Explore the VHF spectrum with this

Simple VHF Receiver

Here's a novel little project designed especially for the experimenter. You can build it up very easily and use it to explore the VHF radio spectrum. It can be modified in a number of ways, if you wish, to extend its performance — you can even listen in to the FM broadcasts, using the "slope detection" technique.

by IAN POGSON

Simple regenerative receivers have always had a fascination, especially for beginners but also for more experienced hobbyists. The most common types in the past have been made to tune the medium wave or broadcast band, although some have also been made to tune the lower end of the high frequency range. Generally the upper limit seems to have been drawn at about 30MHz; rarely does one see a simple regenerative receiver made to tune any of the VHF band.

Recently my attention was drawn to a neat design for a VHF regenerative receiver tuning the VHF FM band (88MHz to 108MHz) and described in "Radio and Electronics Constructor" for May, 1978. It looked quite promising and suggested the idea of producing a similar unit adapted for Australian conditions. The idea seemed straightforward enough, although on further analysis component availability posed some problems.

There were three items in particular which posed problems. They were (1) a direct replacement FET for the regenerative detector; (2) a variable capacitor for tuning; and (3) a specified name-brand inductor with no value given. All of these obstacles were overcome, as the circuit diagram bears witness.

A rough prototype was made up using a locally available junction FET. The inductor was provided for by using a low value RF choke, one of a series readily available. The inductor turned out to be non critical and no further problem was encountered here.

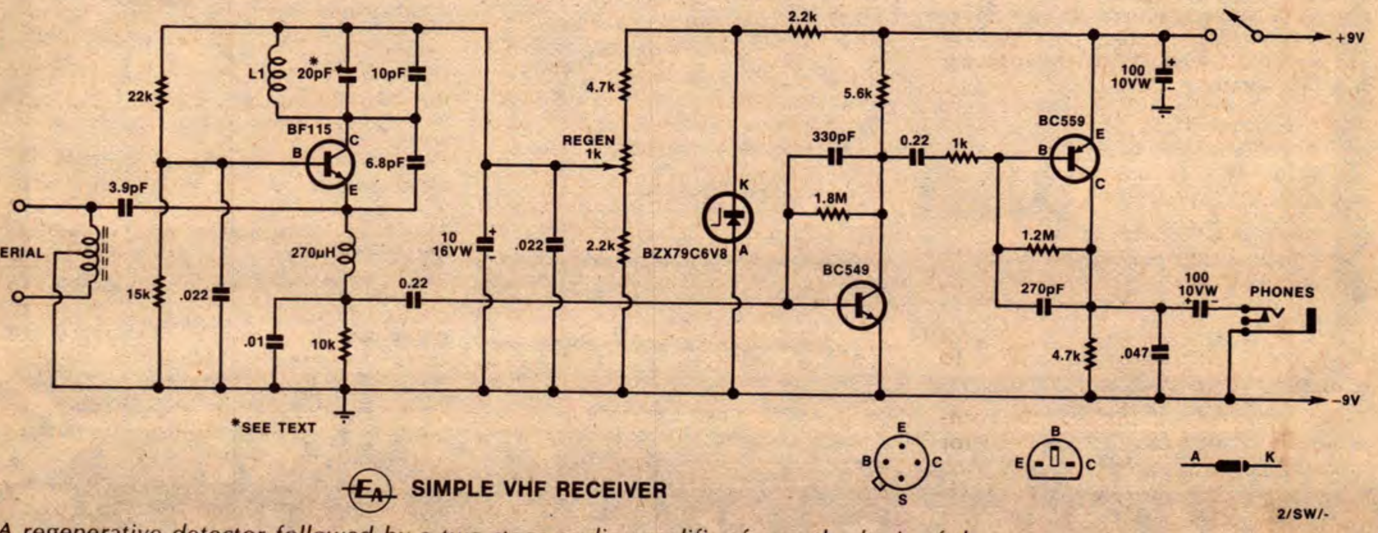
For the tuning capacitor I first used a BA102 varicap diode, controlled by a potentiometer from a zener regulated power supply. The varicap did work, but it was difficult to make it cover the full band. Also, the "Q" of the tuned circuit seemed to be low and it was difficult to maintain satisfactory regeneration right across the band.

