Building Simple Receivers

After reading the last chapter, no doubt many readers will want to try their hand at building simple radio receivers based on the concepts which they have met. The circuits presented here have been designed for just this purpose.

Three basic simple receiver circuits, with variations, were described in Chapter 11. They were active detector, active detector with regeneration, and the latter with an audio amplifier stage.

In this chapter we shall describe simple receivers based on each of the circuits and discuss the level of performance to be expected from each. Figure 1 shows the first circuit, an active detector using an N-channel FET. This circuit is the same as figure 3 in the last chapter but component values have been added.

The active detection function is performed by an N-channel FET, the 2N5469 (formerly called the MPF105) from Motorola. The coil assembly is a time-honored "valve" type Reinartz coil, still made by Aegis Pty Ltd and designated type M.12. The tuning capacitor can be any tuning gang with a maximum capacitance of about 400pF.

Our photograph shows a nine-volt battery but the circuit will give better performance with a 12 volt battery. Note however, that voltages over 12V should not be used otherwise the FET may be damaged. An old 12V car battery may be used to power the circuit, if one is on hand. One can really raid the junk box for a project like this.

There is no need for a metal chassis. Ours was made from a piece of particle-board and tempered hardboard (Masonite or Burnieboard) for the front panel. Wiring layout is not critical but novice readers should follow our wiring diagram of figure 2 to avoid mistakes. Cross check it with the circuit diagram, figure 1. At any rate, keep all wires as short as possible, consistent with neatness.

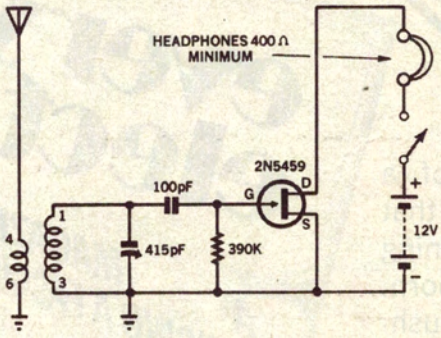


Figure 1: One FET and a handful of components make up the simple active detector circuit.

The Reinartz coil was mounted on the board with the aid of an electrolytic capacitor mounting clamp, but there is no reason why it must be mounted in this attitude. It may be mounted on its side, if convenience dictates. Just don't let it float around. When making connections to the coil, take care not to overheat the coil terminals otherwise the plastic former will be melted.

If you use a tuning gang salvaged from an old radio set, make sure it is clean and that the moveable plates are not shorting to the fixed section. This can be easily checked with the aid of a multimeter switched to the "ohms" range.

If you are going to make a dial for the set remember that stations at the low frequency end of the broadcast band are received when the tuning gang capacitance is relatively high, i.e., when the plates are meshed together.

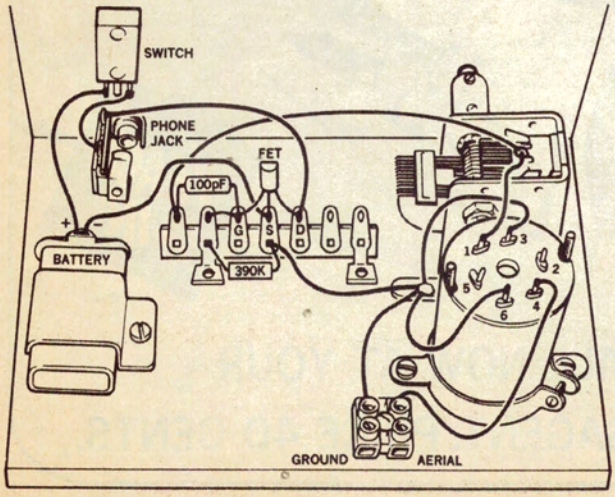
The FET and its gate components, 390K resistor and 100pF capacitor, can be mounted on a tagstrip as shown in the diagram. If you wish, it is not necessary to install an on / off switch for this circuit — disconnecting the phones from the jack socket effectively disconnects the battery.

Again, take care not to overheat components when soldering. This applies particularly to transistors and polystyrene capacitors. It is wise to tin the leads and to use a crocodile clip or a pair of long-nosed pliers as a "heatsink", if you are a novice at soldering. The idea is to use the clip or pliers to grip the component lead between the solder joint and the body, so that most of the heat is conducted away from the lead before it has a chance to heat up the component itself and cause possible damage.

