TAKE 20 COMPONENTS

A further group of simple transistor projects, each using less than 20 low-cost components.

by JULIAN ANDERSON

One of the main aims of this series of projects is to introduce readers to a wide variety of simple circuits. With some exceptions, a few components can be made to do the job of a large number of components though less efficiently; however efficiency and accuracy are not always of prime importance. By designing and writing articles on very simple projects, I am not pretending that highly complicated circuits are a waste of time.

This shows up the "Take 20" philosophy; some designers — most of them in fact — try very hard to make their equipment operate as perfectly as possible. The "Take 20" attitude is to use the absolute minimum of components that will do the job. Of course the fewer components used, the easier the project is to build and the less the likelihood of mistakes.

Signal Generator

I mention this because our first project this month is an RF signal generator, which while very simple, will prove very useful when building other equipment and lining

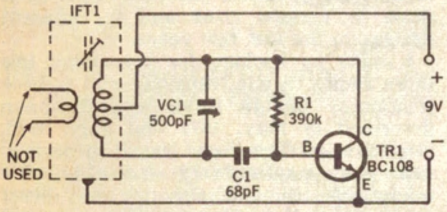

Fig 1. The circuit of the MW signal generator and BFO.

up superhet receivers, as well as acting as a beat frequency oscillator (BFO) for radios using either a 455kHz or 1.6MHz IF. It cannot however be compared to other designs for signal generators or commercial equipment of this type.

Fig. 1 shows the circuit. It consists of a straight-forward Hartley oscillator using a high gain NPN transistor. There is however no need to use the BC108, almost any RF transistor could be used — such as the old faithful OC44 — except of course when PNP transistors are used the battery polarity must be reversed.

Coils are not the easiest things to construct and where possible I try to use readymade ones, in this case an IF transformer of 455kHz. Most of these are fitted with a capacitor of 250pF or below, and by removing this and replacing it with a variable capacitor we will not only be able to tune to the IF but also cover the complete range of the medium wave broadcast band, if not on fundamentals then on harmonics.

The tuned circuit comprising the IF coil and VC1 is in the collector circuit and feedback is by means of C1 which couples back part of the signal to maintain oscillation. The value of C1 can be almost anything between 10pF and 1,000pF, its actual value being unimportant. R1 provides the base bias.

Building the signal generator is a simple matter and should present no problems; the layout of the components is shown in Fig. 2. The prototype was built on a pin-board but

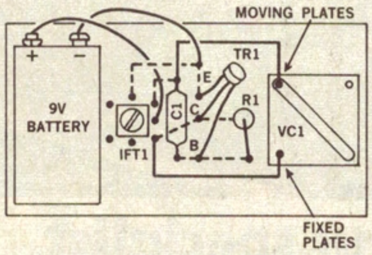

Fig 2. A suggested component layout for the signal generator.

Veroboard or Paxolin could easily be used. For equipment of this type an on / off switch is hardly necessary and removing the battery terminals will serve this function.

After switching on place the unit near a superhet radio tuned to a station and adjust VC1 until a whistle is heard. Unscrew the IF adjusting core and retune until VC1 is nearly in the fully-meshed position (maximum capacitance) when the whistle is heard. Some IF transformers will not be suitable for tuning this low but the actual position in unimportant. Set your radio to 530kHz and mark the position of the setting of VC1 when the signal generator is on that frequency, similarly tune to 1,600kHz and mark the position.

These two points, together with a mark where a whistle is heard on all stations, will be all that is necessary for lining up a superhet on the medium wave band. If the unit is tuned to the IF frequency of a receiver and placed near it a beat note will be heard enabling CW and SSB transmissions to be heard; all in all your signal generator should prove to be a very useful piece of equipment.

Parts for Signal Generator

R1 390k ¼ watt miniature 10%
C1 68pF — see text
VC1 500pF variable
Tr1 BC108 — see text
IF Transformer, 455kHz

Miscellaneous
Paxolin board, 9V battery, battery clips, knob etc.

Lie Detector

Assuming that the reader has a multimeter, this project should cost no more than about 50c since it consists simply of a single transistor, with no associated components "pepping up" the performance of the resistance range on a multimeter.

Lie detectors are not very accurate pieces of equipment but they do work in a vague sort of way using a very simple principle and they provide endless hours of fun. The principle of simple lie detectors is that the skin resistance of a person varies with changes of emotion. These changes can easily be measured and are surprisingly rapid especially when the emotion is fear.

Many readers will know that a reading of skin resistance can be obtained using the high resistance range on a multimeter simply by holding the probes, one in each hand. The actual resistance varies enormously — between about 20k and 300k but under most conditions the resistance is between 100k and 250k. Cheaper multimeters will certainly show a reading for this sort of resistance but it will almost certainly be at the extreme end of the scale and to observe changes of about 5 per cent is very hard.