At this stage, it seemed wise to try to locate a suitable miniature variable capacitor. After some searching, one which is little larger than a trimmer was located at Davred Electronics Pty Ltd, 104-106 King Street, Newtown, NSW 2042, where readers may obtain similar ones for building this receiver (type C1604). After fitting this capacitor, it was found that it would easily cover the wanted band, as well as making regeneration of the stage more satisfactory. However, I was still anything but satisfied with the overall performance, particularly with regard to sensitivity.

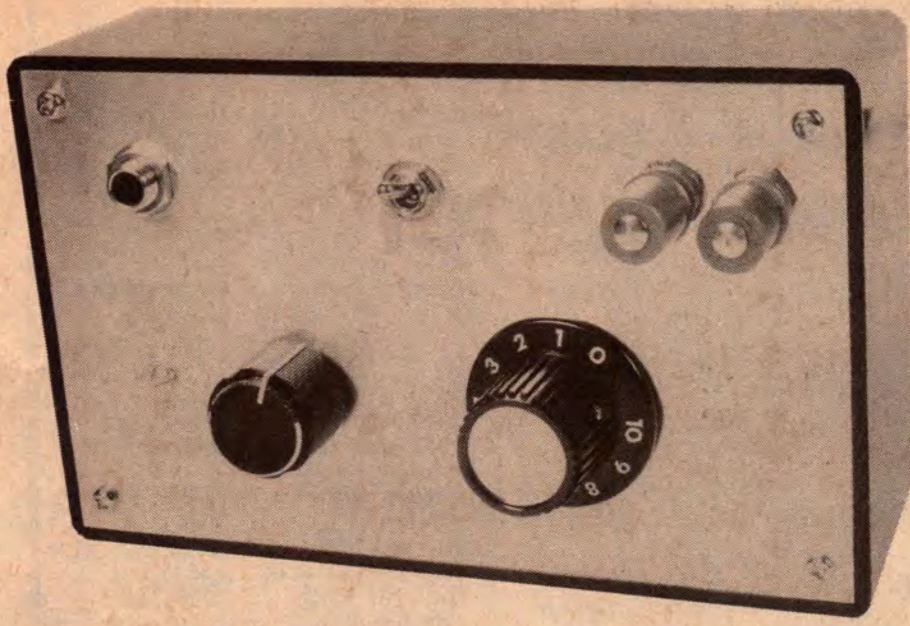
I must hasten to mention at this point that a simple receiver of this type cannot be expected to bring the world to your doorstep. It is purely a "fun" type of device but I felt that in spite of all this, it could be improved. But how?

The thought that a good bipolar transistor can give quite high gain, particularly when compared with the usual junction FET, prompted me to try a substitution. Obviously biasing would have to be changed, but this could be done without introducing any real problems. This done, we were rewarded with a receiver which had rather more "get up and go" than previously. The operating conditions were optimised and this is how we arrived at the circuit for the detector.

At this stage, let's have a look over the whole circuit and see what makes it go. In order to provide for a balanced aerial feeder system, a "balun" transformer is used to feed the signal into the emitter of the detector, via a 3.9pF blocking capacitor. Incidentally,



A regenerative detector followed by a two-stage audio amplifier forms the basis of the new receiver.



Front panel facilities are (clockwise from top left): headphone socket, on/off switch, aerial terminals, tuning control, and regeneration control.

the capacitor is made very small to avoid loading the detector unduly, which would stop its proper operation. The 270uH RF choke is used to prevent the RF signal from being short circuited to earth via the .01uF capacitor, which bypasses the 10k emitter resistor.

The 10k emitter resistor just referred to is somewhat higher in value than would normally be expected. However, although the value is not critical, this order of resistance seems to give close to optimum performance. It is also worth noting that it is across this resistor where the audio is taken from the detector. The .01uF capacitor is of such a value that it bypasses residual RF components but not the audio frequencies.

