Hot Iron #114

End November / start December 2021

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CQ-CQ-CQ

My beginnings…

The whole issue to my mind revolves around the simple human response: once the novelty of a new toy, the commercial transceiver, let's say - has faded, just as a Christmas present ends up languishing in a cupboard in the New Year when the novelty has faded. These thoughts prompted me to think back to my first steps in amateur radio; not particularly the technical issues or construction, but *why* I found it interesting and the *route* I took which still inspires me to this day, many years down the line.

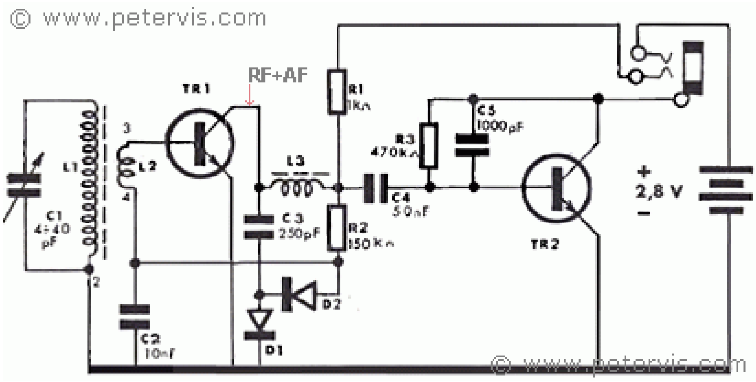
The fascination then was to listen to radio stations from far distant lands; household radios could, with luck receive stations from Europe (Luxembourg on 208 metres for instance) or Eire when holidaying on the West coast of Wales: hearing stations further afield was a fascination. Inspired at work too by the combination of repetitive tasks and that radios were banned in my workplace, I asked my mentor, Stan, how I might assemble a "covert" receiver with components to hand or scrounged.

Stan reckoned I should build a super-regen receiver (he drew out a simple one transistor circuit for me) and a 50mW audio amplifier so I could listen to the VHF stations then available, using some crystal earphones, with their lead making a VHF antenna. This probably explains my love for super-regens, as the circuit worked first time and VHF stations from 80 to 150 MHz stormed in at ear-cracking volume. I did note some odd bits of conversations way up towards 150MHz, which Stan explained were probably amateurs on 2m using A.M. phone - again, this is probably why I have a fascination for A.M., it being the simplest phone technique an amateur can use and readily received on simple receivers.

My interest in radio, both receiving and transmitting, advanced, but the trials and tribulations of life meant amateur radio had to take a back seat for some years: but I never lost the bug, it had bitten me deep and hard. I built many super-regen receivers for many frequencies; much experimenting with super-regen RF amplification, separate detection, a superhet using an RF "converter" to feed a fixed frequency super-regen detector stage and many more bits and pieces. To this day I'm fascinated by the super-regen and it's foibles. Clive Sinclair's designs appeared about this period, his "Micro FM" VHF pulse count receiver was rapidly duplicated in silicon to compare with my VHF Super-Regen using transistors to hand and reworked biasing. It worked OK; it was vastly more complex than a Super-regen, but was more selective and stable across the VHF broadcast band.

After a fair amount of bending Stan's ear, built a silicon version of Sinclair's "MicroMatic" two transistor reflexed A.M. Broadcast band, which proved suprisingly good. Stan helped me bend the MicroMatic onto "Top Band", where I heard - especially in early evenings at work on the back shift, "2 / 10" - a host of amateurs running A.M. on 160 metres.

No need nor desire for Japanese technology; just a thorough learning curve which instilled a respect for those who knew the technology of radio and used it in home built gear day in, day out as commercial gear was nigh on impossible on my wages of those days.
Thanks to https://www.petervis.com/Radios/sinclair-micromatic-pocket-radio/sinclair-micromatic-pocket-radio.html for the following schematic, and Peter gives a thorough write up of the circuit.



This simple technology works fine; building it gives an immense satisfaction that no commercial gear can ever bring - then, now or in the future - as we humans only appreciate something that we have put effort into and created ourselves, and this is what makes true amateur radio.

Subscribers…

Hot Iron relies on input from subscribers; and thank you to all who email me comments, ideas and suggestions. It's good to know that the spirit of amateur radio is still alive, albeit in the small proportion of amateurs who aren't satisfied or content with being "machine operators". Commercial radio gear is truly excellent in terms of performance and price: it's as near as you'll get to a *professional* communications system your money can get. That, in my opinion, is the very crux of the fading support for "amateur" radio.

So it's with great thanks I receive your notes and emails - the more the merrier! From subscribers, I have definitive results about coil dope and Q; some great ideas about crystal oscillators; a lovely circuit for a signal injector / tracer; a kaliatron (transistorised) grid dipper which illustrates how you can use **any** oscillator with a simple add on metering stage to resonate antennas, coils, etc.; winding toroids without ferrites for ultimate "buildability" All using standard technology that can be built on a kitchen table (suitably covered of course…!) but oh so useful and inspiring. That's the best of amateur radio: it gets your grey cells, neurons and synapses a'firing on all cylinders!

Below is an article which chimes very much with my opinions and I sincerely hope he writes more along these lines!

From Lindsay Pearson...

"Our esteemed Editor has, for reasons unclear, (Hah! If only you knew… Ed.) *asked me to pen (or type) a few words as a contribution to this excellent journal. I must confess, with some embarrassment, I have only just discovered it, and you can blame the G-QRP Club for the introduction.*

A brief introduction. You can probably tell that I am on the wrong side of 70, having been let loose on the Amateur bands in the early 1960s with all-home-brew radio. Those with a strong disposition can try searching my call-sign on Google and find I won a competition for the smallest mobile transceiver – fitted to a pair of roller-skates. I have drifted in and out of Amateur Radio over the years, an early introduction to Top Band AM in the Bristol area, a flurry of activity when my wife, a Guide Leader, suggested a "Thinking Day on the Air" station (many thanks to Ipswich Radio Club), then finding the G-QRP Club and a few trips to Yeovil, another gap, and now back to radio, trying to get my CW up to "head copy" (yet to be achieved, but via the inestimable G4FON method, Ray now sadly a Silent Key).

I have been a professional Electronics Engineer for over 40 years, and this has coloured my hands-on approach to Amateur Radio. I found myself wondering why I was messing about with scraps of PCB, random components and making something that looked like a rat's nest. So I have been over to the Dark Side, with commercial radios for a few months, and now treading back to construction, with a kit from QRP Labs. Who knows what may follow?

I now look at Amateur Radio and wonder what went wrong. OK, we are a diverse group, but I see the tendrils of microprocessors feeling their way into everything, surface-mount components pushing hand-manageable components into the long grass, and don't get me started on software and computers. How is a youngster expected to learn about radio?

When someone asks me what is the point of Amateur Radio, holding up their mobile phone and saying "I can chat to my pal in Australia with this", my answer is "So can I, but I don't need several hundred million pounds worth of kit owned by someone else to do so".

I note, with sadness, that a "Foundation Licence" holder cannot build a transmitter and operate it legally – but then I have looked at the multiple-choice exam papers and see that actually knowing how a transmitter works is not required.

Several years ago, I taught some youngsters through to getting their "Novice" licence – we built simple circuits and generally messed around with electronics, as well as the theory necessary to get them through the exam. But very few stayed with the hobby for more than a few months.

Back to "what is the point?" Quite simple. Some of us like to make something, understand how it works, get it working again when something goes "pop". Oh, I miss the days of minor explosions as an over-voltaged electrolytic turns the room into one of those snow-storm toy globes, though I'll pass on again seeing the plume of blue smoke rising from my arm as it touched the top-cap of a 6146 running at 400 volts…

The same applies to any hobby. You can buy anything you can make, far cheaper if you cost your time at commercial rates. But that misses the point, you enjoy the "making".

Which is why "Hot Iron" exists, and long may it do so!"

(I sincerely hope we hear much more from Lindsay, this is exactly what Hot Iron is all about! Ed.)

From Radio History…

I often like to browse through old copies of radio magazines, my favourite (at the moment!) is QST. I find it very stimulating to see how the exact self-same problems encountered nowadays were tackled yesteryears! Take a look, let your imagination wander, and check out any article that catches your eye. See:

https://www.rfcafe.com/references/qst/vintage-qst-articles.htm

https://worldradiohistory.com/QST.htm

where you'll find just about everything you might ever need or want to know about Amateur Radio!

There is a library of Technical magazines in the commercial and amateur radio field: a truly monumental reference of most of the history of radio in print. See:

https://worldradiohistory.com/

I give you fair warning, make sure you've plenty of time in hand when you dip in there – you'll be in there for days!

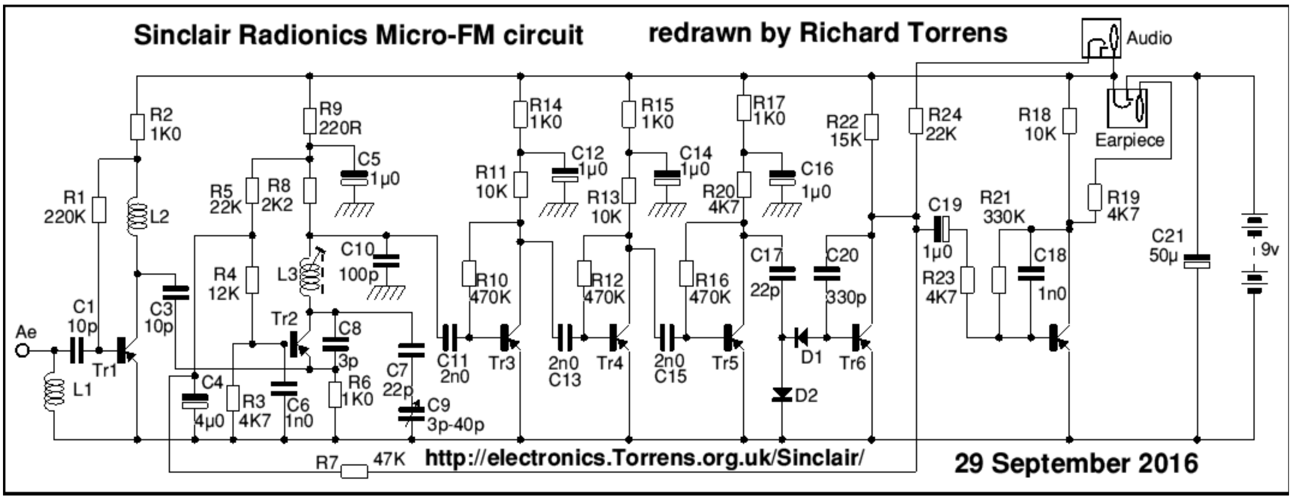
Receiver Topics

Sir Clive Sinclair

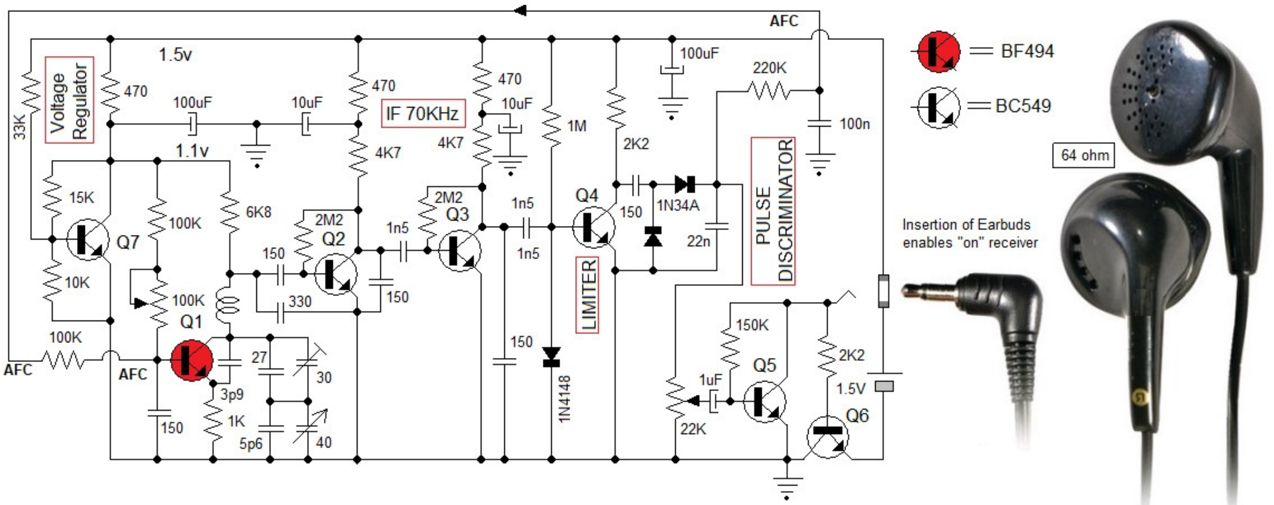
With great thanks to Richard Torrens, who worked with Sir Clive and has produced the most complete history of his time with Clive Sinclair. See:

http://diy.torrens.org/Sinclair/index.html

For your delectation, below are two circuits: the first is the original schematic of the "Micro FM" VHF receiver, and second is a modern version both of which use the Armstrong "Pulse Counting" FM demodulation system.



This is the “ modern” schematic, from http://www.vk6fh.com/vk6fh/pulsecountrcvr2.htm :



You can see the genealogy of the design; Sinclair took it from valve technology and solid stated it in germanium devices; VK6FH put it in silicon. Now, dear reader, spot the antenna in the silicon version above! It’s not noted, and I can see several candidates, but would really like to know.

IF thoughts…

The IF strip of a receiver is where the bulk of the gain can be concentrated, as well as the selectivity. But keep to mind, several other signal handling features can be built in too - purely because the signal waveform distortion introduced at IF frequencies is more or less (give or take…) absent after post IF demodulation.

The AGC can be derived from the IF output; the DC AGC signal an analogue of the signal magnitude. This AGC signal is used to alter the bias of one or more stages of the IF strip, the consequent distortion of an amplifier stage rendered irrelevant as demodulation doesn’t (usually…) cause any problems. For simpler receivers, a crafty trick to limit the gain - and thus effectively put a “ceiling” on the signal amplitude available - by allowing an IF stage to clip, either saturating fully “on” on positive signal input peaks, or the output hitting positive rail voltage as the stage shuts off on negative signal peaks - or both! Once a transistor has hit saturation or is fully off, then no matter how much more the signal wants to go, it physically can’t. That gives a very definite clamping of the amplitude the IF strip can feed to the demodulation stage(s) - the audio recovered is (almost…) free from any distortion. Sinclair used this approach in his germanium Micro FM IF strip I'm told.

IF strips can be made with conventional IF transformers, with tuned windings to give the bandpass characteristic desired. Indeed, double conversion receivers with multiple IF strips can be made incredibly selective: a 10.7 MHz first IF driving a 80kHz second IF can deliver astonishing performance, so much so audio frequencies can be clipped as the combined bandwidths of an 80kHz IF can easily be just a few hundred Hz; ideal for CW, but horrible for SSB or AM speech!

It should be kept in mind that other selective methods are available: crystal filters are superb, easy, cheap (if home made!) by using the very cheap PAL-TV colour sub-carrier frequency crystals and the like, set up in ladder filters.

One option is rarely seen nowadays: the RC band pass filter, set up for (say) 40kHz, set in chains with a buffer amplifier stage every other stage can prove useful: being cascaded *single order* filters, they do not "ring" - a defect seen in "conventional" IF strips under impulse noise attack. But you pay for this: the output is delayed, by a significant (but constant) amount of time - these filters are sequential low pass / high pass networks and the low pass elements slow things down!

I first saw the passive filter IF principle in a Rohde & Schwarz AC nano-voltmeter way back in the 70's, whilst categorising pulse driven Gallium Arsenide laser diodes. The instrument was remarkably robust coping with industrial scenario RF electrical noise; our other instruments had to be run in our cramped double walled Faraday cage to achieve similar performance.

As a brief introduction, try the filter design gizmo below where you can plug in any frequency and see how the components change:

http://www.learningaboutelectronics.com/Articles/Bandpass-filter-calculator.php#answer1

Plug in frequency values a kHz or two apart, as a start. For an IF of 145kHz, bandwidth 2kHz, you get C1 = 100nF, R1 = 11 ohms, C2 = 1nF, R2 = 1091 ohms.

Similarly, for and IF of 42kHz, bandwidth 200Hz (for the CW man, set at 41.9kHz and 42.1kHz) you get:

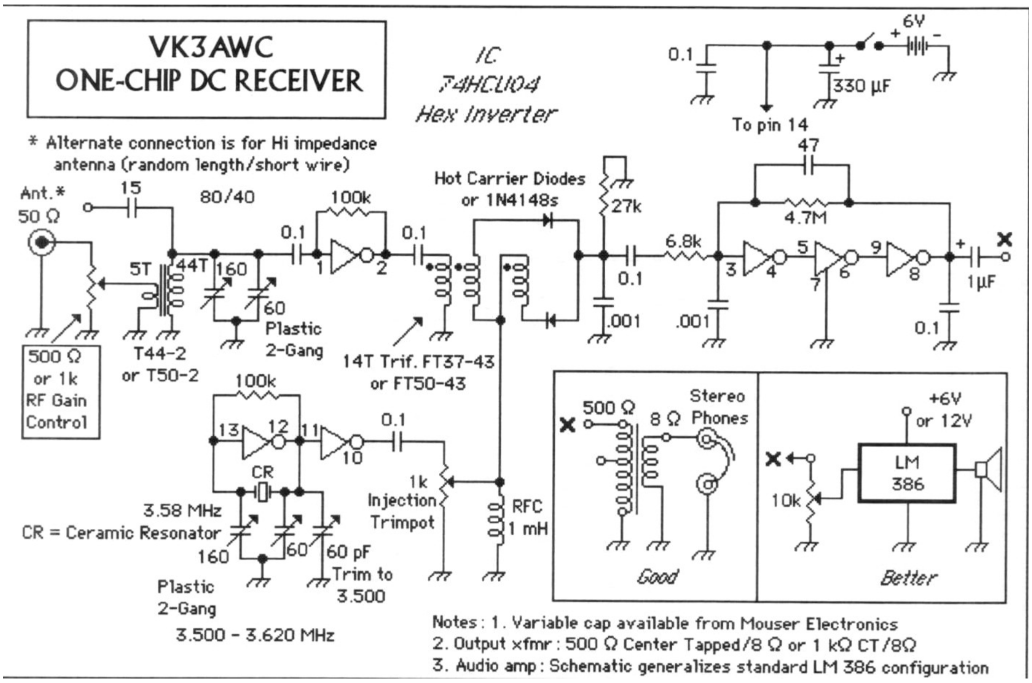
C1 = 100nF, R1 = 38 ohms, C2 = 1nF, R2 = 3782 ohms

The capacitors are easy 1% poly values; the resistors are 2% metal oxides and close to standard ranges. A slight tweak to frequency values will get you to standard values near as makes no difference and who cares what the *exact* IF frequency is?

One thing is important: the resistor and capacitor values need to be matched in every section of a cascaded IF strip, but I'm sure you can find an IF frequency that facilitates "easy" component values - the whole beauty of this approach is you can select any IF that suits you.

A Single Chip complete receiver

From that amazing Antipodean, Bill Currie, VK3AWC…

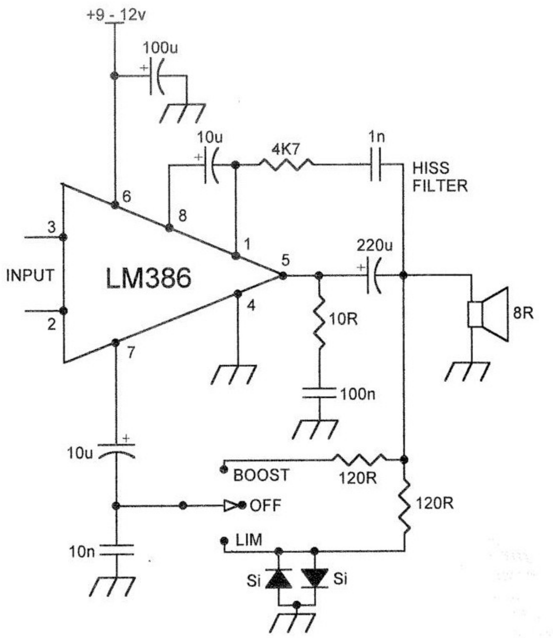


Here at Hot Iron, we reckon simple, easy, low cost home made radio is the way to enjoy Amateur Radio; taking that stance allows even the hardest up, impoverished amateur can get on the air and have a lot of fun whilst learning from doing - surely the very best way to learn. Bill Currie's design above exemplifies everything that Hot Iron stands for! Thanks Bill, much appreciated.

Audio topics

The LM386 - again...

That old workhorse beloved by most (ahem…) the LM386 can be adapted with a few external components to deliver functions and performance not initially designed in the chip. I have a suspicion this little adaptation was by Bill Currie, VK3AWC:

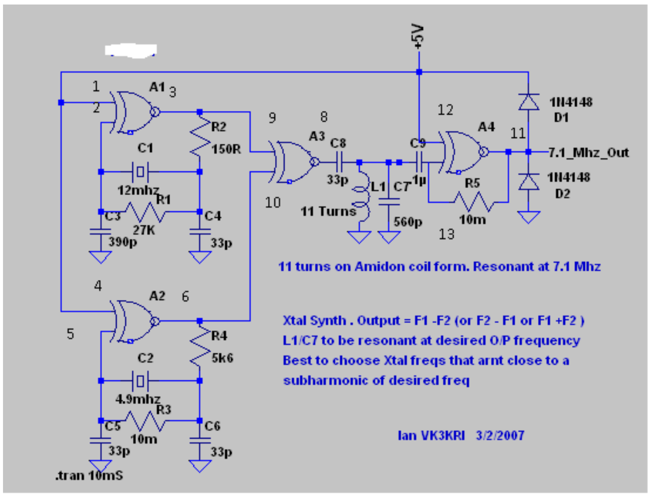


This circuit is so simple, yet delivers so much from a minimum of components. Beautiful! Should the circuit oscillate on “Boost”, then increase the 120R “boost” resistor up a tad; try 150R or 180R.

Oscillators

A novel crystal oscillator, John Kirk, VK4TJ…

“The Silence Is Deafening...



Back in Hot Iron #109, Peter threw down the gauntlet for a “single active device / dual (or more) crystal oscillator” circuit, and describe their adventures with it.

