO1MdM%252C_&vet=1&usg=AI4_-kQbNjh4stya7KGAgrJIqGYCQ05NwQ&ved=2ahUKEwiP_c2a1NLhAhWKpYsKHSuwBzQQ9QEwA3oECAgQCA#imgrc=5NVF-7kbIbc4gM

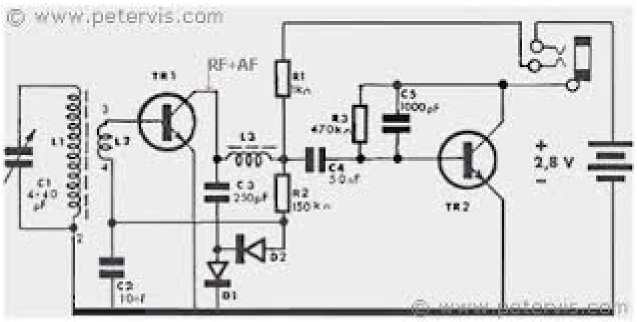
...all very interesting circuits - unfortunately no write up, but hey - experimenting with ONE transistor, what more do you want?

I admit trying to get a recalcitrant one transistor self oscillating squegging circuit running can be VERY frustrating, though. The FM receiver on this page struck me as being very simple; admitted, this is no “DX’er” but for local QRP fun, this has got to be worth an hour or two experimenting. Take a look at some of the other circuits too; some lovely little “dabbling” suggestions!

On this theme, take a look at:

https://www.petervis.com/Radios/Radios.html

...where you’ll find items like this:



Now ain’t that a cute little receiver for 160m, 80m or 40m A.M.?

Now an item from Rick Andersen, KE3IJ; a man from whom I have learned a great deal, and admire his simple and lucid approach. The idea of reflexing a receiver is a very useful way to get the most from a simple design. This would make a superb little Top Band natter box receiver; now if someone could design an efficient, small and light 160m portable antenna, that would be very just the job! To see what I mean... take a look at:

http://www.ke3ij.com/reflex.htm

I’d advise you to have a good trawl round Rick’s pages: good RF engineering on every one of ’em.

Tx Topics

Amplifier classes...
...apparently baffle some amateurs: so some simple notes to explain the “why and wherefore” are included.

A few facts, often missed, are in order here. A class A audio amplifier will give you the lowest distortion; but it will still distort. It is NOT a perfect amplifier! Gets very close, mind; but a properly designed class AB will be nearly as good you’ll never notice the difference.

Class B is where the output stage(s) have no standing current: the power devices switch on at each half cycle, but you get cross-over distortion - so allowing a sniff of standing current in the power devices helps eliminate distortion and is described as Class AB.

Class C is the well known RF technique: ensure you use high Q inductors in the output resonant circuits to get the best efficiency.

Class D is a pulse width modulation technique: very efficient, and low distortion; but it has the dreaded digital clock syndrome, where you have very high speed digital edges within and is just asking for trouble. The interference and edge issues are beatable, but the apparent ease and simplicity of the principle vanishes.

Below are some links and information:

Audio: https://sound-au.com/

A,B,C,D, and F => https://www.electronics-tutorials.ws/amplifier/amplifier-classes.html

E => https://people.physics.anu.edu.au/~dxt103/class-e/

E => http://www.wa0itp.com/class%20e%20design.html

(includes MOSFET characteristics in the spreadsheet)

Just fill in your requirements, power, supply volts, device, and the job's done.

Audio Topics

Analogue Switched capacitor filters

These little beasties promise superb results from one chip: varying the clock speed shifts the filter "pole/zero" characteristics, but - yes you guessed it - if it's got a clock then it's a source of digital noise. Another reason to split the RF bits and Audio / Power Supply methinks?

A typical example of this technology is the MAX291 family; I have no particular recommendation for Maxim, other makers devices are available, but I find the data sheets from Maxim are very easy to follow. The MAX291 offers an 8 pole filter network, configurable to Butterworth, Bessel and other filter characteristics: you pays your money and makes your choice.

But... and it's a big "but" - it needs some amateur experimentation here. Let's see one of these in an amateur receiver as a bandwidth defining speech processor for SSB transmitters. Anything with a digital clock is an uncomfortable passenger in an analogue system!