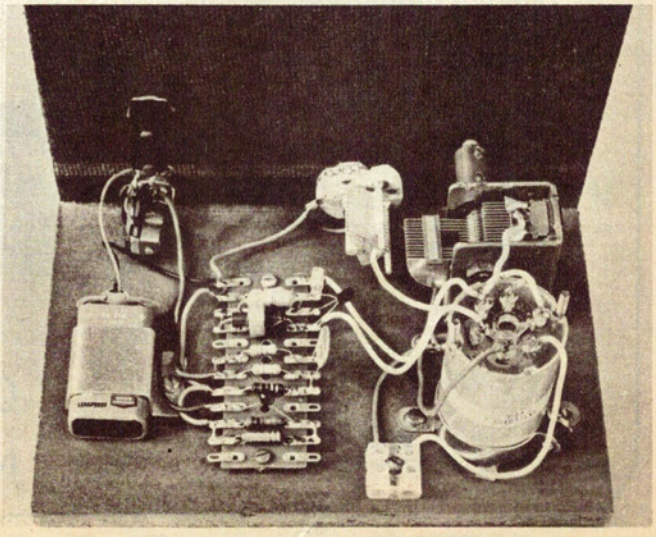
The headphones should be "medium" to "high impedance" — i.e., they should have a nominal impedance of at least 400 ohms and preferably higher.

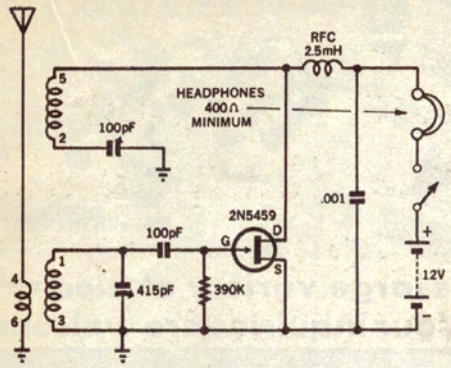
An insulated terminal block is mounted on the board for connection of earth and aerial wires. Strictly speaking, the earth con-

Figure 2: Below is the wiring layout for the active detector circuit of figure 1. Follow the diagram carefully to ensure correct connections.



Below is shown the prototype receiver complete with regeneration and a voltage amplifier stage. The wiring diagram for the complete receiver is shown in figure 6.





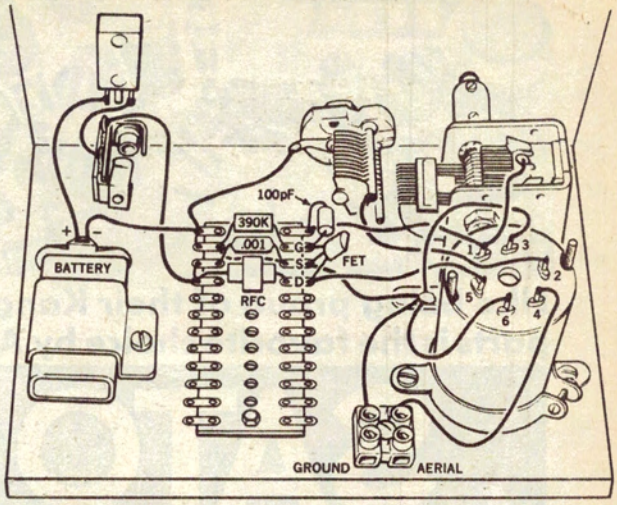


Figure 3, above, is the circuit for the active detector with regeneration while at right, figure 4, is the wiring diagram. Note the extra components compared with figure 2. For those wishing to wind their own Reinartz coil, winding details are given on the following page.

nection should be made to a water pipe or a metal plate buried in the ground.

For best performance, the aerial wire should be as long and as high above ground level as possible. But many readers in the metropolitan areas may obtain adequate performance with just a few feet of wire.

Having checked all connections for errors, you are ready to apply power (connect the battery) and put on your headphones. As readers will remember from Chapter 11, the FET operates without bias when no signal is applied to the gate. This means that the current drain is relatively high at around 10 milliamps, depending on the impedance of the headphones.

When signal is applied to the FET gate, the FET develops a negative gate bias which is proportional to the peak value of the RF input signal. The mechanism by which this happens is fully discussed in Chapter 11. The effect of the negative gate bias is to reduce the current drain, although with this circuit unless the stations tuned are particularly strong, any reduction is likely to be minimal.

With this basic receiver you should be able to tune several radio stations, but this will depend very much on the area in which you live — whether or not it is a strong signal area, and on the parameters of the particular FET used.