Anyone...anyone....Bueller? Who knew? The ever-efficient Kostas, SV3ORA, had actually solved this riddle 5 years before Peter even posed it! http://qrp.gr/multiosc/index.htm

I declined to dip my toes in those waters. It had a whiff of “Well, it worked for me!” about it. In my “metal years” (silver in my hair, gold in my teeth, and lead in my arse), “Starts every time” begins to influence my choice of not just vehicles, but oscillators as well.

Having said that, I think we could reasonably expect the sum & difference products from said crystals to appear in the output, an absolute boon if Alibaba's 40 million thieves failed to come up with a suitable rock (See Hot Iron #110) for your latest madcap invention. Clearly, playing off the 150-odd frequencies available against each other results in a MUCH higher probability that something can be made to work.

Scanning the web on a completely unrelated quest, I tripped over Ian, VK3KRI's “XTAL Synth Using 74HC86”: http://www.smoke.com.au/~ic/ham/xtal_synth.html
He has kindly allowed us to reproduce the schematic here. Ian may know it as a synthesizer, but “crystalplexer” was the term more in vogue back in the days of 23-channel AM CB, and certain Ed Clegg early 2 mtr FM transceivers. A quick check online revealed that the 74HC86 currently retails for something like 10 cents USD, or 2.5 cents per gate, so I thought “damn the expense!”, and blew the kid's inheritance on one. I'm not sure why Ian ended up with radically different component values in the two oscillators - mine ended up with 1K series resistors, 1 meg parallel resistors, and 47 pF phase shifters fore and aft, and cheerfully took on all comers from 1.8 MHz to 20 MHz.

In playing with my new “crystalplexer”, I was very surprised to see that both input frequencies are totally suppressed in the output! 'Tis the nature of exclusive OR gates thusly wired, apparently. No doubt this will make life considerably easier for experimenters trying to tidy up the output with primitive test gear or low-parts-count output filters. Of course, it also means that this little circuit will not take pride of place over my universal test oscillator, as my junk box does occasionally come up with exactly the right (single) crystal.

OK, so I failed to “meet the brief” of one active device/two (or more) output frequencies, but managed to trip over a pretty useful addition to the shack, no? So how does it play in the real world? Calculating sum and difference products in my head was rapidly giving me a brain hurt, so I spent a few minutes trying to be oh-so-clever with Excel's “Goal Seek” function, trying to persuade it to ease my aching cranium by doing the mind-numbing repetitive calculations required to nut out a specific frequency. As usual, I was making it harder than it needed to be. Another name for “sum and difference products” is “intermods”. Huh? Yep. For my sins, I was heavily involved for decades with VK Intruder Watch, and used to use a great little freebee program called PRFIntermod: http://www3.telus.net/PassiveRF/
to try to keep VOA honest when they tried dumb-arse stunts like feeding two (or more!) transmitters into a single antenna, then wondering why we observed little replicas of their propaganda right across 20 mtrs. Don't try this at home, kids! I digress...

