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Air Research and Development Command, United States Air Force, Wright-Patterson Air Force Base, Ohio, WADC Technical Report 57-660, ASTIA Document No. AD-155573, page 4.
5. Feldman, C., Culver, H. E., and Davies, L., January, 1962, "Review of Scientific Instruments", Volume 33, No. 1, page 124.
6. Benel, H., August, 1959, "Thermoelectricity Abstracts", U. S. Department of Commerce—Office of Technical Services, PB-151810, Abstract #650, page 6.
7. Belser and Hicklin, *op. cit.*, page 23.
8. Calsyn, M., and Norman D., September, 1961, "Science Education News", American Association of the Advancement of Science, Washington, D.C., page 5.
9. Weber, *op. cit.*, page 68.

A Simple Transistor Characteristic Curve Tracer

EDWARD J. HILL[1]

Abstract. A simple, inexpensive circuit for displaying the grounded emitter characteristic of transistors on a cathode ray oscilloscope is described. It is designed as a demonstration unit. With a calibrated oscilloscope, quantitative information can be obtained suitable for laboratory experiments.

The characteristic curve tracer to be described here was developed to permit the immediate examination of an entire family of transistor curves on an oscilloscope. Six characteristic curves are displayed. Each represents the range of collector current as a function of emitter-collector voltage for a particular base current. The simplicity of the circuit makes it a very instructive demonstration unit.

The curve tracer may be divided into three parts: (1) the collector-emitter sweep voltage, (2) the base drive generator, (3) the oscilloscope. The transistor is operated as a grounded emitter amplifier. The grounded emitter configuration is an important type of circuit: it is the most commonly used in amplifiers, and the parameters of transistors used in this circuit are published in transistor handbooks.

R_1, the load resistor, has a voltage drop proportional to the collector current and this signal is applied to the vertical input of the oscilloscope. R_2 is the base limiting resistor. Since the maximum base and collector currents for a particular transistor can be found in a transistor handbook, and the voltage that will be applied is known, R_1 and R_2 may be determined by Ohm's law. For the TI492 NPN transistor, 1_1, 2.2K and 56K were used

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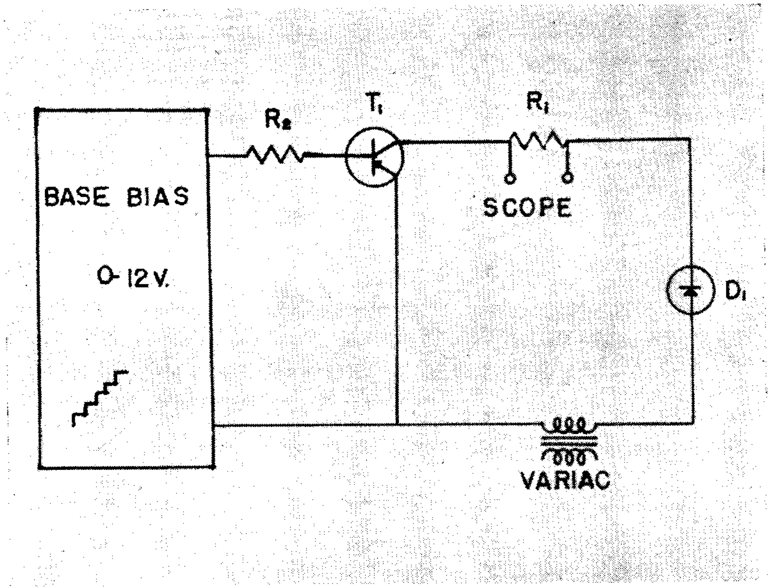

Figure 1. Block diagram of transistor curve tracer.

for R_1 and R^2 respectively. The diode D_1 is a 1N34A which is inserted in such a direction as to produce the desired reverse bias on the emitter-collector junction.

The AC collector voltage is provided by a variac. The basic assumption is that the sinusoidal variac voltage is nearly linear during the first 10% of the cycle. During this portion of the cycle voltage increases as a function of time, just less than would be expected from a linear source. Beyond the knee of the curve, the current is independent of an increase in voltage, and there-

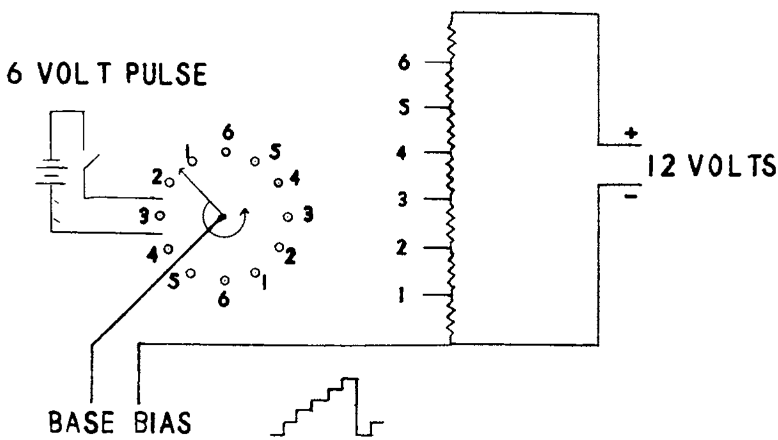

Figure 2. Schematic diagram of the stepping relay base bias.

fore the non-linearity of the variac voltage is not significant here. (see figure 4) The horizontal sweep of the oscilloscope is adjusted until only the part of the transistor curve controlled by the rising section of the variac voltage is shown on the screen. For accurate quantitative work, a saw-tooth generator could be substituted for the variac.