The base bias is set by the 22k and 15k resistors and the base is grounded to RF by the .022uF capacitor. Feedback is obtained with the 6.8pF capacitor between collector and emitter. The collector circuit is tuned with the inductor L1 and the variable capacitor of 20pF. The tuning range is limited with the 10pF fixed capacitor shunted across the variable capacitor.

Regeneration is controlled by the 1k potentiometer, by varying the supply rail voltage to the detector transistor. The voltage supply for regeneration is regulated by the 6.8V zener diode. This helps to avoid having to change the setting of the regeneration control with changes in battery voltage due to aging.

As mentioned earlier, the audio component is taken from the 10k detector emitter resistor. From here it is fed via a 0.22uF capacitor to the first audio amplifier, BC549. From this stage, the signal is also fed via another 0.22uF capacitor to the second audio amplifier, BC559.

High frequency response is limited in the audio amplifiers by the 330pF and 270pF capacitors shunting the 1.8M and 1.2M resistors respectively. The high frequency response is limited further by the low pass filter consisting of the 1k resistor and the capacitance in the base of the second audio amplifier, together with the .047uF capacitor across the 4.7k collector resistor. All this is done to avoid any trouble with RF getting into the audio stages.

The audio output from the receiver is sufficient to drive a pair of headphones or an earpiece. We have tried a crystal earpiece as well as high and low impedance headphones. While high impedance headphones are to be preferred and I suggest that you use them if you have a pair, even 8 ohm headphones can be used quite satisfactorily. A crystal earpiece is not very comfortable to use in my opinion, but it will do the job quite well and it may be connected directly across the 4.7k collector resistor by omitting the 100uF electrolytic if you wish (although leaving it in won't do any harm).

Another idea would be to use a set of low-impedance (8 ohm) phones with an old speaker transformer for matching. Connect the phones to the "voice coil" side, and the high impedance side to the receiver output.

The current drain of the whole receiver is only about 2 or 3mA and so the relatively small 9V battery should give many hours of listening time.

Construction of this little receiver is simple and straightforward but as it is for use at very high frequencies, a certain amount of care must be taken to ensure satisfactory operation.

PARTS LIST

1 Zippy box, 150mm x 90mm x 50mm
2 Aerial terminals
1 SPDT miniature toggle switch
1 6.5mm stereo panel socket
1 Variable capacitor 20pF (see text)
1 Potentiometer 1k linear
2 Knobs to suit
1 9V battery No 2362
2 Brass spacers 25mm long tapped ⅛in Whitworth
1 Balun core Neosid type 1050/1/F14
1 Miniature resistor panel, 18 tags long
1 270uH RF choke
1 Zener diode BZX79C6V8 or similar 6.8V type
1 Transistor BF115 or similar
1 Transistor BC549 or similar
1 Transistor BC559 or similar

RESISTORS (½ watt)

1 1k	*1 15k*
2 2.2k	*1 22k*
2 4.7k	*1 1.2M*
1 5.6k	*1 1.8M*
1 10k	

CAPACITORS
1 3.9pF NPO ceramic
1 6.8pF NPO ceramic
1 10pF NPO ceramic
1 270pF polystyrene
1 330pF polystyrene
1 .01uF 50V greencap
2 .022uF 25V ceramic
1 .047uF 63V ceramic
2 0.22uF 100V greencap
1 10uF 16VW electrolytic
2 100uF 10VW electrolytic

MISCELLANEOUS
Hookup wire, solder lugs, solder, battery clips, insulating washers, 20 gauge tinned copper wire, 24B&S enamel wire for balun.

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used in the prototype. Components with higher ratings may generally be used provided they are physically compatible. Components with lower ratings may also be used in some cases, provided the ratings are not exceeded.

Before proceeding, it should be pointed out that not all locations have an FM broadcasting service and this should be considered before readers embark on the construction of this little receiver. However, it is possible to make some simple alterations to make the receiver cover other ranges. These could include the 144MHz to 148MHz amateur band, the 118MHz to 136MHz aeronautical band, the 75MHz to 85MHz fixed and mobile band, and possibly some others.

