Basic Electronics

by GERALD COHN

A simple Lie Detector

Do you have lying friends or honest enemies? One way to find out may be to use our simple lie detector. Whether you will ever find out the truth is another matter. What we can guarantee is that you will learn something about the elements of a differential amplifier if you build this lie detector. And you will have some fun into the bargain.

Over the years, many methods have been developed which have been claimed to be capable of lie detection. Of these, two methods have been subject to particular controversy, and these are the "polygraph" and voice analysis. Both methods have been widely used in the United States particularly for employee selection procedures. Fairly clearly, these methods have proved to be often unreliable and subject to abuse.

We have no intention of contributing to or continuing this controversy in presenting this article. Our lie detector is simple and we make no ambitious claims for it. It works by indicating changes in skin resistance and in so doing, can point to changes in emotional stress on the person being tested.

The reason for this change in skin resistance in situations of duress is, quite simply, because the person concerned begins to perspire involuntarily. We have all experienced this situation but it does not necessarily indicate that we are telling lies.

So with the understanding that the circuit presented here is not really intended as a serious attempt to produce a lie detector but is a unit capable of revealing a degree of emotional stress, we shall proceed. Make it up for a few hours of fun with your friends and family. It could be just the thing to liven up a dull party.

The circuit presented here is actually a differential amplifer of the simplest kind. As the name implies, it is an amplifier that detects and amplifies the difference between two signals. To understand how it does this, let's take a look at the circuit of the basic differential amplifier.

The circuit of the basic differential amplifier is shown in Fig. 1. It consists of two NPN transistors each with collector load resistors but both sharing the same emitter resistor. The bases of the two transistors are the two inputs to the circuit and the output is taken from the two collectors.

Now, let's say that we have a voltage applied to each of the two inputs, A and B. These voltages are represented by viA and viB. As a result of these input voltages we can expect respective voltages to appear at the outputs and these are represented by voA and voB.

If the voltages at the inputs are assumed to be equal initially, and knowing that the gains of the two transistors are identical, then it follows that the voltages at the collectors of the transistors will be equal. With equal voltages at the two outputs there is no voltage to be measured between them, ie, there is no differential output voltage. But what happens if we leave one of the inputs at a set level and start to vary the voltage at the other?

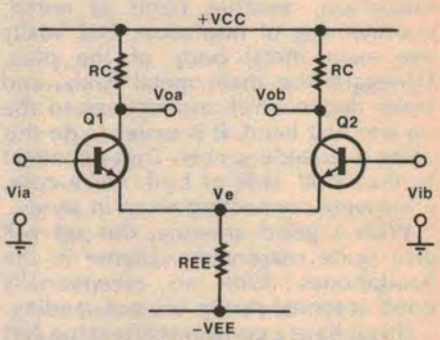


FIG. 1 : BASIC DIFFERENTIAL AMPLIFIER

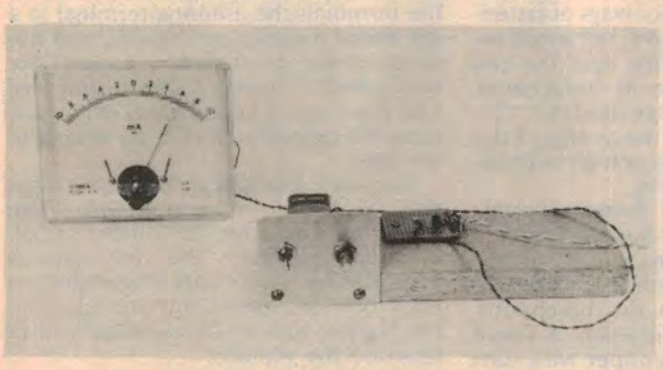
If we raise the voltage level at input B to a value that is above viA, we find that the voltage at the collector of Q2 falls as the transistor passes more current. This in turn causes a rise in the voltage at point Ve in the circuit therefore applying less forward bias to the base emitter junction of Q1. This reduction in forward bias applied to Q1 has the effect of raising the voltage at the collector of Q1. We therefore now have the situation where the collector of Q1 is at a higher voltage level than the collector of Q2, resulting in a voltage difference that is directly proportional to the difference in the input voltages.

The same principle applies if the level at input B is below input A except that the polarity of the output will now be reversed.