Having determined the level of performance available from the simple active detector circuit, you are now ready to add components for regeneration. The circuit is shown in figure 3. The additional components are a 100pF variable capacitor for controlling the level of regeneration, a 2.5mH RF choke and a .001uF capacitor. This is the same as figure 4 of Chapter 11.

Again, we have provided a wiring diagram to facilitate connections — see figure 4. Pins 2 and 5 of the Reinartz coil are now connected into circuit. The FET and its associated components are mounted on a short length of tagboard. Leave sufficient terminals available to add the audio stage to be described in the next step.

The reaction or regeneration capacitor we used is a small variable air dielectric type as used in transmitters but there is no reason why other types could not be used. One could, for example, use a smaller capacitance tuning gang or even a mica "compression" trimmer for the basis of the experiment.

Having connected the regeneration components, apply power to the circuit again and don your headphones. With the regeneration capacitor set for minimum capacitance, i.e., with capacitor plates unmeshed, the circuit behaves very similarly to the active circuit tried previously.

Increasing the capacitance of the regeneration capacitor increases the loudness of the signal but also causes the signal to become distorted. This is because the loading effect of the regeneration coil and capacitor causes detuning of the main resonant circuit. Consequently the tuning and regeneration controls interact and have to be adjusted in conjunction with each other.

As the regeneration control is advanced, the FET drain current is reduced markedly. This is because the regeneration acts to feed much stronger signals to the gate of the FET and consequently develop more negative gate bias.

If the regeneration control is wound up too high, the circuit will go into oscillation. This will be evident in a number of ways. First, if the circuit goes into oscillation while it is being tuned to a station, the oscillation will be evident as a violent squeal. This is the heterodyne or difference frequency between the broadcast station's carrier frequency and the resonant frequency of the tuned circuit.

The reader may query this statement: If the circuit is tuned to the broadcast station, why should there be a difference between the incoming carrier frequency and the resonant frequency of the tuned circuit? This can be answered in a number of ways. First, the tuning gang does not have to be tuned exactly to the station's carrier frequency in order to hear signals — it can be considerably away from it, if the signal is strong enough.

Another partial answer is the detuning effect of the regeneration control. You can easily show this, once the circuit has begun squealing, although you'll need to take the headphones off. Try varying the regeneration control — notice its effect on the pitch of the heterodyne whistle.

If the circuit goes into oscillation between stations it will be noticeable as a single click from the headphones. The click is caused by the abrupt drop in FET drain current as the circuit goes into oscillation. This can be checked with a multimeter switched to a low current range. It can also be verified with the aid of a transistor radio, or any other radio for that matter.

You will be able to tune the radio to the resonant frequency of the circuit as it is radiated from the aerial. As you do so you will hear the familiar heterodyne whistle between the radiated frequency and the frequency of the local oscillator of the radio. Instead of being a sensitive regenerative receiver, the circuit is now a low power transmitter with an unmodulated carrier!

But this is hardly the purpose of building

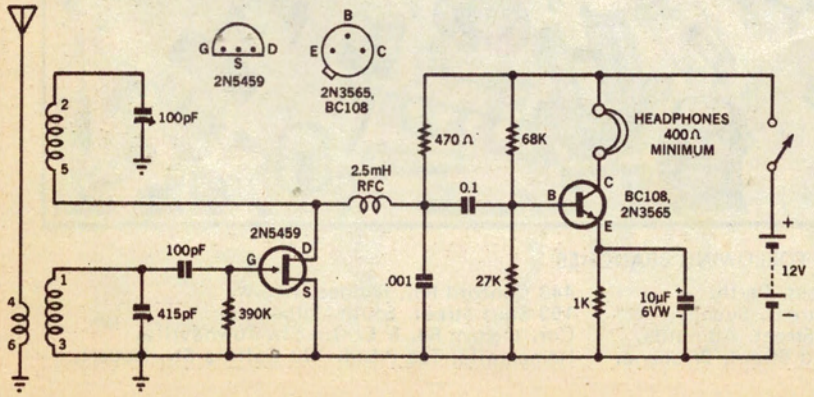


Figure 5, at left, is the final circuit, with an AF voltage amplifier stage to drive the headphones.