It should also be noted that where there is not an FM broadcasting or TV service on a particular channel in a

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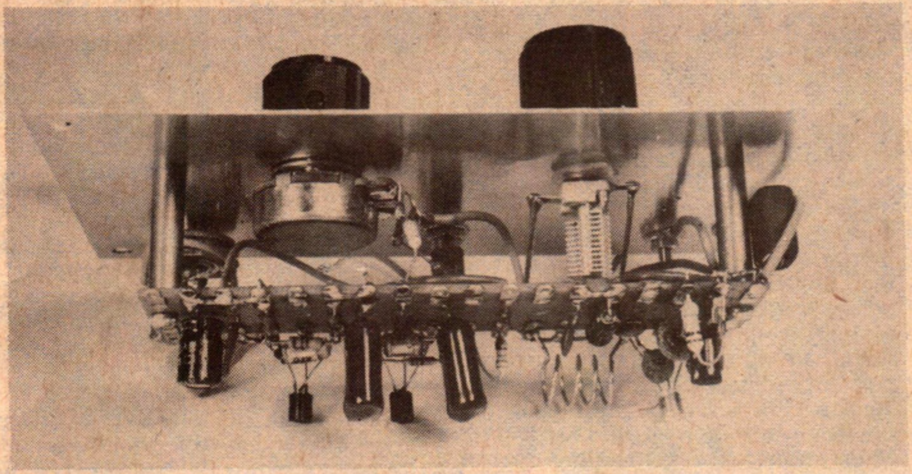


Inside the prototype. Leads to the tuning capacitor should be kept short and neat.

location, there may be other communication systems used by local authorities. At least one way to find out just what is available in any particular location is to listen! More will be said about changes to the tuning range of our receiver later on.

As this receiver is essentially an experimental or instructional type of thing, we have not made up a special printed circuit board for it. Rather we have made use of the technique of fixing the majority of the components on a piece of miniature tag board with 18 pairs of tags. We have prepared a detailed drawing of this assembly and by following it carefully no problems should be experienced.

Before proceeding with the board assembly, the tuning coil L1 and the balun transformer should be wound. The tuning coil consists of four turns of 20 gauge tinned copper wire wound on a 5/16in diameter piece of rod or a drill. The turns are spaced to make the coil 12mm long. Bend the ends at right angles to the axis and cut them to a length of about 6mm. The balun transformer is wound on the ferrite former. 24B&S enamel wire is used and two windings, each having two turns, are wound around the centre core. The finish of the first winding and the start of the second are cleaned of enamel, twisted together and soldered.

When assembling the components on the board, care should be taken to make good soldered joints and components should not be overheated. Regard must be given to the polarity of components such as electrolytics, transistors and diodes. It is also a good idea to follow a logical order of assembly. In general, the resistors could be fixed first, followed by the capacitors and other items.

It is very important that all capacitors associated with the detector stage should be neatly mounted on the board with a minimum of lead length. This also applies to the 270uH RF choke and the tuning coil. Also, it should be noted that we have used a solder lug at each end of the board, from each end mounting hole, to the adjacent earthy terminal. This effectively connects the earthy line of the board to the front metal panel, via the brass mounting spacers.

At this stage, the wiring board assembly may be put aside for the time being. The metal panel of the jiffy box should now be drilled to take the components which are to be mounted on it. These are the tuning capacitor, regeneration potentiometer, headphones jack, battery switch and two aerial terminals. Oh yes, do not forget the two holes for the two brass spacers.

This is all straightforward enough, except for the hole for the tuning capacitor. It must be remembered that both sides of this capacitor are at the positive supply potential, so the mounting bush must be insulated from the metal panel accordingly.

We used part of a plastic mains cable clamp to make up two insulating washers. The two flat pieces were cut off with a pair of cutters and the holes were enlarged to clear the bush on the capacitor. Drilling the plastic will result in a burr surrounding the hole and this should be left on. The front panel hole should be made large enough to clear the burr. This helps to insulate the bush inside the hole and the main body of each washer serves to insulate the shoulders of the bush.