To give this a real-world feel, I grabbed a comment off GQRP's reflector bemoaning the lack of really good 5332 kHz rocks for 60 mtrs. I bunged in pretty much the entire 1 to 20 MHz Alibaba stash, and straight away, a handful of good prospects leaped out! Luck, or good management? Only further road trials will let us know. I'm really looking forward to trying VK3KRI's circuit on a couple of “box of rocks” type HF commercial band SSB transceivers that were gifted to me. At the current price of custom-ground crystals, these have clearly passed their “sell by” date, but, with a bit of “pick a rock - any rock” sleight of hand, particularly if I can get some VXO happening, they might just find a place on our 80, 40 and 30 mtr bands. As an added bonus, they are, of course, loaded with critically-coupled bandpass tuned circuits to meet commercial specs, so are highly unlikely to let anything slip through that would not withstand close scrutiny by the spectrum police.”

~~~~~~~~~~~~~~~~~~~~~~X~~~~~~~~~~~~~~~~~~~~~~

Great stuff, John! I wonder what would happen if we added another crystal and X-OR’ed all three outputs? Or, dare I say it… “N” crystals feeding an N.X-OR tree?

Here’s similar approach from that fount of simple but effective circuitry, Chas. Wenzel:
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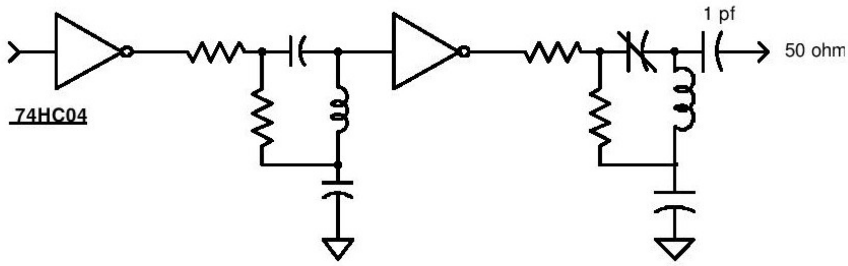


Figure 2: 6 MHz to 30 MHz multiplier with sinewave output.

Note that the output network is tuned to the same frequency as the multiplier network unless two stages of multiplication are desired. The second gate may be left out if a low-level sinewave is adequate.

The frequency synthesizer depicted in fig. 3 illustrates how flip-flops can be used to divide and multiply simultaneously to achieve fractional multiplication factors.

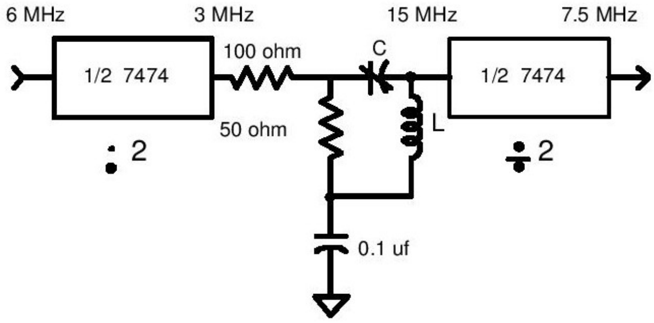


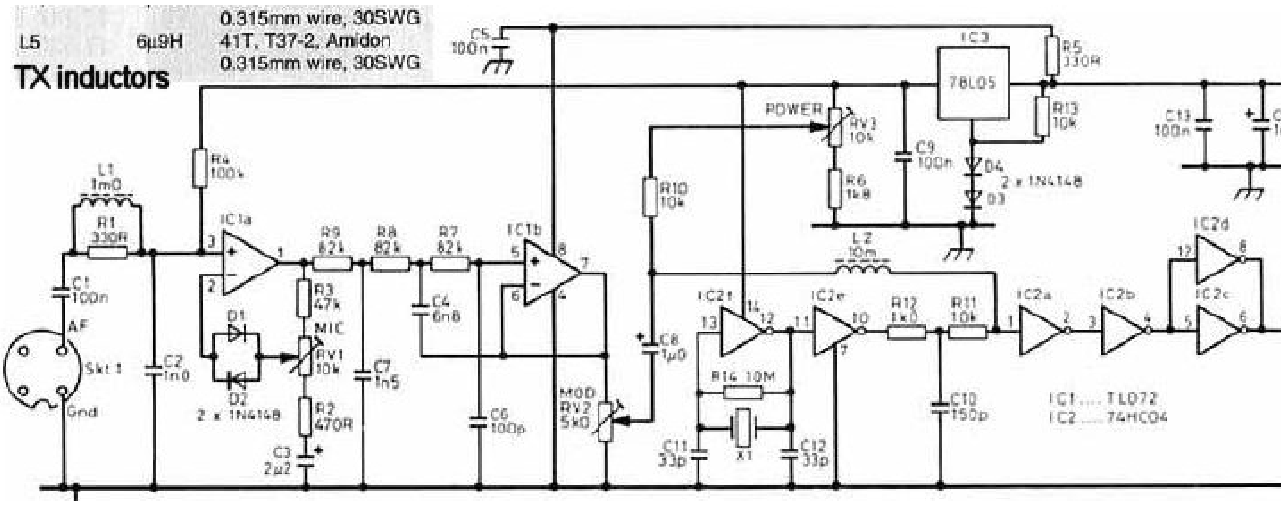
Figure 3 : 6 MHz to 7.5 MHz multiplier

This synthesizer uses a single 7474 flip-flop to convert a 6 MHz input to 7.5 MHz (a multiplication factor of 1.25). The 6 MHz square wave from a clock oscillator is divided by one of the flip-flops and applied to a network similar to fig. 1. The fifth harmonic of 3 MHz (15 MHz) is divided by the second flip-flop to produce 7.5 MHz.

Fig. 4 shows a gated-output multiplier using two nand gates. Network values are selected as before. Gated multipliers are useful when a high on-off ratio at the output frequency is desired since stopping the multiplication process essentially eliminates the frequency. For the best performance choose non-inverting gates since the output will be connected to ground through a very low impedance when the multiplier is off reducing the opportunity for harmonics from other stages to find their way into the output tank via the power buss.

Transmitters

A.M. with C-MOS hex inverter



The diagram is part of a D/F Tx/Rx schematic that illustrates how a logic gate can generate Pulse Width A.M.

Observe dual op-amp Ic1 a and b form a microphone amplifier and clipper, basic speech processing. Note too L1 and C2 stray RF stoppers - excellent RF practice. The processed speech is passed through C8, where a bias voltage is added from the "Power" control pot, and thence via L2 into the input of gate IC2a, the pulse width modulator.

IC2f is the crystal oscillator, in a standard circuit, which ensures the crystal "sees" the correct loading capacitances - in this case C11 (33pF) and C12 (33pF). The oscillator output is buffered by IC2e; R11 and 12 with C10 eliminate harmonics and load IC2e output so as to produce a "clean" RF carrier to the modulator summing junction.

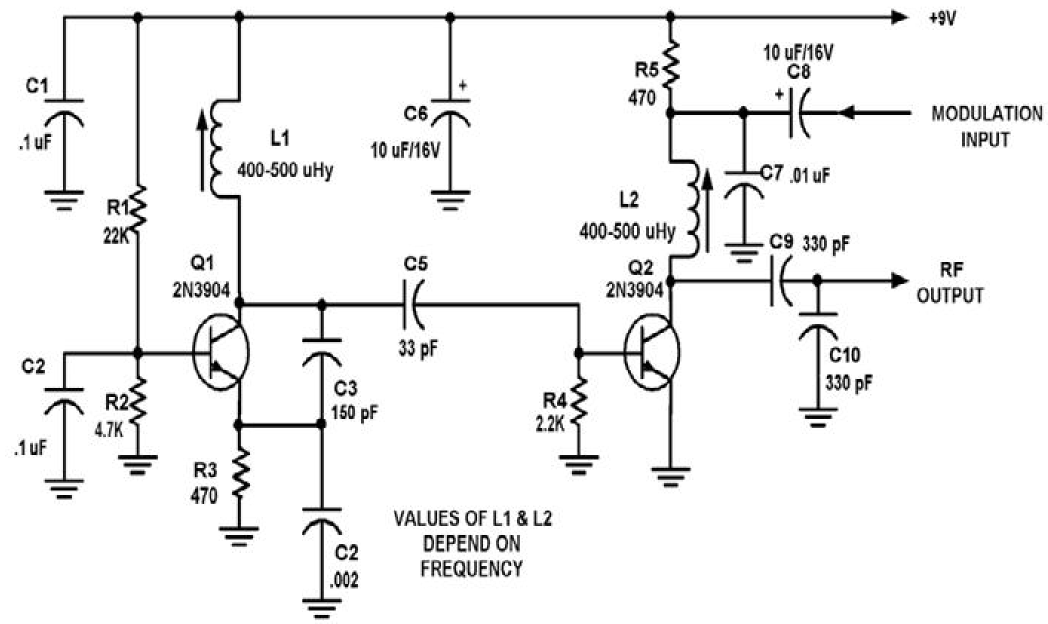
Consider the RF cycles appearing at the input of IC2a, compared to the audio from IC1b: assuming a 3kHz upper frequency from IC2b, a 2 pole active low pass filter, then in one cycle of audio many thousands of RF cycles appear. The audio, compared to the carrier RF, appears like a slow ramp so the point at which the input pin of gate IC2a reaches it's switching point - the voltage that forces the output of IC2a from a "0" to "1" (and vice versa) - sets the width of the RF pulses appearing at IC2a's output. Thus the *average RF power*, appearing at the output of IC2a, varies in proportion with the audio signal: i.e. pulse width modulated A.M.

The other gates of IC2, namely IC2b,c,d are gate drivers, feeding a power mosfet class C "final" (not shown, but a standard circuit). A low pass filter follows the mosfet final in usual practice, set for the band of operation.

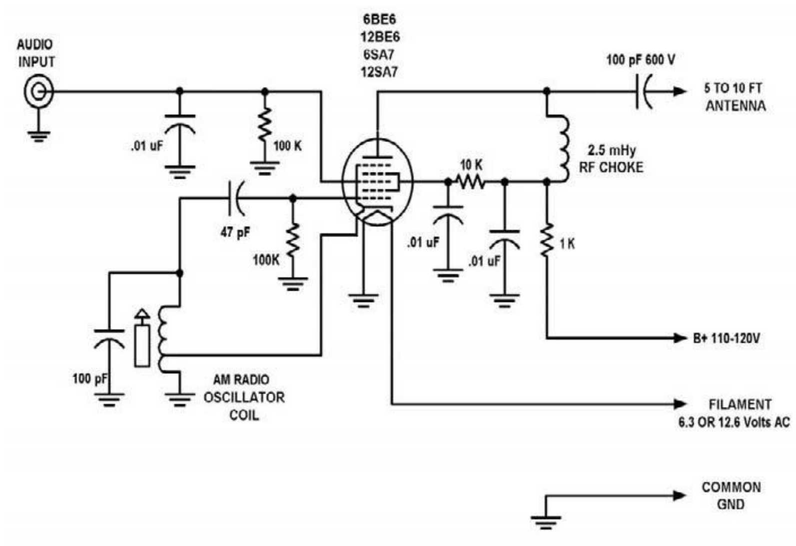
Simple A.M. transmitters

Ideal for test purposes and QRPP operation if adapted to crystal control, from: "Build your own low-power transmitters : projects for the electronics experimenter / Rudolf F. Graf, William Sheets" (copy and paste in your favourite search engine).

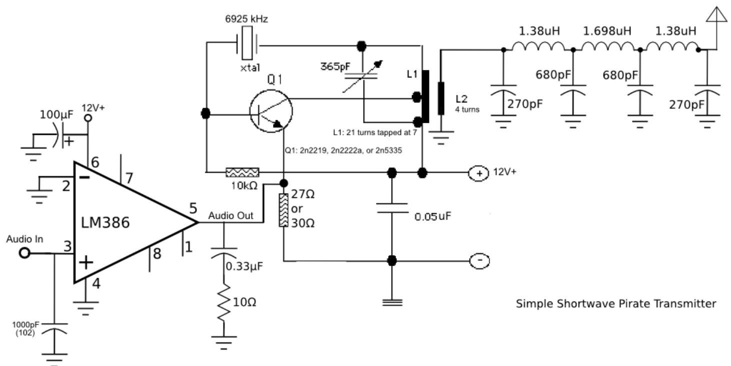
The two circuits below illustrate just how easy A.M. phone is to generate:



In both circuits the audio input should be sufficient to give 10 - 90% modulation; **don’t overdrive!!**



The diagram above shows a Hartley VFO, a crystal can be substituted for “rock solid” stability.



I wonder how many “pirates” tried this circuit (the Michigan Mighty Mite) on A.M. without an RF choke between the LM386 output and Q1 emitter, and to pin 3 of the LM 386? Hah!

Power Supplies

Low voltage AC for transformer test

In trying to identify an unknown transformer it's not a good idea to bung it on the mains and see what happens. That's a recipe for blown fuses, windings or worse!

What the canny amateur might try is a known good transformer to feed low voltage AC into unknown transformer winding(s), then measure the resulting voltages on the other winding(s), and thus deduce the turns (hence voltage) ratio linking the winding(s). Note that this is done without any loads connected and the test transformer's primary safely fed via a "dim lamp" current limiter.

First identify the winding(s) start and finish wires using a multimeter on resistance and label the pairs identified carefully. Centre taps are equal resistance to "ends", measure carefully and (on suspected centre tapped windings) check for "end-to-end" resistance being exactly the sum of two!

You can usually make a guess as to the high voltage winding(s), either primary or secondary, they are usually of thinner wire, and might have extra sleeving insulation; whereas the low voltage secondary(s) will be thicker wire (usually). This test method works best on low voltage transformers if you drive a secondary, because the voltages on the other windings will (usually) be more representative.

Let's suppose you're feeding 15 volts AC into an unknown secondary on an unknown transformer, and read the following AC voltages on the windings identified previously by DC resistance test:

Winding (1) = 15.0 volts (test input drive voltage)

Winding (2) = 278 volts

Winding (3) = 7.7 volts

This indicates winding (2) is *probably* a 230v primary; and that 15 volts driving the secondary is higher than the rated voltage of the winding, by a factor of 278 / 230 = 1.2; the 15 volt drive is 1.2 times the "proper" voltage for that secondary. The winding we're driving with 15 volts is probably designed to be 15 / 1.2 = <u>12.5 volts.</u> (Note that test results for one winding *should hold valid* for all other windings).

We have now identified a 230 volt primary, and a 12 volt secondary, so let's measure the other secondary volts: we see an output of ~7.7 volts so the "proper" voltage is probably 7.7 / 1.2 = 6.41 volts. This seems very much like a 6.0 volt winding, so we now know both secondaries: we have a 12.5 volt and 6.0 volt windings, and a 230 volt primary by the looks of it.

One thing to keep in mind is that transformer designers always specify an output voltage at a certain current to take in account the winding resistances, the "regulation" of the transformer. Because we are driving this transformer "backwards", i.e. driving a secondary, we're pushing against regulation: the windings are yielding slightly high voltages than those specified by the designer.

The next step is to apply mains to the primary as identified above, vis a dim lamp, if all is good, then drive with full mains and load the secondaries one at a time. By varying the load resistance you'll find the current the transformer is designed for: it's when the windings are delivering the expected voltages, in our case, 12.5 volts and 6.0 volts AC, *under load*. Let your transformer drive a load for an hour or two, checking the core and winding temperature every few minutes. The transformer may well run warm, but not “cooking”, indicating the usable VA rating of the transformer.

Batteries, Chargers, and the curse of SMPS’s

Nowadays, battery powered drills are great: no more hours with a wheel brace drilling holes - the battery drill has “revolutionised” (groan….Ed.) home bashing of metal chassis for our latest projects. But - those battery packs are certainly expensive! So we keep them charged, take care not to overcharge them by using an “intelligent” charger… and that’s when trouble can rear it’s ever-present head if you’re not aware of how these things run.

The charger is a power supply designed to monitor the battery under charge, so that it doesn’t push the amps in too fast; these batteries have to be spoon fed their charge *just so*, until the charger sees the voltage and current are within the “charged” specification. To protect the charger and battery pack the current is monitored: it has to be within certain limits or the charger says “not today, Josephine” and shuts itself down. Not that the charger will indicate any of this to you: it just stops, and sits there waiting for you to remove the load drawing too many amps (some form of “foldback” limiting lock out I suspect).

This is a common scenario with SMPS’s (Switch Mode Power Supplies). These are emotional little beggars: if they aren’t connected to a load they expect, they get sulky, and disappear into their own little inner Nirvana and refuse to play any more until all power is removed and a fresh start made. This is the result of shutdown on over-current: typically, the load has sucked out too many amps all in one go and the poor little darling has spat out it’s dummy until you unplug / de-energise the damn thing and start again. However, this can be the case in a battery charger if the SMPS does not deliver enough amps: it shuts down if the volts and amps don’t suit it, it assumes a foetal position until you shut off the juice and start again.

Now, let’s step one pace further: your pal Joe / Josephine calls you and says “my 12 volt shack power supply has died, you got any ideas?” Now you, having been tipped off, know that if the load isn’t just so, the little darling SMPS could, if the mood takes it, up and away with itself into the electronic dark lands, with ne’er a whisper in a buzzer or glint in a LED to tell you that it’s upset and sulking in a corner.

