The Schlockwood Laboratory
Brea, California • www.schlockwood.com

Engineering Brief

The G.W. Short Homodyne

The Schlockwood Resurrection of a Classic Radio Circuit

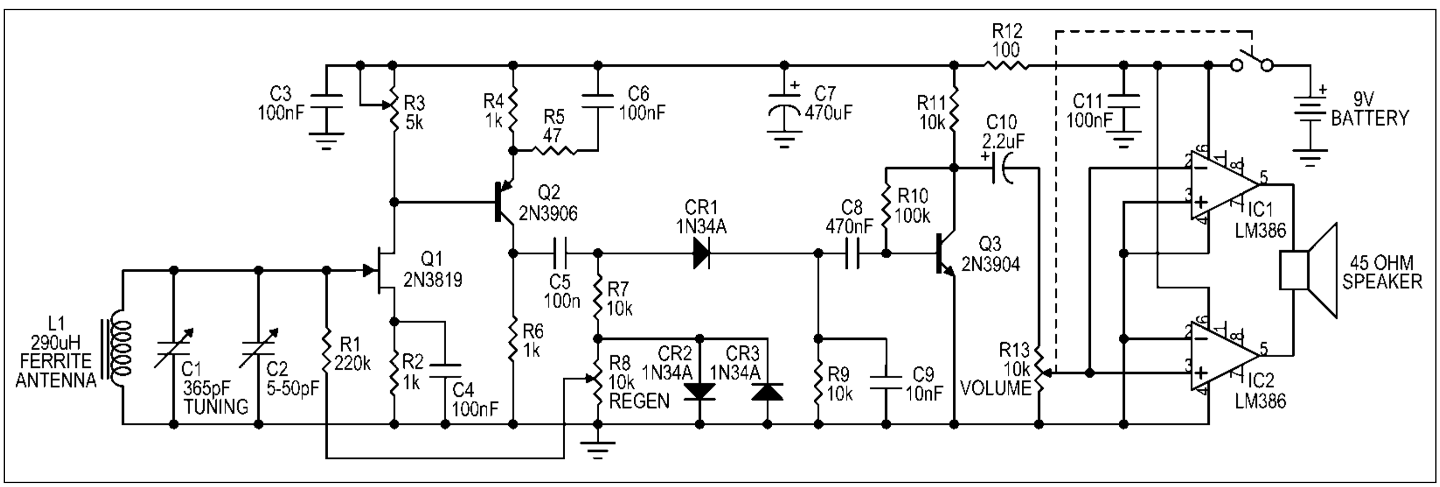
BACKGROUND

The elusive Mr. George (G.W.) Short appears to have been an avid UK electronics experimenter in past years. His writings appeared between 1968 and 1972 in the pages of the British magazine *The Radio Constructor*. Recent efforts to obtain background information on Mr. Short have all led to dead-ends, save his affiliation with a defunct electronic-component mail-order company named Amatronix.

Mr. Short details operation of his homodyne receiver in *The Radio Constructor* article. This may be found on Geoff Brown's very interesting Website featuring historical radio magazine reprints. From Geoff's homepage, www.radioconstructor.info, click-through to ↗ the G.W. Short page, and then to the Homodyne article.

Short's design, uses only a handful of common components, but continues to be an inspiration to contemporary radio experimenters. It has been the basis for recent published versions of the circuit by Jim Kearman, Dave Schmarder, Aren van Waarde, and David Palus.

In short (pardon the pun), the homodyne grabs an incoming AM signal by means of a phase-locked oscillator at the carrier frequency. An amplitude-limited component of the locked-oscillator signal drives a switching (synchronous) detector. Here is the schematic of the Schlockwood version of the Short Homodyne.



CIRCUIT OPERATION

It is important to recognize the homodyne mode of reception for this circuit, otherwise it's easily confused with a traditional regenerative detector. In fact, this circuit is a "tri-mode," capable of operating as a TRF, a quasi-regen, and in the intended homodyne mode.