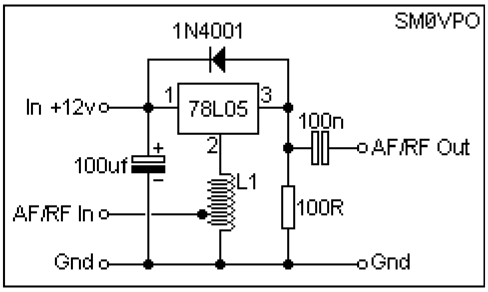
Power Supply Topics

The design of a power supply is usually relegated to the end of a project; it's normally thought of as a given - but this can land your in some real bother! A power supply must not just provide the amps and volts: it MUST be fast enough to cope with any sudden changes in load, either increasing or decreasing. Linear circuits, like op-amps, simple audio amplifiers and the like - rarely have sudden load changes, but if you have anything remotely "digital" you need to think carefully about your power supply and supply rail decoupling. It's all well and good having 0.1 µF disc ceramics scattered around; low series resistance electrolytics are a good idea too. These energy stores have to be refilled after any sudden load changes; and this is where amateur power supplies can fall down.

A technique called ‘step impulse testing’ is how designers check power supplies, as well as testing ampacity, voltage stability and regulation. The “gulp” power supply tester is the tool to use: this uses power mosfets to suddenly (in 10’s of nS!) apply a full load. The current rise characteristic is monitored to ensure the series impedance is low enough to eliminate resonances, formed in the series inductance and stray capacitance of the power supply’s internal wiring.

The moral of this tale: build your power supply as if you’re making an HF linear amplifier. Short, straight and wide printed circuit tracks, thick copper wire, far heavier than just the requirement to carry the amps without excessive volt drop. You have to get the energy out of the storage electrolytics and into the load with minimum time delay - and most im[portantly, without inductive resosnances, which cause over-voltage problems.

Of course, the regulator circuit must be fast, too: you’ll see some HF linear amplifiers that actually use a voltage regulator! Below is one design from Harry Lythall, SM0VPO:



I was responsible for maintaining an Ion Implanter in my previous life; this required a regulated power supply to heat the ion source filament: a 2.5mm diameter tungsten rod, 75mm long, to 1300°C. To get a little longer running life from the filament (it erodes due to sputtering and back electron bombardment) I adapted the power supply: the power supply eventually ran out of volts to drive the increased resistance of the filament when it got very thin. I couldn’t change the transformer or the physical structure of the power supply, so, I found some Schottky diode rectifier modules that were a one-to-one replacement for the PN junction power rectifiers. Schottky diodes have lower forward volts drop than a PN junction: changing to Schottky diodes not only got me 10% more filament life because of lower volt drops in the rectifiers, but cooler running which gave more reliable performance.

If you need reliable low voltage power rectification - consider Schottky rectifiers. They cost more or less the same as PN junction diodes, but give you far less rectifier volt drop.

Component Topics

Using DC bias to adjust toroid inductors

Following the interest I’ve received regarding magnetic amplifiers, I thought about L/C resonant circuits with DC bias applied to the toroid core forming the “L” component. I found some references that suggest this is indeed a practical and useful function, following the theory of magnetic amplifiers. The introduction of a DC bias component allows the inductance to be *reduced*; sorry, but I can’t find any way to *increase* the inductance by DC injection! The obvious thing to do is add a few turns more than the calculated number, and use DC bias to “back off” excess inductance. Obviously this can’t be taken too far; the core will saturate: the inductance - and “Q” - will rapidly diminish.

https://www.mag-inc.com/Media/Magnetics/File-Library/Product%20Literature/Ferrite%20Literature/cg-01.pdf?ext=.pdf and page 3 of https://www.vishay.com/docs/49782/49782.pdf indicates any core can be adjusted down on inductance by applying DC bias.

This idea of DC bias to shift the operating point along the magnetic B-H curve of the core material has, perhaps, a hidden caveat when you're building a simple 5 watt QRP transmitter that employs a 12 volt power supply. It's common practice to use a centre tapped bifilar output transformer to feed DC into the collector (or drain) of the power device and match the resultant ~12Ω collector (drain) load impedance - the power device biased to a nominal 1 amp current - to a 50Ω load. Keep to mind that the core you've used for the output transformer has to carry the 1 amp device current.

