EXPERIMENT 11 TRANSISTOR CURVE TRACER

OBJECTIVE

To apply the principles developed in the experiments performed so far to construct a transistor curve tracer, and to use the transistor curve tracer to measure the characteristics of npn transistors.

THEORY

Transistor curve tracers are commonly used to observe the characteristics of bipolar and field effect transistors as well as other devices. In this experiment you will construct such an instrument. The various sections of the curve tracer are treated separately.

For an npn transistor the voltage applied to the collector must sweep from zero to a few volts positive. A convenient voltage is obtained from the 60 Hz line, by full wave rectifying (without filtering) a center tapped transformer (Fig. 1). It is convenient to think of this waveform as consisting of four different sections: there are two half cycles, corresponding to conduction by the two different diodes, and each half cycle is divided into an increasing and a decreasing voltage region.





The current applied to the base is obtained from large resistors which are connected to the outputs of two op-amps (Fig. 1). The first op-amp is driven as a comparator by one section of the transformer. Thus its output is positive during one half cycle, and negative during the other half cycle.

The second op-amp also acts as a comparator, but after the ac voltage has passed through an RC network. The time constant of this network has been chosen to be quite short, so the sine wave is shifted in phase by almost 90°. Therefore, the output of the op-amp is positive during the rising portion of one half cycle, and during the falling portion of the other.

The resistors from the outputs of the op-amps supply current to the base of the transistor

under test. These currents are ± 0.005 mA for the 2 Megohm resistor and ± 0.01 mA for the 1 Megohm resistor. An additional 620 k Ω resistor to the positive supply assures that the sum of the currents to the base of the transistor is always positive (or zero). There are altogether four combinations of current, corresponding to whether the outputs of each op-amp are positive or negative. The values of the resistors have been chosen to produce base currents of 0, 0.01, 0.02, and 0.03 mA. If the b of the transistor under test is 100, for example, this should result in collector currents of 0, 1, 2, and 3 mA.

The current through the transistor flows through a 100 Ω resistor from the emitter to ground. This value resistor is small enough so only a few tenths of a volt is generated at the emitter. Consequently, the emitter voltage has negligible effect on the current flowing to the base. Note that what is measured is actually the emitter current, which is only approximately equal to the collector current.

PROCEDURE

Set the oscilloscope on "X-Y" operation, with the X axis at 1 volt/division, and the Y axis at 0.1 volt/division. The X-axis scale directly indicates the voltage on the collector of the transistor under test. Because of the 100 Ω resistor, the Y axis scale is equivalent to 1 mA/division. Since the Y axis signal level is relatively low, use a cable (or a 1X probe) to make the connection, to minimize the effects of noise. You may also want to reduce the noise further with a capacitor to ground or a resistor in series with the Y axis output (not shown in Fig. 1).

Measure the characteristics of several npn transistors. *What values of* b *do you observe?* Try heating the transistor by squeezing it between your fingers. Can you get the b to change?

The curve tracer can also be used to measure the forward conduction characteristics of a diode, with the cathode connected to the emitter terminal and the anode connected to the collector terminal. However, the forward current will be very high, since it is limited only the 100 Ω resistor. Before attempting this **put a current limiting resistor**, such as a 1 k Ω resistor, between the anode end of the diode and the collector terminal, and expand the X-axis scale to 0.1 volt/division to clearly see the curve.

ASSIGNMENT

Design a curve tracer to work with pnp transistors.

Design a curve tracer that can test both npn and pnp transistors. Hint: The transistors may either plug into the same socket, in which case some voltages will have to be switched, or they may plug into different sockets. Which do you prefer?