It is however very easy to increase the sensitivity of the meter just by connecting a transistor's collector and emitter to the meter and taking the probes from the base and collector. The battery inside the meter (1.5V in most cases with additional 9V or 15V ones in the better types) provides the supply voltage and it will quickly be seen from Fig 3 that a very high resistance in the base-collector circuit of the transistor

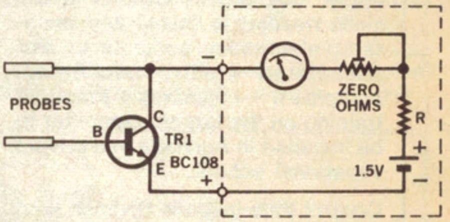

Fig 3. The lie detector circuit. The components within the dotted line are those in the multimeter itself when switched to a resistance range.

brings about a greater current flow through the meter and thus effectively registers a lower resistance.

Note that the positive connection to a meter is actually the negative connection to the battery and so the connections to the transistor are made in what appears to be the wrong way around.

A silicon NPN transistor should be used (so here the meter positive lead goes to the

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emitter) and a 2N2926, BC109 or BC108, or any similar type is ideal. These transistors have very low leakage and very high gain and will bring the meter reading to the centre portion of the scale.

The same circuit is also applicable for measuring very high resistances or checking insulation. Using the circuit shown most meters will give a decent reading for 20M — something quite outside their normal scope. Your scale will of course bear no relationship to the resistance being measured but it is a relatively easy matter to plot points on a graph using known resistances for calibration.

The transistor itself should be mounted on solder tags fixed to a small panel of perspex or polythene. The resistance of wood or similar sorts of material will upset the readings. The hand held probes can be made from brass or copper rod and when used these should be firmly held.

The use of the lie detector can be very amusing and provide hours of fun at parties. There is an admirable solution to the inevitable sceptic who mocks the test — pour your drink over his hands! The surprise itself should be enough to produce the reaction but what he will probably not know is that the liquid will improve the probe contact and increase the reading. (Use water with little salt in for this emergency measure — it looks quite like gin or vodka and after all you don't want to waste your drink do you!)

Two-transistor Radios

From the letters we receive it would seem that there are thousands of readers continually constructing simple radios using one, two or three transistors. I can well understand these people since I belong in their ranks and must have built over 50 of these in various sizes and to different designs in the last few years.

I make no apology for describing two more radios. A one transistor and a three transistor design have already been described in May, 1972 and July, 1972, respectively. The first circuit described here is particularly suitable for miniaturisation and although no direct constructional details are given, several comments are made later regarding component choice etc.

The problem with many published designs is that to achieve the high gains necessary for such sets very accurate biasing etc is required, and since transistors have appreciable spreads in their characteristics the published circuits will only work well with ones used in the prototype. The circuit shown here (in Fig. 4) has been thoroughly tested and over 30 transistors were tried. All worked well and only one resistance has to be chosen with care for the complete circuit to be sensitive and stable.

The supply voltage can vary between 3V and 15V with no circuit modifications though performance is, of course, better using the higher supply voltages. The circuit has very high gain and so the ferrite rod aerial — which is a problem when miniaturisation is the aim — can be very small. The prototype uses a 1½in x ⅜in size cut from a longer length.

VC1, L1 and C1 comprise the tuned circuit and the overwind on L1 auto-transforms the RF picked up and feeds this to the base of Tr1. The collector of Tr1 is connected directly to the base of Tr2 whose emitter

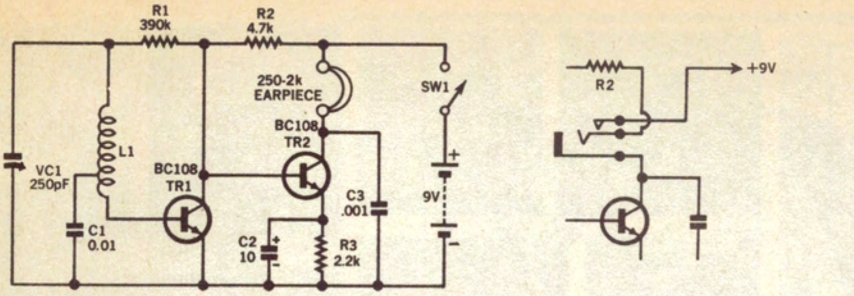

Fig 4. The circuit of the first two-transistor radio. If the jack socket is connected as shown a switch is unnecessary.

voltage is raised to the necessary level by R3 smoothed by C2. Detection takes place in Tr2 and the rectified RF is smoothed by C3 connected between the negative and the collector of Tr2. R2 acts as the collector load of Tr1 and provides the bias for Tr2.

