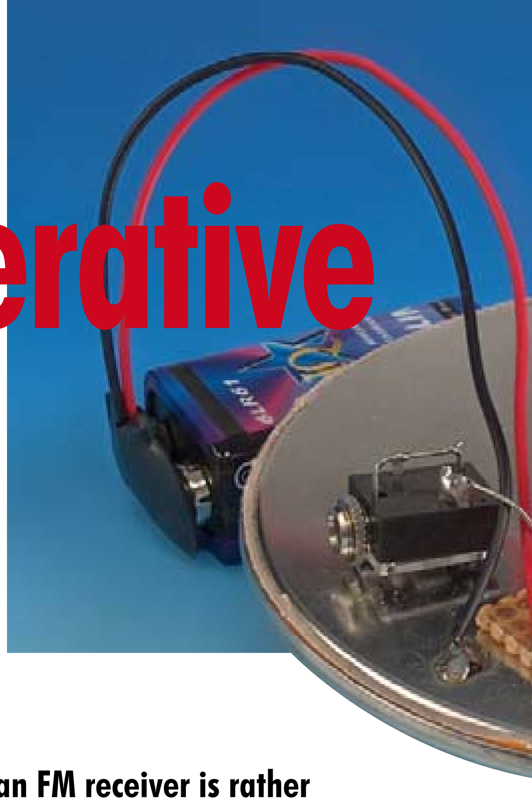


FM Superregenerative Receiver

using only two transistors

Burkhard Kainka

Building an AM receiver is a simple project for a beginner, but building an FM receiver is rather trickier. However, with a little ingenuity we can get away with a very small number of components: our superregenerative 'audion' receiver uses just two transistors, two coils and a few capacitors. A 'mini' project in the true sense of the word!

Component count is not the only respect in which our superregenerative audion receiver design is economical. As most readers will know, good grounded screening is essential in a radio receiver. In our prototype we recycled the tin lid from a packet of coffee for this purpose: the ideal type of packet is one with sides made from cardboard to which the lid is crimped, as the edge can simply be cut with a sharp knife. It is easy to bend to the desired shape, provides a stable base for mounting and takes solder easily. For the circuit connections either plain perforated board or stripboard is suitable (see large picture).

We also wind the coils ourselves. The oscillator coil is made from five turns of 0.8 mm (ideally, silver plated) copper wire on a diameter of 8 mm. Short connections are essential, especially to the tuning capacitor: we soldered a trimmer directly to the ground plane. The second coil in the circuit consists of 20 turns of 0.2 mm enamelled copper wire wound on a 10 kΩ resistor. The rest of the circuit is constructed as shown in **Figure 1**.

The antenna should not be too long, as otherwise the circuit may cause interference: the superregenerative circuit is also a transmitter! Nevertheless the circuit is very sensitive and operates perfectly satisfactorily using a 10 cm length of wire for an antenna. The headphones should ideally have an impedance of at least 400 Ω. The circuit will work with 32 Ω stereo headphones, but the output will not be as loud.

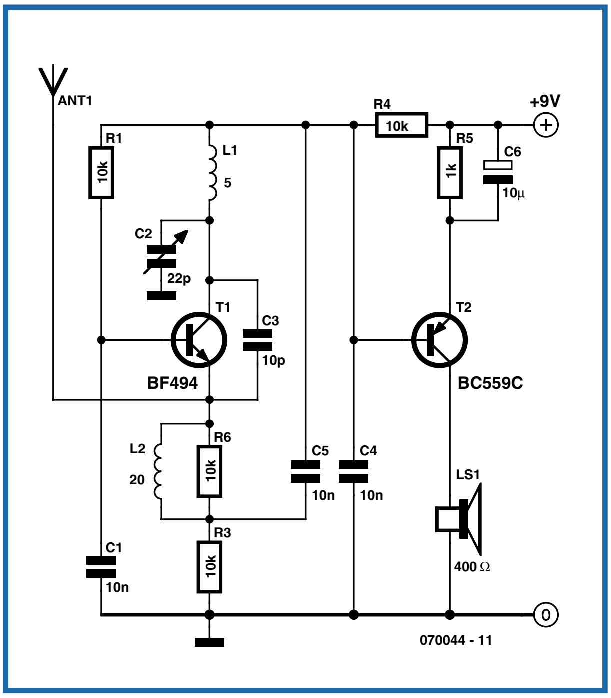
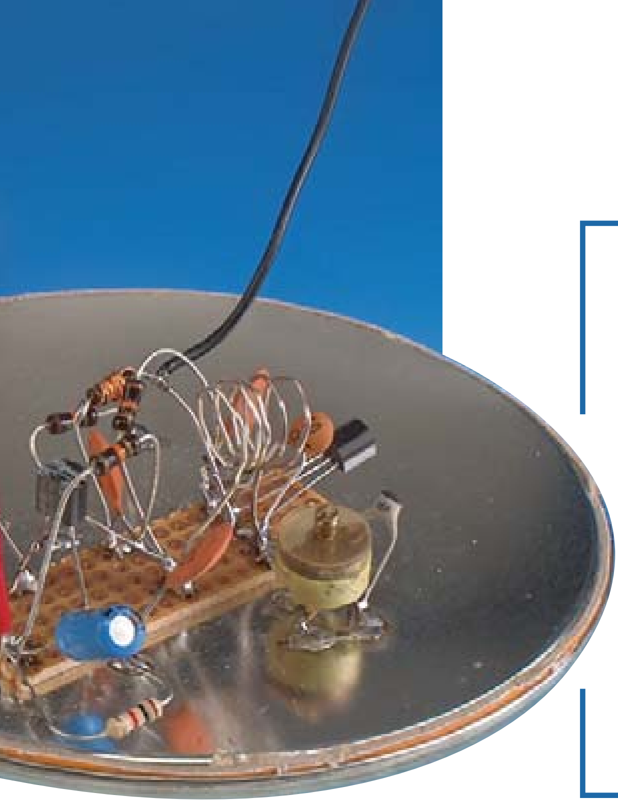