The answer is a trip to your local car spares shop, for some 12 volt 21 watt lamps, used on countless vehicles as brake lights, to make a dummy load. You’ll need a few 10 - 25 ohm power resistors too. I’ll assume you’ve soldered some flying leads and croc clips (or any other easy connection means) to the auto lamps and resistors for easy connections.

First test:

Connect lamp to suspect SMPS and power up. Does the lamp light? Yes = probably good SMPS, it’s managed to drive the inrush current into the load, as the cold filament(s) have a very low resistance. Add more lamps in parallel to the ampacity of the power supply, repeating the start up at every added lamp.

When load lamps fail to light light, it doesn’t necessarily mean the SMPS is faulty: it’s sensed the high current demand of cold filament lamps and shut down. So…

Second test: repeat the above with the 25 / 33 ohm 25 watt resistors as load. Does the load energise (they will get warm…ouch!!) Yes = good power supply, resistors don't have the cold inrush current lamps exhibit.

Failure to drive a load with high inrush current (like the lamps) can indicate the output electrolytic(s) of the SMPS are failing: they do a lot of the heavy lifting in an SMPS, and often give up the ghost first, the "fail to start" on high amps fault being a fair guide to that problem. If this is the case, replace ALL electrolytic capacitor(s) inside your SMPS with IDENTICAL spec. parts (this is important, don't skimp or the SMPS will fail again), as if one electrolytic has shuffled off his / her mortal coil, the others won't be far behind - and now you know why it's important to keep the air louvres clear and clean on an SMPS!

Faults and breakdowns in SMPS's fall roughly into the following sections, common faults first, rare occurrences last:

Output electrolytic: gone high ESR, loss of μF's, leaky (look for swollen cannister!)

Input bridge rectifier: o/c or s/c diodes due to mains transients; ohms check each bridge diode.

Surge suppressors blown: look for exploded VDR's and polypropylene capacitors near mains input. Probably an over-voltage surge; lightning strike, etc.: replace blown bits & clean the PCB!

Input electrolytic: as per output electrolytic above; beware! This can be charged to rectified mains voltages, 330v., so check with a meter before touching!

Start-up resistor o/c: This is a high value resistor from the rectified mains input side to the control chip, to cold start the system which, once running, powers itself from it's own output. 2M2 to 470K are typical, err on high side if unknown, "cut and try" until the SMPS starts up reliably.

Edge connectors: unplug daughter pcb's and reseat; if this doesn't work, then *gently* cleaning the PCB edge connector pads with a soft pencil eraser or similar, never anything abrasive but emphasise *gently;* that gold is thin! Ensure pcb's are fully seated and secured in place.

Control chip faulty: usually bomb proof; look for cracked package or pins shorted with detritus.

Power MOSFET's: look for exploded packages, dead shorts drain to source and / or gate. Gate shorts mean the driver chip's probably shot too.

Schottky diodes: chunky rectifiers found near the power MOSFETs, they rectify the low voltage DC output(s); look for leaky reverse or high forward resistance on ohms check. Remember Schottky diodes have ~ ½ the "ohms" reading of a PN junction; for multimeters showing forward volts, a Schottky will read ~ 300mV, a PN junction ~ 560mV. Sometimes high speed PN diodes are used here, any replacements must be identical to originals, don't substitute!

Blown output tracks on PCB: repair blown tracks with enamelled copper wire, but ALWAYS ohms check for shorts inside the SMPS and load before powering up!

"Hidden" fuses o/c: these look for all the World like surface mount resistors which, of course, they are - of zero ohms value! Test by jumpering a fuse of equal value (take a guess if no markings) soldered across the suspect fuse before replacing, but investigate load compatibility too.

Test equipment & Fault Finding

Kaliatron grid dipper

The Grid Dipper is a very useful bit of kit for any amateur bench: here at GW6NGR it's a permanent resident on the bench, and many a time I've thanked the powers that be for it's assistance. It really is a multi-function bit of kit: as well as finding resonances in tuned circuits, it's a signal source, a fault tracer / demodulator and a general all round useful bit of kit.

A "must have" for a GDO is an oscillator that's robust in output terms: it must drive a significant signal into a circuit under test without crashing the oscillator.

For those who like this sort of thing, the locus of the gain / phase plot of a good GDO oscillator well and truly encloses the -1 &180° point, known as the Nyquist Criterion for oscillation. In general terms, if the gain round the loop is >1, and the phase gives positive feedback then the circuit will hoot. The popular circuit is the Kaliatron oscillator of valve fame; it resists "pulling" by an external tuned circuit better than most other topologies - again, because the oscillator is very "rugged".

The whole article from Homemade-Circuits is at:

https://www.homemade-circuits.com/grid-dip-meter-circuit/

Built with some decent high Ft transistors, and decent diodes (germanium OA81 or similar are good) this little gizmo will help you check your tuned circuits right up to many hundreds of MHz. Calibrate each coil and a simple paper chart beneath the tuning knob with the aid of a receiver; don't look for dead accuracy but "near enough" will suffice for most jobs.

A useful write up about using the GDO can be found at:

https://worldradiohistory.com/BOOKSHELF-ARH/Servicing/How-to-use-Grid-Dip-Oscillators-Rufus-P-Turner-1960.pdf

One easy substitute for a GDO is an oscillator, be it a Signal Generator, a stand alone synthesizer local oscillator, or whatever you have to hand, with a diode RF probe measuring the output. The Sig. Gen. is connected to a test coil and held near the tuned circuit under test. As the frequency of the output is varied, and the tuned circuit resonates, the diode RF voltmeter will show a distinct "twitch" - if it's a parallel tank circuit, the RF volts will kick UP at resonance; a series tank will slump the RF volts DOWN, because parallel tanks show high resistance and series tanks show low resistance at resonance. These alter the loading on the sig. gen. output, and consequently the reading on the RF probe voltmeter.

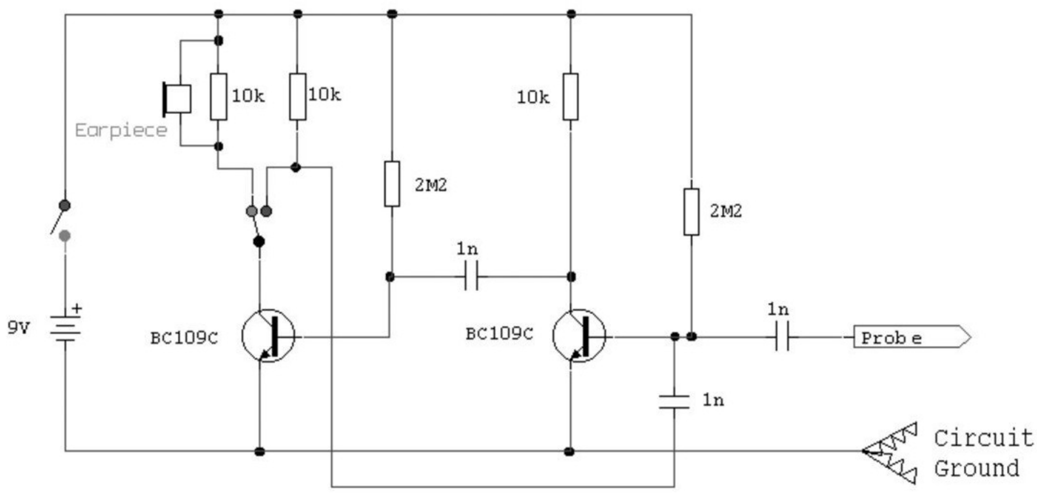
You'll find some superb GDO designs on our old friend Harry Lythall's SM0VPO pages, see:

http://sm0vpo.altervista.org/use/gdo2.htm

I personally prefer single section tuning capacitors, as in the Kaliatron oscillator, but that's just me being stingy!

Signal tracer / injector

This design is ubiquitous: I've seen this diagram on many web pages, it's a two stage audio amplifier for detecting signals that can be switched into an astable multi-vibrator, thus becoming a signal injector. Here at Hot Iron we like circuits that can do two (or more!) jobs for the price of one. We assume the “earpiece” is the very high impedance crystal variety; if you only have low impedance “ear bud” types a small output transformer, 10k to 16 ohm transformer with a series resistor to make a total of 10k (DC) in the left hand transistor collector would be a good idea.



The Growler and Star Point disconnect

How to find shorted turns in a coil or transformer? We all rely on transformers and motors, not always an amateur radio topic, but always useful to know: that bargain HV transformer or rotator motor might be fit for years of service or a doorstop, and you can spot the duds if you know what to look for.

Shorted turns, buried deep within a transformer winding, leakage to the frame from frayed insulation, or a shorted turn in a motor armature coil are all faults I’ve seen: some for no apparent reason, some from lightning impulses, or earth faults caused by 400kV pylon collapse a few miles away, by over-volts from inadvertent opening of star point earths (or in the USA, split leg earths); all are likely problems that can cause severe damage to windings without you knowing anything other than a blown fuse. If you know what to look for you can help protect your “hard earned” in some instances, try the following.

Test for shorts to frame / earth; look for discoloured or obvious signs of heat; always start up an unknown or “bargain” transformer or motor via a “dull lamp” test set-up and / or a low voltage transformer. This will preserve your fuses and sanity, as any decent transformer will need only a touch of AC to magnetise the core with no secondary load connected. Similarly any motor will need only a sniff of AC amps with no mechanical load connected.

Let’s look at a transformer first. Leaks to frame / core earth can be found by an insulation tester – easy, Tiger, go gently with a 500 volt Megger, as the peak volts of a 220v AC supply is 315 volts and the winding might not be insulated beyond that value - a 500 volt Megger might actually ***create*** a short in a sound transformer, by breaking down the inner winding insulation: go easy! A series 1M-ohm in one test lead will reduce the chance of damage. The shorted turn fault is trickier to find, but the Growler principle can help; see:

http://dictionary.sensagent.com/Growler%20(electrical%20device)/en-en/

When a transformer is energised via a dul lamp, a shorted turn represents a significant load and the dull lamp will be brightly lit. This isn't a 100% certain test for a shorted turn; other faults like a primary to secondary short or a shorted start-to-finish winding in either primary or secondary will cause this. One thing is for certain though, a shorted turn will set up a very strong magnetic field.. Thus a thin magnetic probe (a thin steel feeler gauge for instance, try 0.004" or 0.1mm) run all over the outer cover of a winding with no load connected should, if no shorted turns are present, pick up very little field when run over the winding outer cover.

A shorted turn will create another field from fault current so at certain spots whilst searching over the winding cover, anomalies will be felt (or heard!) in the probe. It will begin to buzz or "growl" as the flux set up by the shorted turn bucks against the flux the rest of the winding has created (Lenz's law). This shorted turn flux isn't always obvious; it takes a few tries to spot the anomalies and obviously a small (i.e. less than 20VA transformer) is difficult to probe and diagnose this way.

An alternative method is pulse testing, where you clobber the winding with impulse volts and observe the ringing of the winding inductance with it's intrinsic (or added for test) capacitance. A good winding rings like a bell for a good few cycles after the pulse; a shorted turn winding shows a much shorter ringing transient, the shorted turn absorbing the magnetomotive force in the core. This web page will explain:

https://www.voltech.com/support/technical-articles/detecting-shorted-windings/

The "stress test" they call up is in fact the "dull lamp" test alluded to earlier; you are using a series lamp to limit the input as a good transformer will only need a sniff of AC to energise the core to full flux. Only when a secondary (a shorted turn ***in any winding*** on the core represents an unwanted secondary) "absorbs" flux does the primary current rise. See:

https://static1.squarespace.com/static/575eb8279f7266835098dee0/t/5761b65ed210b8df02c13ec7/1466021471651/coil-a-winding-testing-handbook.pdf

https://www.voltech.com/support/technical-articles/detecting-shorted-windings/

https://www.themagnetoguys.co.uk/using-the-growler

I find myself digging into my experiences for a possible sideways take on the job in hand. I was reminded of doing measurements on Gallium Phosphide wafers, to calculate various properties of the wafer - like carrier concentration, doping profiles and the like by passing the wafer through a powerful magnetic field, using "Hall Effect" millivolt shifts which could be interpreted to give the data required. I've used Hall Effect sensors to detect magnetic fields in designing fail-safe solenoid valve systems, where just putting the volts onto the solenoid coil wasn't enough - we had to know the valve coil had actually magnetised the valve stem, the Hall sensor detected the magnetic field of the energised valve.

Thus, thinking about shorted turns test and the Growler reference above, a Hall Effect sensor could be used to pick up the intense magnetic field a shorted turn creates: by holding the sensor a distance away from the coil assembly (or bobbin of a transformer, for instance) you could distinguish the "fault" field from the steady state field from the core magnetising current on no load.

We can go much further with Hall Effect devices: for instance an over-current situation can be detected, *without any connection or disturbance of the wire carrying the current*. Ideal for High voltage systems, or other EHT situations; or where electrical isolation is required for any reason. Unfortunately for radio amateurs, Hall Effect sensors can't respond to more than a kHz or two, so make no easy "sniffer" or power monitor for a transmitter - but I'm sure you'll find plenty to stimulate the imagination, see:

https://www.digikey.co.uk/en/product-highlight/m/melexis/mlx90392-3d-magnetometer?dclid=CIitvMjV2_MCFddDHQkdaSoK5w (other suppliers are available).

Components & Circuitry

Nylon washer toroids

Farhan, the BITX guru, winds toroids on plastic washers, grommets, tap washers - indeed anything BUT ferrite cores! Why? Because in some parts of the World, Amidon (other makes are available...) iron dust or ferrite ring cores toroids are as rare as Hen's teeth, that's why!

The results using a non-magnetic former ($\mu = 1$) are just as useful as winding on a higher permeability core: the magnetic flux is more or less totally contained within the toroid winding and the distributed capacitance across the winding is reduced as compared to a solenoid. A useful reference to this method is: https://groups.io/g/BITX20/topic/4104526?p=,,,20,0,0,0::,,,0,0,0,4104526

Of course, it helps if you know what inductance you'll get for your turns, so here's a formula and auto calculator that will do just that for you (remember to use $\mu = 1$ in these calculations)

http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/indtor.html

Just plug in your values, press [return] on your keyboard to input the value, shuffle the decimal point a few places and you'll find (for example) a 2cm toroid, wound with 20 turns, each turn of 5mm diameter will give you an inductance of ~ 0.314 μH. Just plug in the values from your winding and the job's a good 'un.

A big bag of plastic / nylon washers from my local hardware store cost me £1.49 for 100 nylon washers, 20mm outer diameter, 12mm hole, 2mm thick, ideal for a good few designs - what's not to like?

Of course, a magnetic core of some sort will require fewer turns for a given inductance - but for my VHF experiments, plastic washers and a bit of cut and try will do me nicely, thank you!

Constant Current sources

These little beasts turn up in almost every op-amp, NiCad battery chargers and the like: they are the opposite to a constant voltage source (also more commonly known as a power supply!). Constant current sources can be very useful in bench test and repair scenarios as well as in testing prototypes, and if implemented as one of their cousins, the "current limiting" circuit. A very useful function is in a linear scale ohm meter where constant current results in a far easier to read meter scale; it will aid fault finding those really tricky intermittent bad connections - commonly those push on ("Faston") connectors crimps, etc., of a spade fitting into a twin furled brass "socket".

Applications include automatic semiconductor test gear, very high gain amplifier stages (they are often found inside op-amps), instrumentation and laser diode modulation circuits (now I bet that's got your attention!), extremely high audio / RF gain stages utilising only one transistor. Yes, constant current circuits crop up in many circumstances; if you recognise the function, you'll see the principle at work in many varied and useful amateur radio scenarios.

There are a couple of unfamiliar terms used in the "constant current" World - the most important being the "**compliance**" of a constant current source - and the "**equivalent source resistance**". To understand these terms, the basic principle of a constant current source needs to be (briefly!) analysed, and the circuit below will illustrate these points. It comprises a (theoretical…) 1kV voltage in series with a high resistance, feeding a variable resistance load. For this illustration, let's consider a 1kV supply with series resistor 1 of Meg-ohm.

<u>[kV supply via a 1meg resistor sketch here; and add the double circle symbol]</u>

If the output terminals are shorted, (i.e. R_{load} = 0 ohms) the current in the load = 1mA.

If the load connected is now 1 k-ohm, the current through it will be = 0.9999999mA.

If the load connected is now 10k-ohm, the current through it will be = 0.999000mA.

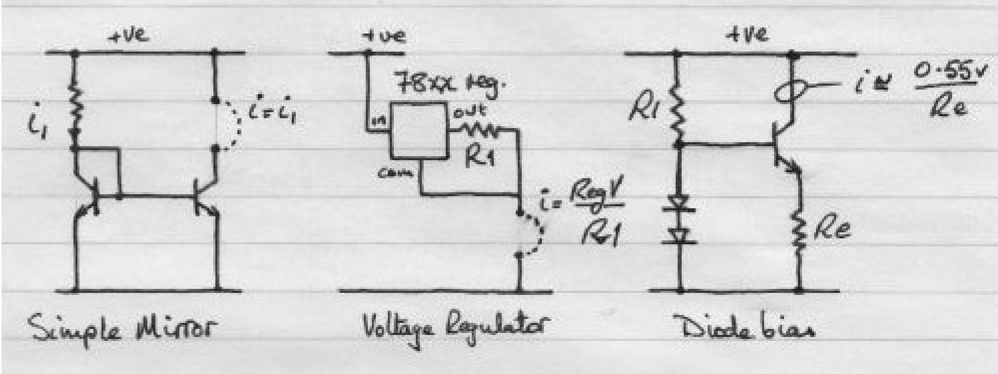
If the load connected is now 100k-ohm, the current through it will be = 0.990099mA.

And so on, and so on. The current is, for all intents and purposes, constant at just a tad under 1mA., ***no matter what load resistance*** is connected.

We can now define the two criteria mentioned above for a practical constant current source - the "compliance" is the maximum voltage available to drive the load, i.e. 1kV. The "equivalent source resistance" is 1M-ohm, and it's this value which defines the current regulation available.

For the best constant current source, you need an infinitely high voltage source, feeding an infinitely high series resistance: these components are not readily available from suppliers (for obvious reasons!). What we have to do to implement a "quality" constant current source is apply a dose of active components - usually bipolar transistors and diodes - to implement the function. If you're building very high precision current sources for test and calibration purposes, you might choose an esoteric op-amp, precision voltage reference IC's and precision resistors to get the range and accuracy you need.

The simplest circuits are the diode biased bipolar transistor brethren. They can be implemented very easily in both NPN and PNP versions, depending on how you want to connect the load: supply +ve connected (NPN) or supply ground connected (PNP).

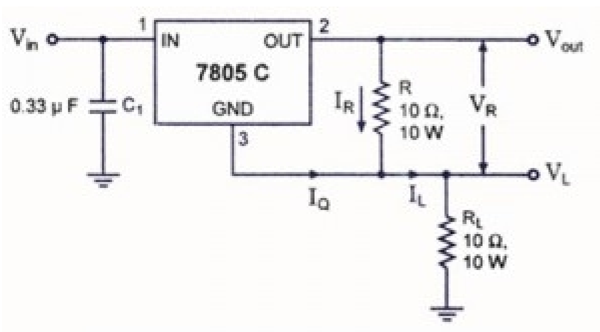


A similar (but subtly different) circuit is the “Simple Mirror” - in this, a transistor is directly controlled by another, which is “diode connected”, the subtle difference is that both transistors are fabricated right next to each other on a silicon chip so are both subject to identical temperatures and operating conditions, guaranteeing tracking and matching to a very high degree. You’ll see many of these in the inner workings of quality op-amps specifically for this tracking and matching capability.

This Diode Bias design relies on the biasing in one transistor (usually the diode connected device) driving the second (open collector) device: and this makes an ideal laser, Infra-Red or visible LED modulator feasible. Simply add a few millivolts of audio (or digital pulses) to the standing DC bias in the diode connected device and the mirror will slave the signal in the open collector device - this can be an LED or similar, NO limiting resistor required, but watch the dissipation in the LED driver! You can very usefully use plastic tab power devices in this role, you can bolt them together for good thermal tracking, and they’ll certainly do the business for you - but watch the bias stability in the diode connected device; the Vbe of this transistor will drop at 2mV per °C. Think of it as you would biasing an RF power bipolar amplifier, and you’ll not go far wrong.

A useful device too for power constant current sources is the Voltage Regulator design, the 7805 type and it’s many variations works remarkably well, and I use them for high current ohms tester designs, for PCB track evaluation, solder joint quality, crimp connector testing and any other ohms test jobs that needs amps, and plenty of ’em.

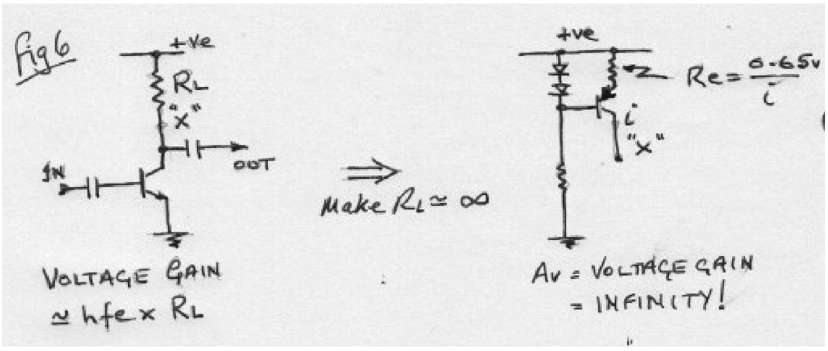
The circuit is very simple in it’s operation: the 7805 strives to create 5 volts difference between the “output” pin (labelled 2) and the “common” terminal (labelled 3). If we connect a load between the “common” and ground, a constant current, set by the resistor from “output” to “common”, flows to ground from the “common” terminal.



The 7805 as a 0.5 A Current Source

By fitting a “wrap around” booster PNP transistor, the 7805 applies precision regulation to the output voltage up to as many amps as you require; the PNP wrap around booster can handle the amps, and leave the 7805 to keep it’s cool and regulate the load voltage. Assuming the output current setting resistor is hefty enough to cope with the amps, you get a very low cost constant current source with superb regulation; modulation can be applied in the common terminal too, but I prefer the current mirror for that job, it’s a simpler method. The regulator won’t allow too much adjustment by jacking the common pin; push it too far and you’ll lose all hope of linearity and you’ll possibly kick the regulator into instability. But - here’s a thought - you could drive audio at a suitable level into the common pin to amplitude modulate the output voltage (and hence current). I’ve not tried this, so can’t comment on frequency response, linearity and the like, so if any readers have gone down this route to generate A.M., then I’d very much like to know!

Of course, nothing in this Universe comes *cheap ’n easy*! The compliance of the 7805 current source is reduced by the drop out voltage of the 7805 chip. It’s going to take at least 6 or 7 volts (depending on the 7805 regulator you choose) across the regulator to maintain stable running; you could try a low drop out 3.3 volt regulator, driving a 3.3 ohm resistor for a 1 amp super stable current source. Using a wrap around, you can easily extend this to 10 or more amps, but again, watch the linearity. Voltage regulators aren’t often used as audio amps, but maybe our old friend Harry Lythall SM0VPO can help, as he’s used them in various amplifier configurations.



