A very simple LF receiver

Klaus Betke

20 June 2004

Recently I was looking for a portable direction finding tool in order to locate some stations of the Siemens-Datatrak network (a road fleet management system with combined GPS/LF navigation and transmitters in the 130...146 kHz range). This initiated some experiments with regenerative receivers. Can this old-fashioned but simple principle be used for monitoring utility stations on longwave? Is there enough sensitivity with a ferrite loopstick antenna as the only tuned LC circuit? First tests were made with a circuit designed by Charles Kitchen N1TEV [1]. The RF section of the receiver described below is even more simple.

Circuit description

The schematic is shown in Fig. 1. Any oscillator circuit can provide very high signal amplification if it is operated near the point where it just starts to oscillate. Here an emitter-coupled oscillator is used. The frequency is determined by L1 and C1, and L1 is also the antenna. Oscillation onset is controlled by R6. Collector currents of T1 and T2 are extremely low, only a few µA. D1 stabilizes the supply voltage of this stage to about 1.6 V.

T1 and T2 also provide the demodulator. A low-pass filter comprising R2 and C3 keeps RF out of the audio amplifier. U1 is a low-voltage stereo amplifier; one half of it (U1a) is "misused" as a preamplifier. A second low pass (R9, C7, R10, C8) provides a soft cut-off at about 1 kHz. This makes the receiver's frequency response unsuitable for AM reception, but acceptable for monitoring digital communication, navigation and time signal stations.

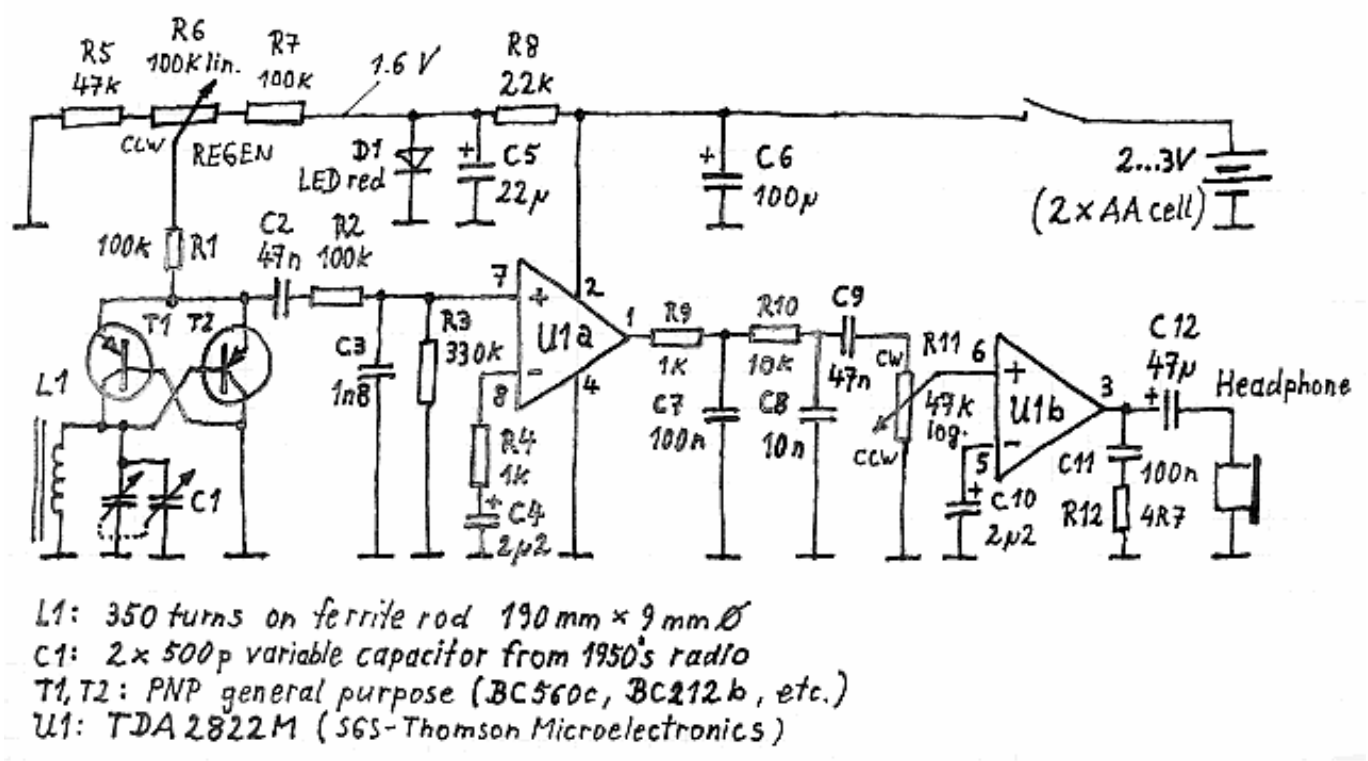

Figure 1: Schematic of the receiver.

The circuit was built into cheap but somewhat oversized plastic enclosure. A stereo potentiometer for volume control (R11), as it can be seen in the photo, is of course not necessary, but gave better mechanical stability, since the potentiometers were not screwed to the front panel – and because nothing else suitable was found in the junk box. The antenna coil (L1) on the photo was made of 0.18 mm enameled wire, but a "wild" winding of 0.4 mm wire worked as well.