Figure 1. A handful of components go to make our FM receiver.

Reception in practice

When the receiver is switched on the output will consist of noise. The frequency can now be adjusted using a screwdriver: when an FM station is encountered the noise will reduce in volume or disappear altogether. The tuning must be adjusted so that it is just on the edge of the band occupied by the transmitted signal: this requires a little patience, luck, and skill with the screwdriver. Once you have found your favourite station, of course, there is no need to adjust the circuit again.

The sound quality from this simple receiver is admittedly somewhat mediocre, although it is remarkable that it works at all given that only two transistors are used. In the early days of radio the superregenerative audion receiver design was very widely used (although of course the circuit was built using valves). The design subsequently fell from favour as it became apparent that, since it also acted as a transmitter, it could interfere with a neighbour's radio reception: this applies also to our design. It is doubtful whether such a radio could obtain its 'CE' certification mark today, and the radio is thus more of an interesting experiment than a potential challenge



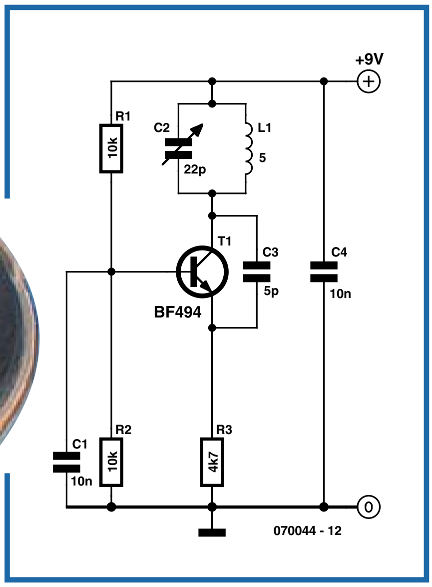


Figure 2. Circuit of an RF oscillator.

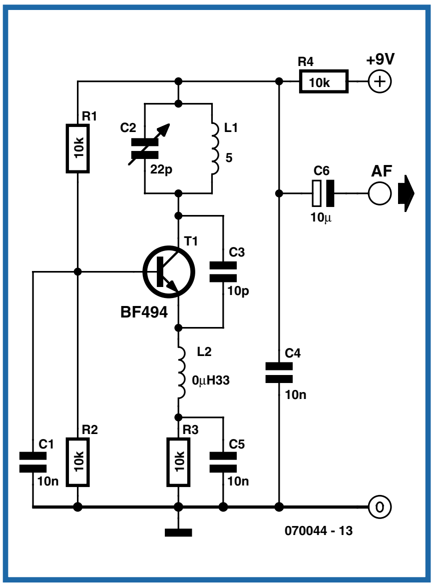


Figure 3. The capacitor in parallel with the emitter resistor makes the RF oscillator flip between 'oscillating' and 'not oscillating' states.

to the tried-and-tested superhet design. The superregenerative audion design still features in simple radio remote control receivers, remotely-controlled power sockets and remote temperature monitors.

A little theory

How does the receiver work? At first sight the circuit appears to be a simple oscillator. **Figure 2** shows for comparison a well-known RF oscillator design.
The simple oscillator keeps the amplitude of its output constant. We now modify the circuit so that the amplitude of the oscillations is much greater, and so that the transistor can be switched fully off. The value of the feedback capacitor has to be increased. It is important to use a transistor designed for radio frequency use (such as the BF494) as it is difficult to get the circuit to work using an ordinary audio frequency device such as the BC548B.
The circuit shown in **Figure 3** also includes a coil in the emitter connection. Finally, the capacitor in parallel with the emitter resistor also plays an important part in the circuit: as soon as oscillations start, it starts to charge. When the potential difference between the base and the emitter of the transistor falls far enough, the transistor turns off and oscillations can no longer be sustained. The emitter capacitor

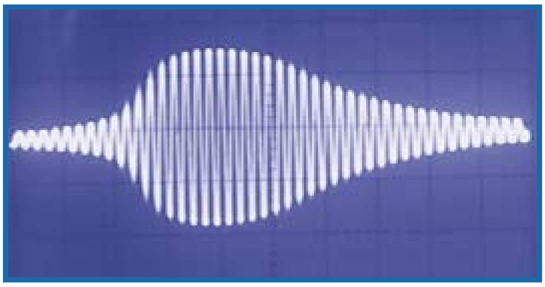


Figure 4. The RF oscillation builds up practically from zero.