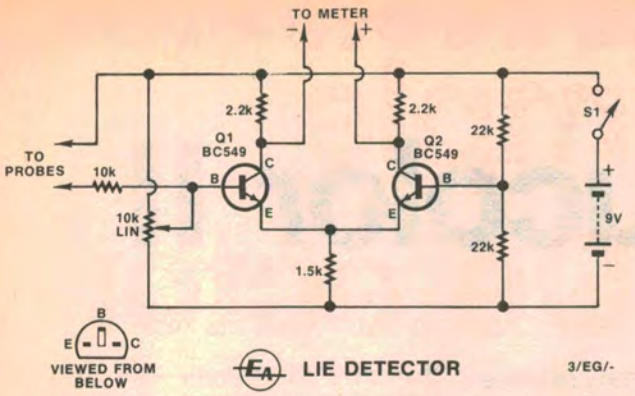
We can do the same thing if we decide to fix the level at B and to vary the level at A. Assuming that any measuring instrument is left connected as in the previous example, then we will note similar results, with polarity reversal, for the same input conditions.

Now let's take a look at how this applies to the circuit of the lie detector. One of the first things that becomes apparent is that we have used a single supply instead of a dual one by splitting the voltage from a single 9V battery into ±4.5 volts. This splitting is done by the two 22k resistors at the base of Q2.

This voltage divider across the 9V



This photograph of our prototype shows it connected to a centre-reading meter, but it would be cheaper to employ a multimeter (see text).



This simple differential amplifier circuit registers changes in skin resistance.

LIE DETECTOR 3/EG/-

battery sets a reference voltage for Q2. The potentiometer at the base of Q1 is used to "null" the circuit so that the voltages at the two collectors are equal.

A meter is connected between the collectors of the two transistors and this is used to indicate a change in the skin resistance of the person being tested. We opted to use a multimeter here as it is the cheapest option whereas the cost of purchasing a separate meter movement may not be justified.

The skin probes are connected to the positive supply rail and the base of Q1. These when connected to the "victim" will raise the voltage at the base of Q1 and unbalance the circuit. This is where the significance of the potentiometer becomes evident. Before any readings can be taken we first have to null the meter so that even the smallest change in skin resistance will show up as a deflection from zero on the meter.

In general, you will find that changes in skin resistance will cause the meter to deflect in the positive direction.

CONSTRUCTION

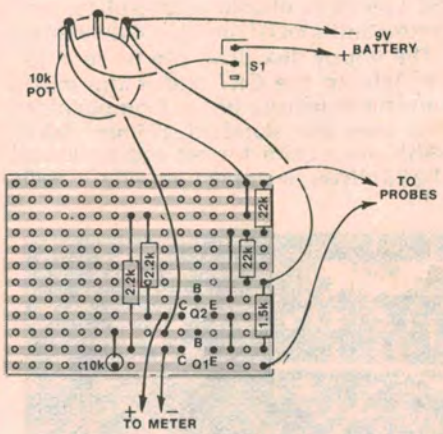
Construction of the unit is a simple process and should only take about one and a half hours or so. We used Veroboard for the prototype since this is a very convenient medium for the construction of these simpler projects. The piece of Veroboard is mounted onto a piece of offcut timber together with a small piece of aluminium sheet onto which are mounted the power switch and the potentiometer.

The first part of the construction entails cutting the Veroboard to the appropriate size and then cutting the tracks as shown in the overlay diagram. Having done this you can proceed to mount the components, starting with the wire links resistors, leaving the transistors until last. The positions of all the components are clearly shown on the component overlay diagram.

Connect all the wires to the board and put it aside. The next thing now is to prepare the front panel for the unit. This is made from a small piece of aluminium (or whatever is handy) and has the power switch and potentiometer mounted on it. This is screwed to the edge of the base as is shown in the photograph. The battery is held in place by a small bracket cut from an empty food can.

The piece Veroboard is held in place with a single screw as shown in the photograph. The output leads are terminated with crocodile clips which then connect to the probes of your multimeter. The best range to set the multimeter on is either 5 or 6mA depending on the type of meter you happen to have. The probes that connect to the skin can be made from aluminium foil held in place with a rubber band.

All that now remains to be done is a final check on all the wiring to ensure that it is free of errors, after which you can turn the unit on and start to ferret out the liars from the honest people. Have fun!



PARTS LIST

1 piece Veroboard 40 x 35mm
2 BC549 transistors

RESISTORS
1 x 1.5k, 2 x 2.2k, 1 x 10k, 2 x 22k
1 10k linear potentiometer
1 single pole miniature toggle switch
1 No. 216 9V battery and clip to suit
Knob to suit potentiometer

MISCELLANEOUS
Timber offcut, aluminium sheet (see text), tin plate, aluminium foil, screws, hookup wire and solder.