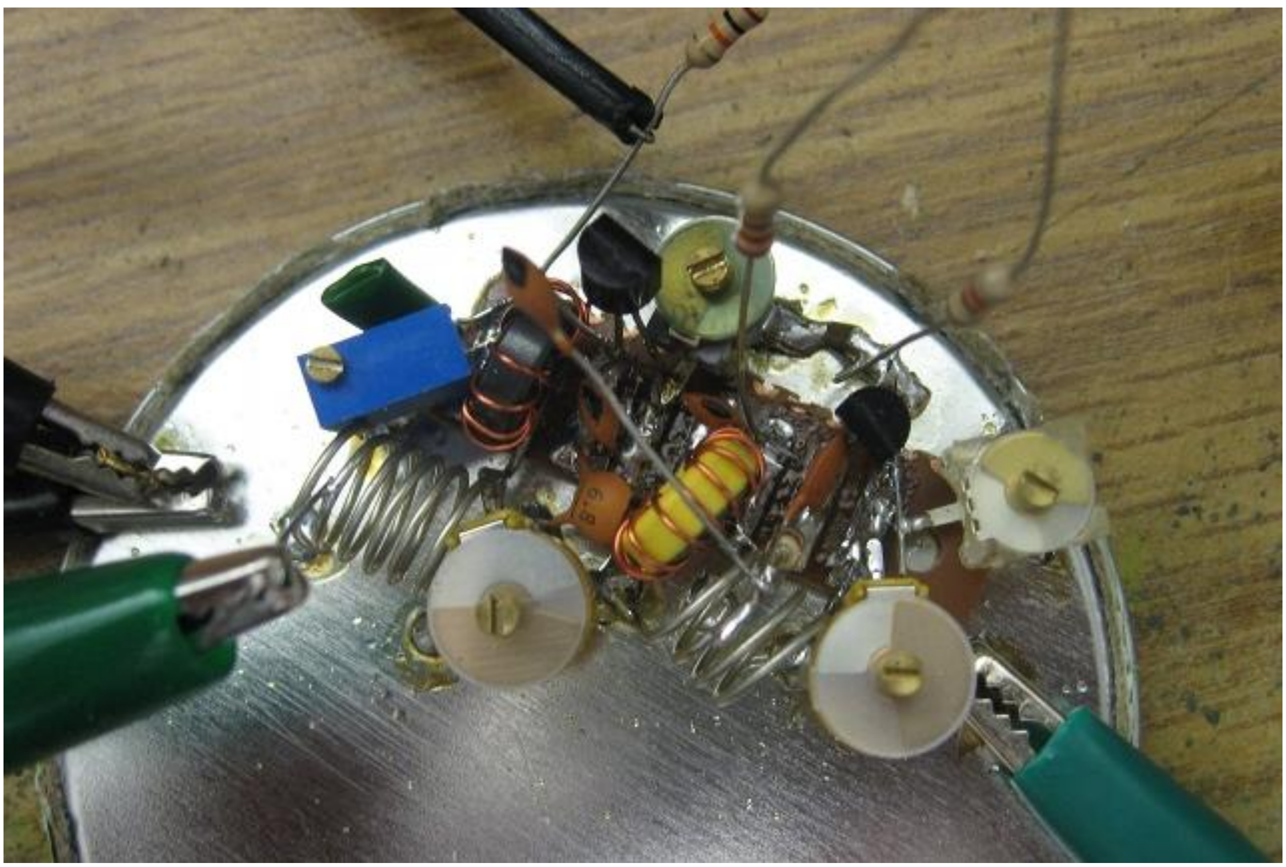
Fremodyne VHF AM/FM Receiver

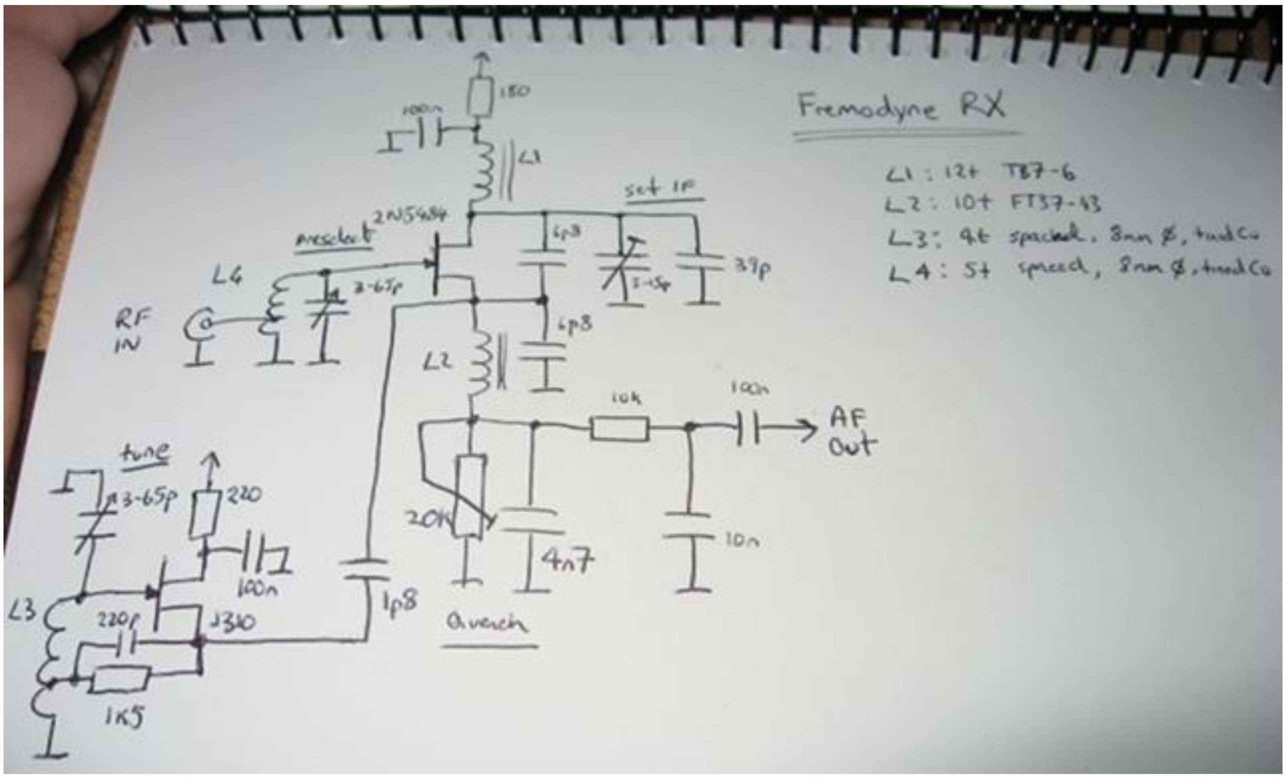
The Fremodyne is a type of minimal super-heterodyne receiver intended for FM reception. It utilises a super-regenerative IF detector which doubles as a mixer stage. It has a long history, that began with vacuum tubes back at the beginning of FM broadcasting when a cheap receiver was needed to fill the lower-end market of receivers for the new FM services. John Hunter has an excellent site covering Fremodyne Receivers.

While the great majority of published designs are for vacuum tube devices my interest was in building a solid-state version for fun. This little experimental radio is the result of a quick back-of-the-envelope design during my commute to work, and a few hours of work on a late Sunday evening. It was intended to be an experimental receiver purely to work the bugs out of the design, so no effort was put into calibrating its tuning elements. Physically, the ugly hack was built on the tin-plate bottom of a Pringle chips can with a fragment of PCB edge connector glued to it acting a bit like a tag-strip.



Despite having no in-built AF stage and needing about 6-8 volts for the detector to oscillate well, it is quite a good little receiver. It is sensitive enough to pick up all the local FM stations (even with little or no antenna) and works quite wonderfully on the air-band and TV-audio channels.

Like all minimal self-quenched designs it is basically impossible to completely eliminate interaction between the quenching of the detector and the FM multiplex signal. A multi-turn trimmer allows positioning the quench frequency so as to minimise any objectionable squeals mixed down to base-band, but the modulation of the oscillator operating point by the super-sonic multiplex signals produces intermodulation distortion and rumbling effects that are rather annoying to listen to. With monophonic signals this does not occur, and with AM signals one does not need to tune off centre to slope detect and gains a little more sensitivity from the IF.