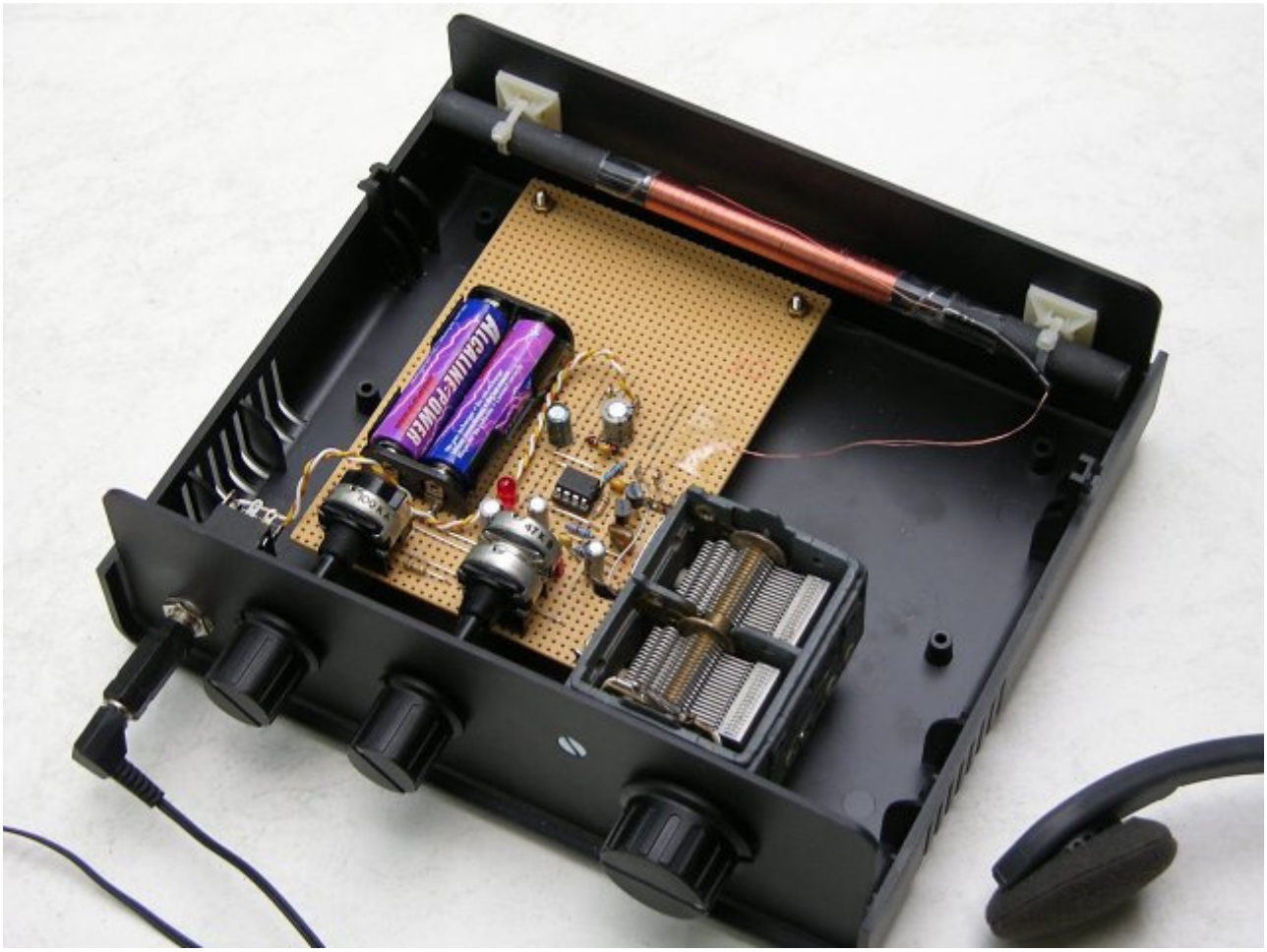

Figure 2: Prototype setup.

Operation

Regeneration control R6 works quite smooth, as it should be. It was found easiest to start with the receiver moderately oscillating. Oscillation starts at about 0.5V at the wiper of R6. In this mode, it behaves similar to a direct conversion CW/SSB receiver. Once a station is found, the receiving quality can be optimized by adjusting R6 and C1 alternately. The upper end of the tuning range is in the longwave broadcast band, which is useful for first tests. Meteo station DCF47 on 147.3 kHz, EFR telecontrol [2] on 129.1 and 139 kHz and DGPS station DCF42 on 123.7 kHz are quite loud here in northern Germany. These are all high power transmitters with 10...100 kW, but the "bleep-bleep" of some Datatrak stations in between them can be heard as well, especially when the receiver is operated outside the house. Below 100 kHz, a frequency marked by the tackling Loran-C signals, the receiver is less sensitive, but time signal station HBG on 75 kHz can be heard, though very close in frequency to DCF77. The bottom end of the tuning range was found just below MSF on 60 kHz, but this depends of course on the number of turns of L1, the material and the size of the ferrite rod, etc.

Problems

The extremely simple oscillator circuit has some drawbacks. The LC circuit is coupled very tight to the transistors. If the current through T1/T2 rises, the frequency is not only determined by L1 and C1, but by some less well-defined time constants. Hence the actual frequency can be significantly lower than given by $f = 1 / 2\pi \sqrt{LC}$.

For this reason, the oscillator is subject to pulling: The input signal can affect the frequency. If, say, a strong RTTY signal is received with a beat tone of 800 Hz, this pitch varies slightly if the signal strength is varied by rotating the antenna horizontally. With the component values given in Fig. 1, the effect is just acceptable (which of course is also a matter of taste). It is less pronounced with a lower L/C ratio, but this also lowers the receiver's sensitivity.

References

1. Charles Kitchen: A Simple Regenerative HF Receiver for Beginners. The ARRL Handbook for Radio Amateurs 2002, 17.99 - 17.101. ARRL, Newington 2001
2. EFR - Europäische Funk-Rundsteuerung **http://www.efr.de**/.