One use - and this one really caught my attention when I first saw it - is the “infinite gain” amplifier shown above in Fig. 6, using one ordinary audio transistor as the amplifier device. The constant current circuit feeds current into the collector (at point “X” above) of the gain stage; gain ~Hfe x R_L. If R_L approaches infinity ohms, gain = infinity!

This circuit’s a good ‘un, used many times in power amplifiers and op-amps. I saw it in the ZN424 op-amp applications booklet from Ferranti Semiconductors (oh, how I wish I could get another copy of that booklet...), which illustrated a 150 watt gated audio amplifier using this gain stage; this also taught me that infinite gain = oscillation every time! Care has to be taken to stabilise the beast by rolling off the high frequency gain (a capacitor between collector and base of the NPN, 22pF - 470pF is typical) and hefty decoupling of the power supplies, or the infinite resistance ability of the current source will readily become obvious: infinite gain = full output with no input!

It works like this: the AC signal gain of a common emitter amplifier is (approximately) collector current divided by the base current, multiplied by the load resistor in the collector. If this load resistor is replaced by a constant current source, you’ll recall the equivalent series resistance of a constant current source is not just high, it’s nigh on infinite, so the AC signal gain is approaching infinite too. But… it is possible to stabilise the beast, note the collector to base capacitor in the gain stage rolling off the HF gain. You'll need to experiment here to get the beast under control before you allow it to modulate a signal, or you'll be looking at some mighty wide bandwidths in an optical comms system.

Sticky Pads and Manhattan construction

Hot melt glue slivers, cut with a craft knife from a stick, slipped beneath the "pad" to be fixed make the job of placement, removal and / or remodelling a doddle. A touch longer than usual on the pad with a hot iron and the pad lifts off clean as a whistle; any remnants are easily cleaned with a fine tipped screwdriver used as a scraper once everything has gone cold.

This trick also keeps more in line with Health and Safety issues: the nasty niff from some overheated super-glue formulations isn't at all pleasant, and may well be toxic (iso-cyano-acrylates if I recall right).

For the over enthusiastic amateur, pushing the "final" a bit too hard, the scheme also provides some protection if designed with disconnection in mind: the pad removes itself with the excess heat and can be arranged to open the critical part of the circuit.

Croc clips and test leads

An old dodge which vastly extends the working life of croc clip test leads is to run the wire through the longitudinal split clamp / entry section (which, incidentally, is often a perfect fit for 4mm test plugs, allowing the use of double plug ended 4mm test leads) for a lifetime (almost a lifetime; mine made up this way are still reliable in regular use after 50+ years) of reliable test clipping.

The job's a lot easier if you do the soldering first, then open up the clamp section to allow looping the wire two times before carefully closing with pliers. With modern "fat" silicone leads it takes a bit of juggling to get two turns on and clamped up, but the key seems to be the clamping of not just the insulation but the core too, locked by the double loop.

Antennas

Mobile bobtails, the VK3YE way

VK3YE has demonstrated a dinky mobile Bobtail curtain - and his modifications thereof, which he shows to be a real performer. I have heard of the Bobtail before; I've seen it used on low VHF too, but it's a bit big for anything below 20m though for those with enough space can be useful down to 30m if you really try. Peter gives his summation in a neat video, well worth watching (as is all of Peter's output!), see:

https://www.youtube.com/watch?v=1cnc14VW8Ro

WQ1GV gives this analysis of the Bobtail without any deep maths, with known solid RF practice and illustrates how the directivity can best be be utilised. See:
https://www.simplehamradioantennas.com/2019/09/bobtail-curtain-antenna.html

The Bobtail isn't a new antenna; it dates way back to the early 20th. Century if not earlier, and is a proven winner far outpacing a dipole for instance. You don't need any fancy or demanding earth mats or grounding; it's fairly easy to match and delivers. Just the job for portable, if you can get your hands on cheap fishing poles for support and can build a simple "L" tuner ATU to drive the centre "leg". The outer leg insulators can usefully be polypropylene rope or cord, but make sure it's clean and dry if you're driving more than a few watts into the beast or the resonant Q factor voltage multiplication will sizzle the insulators!

An ATU for all seasons

There have been literally hundreds of ATU (antenna tuner units) over the years; I spotted this design (QST, November, 1941) as it is a "plug-n-play" design and readily adaptable to single band or whatever particularly suits your needs. The basic principle remains the same: if your antenna is short (the usual case for lower HF bands) for the wavelength, you add inductance. If it's long (typically 15m band and higher) you add capacitance to ensure the reactive part of the antenna impedance is resonated out. All that then remains is the impedance matching of the transmitter output to the antenna; and that's where a lot of designs fail. This design uses the link coupling to adapt the impedance match to the output device(s) be they valves of solid state: where "plate current" is discussed, substitute "collector" or "drain", and observe the use of simple current indication (i.e. filament lamps) and RF volts (neon bulb with earthed plate nearby for capacitive coupling).

"L" networks will match impedances as well as reactive loads; but you're better to get the impedances somewhere near matched so as not to compromise the "Q" of the L Network.

• *For the Junior Constructor —*

An Antenna Tuner for the Beginner

A Low-Power Coupler and How to Use It

ANTENNAS fed by tuned lines have long been popular with old hands at the game as well as beginners. The use of transmission lines permits the antenna to be placed in the most favorable position available without regard to the location of the transmitter. While the line may be either tuned or untuned, the tuned line is more tolerant in adjustment and is, therefore, more easily handled by the beginner.

While it is possible to connect a tuned line directly to the tank coil, this practice is not recommended, because not only is it impossible to segregate the tuning of the transmitter output tank and that of the antenna system, but also direct coupling provides an excellent means of introducing undesired harmonic frequencies in the antenna system. For these reasons, it is advisable to provide a separate circuit for tuning the antenna system

This tank circuit may be coupled to the transmitter output tank circuit by placing the two coils in inductive relation to each other. Coupling may be adjusted by changing the distance between the two coils. Another method of coupling the two circuits, more popular in recent years, is one in which the two circuits are coupled with a low-impedance line or "link" between the two. This permits mounting the antenna tuner at a distance from the transmitter, if desirable, and allows the antenna coil to be fixed in position, the coupling being adjusted by altering the number

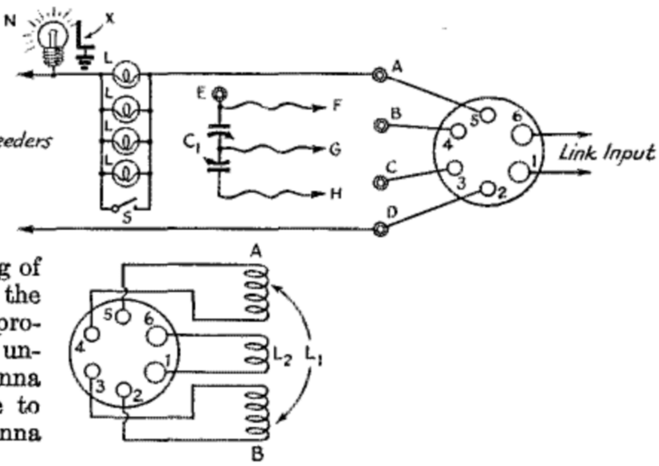


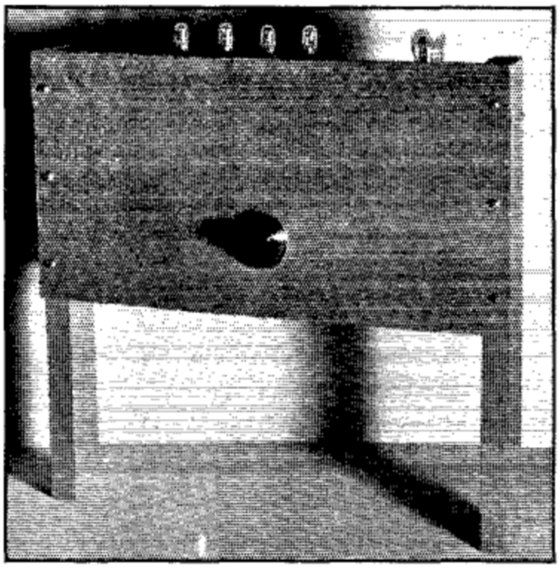
Fig. 1—Circuit diagram of the low-power antenna tuner.

Section A shows the connections to the coil socket. C_1 has a capacity of 140 μμfd. per section (Hammarlund MCD-140). L is a 250-ma. dial light, No. 46. N is a ¼-watt neon bulb. X is a grounded piece of metal to form a capacity for igniting the neon bulb. S is a switch or clip for short-circuiting the lamps after tuning.

B shows the connections to the 6 pins of the coil form. L_1, whose approximate dimensions are given below, is wound in two sections on the form, with the link winding, L_2, in between.

L_1 — 1.75 Mc. — 20 turns No. 22 enam., ¾-in. long each section, ½-in. space between sections, 40 turns total.
3.5 Mc. — 11 turns No. 20 enam., ¾-in. long each section, ½-in. between sections, 22 turns total.
7 Mc. — 6 turns No. 20 enam., ¾-in. long each section, ½-in. space between sections, 12 turns total.
14 Mc. — 3 turns No. 20 enam., ½-in. long each section, ¼-in. space between sections, 6 turns total.

Number of turns for the link winding, L_2, will vary from 2 to 6 or 8 turns, depending upon coupling required for proper loading. Coils are wound on Hammarlund 6-prong, 1½-in. diameter forms.



The low-power antenna tuner is built up in panel form to mount on the operating table within reach of the operator. The indicator lamps are visible from the front.

of turns in the link coil at each end of the line. Providing the power-output level does not change greatly, the same antenna tuner may be used with several different transmitters without rebuilding it.

Such an antenna tuner is shown in the photographs and the circuit diagram is shown in Fig. 1. In the form shown, it may be mounted on the operating table within easy reach and view of the operator. It consists essentially of a plug-in coil and tuning condenser with a system of clips by which several different combinations of inductance and capacity may be selected to suit requirements. Since meters to indicate r.f. current in the feeders are expensive, cheap dial lamps and a neon bulb serve as indicators of optimum antenna-circuit adjustment.

Construction

The two uprights and the strip supporting the indicating lamps are pieces of "one-by-two" stock. The uprights are each 13 inches long, while the cross-strip is 12 inches long, although these dimensions may be changed to suit the constructor. The shelf for the condenser and coil is made of a piece of crate wood 4½ inches wide. The panel may be made from a scrap of plywood 7 inches high and the whole thing may be given a couple coats of shellac or paint to suit the taste.

The dial lamps are soldered to a pair of parallel wires supported at each end on small stand-off insulators. The bottom of the neon bulb is soldered to a short piece of wire between a third pair of standoffs. The piece of grounded metal next to the neon bulb is about 1¾ inches square. This provides a capacity to ground to enable the neon bulb to operate without touching the hand to it.

The socket for the plug-in coil is mounted on the shelf with spacers and woodscrews. The shield between the two sections of the variable condenser is removed to allow mounting with a screw through the hole to the shelf. The shaft of the condenser is cut off and an insulating coupling inserted between the shaft and the control knob. The contacts for shifting connections consist of machine screws set in a small strip of bakelite.