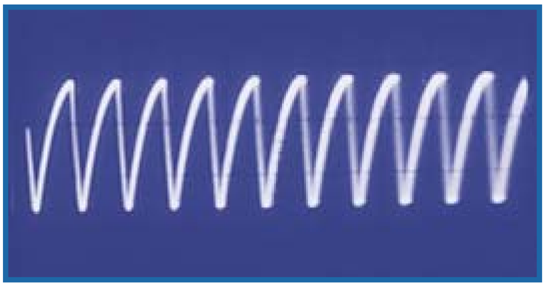


Figure 5. The quenching gives rise to a very noisy sawtooth signal at the output.

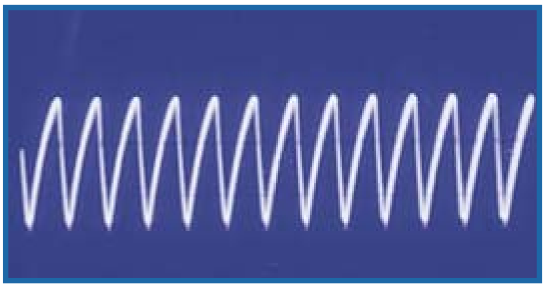


Figure 6. If a signal is received, the circuit flips between its two states more quickly and more regularly.

discharges again, a collector current once again starts to flow, and the circuit starts to oscillate again. The circuit thus flips between two states: oscillating and not oscillating. At the output we obtain a sawtooth signal with a frequency of about 50 kHz.
Each time the oscillator swings into action the amplitude of its oscillation builds up practically from zero (**Figure 4**). Thermal noise in the circuit helps to start the oscillations going, which means that the start-up time can vary considerably. This variation (**Figure 5**) leads to noise in the collector current, which in turn is heard when no station is being received.

To and fro

If, however, a signal is received at the tuned frequency, this will help the amplitude of the oscillations build up more quickly each time (**Figure 6**) and the rate at which the oscillator starts up and stops (the 'quench frequency') increases. An unmodulated RF signal gives rise to a stable quench frequency and little noise at the output. If the signal is amplitude modulated, this will affect the degree to which the it helps oscillations start up, which in turn will be reflected in the average collector current. To demodulate an FM signal we adjust the tuning so that the centre frequency of the signal is on the edge of the range that will stimulate the oscillator: this makes the FM signal have the same effect as an AM signal.

The whole process can be seen clearly on an oscilloscope. The sawtooth signal on the emitter resistor will indicate whether a station is being received. The receiver is so sensitive that it does not actually need an antenna: the oscillator coil can pick up enough energy directly.

The circuit in Figure 3 has a further weakness in that its output consists of a high-amplitude sawtooth signal plus the desired signal at low amplitude. The cunning technique we use to avoid this is illustrated in **Figure 7**. The emitter capacitor is now wired not to ground, but to the output. As the collector current rises the collector voltage will fall and the emitter voltage will rise, and the emitter capacitor will now act to counteract this effect on the output. The amplitude of the sawtooth signal is reduced practically to zero, leaving just the desired demodulated audio output. This can be taken to an audio amplifier.

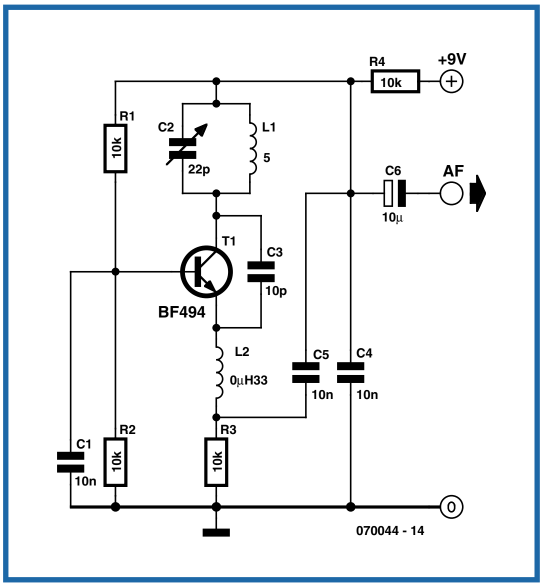


Figure 7. If we take the emitter capacitor to the output the sawtooth signal is almost completely suppressed. Just the desired signal remains.

The basic circuit is now essentially as shown in Figure 1. We have added the audio amplifier stage, and the base bias circuit for the oscillator transistor is slightly simplified. Connecting one side of the tuning capacitor to ground does not affect the circuit as far as radio frequencies are concerned, and for simplicity we wind the RF coil on a resistor.

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