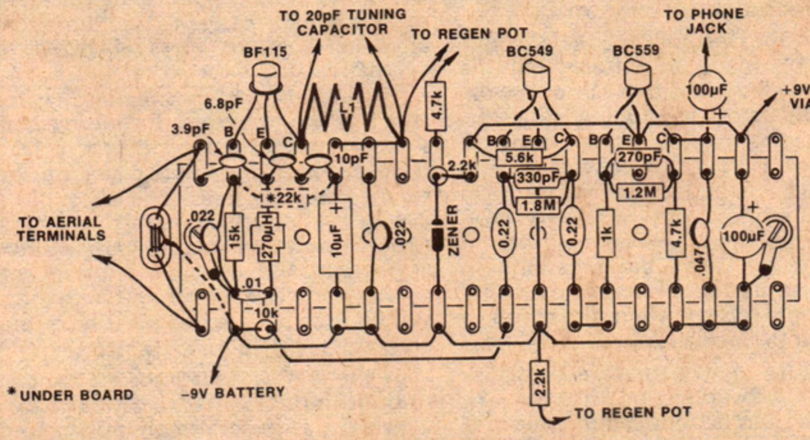
The components are now mounted on the panel. It should be noted that both of the aerial terminals must be insulated from the panel with the washers supplied. Also, the aerial terminals should be provided with solder lugs.

The main board assembly may now be fixed to the panel. Make sure that it is the right way around, so that the leads to the tuning capacitor and other items will be short.

The two leads from the tuning capacitor to the coil should be of 18 or 20 gauge tinned copper wire and they should be straight and direct, for minimum length. The 4.7k and 2.2k resistors should be strung between the appropriate terminals on the potentiometer and the board. Similarly, the 100uF electrolytic capacitor is strung between the jack and the board. If you are using a stereo jack and headphone combination, the two corresponding terminals of the jack should be tied together.

The balun transformer is mounted between the three lugs on the board, using its own leads which have been cut to avoid any excess length. All other leads to complete the wiring consist of normal hookup wire.

The receiver is virtually finished now but before going further, the whole unit should be carefully checked to make sure that there have been no errors in construction. Satisfied that all is well, you will need a good antenna system to use with the receiver. If you have an FM antenna available, then this



Follow this diagram when wiring up your receiver.

would be ideal. If the feedline is of 300 ohm ribbon, just connect a conductor to each terminal. If the feedline is coaxial cable, connect the inner conductor to one terminal and the outer braid should be connected to the earth line. An extra terminal could be used for this.

If you do not have an antenna available, then it is quite an easy matter to make one. The suggested antenna consists of a piece of 300 ohm TV ribbon, with both ends shorted and one connector cut in the centre to connect in another length of ribbon, which acts as a feeder. The length of the antenna proper is calculated by dividing the desired frequency in MHz into 14070. This gives the length of the dipole in centimetres.

As we are interested at present in the FM broadcast band, 88MHz to 108MHz, then the antenna may conveniently be cut for 98MHz, which is the centre of the band. Using the above formula, we find that if we divide 98 into 14070, we get very close to 144cm. The antenna should be made to this dimension, with a feedline no longer than necessary to do the job. The antenna may be fixed for example, by taping it to a piece of wooden dowel to act as a stiffener. It should then be mounted as high and as in the clear as possible and it should be broadside on to the wanted station(s). Remember that the better the antenna, the better your reception is likely to be.

With the receiver and antenna now ready, we are in a position to try them out. However, on switching on for the first time, it is a good idea to make sure that all is well before continuing. A multimeter check of the supply voltage under load and a similar voltage check across the zener diode are a worthwhile precaution. One should be close to 9V, the other around 6.8V. Also, having made voltage checks, it is a good idea to set the multimeter to a current range and connect it in series with the supply to check the actual current drain. As mentioned earlier, ours was around the 3mA mark.

Before looking for stations, a check should be made to ensure that the receiver will go into and out of oscillation right across the tuning range, by varying the regeneration control. Oscillation is indicated by what may be described as a loud fast ticking sound in the headphones. With the regeneration control correctly wired, oscillation should occur when the regeneration knob is turned clockwise and oscillation should cease when the knob is turned anti-clockwise.

If you are unable to achieve oscillation right across the band, then the 4.7k resistor should be reduced in value and the 2.2k resistor could possibly be increased in value. A certain amount of experimentation is possible here. If on the other hand, it is not possible to stop oscillation at some part of the band, then the opposite will apply.