The bias of a transistor changes the resistance across the emitter-collector circuit. While a staircase signal is put into the base, the voltage applied to the collector is swept from zero to the selected value on each input step. (A staircase generator produces a signal which increases in voltage by increments and then recycles).

Three methods have been investigated for applying the base current. The simplest is to replace the generator with a six volt battery and manually switch R_2 for each curve. The second method innvestigated involved building a transistorized staircase generator.[1]

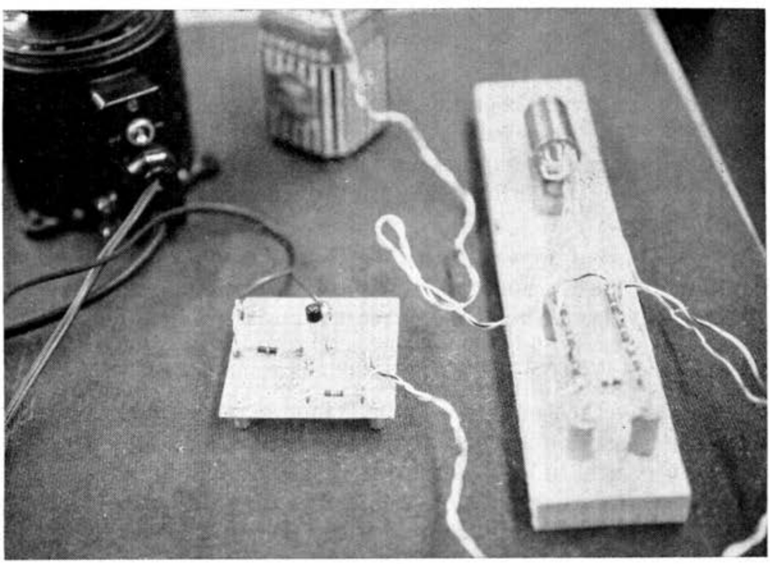

Figure 3. Picture of entire curve tracer unit.

The method used to obtain figures 3 and 4 makes use of a twelve position rotary stepping relay[1] which is pulsed by six volts DC. Each resistor in the bleeder chain is 120 ohms. A cam on a variable speed motor is used to trip a leaf type microswitch to pulse the relay. The motor speed is about five revolutions per second. Each consecutive pulse increases the voltage until, after the sixth pulse, the traces recycle (see figure 2).

[1] Guardian, Rotomite 706-12p.

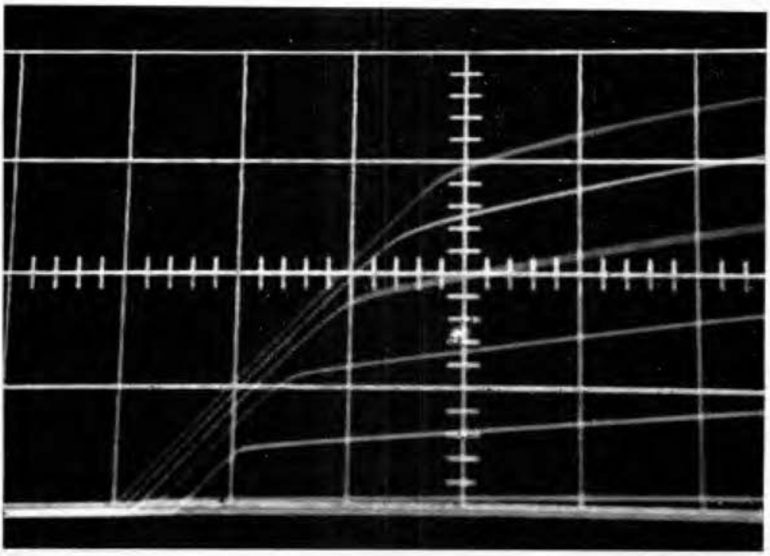

Figure 4. The grounded emitter characteristic curves of a NPN, TI492.

Figure 4 shows the transistor characteristics. The ordinate is collector current (in milliamperes); the abscissa is collector-emitter voltage (in volts). The origins of the traces are not coincident, as in the manufacturer's characteristics, because of the difference in triggering and lower discrimination levels in the oscilloscope.

These curves may be used to draw load lines in designing grounded emitter amplifiers. The useful parameter h_{fe} (current gain) may be estimated for most transistors within about 6% from this curve by the approximation $\frac{\Delta i_c}{\Delta i_b}$ (2)

To change the circuit to a PNP curve tracer, both the diode and the base signal polarity are reversed. If NPN and PNP transistors are to be interchanged, frequently, it is suggested that two circuit be made on the chassis, using only one generator and variac. This circuit may also be used in the grounded base and grounded collector configurations with appropriate changes in R_1 and R_2. The entire curve tracer can be built with stepping relay for less than ten dollars.

Acknowledgements

I wish to express my gratitude to Dr. William H. Sandmann of Grinnell College for suggesting the project and for his guidance throughout.

Literature Cited

1. *General Electric Transistor Manual* (1960), New York: p. 146.
2. *Ibid.*, p. 31.