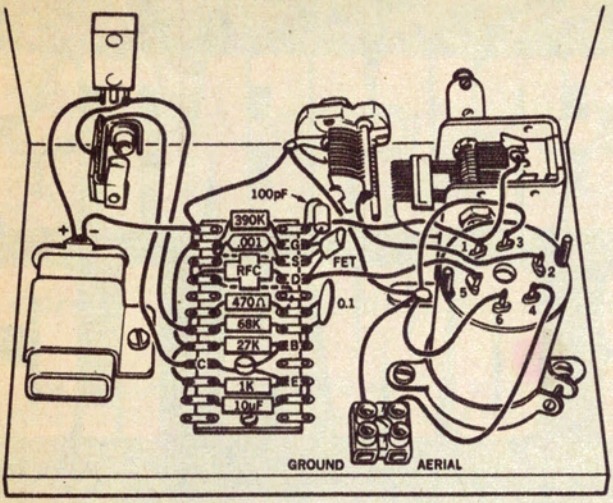


Figure 6, left, is the complete wiring diagram for the circuit in figure 5.

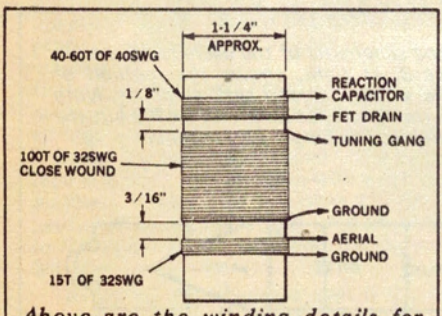
the receiver. We mention it as part of the discussion of its behaviour and to point out that an incorrectly used regenerative receiver can be a source of interference to radio communications.

The essential purpose of building these circuits is for the reader to discover the high degree of performance that can be obtained, with patience, from what is basically a very simple receiver.

The performance of the receiver of figure 3 can be further increased by the addition of an audio stage to drive the headphones. The additional gain renders the receiver somewhat easier to use — the regeneration control does not have to be advanced so far to make stations listenable and consequently there is less likelihood of the FET detector breaking into oscillation.

Figure 5 shows the additional components for the audio stage. This is the unit shown in the photographs. In this circuit, the 470 ohm resistor becomes the audio frequency load for the FET and the signals developed across it are fed to the audio stage via a 0.1uF capacitor. No volume control is fitted to the circuit. One can use the regeneration control for this purpose, although admittedly, it is not ideal. We have omitted a volume control because it introduces a loss in gain.

The circuit is built along the same lines as the other two, with most of the smaller components mounted on a 12-lug length of miniature tagboard (see figure 6). This should be completely wired as an assembly and then mounted on the board. As before, components salvaged from old radios may be used here but they should be checked before installation.



Above are the winding details for those who wish to make their own Reinartz coil. Use a cardboard or plastic former.

Resistors can be checked with a multimeter switched to the ohms range for correctness of value, and capacitors can be similarly checked for insulation resistance. It would be wise, though, to use a new electrolytic capacitor for the bypassing of the emitter resistor of the audio stage, because electrolytic capacitors deteriorate quite markedly with age.

The additional transistor is a general purpose silicon NPN bipolar type. Do not substitute other transistors unless you are sure they are directly equivalent.

The prototype receiver was tried out in the Western suburbs of Sydney, which is a strong signal area. With just a few feet of aerial, all the local broadcast stations romped in, plus a few country stations and Radio VL2UV, the University of NSW broadcast station on 1750KHz. With a longer aerial, it should do equally well in rural areas.

PARTS LIST FOR REGENERATIVE RECEIVER

1 Chassis and panel to suit components.
1 12V battery and connections to suit.
1 Reinartz coil, Aegis type M12 or similar.
1 Tuning capacitor, 415pF (see text).
1 100pF variable capacitor for regeneration (see text).
1 2N5459 field effect transistor (FET).
1 BC108, 2N3565 or similar silicon transistor.
1 phone jack.
1 pair of headphones; minimum impedance 400 ohms.
1 on/off switch.
1 12-lug length of miniature tagboard.
1 2-way insulated terminal block.

RESISTORS
(½ or ¼ watt rating).
1 x 390K, 1 x 68K, 1 x 27K, 1 x 1K, 1 x 470 ohms.

CAPACITORS
1 x 10uF/6VW electrolytic,
1 x 0.1uF/25VW ceramic, polyester or paper,
1 x .001uF/100VW ceramic, polyester or polystyrene,
1 x 100pF/100VW ceramic or polystyrene.

MISCELLANEOUS
2 Knobs, screws, nuts, wire, solder, battery clamp.