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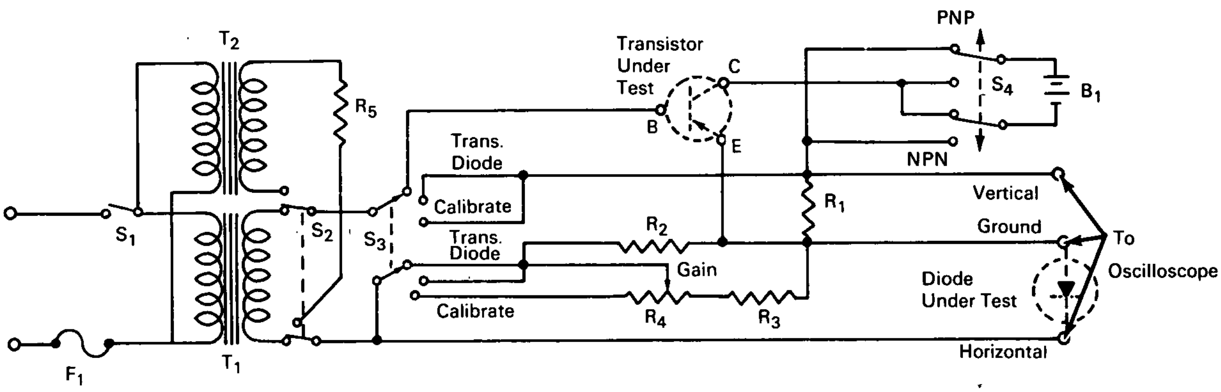
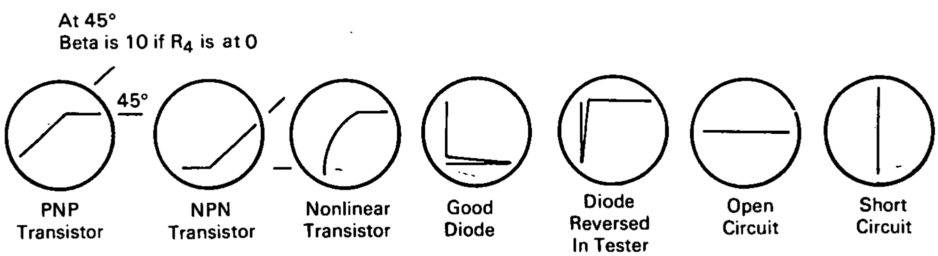
NASA TECH BRIEF

Semiconductors Can be Tested Without Removing Them from Circuitry





The problem:

To devise a method of testing semiconductors without removing them from the circuitry. Prior art required that semiconductors be unsoldered from the circuit for checkout.

The solution:

An oscilloscope with specially developed test circuitry that can be used for a quick check of semiconductors while in a circuit. For transistors, approximate gain and linearity, as well as PNP or NPN determinations can be made. When testing diodes, open or short circuits, and reverse polarity show up plainly. The condition and the estimated breakdown voltage may be obtained on low voltage Zener diodes.

How it's done:

With a PNP transistor under test, the emitter has a positive voltage applied through R_1 and the collector is at a negative potential. Unless there is current flow in the base-emitter circuit, only a very small leakage current flows in the collector–emitter circuit. Whenever the alternate half-cycle makes the emitter positive, emitter–base current flows through R_3 and R_4 (R_3 is used for current limiting when R_4 is at zero). The current flow is measured as a voltage across R_3 and R_4 at the horizontal terminals of the oscilloscope, and is a measure of the transistor input current. Since the collector–emitter circuit is forward biased by B_1, it follows that when base current flows, collector current flows through R_1. This

(continued overleaf)

is the output current, which is read as a voltage at the vertical terminals of the oscilloscope. When the slope is 45°, it means that the input voltages are equal. The voltages are dependent on the current flow through resistors R_1, R_3, and R_4. If R_4 is set at zero to get a 45° slope, then there is 10 times the current flowing through the output resistor R_1 than flowing through the input resistor R_3 to make their voltage drops equal. The output current is 10 times the input current so the transistor has a beta (current gain) of 10. As the value of R_4 is increased to set the scope trace at 45°, the ratio of the output current to input current goes up. Using a numbered dial plate under R_4 knob, the approximate gain can be read. In calibrating, when switch S is closed, equal voltage appears across R_1 and R_2 thus giving equal deflection voltages across the scope horizontal and vertical inputs. (The scope sweep selector must be set to horizontal input or external sweep.) By proper adjustment of the scope vertical and horizontal gain controls, a sloping 45° line can be obtained on the screen. This sets the scope controls for equal gain on the vertical and horizontal channels.

When testing a low voltage Zener diode, the horizontal leg will break down at some distance out from the junction if the Zener is rated at less then 10 volts. Higher back resistance shows up on the trace as a downward slanting of the horizontal leg. With poor forward resistance, the vertical leg slants to the right. In-circuit testing will reveal the mentioned traces if the circuit resistance is more than the component under test; if not, the trace will vary by the degree of external circuit properties. When the printed circuit board has more than one identical circuit, it is a simple matter to compare these to find a bad component.

When testing a diode, apply 6.3 vac to the diode. The positive half-cycle forward biases the diode and the negative half-cycle reverse biases it. When the diode is conducting, it is the same as short circuiting the scope's horizontal terminal to ground and the full voltage will appear across R_1. The scope shows only a vertical line under these conditions. However, when the diode is not conducting, there is no current flowing through R_1 and therefore there is no vertical deflection, but full horizontal deflection. When the recurrent half-cycles are combined in the scope trace, the pattern is half vertical and half horizontal for a perfect diode. The poorer the diode, the less perfect is the pattern.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
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Reference: B66-10447

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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