Because of the simplicity of this receiver, quite a deal of skill is required on the part of the operator — you must develop a "feel" for the receiver to get the best out of it. What this means is that the receiver must be kept just below the point of oscillation when tuning for signals. This is rather easier said than done, mainly because the point of oscillation changes as the tuning capacitor is varied. This means that the receiver tends to go into oscillation, whereupon the regeneration control must be slightly reduced, or the receiver requires more regeneration, at which point the sensitivity is seriously reduced.

I hope that I have not discouraged prospective builders. Indeed, this is not the intention. What I am trying to say is that you must give the receiver a fair trial by playing your vital part as the operator. In short, it is not like tuning your broadcast transistor portable receiver. Suffice to say that a few minutes of careful twiddling of the controls will give you the general idea.

Provided you have made the receiver according to instructions, particularly with regard to the coil and tuning circuit components, then you should have no trouble with band coverage. However, due to some unavoidable spreads, you may find that either one end or the other of the band may be missing. If you cannot tune to the lowest end of the band, then squeeze up the coil a little. On the other hand, the coil turns should be spread out somewhat to make the receiver tune higher in frequency. Actually, our prototype tuned from 75MHz to 111MHz.

Earlier I mentioned the possibility of modifying the tuning circuit so that the receiver could be made to cover other frequency bands. A very easy change is to alter the coverage so that it tunes the amateur 2 metre band, 144MHz to 148MHz.

To do this, lift the 10pF capacitor which is wired across the tuning coil. Remove the tinned copper wire lead from between the fixed plates on the tuning capacitor to the coil and replace it with a 4.7pF NPO ceramic capacitor. Makes sure that leads are kept as short as possible. Squeeze up the tuning coil so that it is a little less than 10mm long. With these changes our prototype tuned from 144MHz to 151MHz.

By the way, if your interests happen to be with the 75MHz to 85MHz band, which is a general communications allocation, including taxis and many other services, then you will not have to make any changes as the receiver already covers this range together with the FM broadcast band.

Another possible band of interest is that for aeronautical use, from 118MHz to 136MHz. This range may be covered with our little receiver by making a few changes to the circuit. A new coil is required. It consists of three turns, 5/16in diameter and 5mm long, wound in a similar fashion to the four turn coil described earlier. The 10pF capacitor shunted across the coil is changed to 6.8pF. The lead from the collector side of the coil to the variable capacitor is replaced with a 10pF NPO ceramic capacitor. It may be necessary to change the length of the coil slightly to get the proper band coverage.

By the way, don't forget that if you elect to make the receiver cover any range other than that for the FM broadcast band, then you will need to change the length of the aerial accordingly.

Apart from checks and measurements on the receiver in the EA workshop I tried it out at home in one of the northern suburbs of Sydney. The two FM stations ABC-FM and MBS-FM were both received very well. At low level in the background was some other program material, possibly from one or more of the television services. Also, some frame buzz was also heard, no doubt from the same source. It did not interfere unduly with the wanted signals however. This effect will vary according to the ratio of signal strengths between the wanted FM signal and the TV signals, at your particular location.

The usefulness of this receiver on 144MHz to 148MHz would possibly be greatest where one or more repeaters are available. Our own tests on this band were a little disappointing. During a short test one repeater was heard, but although the amount of audio level was sufficient in the headphones, its resolution was not good. This is more than likely due to the fairly narrow deviation used by amateurs, when compared with the deviation used by TV sound and FM broadcasting.

Having brought the receiver back to the workshop I made the changes to cover the aeronautical frequencies. Our workshop is in the City and not very good for reception, but it is fairly close to the Sydney airport. Listening across the band would give the impression that it is not used very much. Transmissions on any one frequency are very short and to the point; you have to be lucky to be tuning across a particular frequency to catch anyone on the air. To one not familiar with this band, it is quite a challenge to log any transmissions. In case you were wondering, I did get a few words here and there!

So there it is. A "fun" receiver which is wide open to experiment, and a challenge to get the most out of a small unit. Quite a good project for a wet weekend!