The base bias for Tr1 is provided by R1 which is connected through the aerial coil. This gives a measure of regeneration to the first stage and has the advantage over capacitively coupled feedback in that it is not frequency selective and gives smooth regeneration over the complete MW band. It is this resistor that has to be chosen with care. Stray capacitance will contribute to the regenerative process and so the value will depend not only on the actual transistor used but on the physical layout. The values in the prototypes varied between 56k and 1M.

The earpiece used should be a high impedance magnetic type between 250-ohms and 2k. These earpieces seem to be fairly widely available (they're all made in Japan of course) but if these are difficult to obtain in your area a crystal earpiece connected across a 3.3k resistor will work just as well.

The aerial rod is easily made and about 80 turns on a ⅜in ferrite rod tapped at 8 turns will do. Enamelled copper wire of almost any gauge will suffice.

The cheapest and smallest tuning capacitors are 250pF or 500pF trimmers and these are ideal for miniature radios. The 250pF is quite adequate for this set and using the aerial coil described above will give a coverage from about 600kHz to 1.5MHz.

The components can be mounted on Veroboard or on Paxolin sheet. The battery switch can easily be incorporated in the earphone socket by bending the contacts so that the jack socket makes rather than breaks the switch contacts. The finished set draws only about 1.5mA and so all resistors can be ⅛W types and the battery will last a long while.

Despite the fact that the previous circuit used two transistors, the similarity between the circuits stops there, for the second one is not only simpler but, in my opinion at least, it is rather better.

The function of any radio, whether it be a communications receiver or a simple little design of the type shown here, is to pick up the radio waves, amplify them, detect them and present them as usable information, which in the case of normal sets is in the form of sound waves. To pick up radio waves an aerial is required and to differentiate between the various frequencies (for an aerial will of course pick up all frequencies) a tuned circuit is needed.

In the design, shown in Fig. 5, the coil part of the tuned cirucit also acts as the aerial, the rest of the tuned circuit comprising VC1 and the 0.01uF capacitor. The radio frequencies appearing across the tuned circuit are coupled to the base of Tr1 and amplified by it. The amplified signal appears at the collector, R1 acting as the load and this is directly connected to the base of Tr2 which acts as an emitter follower.

Now the emitter "resistor" of Tr2 is a 2,000-ohm magnetic earpiece which has considerable inductance and RF signals will not pass through it, but the detector diode D1 will pass them and these are smoothed by the 0.01uF capacitor which also forms part of the tuned circuit so that audio frequency signals are presented to the base of Tr1.

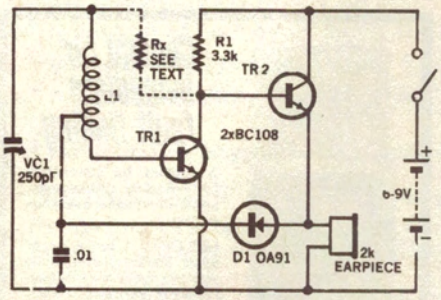

Fig 5. The complete circuit of the two-transistor reflex receiver.

The same amplification action takes place as for the RF signals but this time the inductance of the earpiece is far less effective at blocking the RF signals and so it is heard in the earpiece itself. Some of the AF does get through for a third trip but so little that it doesn't really matter.

DC base bias for Tr1 is taken from the emitter of Tr2 through D1. Depending on the characteristics of Tr1 and D1 an additional resistor Rx may improve the performance and indeed with some components may be essential. It's value will probably lie between 100k and 3.3M. In addition to helping with the base bias it will also introduce a certain amount of regeneration which will improve the performance. R3 is nominally 3.3k but values between 2.2k and 22k can be tried for best results.

Generally speaking I dislike reflex circuits (which of course this one is); they tend to be unstable, highly dependent on component values and poor value for money (the extra components usually cost more than an extra transistor) but in this circuit it works very well and none of the values are critical.

It must be emphasised that low impedance and crystal earpieces are not suitable for this type of circuit and only high impedance magnetic types will work at all.

The coil L1 is the same as that used for the first radio. It consists of about 80 turns of enamelled copper wire wound on to a 3/8in diameter ferrite rod tapped at eight turns. The acutal gauge of wire used is not critical, but I usually use 36SWG size.

Parts for First Simple Radio

Resistors:
R1 390k — see text R3 2.2k
R2 4.7k
All ⅛th watt
Capacitors:
C1 0.01uF
C2 10uF 10V
C3 0.001uF
VC1 250pF trimmer
Transistors:
Tr1 Tr2 BC108
Miscellaneous:
L1 — see text
250-ohm or 2k magnetic earpiece — see text
miniature jack socket
4.5V-15V battery — see text.

Parts for Reflex Receiver

R1 3.3k 10%, ¼ watt — see text
C1 0.01uF
VC1 250pF variable
L1 See text
D1 OA91 diode
Tr1 BC108
Tr2 BC108
Earpiece, 2k magnetic type
9V battery
On/off switch