A.M. advocates will recognise this problem, it's traditionally overcome by adopting Heising Modulation. This (in essence) uses an RF choke to feed DC into the power device, and capacitor couple the bifilar output transformer to the collector (drain) side of the choke. Thus DC is eliminated from the matching transformer, at the expense of an RF choke that carries DC. The collector (drain) "Heising" choke doesn't need to be too large an inductance, though: otherwise you're asking for spurious / parasitic oscillation in the choke. Better to err a touch on the less inductance side than too much.

Sometimes, it's less costly...
To buy ready built assemblies for home construction. Take a look at:

https://www.ebay.co.uk/itm/10X-Pre-wired-Mini-Toggle-Switch-ON-OFF-Control-for-Car-Emergency-Lighting-B2Z/233692719260?hash=item36692be89c:g:6G0AAOSwa55cKbaV

I couldn't buy the bits to make these up for that price! What I don't know is the electrical specification; but for anything under 50v AC or 70v DC and an amp or two, they will be fine.

Construction Topics

Video training and demonstration
It can make life much easier if you are shown how to build something, either person to person or a video showing the how and why of the assembly. Some years ago I was involved in training Eastern European operators who had no grasp of English how to assemble pcb's; to surmount the language barrier, we video taped a skilled operator completing the assembly, carefully and slowly, illustrating the critical steps. If the trainee couldn't quite grasp the particular step, they could "rewind" the video and see the step repeated over and over - and in freeze frame too, so the exact detail could be studied. A video monitor set up over the benches meant that no language was required: the operators very quickly picked up the assembly procedure and production went at a very fair clip - the video scheme is still in use at the production plant and has being developed for many other tasks in the factory.

Stripping parts and wiring
Microwave ovens provide a host of useful "junk". The wiring - in all the m-waves I've dismantled - had radiation hardened PVC wiring ("poor man's PTFE") high temperature cables, Molex type connectors, HV capacitors with inbuilt bleed resistors, mains input filter modules, microswitches and HV diode(s), not to mention miniature lamp holders and those whopping HV transformers. All

these parts are grist to the mill for the home constructor: grab every scrap m-wave you can and strip it to the bone.

Scrap washing machines can be stripped too; they have yards of superb quality wiring inside, many wires terminated with ¼" Faston crimp push on connectors for easy assembly, and chunky mains filters capable of running many amps. They would cost a fortune to buy - so don't let these treasure troves escape your salvaging. Modern brushless drives also feature HV MOSFET power bridges, or BiCMOS power devices - ideal for HV jobs of all kinds. You'll not regret it!

Copper connecting straps

It's often far better to use broad copper straps, between hefty brass bolts with brass nuts and washers rather than a toggle or slide switch - especially if you're dealing with more than 5 watts. The simple combination of L & C in a 'L' tuner is one of radio's earliest and most reliable antenna tuners that can easily be reconfigured between series or parallel connection of the L and C elements, by using copper links and brass bolts. An L tuner, given enough turns on the coil and wide enough spaced variable capacitor will tune almost anything that conducts electricity to resonance and match almost any transmitter to a load.

Finding hefty copper strap, however, is not a easy or cheap task. Flattening copper water pipe is a possibility, but after a severe battering those pipe sections don't look pretty. "Pretty rough" is more like it! You might find copper sheet / strip in roofing suppliers; it's sometimes used for flashing strips and flat roo sheeting, as it can be soldered so readily.

A useful substitute for solid copper in this job is double sided 2oz. copper (or if you can get it, 4, 6 or even 8oz. copper) FR4 pcb material. I recall the Applications Laboratory design engineers scrounging from a sister factory some 6mm thick single sided FR4 material; this had 8oz. copper and was used to make stripline kW microwave equipment to test a proposed new range of high power FET's. The offcuts were voraciously grabbed by those in the know to make stable VHF super-regen receivers (radios were banned in the factory as being a "disruptive influence"). The 6mm FR4 was so rigid and stable, the receivers, despite being of the simplest designs, would hold a station rock steady for days on end without retuning (a lesson for regen. receiver designers: make it as rigid and solid as possible).