The circuit is quite straight forward, but has a number of adjustable elements which makes this unit challenging for beginners to operate (Ironically exactly the opposite of the original point of super-regeneration). The quench adjustment can be set and left if AM and mono FM content is being received, but will almost always need to be tweaked when listening to a stereo signal. The quench frequency is a strong function of the received signal strength, so this adjustment is best performed last, mercifully it does not pull the IF detector frequency too much, so retuning for optimal slope-point is generally not needed. The front-end pre-selector adjustment on the other hand can drastically change the signal seen at the detector and alter the quench, so it is best to set it first. The pre-selector tunes fairly sharply, I roughly set it by dipping with the tone-dipper, then more precisely once a signal is being received by maximising the quench frequency observed on the oscilloscope. You can still tune about a bit either side with reduced sensitivity without touching the pre-selector, definitely enough to locate signals of interest before re-peaking if so desired (the radio works fairly well with the strong FM broadcast band signals if to just centre the pre-selector at 100 MHz and hope for the best). The LO frequency adjustment is quite straight forward, it must be set at +/- the IF frequency (or a harmonic) from the signal of interest to mix it to the IF. There are two trimmers offered, a coarse band-set one, and a finer band-spread unit (not in the circuit diagram, 1-7 pF) which is very helpful for positioning an FM signal correctly for nice slope detection. The receiver may be operated at either high or low-side LO injection, low side tunes easier (more band-spread), high side has better image rejection. The pre-selector determines which image will be favoured. The IF detector tank has a trimmer too, which can be used to precisely set the IF frequency if so desired. I run it at about 28 MHz which is near optimal for FM broadcast band reception, causing no in-band spurs.

Notes

Building something similar is easy. There are no special parts, almost everything is junk-box sourcable. The toroids used can be replaced with air-coils at some increase of physical size. The source RFC is non-critical and need only be about 10 uH, just make sure its SRF is > 30 MHz. The receiver is quite forgiving, the only critical thing is getting the IF detector to super-regenerate, you may need to tweak the Colpitts feedback (the two 6.8 pF capacitors) if it refuses to squegg at any reasonable voltage and setting of the source trimmer. Like all super-heterodynes test equipment is very useful, but by no means mandatory. I originally used my signal generator as the LO before I built the Hartley oscillator onto the board. My tone dipper and VHF wavemeter are the main tools I used to play around with the circuit - so no digital gear is really needed if you have some experience with VHF work. An oscilloscope is darn useful for checking the quench action, but an audio amplifier will tell you when it is working right.

Layout is surprisingly non-critical for a VHF circuit, my first version of the IF detector was built on a solderless breadboard and worked fine - the IF is only high-HF so it somewhat less demanding. The LO needs fairly good layout, it operates at mid-VHF, but being a Hartley is rather hard to mess up (it also generates way more LO energy than needed, you can decrease its current consumption quite a lot and still have sufficient injection amplitude). The gate pre-selector circuit is also ideally built using good RF hygiene, but initially to prove the IF detector I just grounded the gate and tested the IF directly at about 30 MHz. Later I used an RFC to inject signal at the gate rather than a tuned circuit. You could just as easily use a resistor, but high-value resistors inject more broadband noise into the circuit and really high values allow stray signal pick-up, including AF which will be followed to the source and straight into the audio amplifier.

The LO tunes 54-183 MHz. This means with a suitable front end resonator it can tune 26-155 MHz with high-side injection and 82-211 MHz with low-side, assuming you hold the IF at 28 MHz. Various spurs will be seen through-out the range however. The IF detector really misbehaves when the pre-selector resonator is tuned to the IF or LO frequencies, generally dropping out of oscillation completely or the quench becoming audible and/or chaotic.

Ideas

Clearly the mixing function can be performed in an extra transistor, this may reduce IF leakage and may improve IF rejection. Adding band filtering, buffering and amplification of the RF would be a good idea for a real receiver and may improve LO leakage. Separate quenching is worth experimentation, in particular this should help with the inherent distortion and intermodulation effects associated with the self-quenching detector. Digital control is something I am actively working with, and using an MCU to control the quenching allows easy RSSI and squelch integration.

Source: http://www.vk2zay.net/article/245