Transistors Q1 and Q2 comprise a two-stage RF amplifier with a large amount of open-loop gain. Positive feedback, controlled with REGEN pot R8, allows the stage to be brought into controlled oscillation. This topology is essentially a Franklin oscillator, characterized by its very light loading of the tuned circuit, ensured by the negligible load of FET Q1 and the high-value feedback resistor R1. This oscillator configuration is very stable.

In a traditional 'regenny,' the off-air signal is amplified by positive feedback, while at the same time the 'Q' of the tuned circuit is increased, narrowing the reception bandwidth. Both a CW carrier (carrying Morse code) and amplitude-modulated waveforms are increased in amplitude as regeneration is advanced. When the stage breaks into oscillation, CW signals are then heard as a 'beat note' between the carrier and the slightly-offset oscillator frequency. Single-sideband (SSB) modulation can be recovered this way as well. But an oscillating detector is not very suitable for amplitude-modulated signals, so regeneration is generally held just below the point of oscillation to hear AM broadcasts with a traditional regenerative detector.

In Short's homodyne, feedback amplitude is pre-limited by back-to-back diodes CR2 and CR3. Once the signal level across the diodes brings them into conduction, amplitude modulation within the feedback path is essentially 'stripped' from a received carrier. At this point, the positive feedback level becomes solely a function of the REGEN control setting, preventing runaway feedback from driving the RF gain stages into saturation.

With REGEN control R8 turned all the way down, the Short design functions as a TRF receiver, CR1 serving as a simple envelope detector. Although CR1 is a germanium diode with a low forward drop, it makes an imperfect detector for anything but a strong local signal.

As the REGEN control is advanced and positive feedback is introduced, the TRF receiver becomes more sensitive and CR1 does a better job as an envelope detector. But as soon as CR2 and CR3 begin to conduct, the amplified AM envelope becomes clipped, causing audio distortion.

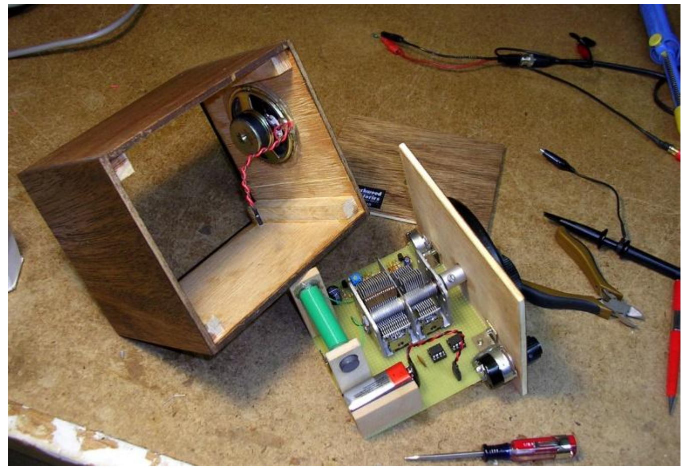
Advancing the REGEN control to the point of circuit oscillation brings reception into the homodyne mode. Feedback is limited by CR2 and CR3, thus preventing runaway oscillation and keeping the amplifier stages linear. This 'oscillating amplifier' may be 'pulled' by the incoming carrier when it is (skillfully!) tuned close to the carrier frequency. Once the oscillator phase-locks to the carrier, its output consists of a steady-state, amplitude-limited component, which is large with respect to the incoming AM waveform that rides atop it.

CR1 then no longer functions as an envelope detector, but as a switch. It is turned on 'hard' with positive-going carrier excursions, and is turned off completely with negative-going ones. CR1 becomes a synchronous detector in this instance, so long as the oscillating amplifier is locked to the incoming carrier.

Audio is cap-coupled off the cathode of CR1, where it rides on a DC voltage that represents the limited positive feedback. Q3 is a simple audio gain stage; loudspeaker drive is provided by a pair of LM386 amplifier chips in a bridge configuration.