Of course, the HV capacitor is the "elephant in the room". Tuning high power RF systems into random antenna structures inevitably involves high voltages: Nikola Tesla strikes again. The Applications Lab. engineers had a sure favourite for fabricating high voltage capacitors: finned heatsinks. You can get these with wide fin spacings, they are easy to machine, drill and tap. Mesh a couple of these together on some simple mechanical sliders (nested aluminium angle sections make a good linear slider) and voila! You have a kV rated variable capacitor. If you're pushed for space (and money!), use just one heatsink, and assemble the other "plate" out of pieces of double sided FR4 material, stacked using spacers and brass studding. The main electrical connection to the FR4 "plates" should be a wide strap of FR4 material, soldered to each "plate"; I don't like the idea of relying just on the studding, especially 40m and above. All you have to do is set the heatsink up on a base and rig a simple mechanism to engage the "plates" together. Get a rough idea of the available capacitance by calculating 8.85 x (plate area) divided by (plate separation) = pF's, all dimensions in metres or sq. metres ($\varepsilon_o.\varepsilon_r$. A/D in Farads)

Don’t be tempted to use insulation between the “plates” in a capacitor that’s carrying kW’s of RF. As my mentor Stan told me “for kW’s of RF, you can’t beat clean dry fresh air as an insulator. Cheap and plentiful... and it don’t catch fire with Tan δ (delta) losses”. There speaks the voice of experience!

VXO’s...
It’s not commonly known that the metal cover of a crystal, when used in a VXO application, should NOT be earthed - as is the usual practice for a fixed crystal oscillator. Why? Because removing as much stray capacitance around the crystal gives more “pull”. I can’t guarantee extra kHz, as it depends on the surrounding construction and the cut of the crystal, but it’s so simple it’s worth a try.

Another method of adjustment that might get you that bit further is to run the VXO from an adjustable voltage regulator; varying the supply will shift the frequency too. Often forgotten too is that an overtone crystal, run on it’s fundamental frequency, usually has much more “pullability” than a fundamental crystal.

Test Gear Topics

Febetrons & Marx Generators for RFI proofing
I once had the onerous task of maintaining laser marking machines that burned part numbers into plastic bodied transistors, by firing an IR laser via a text “mask” into the little beasties at a rate of 80 or so per minute. Ablated marking is very much more robust than printed ink marks, but... it had an “interesting” effect on the test equipment in the Test Hall nearby. The laser marker used a miniature Febetron to power the laser: most folk have never heard of Febetrons (or Marx Generators, from which they are derived) these being beasts of high energy research and the like - these devices can rip protons apart (if you build ‘em big enough - and inside a mountain). They use a triggered spark gap to initiate the main pulse: 25kV, 100 amps for ~10 nanoseconds.

A miniature version would be an ideal gadget to see if your designs can withstand RFI; before we tamed the Production beasts, we could draw fat 2” sparks to a screwdriver from the earth bonding braids! I’m not giving any designs or drawings for these devices: if you want to play “big boys electronics”, the kind of energies nuclear research indulges in, you’ll have to look them up yourself!

We ended up building a lined room around the machine, using 18swg aluminium sheets, pop rivet jointed, and 12” wide strips of aluminium from the machine’s copper earth bus bars - which ran all round the machine frame - to the screened walls; these connected to earth spikes spaced every foot sunk through the concrete floor into 12’ deep earth pits, connected with multiple 12” wide aluminium strips. That stopped the Test Hall adjacent from complaining about “odd” behaviour when running leakage tests; but when 500 amp SMPS’s in the nearby electro-plating shop blew up for no apparent reason, my mentor Stan thought it time to get the local electricity supply engineers involved. They set up distributed lightning arrestors and quench capacitors at appropriate points in the plant’s distribution system, which solved the problem! See:

http://www.electricstuff.co.uk/marxgen.htm & https://hibp.ecse.rpi.edu/~leij/febetron/febetron.html

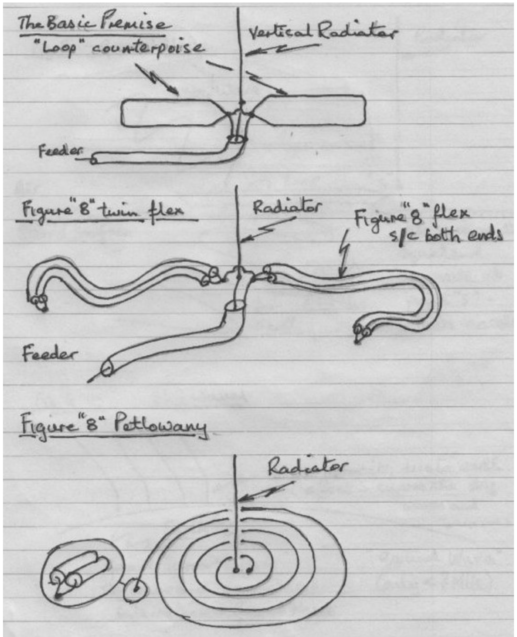
Antenna Topics

Home made HV Capacitors (again)

A home-brewed well engineered approach to high voltage capacitors can be seen at http://www.ta1lsx.com/high-voltage-diy-air-capacitor-for-magnetic-loop-antennas/, and I thank TA1LSX for his superb professional standard approach. Of course, the principle can be adapted to heatsink capacitors mentioned previously for use in hefty "L" section ATU's.
TA1LSX design is for his small transmitting loop, nicely engineered and functional.

