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Diode and Transistor Test Circuits

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Testing diodes and transistors can easily be done as shown here with an analog VOM (volt-ohm-meter) for general quality. In addition, more involved tests for leakage, gain, and other parameters can also be done with the simple circuits in this article. These circuits can also be used for sorting and matching components which is often important for precision circuits.

Diode Tests

Diodes should be tested out of circuit. Disconnect one lead of the diode from the circuit, then measure the forward and reverse resistance. Diode quality is shown by the ratio of reverse to forward resistance. A ratio of 100:1 or greater is common for signal diodes. The ratio may go as low as 10:1 for old power diodes.

Using a VOM or multimeter set on the lowest scale for which resistance does not exceed full-scale, a good silicon diode will show 200 to 300 Ω of forward resistance and 200 to 400 Ω for a good germanium diode. The exact value can vary quite a bit from one meter to the next.

Next, test the reverse resistance. Reverse the lead polarity and set the meter to the highest resistance scale to measure diode reverse resistance. Good diodes should show 100 to 1000 MΩ of reverse resistance for silicon and 100 kΩ to 1 MΩ for germanium.

The preceding procedure measures the junction resistances at low voltage. It is not useful to test Zener diodes. A good Zener diode will not conduct in the reverse direction at voltages below its rating.

We can also test diodes by measuring the voltage drop across the diode junction while the diode is conducting. This is the test performed by a multimeter's diode junction test function. Silicon junctions usually show about 0.6 V at typical meter test levels, while germanium is typically 0.2 V. Junction voltage-drop increases with current flow. The circuit in **Figure 26.27** can be used to match diodes with respect to forward resistance at a given current level.

A final simple diode test measures leakage current. Place the diode in the circuit described above, but with reverse polarity. Set the specified reverse voltage and read the leakage current on a milliammeter. (The currents and voltages measured in the junction voltage-drop and leakage tests vary by several orders of magnitude.)

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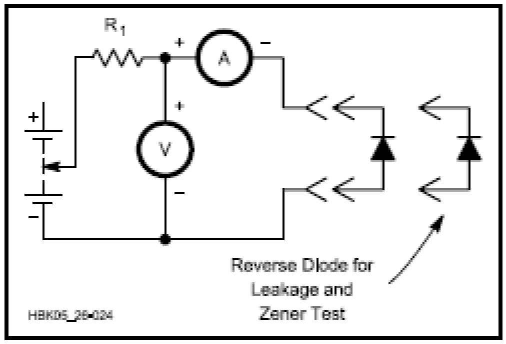

Figure 26.27 — A diode conduction, leakage and Zener-point test fixture. The ammeter should read mA for conduction and Zener point, µA for leakage tests.

The most important specification of a Zener diode is the Zener (or avalanche) voltage. The Zener-voltage test also uses the circuit of Figure 26.27. Connect the diode with reverse polarity. Set the voltage to minimum, then gradually increase it. You should read low current in the reverse mode, until the Zener point is reached. Once the device begins to conduct in the reverse direction, the current should increase dramatically. The voltage shown on the voltmeter is the Zener point of the diode. If a Zener diode has become leaky, it might show in the leakage-current measurement, but substitution is the only dependable test.

Bipolar Transistor Tests

Transistors can be tested (out of circuit) with an ohmmeter in the same manner as diodes or a multimeter with a transistor test function can be used. Before using the ohmmeter-transistor circuit, look up the device characteristics before testing and consider possible consequences of testing the transistor in this way. Limit junction current to 1 to 5 mA for small-signal transistors. Transistor destruction or inaccurate measurements may result from careless testing.

Germanium transistors – still occasionally encountered – sometimes show high leakage when tested with an ohmmeter. Bipolar transistor leakage may be specified from the collector to the base, emitter to base or emitter to collector (with the junction reverse biased in all cases). The specification may be identified as I_{cbo}, I_{bo}, collector cutoff current or collector leakage for the base-collector junction, I_{ebo}, and so on for other junctions. Leakage current increases with junction temperature. (See the **Analog Basics** chapter for definitions of these and other transistor parameters.)

A suitable test fixture for base-collector leakage measurements is shown in **Figure 26.29**. Make the required connections and set the voltage as stated in the transistor specifications and compare the measured leakage current with that specified. Small-signal germanium transistors exhibit I_{cbo} and I_{ebo} leakage currents of about 15 µA. Leakage increases to 90 µA or more in high-power components. Leakage currents for silicon transistors are seldom more than 1 µA. Leakage current tends to double for every 10°C increase above 25°C.

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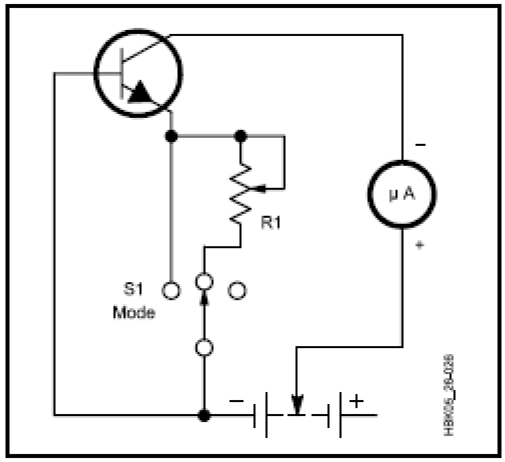

Figure 26.29 — A test circuit for measuring collector-base leakage with the emitter shorted to ground, open or connected to ground through a variable resistance, depending on the setting of S1. See the transistor manufacturer's instructions for test conditions and the setting of R1 (if used). Reverse battery polarity for PNP transistors.

Breakdown-voltage tests actually measure leakage at a specified voltage, rather than true breakdown voltage. Breakdown voltage is known as BV_{cbo}, BV_{ces} or BV_{ceo}. Use the same test fixture shown for leakage tests, adjust the power supply until the specified leakage current flows, and compare the junction voltage against that specified.

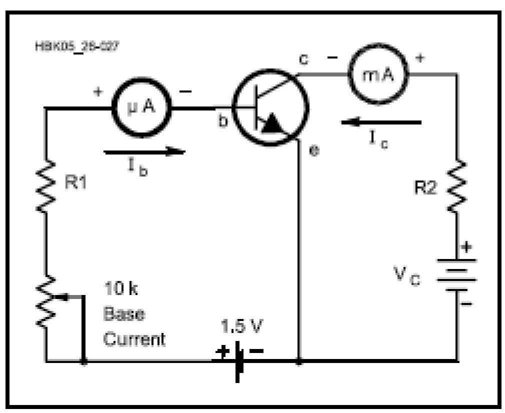

Figure 26.30 — A test circuit for measuring transistor beta. Values for R1 and R2 are dependent on the current range of the transistor tested. Reverse the battery polarity for PNP transistors.

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A circuit to measure dc current gain is shown in **Figure 26.30**. Transistor gain can range from 10 to over 1000 because it is not usually well controlled during manufacture. Gain of the active device is not critical in a well-designed transistor circuit.

The test conditions for transistor testing are specified by the manufacturer. When testing, do not exceed the voltage, current (especially in the base circuit) or dissipated-power rating of the transistor. Make sure that the load resistor is capable of dissipating the power generated in the test.