CONSTRUCTION NOTES

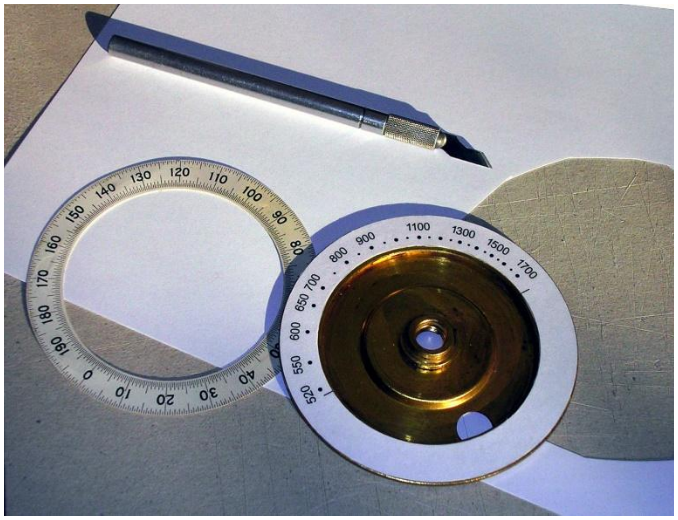
This version of the Short Homodyne is built on a piece of perfboard and housed in a simple wooden box.



It uses a variable capacitor scavenged from an old "All-American Five" table radio, and a home-wound antenna with about 60 turns of hookup wire around a hunk of ferrite material. The inductance was chosen to resonate just below 520kHz with the tuning capacitor fully-meshed. A small trimmer cap, C2, sets the top of the dial to about 1730kHz.

The vernier dial mechanism came from a ham radio flea market and dates to the late 1930s. Its linear 'logging' scale was replaced with one that carries actual AM-band frequencies.

The new dial was created in Microsoft Publisher, a desktop-publishing program. The original linear dial markings were converted to kilohertz, the conversion done with the aid of the receiver and a frequency counter once everything was up and running.



One element in the current circuit that does not appear in the original design is emitter degeneration of Q2 afforded by R5 and C6. The original circuit used a germanium PNP transistor in the Q2 spot, which must have had lower gain than the popular 2N3906 silicon part. At any rate, it was not initially possible to control regeneration… the circuit oscillated with R8 all the way down. Spoiling the open-loop gain of the Q1/Q2 transistor pair made the circuit stable.

Because the DC parameters of junction FETs are customarily all over the map, trimmer resistor R3 is used to bias this 2-stage amp to its proper Q-point. Mr. Short used a similar trick, but because Q2 is now silicon, rather than germanium, a pot in this particular spot gives best compensation for the Q1 parameter spread.

R3 may simply be adjusted for optimum reception, but careful adjustment for best waveform symmetry across CR2 and CR3 at maximum regeneration sets the operating point with optimum accuracy.

This version of the radio uses germanium diodes per Short's instructions, although it was discovered early-on that silicon diodes worked nearly as well except in the TRF reception mode. The circuit does seem to lock to the carrier better with the germanium diodes.

Using two audio-amp chips might seem excessive in a simple radio, but the only suitable speaker on hand was a 45-ohm unit. This takes a higher drive voltage, which the bridge configuration provides, and also obviates the need for a large coupling capacitor as both outputs sit at half the battery voltage. It's necessary to feed the IC inputs out of phase, an easy matter as LM386 inputs sit at DC ground potential.

Here's an oblique-front view of the receiver that shows the side-mounted speaker with its painted plastic irrigation-part grille:

The front and rear panels actually form a 'sandwich,' and the radio is held in its box with only one screw through the back:

OPERATING THE HOMODYNE

Tuning the homodyne, or any regenerative receiver, is a ticklish proposition. The circuit should be in oscillation as the radio is tuned. AM stations will appear as whistles, dropping in pitch until the receiver locks to the incoming carrier. Much patience is required, and a second 'bandspread' tuning cap would be a welcome addition to the design and really should have been included.

The receiver has surprising sensitivity, but of course it has no AGC. Weak stations require more patience to bring into lock and will yield a correspondingly low audio output. Strong stations are received easily, but may require the REGEN control to be advanced all the way to prevent audio distortion.

A strong station will invariably override an adjacent weak one. More regeneration will help reduce the level of the interfering strong station, but will also drop the audio level from the weak one. The highly-directional property of the ferrite loop antenna is an advantage in nulling a strong station or other interference.