Loop Counterpoises

I have been told of some rather novel counterpoise experiments that use short circuited loops of wire rather than single wires of λ/4 and the like set up beneath a vertical radiator element that on reception, outperform all expectations - on the lower bands, below 7MHz at any rate.



It has always seemed a bit of a oddity to me that we spend any amount of effort in the "radiating" bit of an antenna as it is suspended, cut, trimmed and generally laid out in a tight geometric form: yet the counterpoise, forming the return path to the transmitter, is any old bit of wire strewn about in any manner that will fit. Common savvy surely says the counterpoise should be aligned with the radiating element(s)?

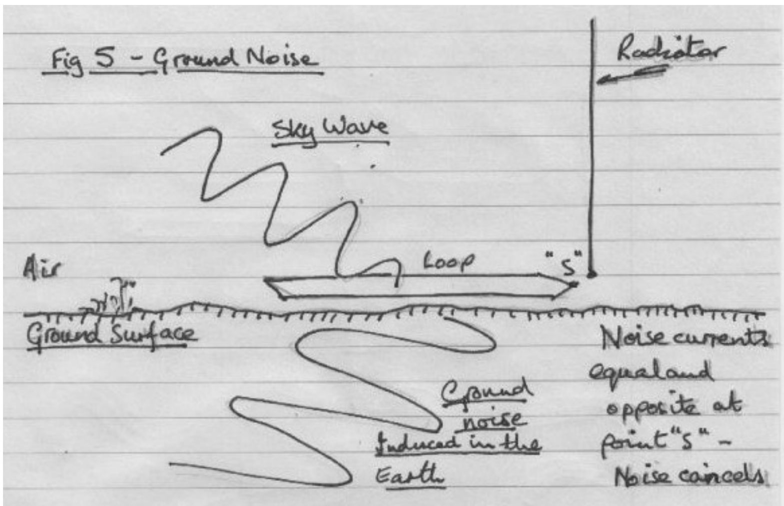
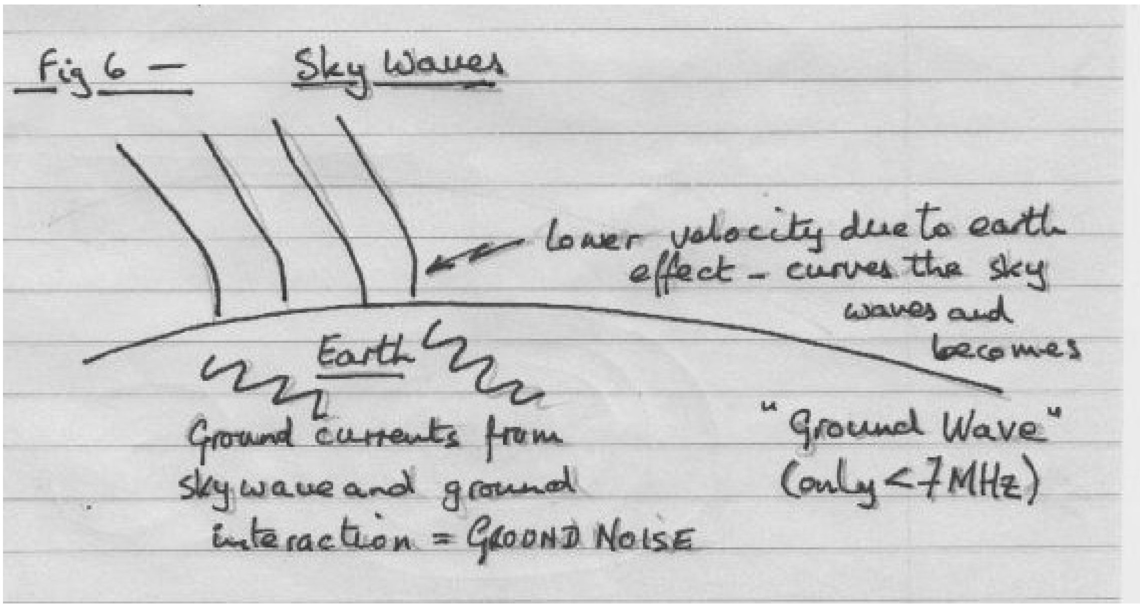