Antenna and Feeder Dimensions

In order to avoid possible difficulties in tuning and coupling, both antenna and feeders should be cut within reasonably-close limits dependent upon the frequency at which the transmitter is operating. Charts are shown from which both proper antenna length and feeder length may be determined for any frequency. To determine the length of the antenna, place a point on the horizontal scale at the desired frequency. Now

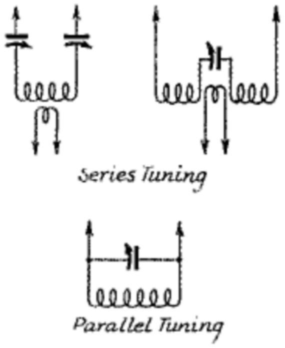
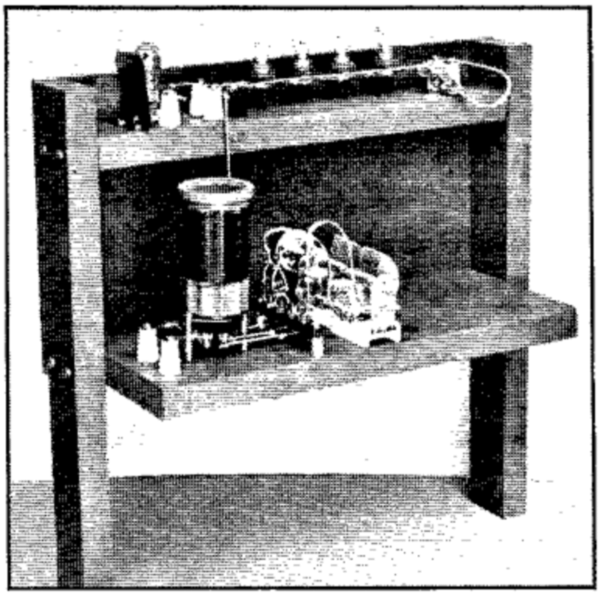


Fig. 2 — **Circuits for series and parallel tuning. Separate series condensers may be used in the feeders or a single condenser may be used at the center of the coil to maintain balance.**



Rear view of the low-power antenna tuner.

run the point vertically until it hits the solid diagonal line. Then run the point horizontally to the left to the vertical scale which will show the proper length of antenna. With a center-fed antenna, the length given is the sum of the lengths of the two halves of the antenna.

To determine the length of feeders to use with this antenna, start out as before, but run vertically to the dotted diagonal line and, thence horizontally, to the right to the vertical scale indicating feeder lengths. Choice of feeder lengths for the same frequency is given so that some selection is possible in choosing a length which will cover the distance between antenna and transmitter. The lengths used should not vary more than 25 per cent of the length given in the *first* feeder-length column of each chart. If a 125-foot antenna with 187.5-foot feeders are chosen, both should be within 25 per cent of 62.5 feet (3.5-Mc. Chart), the length given in the first column. Be sure to include any length of feeder which must be run inside the station to reach the coupler terminals.

End Feed or Center Feed

Tuned feeders are normally used either at the center of the antenna or at one end. Center feed is preferable whenever possible, since a balanced line is automatically maintained, regardless of antenna length. With the end-fed or Zepp system, a complete balance is never possible and the situation becomes worse as the length of the antenna varies from the exact proper length for the frequency in use. If the antenna is operated at a harmonic, different patterns of directivity will be obtained with end feed and center feed.[1]

[1] Don Mix, "Antennas for Domestic Work," *QST*, Sept., 1941.

Charts showing correct antenna and feeder lengths for antennas fed by tuned lines for frequencies in the 1.75-, 3.5-, 7- and 14-Mc. bands.

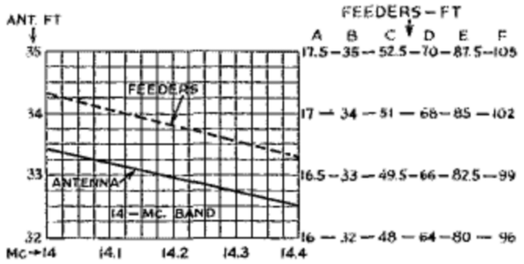


Chart for 14-Mc. band. With end feed, use series tuning for A, C and E; parallel for B, D and F. With center feed, use series tuning for B, D and F; parallel for A, C and E.

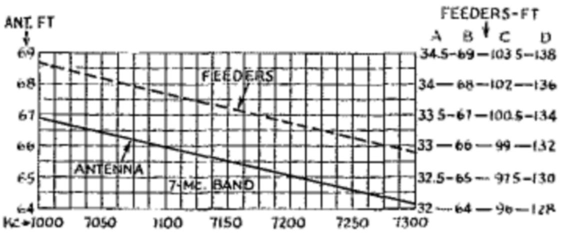


Chart for 7-Mc. band. With end feed, use series tuning for A and C; parallel for B and D. With center feed, use series tuning for B and D; parallel for A and B.

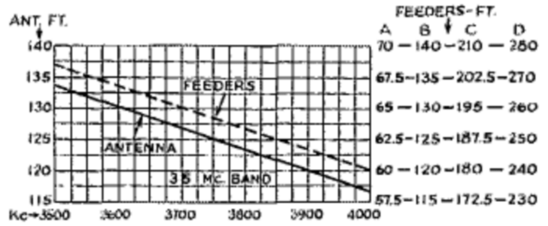


Chart for 3.5-Mc. band. With end feed, use series tuning for A and C; parallel for B and D. With center feed, use series tuning for B and D; parallel for A and C.

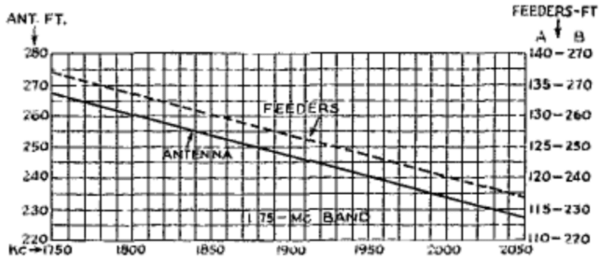


Chart for 1.75-Mc. band. With end feed, use series tuning for A; parallel for B. With center feed, use parallel tuning for A; series for B.

Series and Parallel Tuning

With feeders of certain lengths the antenna-tuner tank circuit must be connected in series with the feeders, while for other lengths it must be connected in parallel, as shown in Fig. 2, to resonate. Feeder balance will be maintained with series tuning by the use of separate condensers, one in each feeder, set to equal capacities or by a single condenser at the center of the coil. For any given length of feeder, the proper use of series or parallel tuning will depend upon whether the antenna is end fed or center fed. The correct system to use with feeders of any chosen length is indicated above the feeder-length columns to the right of each chart.

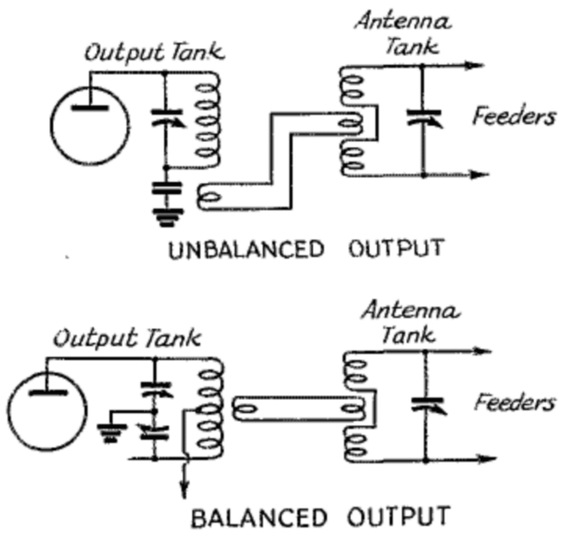


Fig. 3 — The antenna tuner is coupled to the output stage with a link line. The link at the transmitter end is coupled to one end of the coil if the output circuit is unbalanced or to the center if a balanced circuit is used.

The antenna tuner shown in the pictures is arranged so that either series or parallel tuning may be used at will by shifting the position of the clips marked F, G and H in the diagram. A, B, C and D represent the four machine-screw contacts in the strip near the coil, while E represents a contact on the rear stator of the condenser. When F is connected to A, H to D and B to C, the two sections of C_1 in series are connected across L_1, forming a low-capacity parallel-tuned circuit. When H is connected to E and G to D, other connections remaining the same, a high-capacity parallel circuit is formed. For series tuning, H is connected to E, F to B and G to C. A low-capacity series-tuned circuit is formed by connecting F to B and H to C. The high-capacity circuits will be used at the lower frequencies, while the low-capacity connections will be found useful at the higher frequencies. Approximate coil dimensions for parallel tuning for each band are given under the diagram. Slight alterations in specific instances may be required. Where series tuning is required, the coil for the next-higher frequency band will usually be satisfactory.

Tuning

The antenna tuner and the output tank circuit should be coupled by a link line as illustrated in Fig. 3. This line may consist of a pair of closely-spaced parallel wires. When the tank circuit of the output stage is unbalanced, the link at that end

(Continued on page 68)

U. S. Antarctic Service

(Continued from page 17)

on the air in contact with KC4USA. Charlie has the greatest number of contacts (followed closely only by "Skunk" Scrivener, W3EXI).

Why the special test and observation skeds with W1FH? Well, I'll tell you — that's where Mama was. You see, in 1934 we were unable to work Boston on 20 meters from Little America. In 1940, 'twas no trouble at all.

Thanks a lot for the kind assistance rendered by you and your staff in handling our amateur business.

— *Clay W. Bailey*
Communications,
U. S. Antarctic Service

An Antenna Tuner

(Continued from page 20)

should be coupled to the end of the tank coil opposite to that to which the plate is connected. With balanced-output circuits, the link winding should be placed at the center of the tank coil. The link at the antenna tuner will always be placed at the center of the coil.

The tuning procedure with series tuning is as follows: With C_1 at minimum capacty, couple the antenna coil, L_1, loosely to the transmitter output tank circuit, by using a single link turn at each end of the line, and observe the plate current. Then increase C_1 until a setting is reached which gives maximum plate current, indicating that the antenna system is in resonance with the transmitting frequency. Readjust the plate tank condenser to minimum plate current. This is necessary because tuning the antenna circuit will have some effect upon the tuning of the plate tank. The new minimum plate current will be higher than with the antenna system detuned, but should still be well below the rated value for the tube or tubes. Increase the coupling between the two circuits by adding link turns, one at a time at each end, each time retuning both antenna tuner and output tank until the minimum plate current is equal to the rated plate current for the output tube or tubes. Always use the degree of coupling which will just bring the plate current of the output stage to rated value when the antenna circuit is tuned through resonance.

With parallel tuning, the procedure is similar. When the correct degree of coupling has been attained, the simplest procedure is to tune the output tank to resonance with the antenna circuit well detuned and then swing the antenna tuning up to resonance. This procedure will cause the least detuning of the output stage, although the tuning of the latter should always be checked as the final adjustment.

R. F. Indicators

Feeder current, as indicated by the lamps, is useful for tuning purposes only and will not give an indication of the actual power output. When series tuning is used, the lamps should glow more brightly as the antenna is tuned to resonance and the coupling is increased. Tuning should be started with all four lamps in the sockets. If no indication is obtained with the antenna tuned, the bulbs should be unscrewed, one at a time, until an indication is obtained. If a single lamp shows sufficient brightness to be in danger of burning out, another should be inserted in the circuit. Greatest output will be obtained with the lamp or lamps glowing most brightly. When the antenna tuning is complete, the lamps should be short-circuited with a clip to eliminate the power consumed by them.

With parallel tuning, the lamps will seldom be of great value, since they are then near a point on the feeders of maximum voltage and minimum current. In this case, the neon bulb will probably be a more useful indicator. With the antenna circuit tuned to resonance as indicated by the plate current, the grounded metal piece X should be bent toward the neon bulb until it ignites. The bulb will glow most brightly when the transmitter is delivering the greatest output. The distance between the neon bulb and the metal piece should be adjusted for best indication.

Harmonic Operation of Antennas

Any of the antenna dimensions given in the charts will be satisfactory if the antenna is operated at harmonics of the frequency for which it is cut. Parallel tuning will always be used for harmonic operation. A tank coil suitable for the harmonic frequency should, of course, be employed when operating at the harmonic.

—*D. H. M.*

What the League Is Doing

(Continued from page 21)

numerous W7 amateurs, considering that Section 2.91 gave them that authority. As it is reported to us, some of the amateurs operated at addresses other than the licensed ones, including the moving of their portable equipment to Army locations contrary to Order No. 73. The Seattle R. I. started citing amateurs and finally descended upon the scene with fire in his eye but, after going into a huddle which showed that all concerned had acted in good faith because of the language of 2.91, the citations were squashed.

The matter has now become the subject of an understanding between the War Department and FCC. It is henceforth to be understood by all concerned that before Army field commanders can secure the participation of amateurs in Army communication systems, they must get the approval of the War Department at Washington and, at the latter's request, the issuance to the amateur by FCC of special temporary authority.

Strays

October *Harper's* has a grand article on "Our Radio Amateurs," by Carl Dreher and Zeh Bouck. Good publicity for us with the general public, you'll enjoy it yourself.

Elf-n-Safety Dept.

Pencil RF detectors...