Fig 5 shows how sky wave "noise" - this includes ANY signals interfering with your desired signals of course - induce earth currents, which are capable of inducing noise currents in any conductor, including a counterpoise. To my way of thinking the fact that the loop counterpoise idea is specifically effective on low bands indicates to me that the effect we're looking for is LF: Fig 6 shows how the ground wave bends round the earth's curvature, thus is inducing strong earth currents over a larger area than, say, 30m and higher frequency signals which have a tighter "footprint" as they return to earth from the ionosphere.



The idea of a short circuited loop, the loop thus formed being no relation to $\lambda/4$, or any other fraction / multiple, being far lower noise, easier to match, etc., etc. seems to me to indicate that noise currents in each "half" of the loop, cancel at the "junction" ("S" in Fig 5), thus giving the better performance quoted. This immediately suggests to me a whole series of experiments: for instance, does it have to be a rounded / elliptical / circular loop, or will some twin core flex, shorted at the far end, do the same? Does the enclosed area of the loop have an effect, maximising the loop's area? Would a "Petlowany" spiral, with a radial short circuiting wire, work even better as it would be inductively self loading? Does the resonance of the loop play a part, or is it important it's non-resonant?

One thing I do know: the earth - and it's surface soils - carry hefty earth currents back to the sub-stations / distribution transformers from the noise filters now mandatory on SCR / Triac / mosfet bridge motor drives and power control mechanisms commonly used on washing machines and the like. And these earth current certainly can radiate: if you have RF current moving in a conductor, then you'll certainly make magnetic fields and those will in turn create electric fields around them. That's how your transmitting antenna works! Roger Lapthorn, G3XBM, has made effective transmitting antennas using an earth path for one "side" of a loop antenna. Thus, signals radiating up and out of the ground, encountering a counterpoise "short circuit loop" will induce signals equal and opposite in each half of the counterpoise: thus cancelling noise currents at the summing junction where the short circuit exists.

I shall be keeping an open mind on this matter and awaiting more results, especially those testing the limits and shapes of these counterpoise loops. That something - not fully understood nor maximised as yet - about "loops on the ground" antennas, proven successful in many cases on low bands (but where's the upper frequency limit?) are very similar to the short circuit loop counterpoise idea. If it only works on (say) 40m and under, is there a mechanism - akin perhaps to skin depth? - that is how these counterpoise loops work? What happens if the short circuit loop counterpoise is buried at a shallow / spade depth / yard below ground? In wet loam, sand, rocky sub-strata? Could low cost "Cat-5" twisted pair cables be used to form the loops or Petlowany spiral counterpoises? As ever, in the RF world, one idea spawns a hundred more questions!

One day I'll learn to just accept things at face value, stop questioning and attempting to understand the mechanism that's at work. Every time I ask a question to myself, another hundred take root, sprout and burst into full blown projects in my mind! Mind you, isn't that what amateur radio is really all about? If we look back to the giants of RF engineering, Terman, Jones, et al, this is what motivated them to simple yet far reaching conclusions. Jones especially espoused symmetrical circuits, antennas, and the like: he considered Nature to prefer balanced systems, electrical Yin and Yang, as his push-pull transmitters illustrate so well. Maybe it is best to keep to loops, balanced systems, symmetry at work?

Grounding, VDR's & Gas Tubes...

Thinking of earthing, ground currents and the like, here's a note from Frank Barnes, W4NPN, about grounding and other outdoor "aerial" bits-n-bobs in an article by Radio World (both of whom I thank muchly):
https://www.radioworld.com/columns-and-views/workbench/workbench-a-linemans-tips-to-ground-an-stl-pole?utm_source=SmartBrief&utm_medium=email&utm_campaign=0028F35E-226C-4B60-AC88-AB2831C8A639&utm_content=81D93CAF-3748-4527-AA52-AE635F78583D
All good practical stuff for the amateur antenna farmer!