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# Reverse Breakdown Voltage Measurement Adapter

*Build this simple project for your bench.*

*The circuit shown in **Fig. 1** is the schematic for a Reverse Breakdown Voltage Measurement Adapter. Many times it is necessary to determine the breakdown voltage of a semiconductor. A reverse-biased P-N junction conducts current when its reverse breakdown voltage is exceeded. For a regular diode, this is the same as the peak inverse voltage (PIV).*

Bipolar junction transistor reverse breakdown voltages can also be measured with this device. Furthermore, a zener diode's breakdown voltage can be measured. If the current through the device under test (DUT) is limited during reverse bias, the junction voltage drop remains relatively constant.

This design will test zener diodes from 5.1 V to 75 V. A multimeter set on DC volts is plugged into the unit along with the DUT.

Reverse breakdown voltage is read directly from the meter. When testing reverse bias diodes, a display of 5.1 V denotes a 5.1 V zener diode. Similarly, a display of 75 V represents a 75 V zener diode. When measuring these voltages, remember that the diodes usually have a ± 5% or ± 10% tolerance.

The zener diode voltage is dependent on the current through the device. The reverse breakdown voltage measurement adapter described here has a short-circuit test current of approximately 10 mA. If the rated operating current of the zener is greater than 10 mA, the measured zener voltage will be incorrect.

### Description

The reverse breakdown voltage

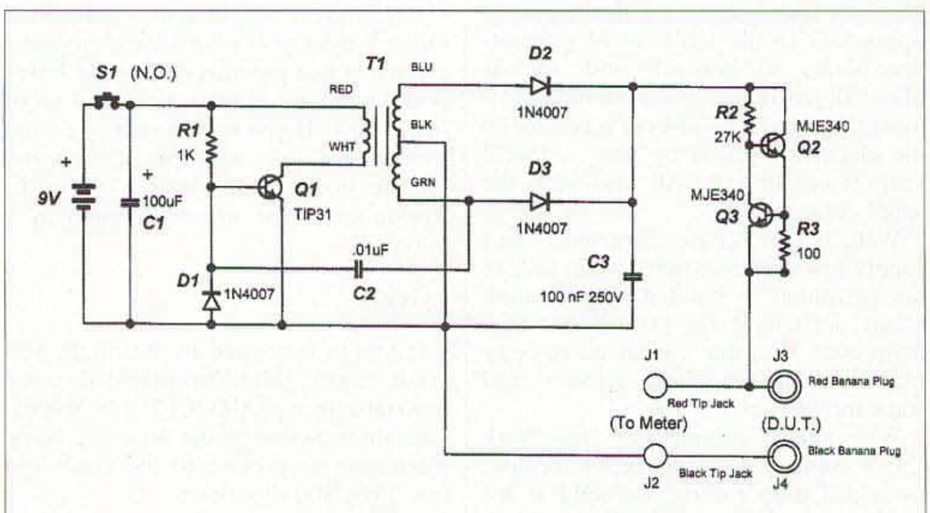


*Fig. 1. Schematic of a Reverse Breakdown Voltage Measurement Adapter.*

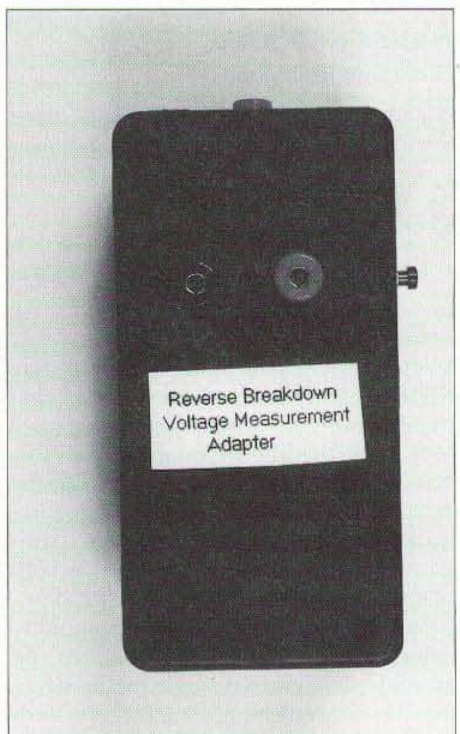


***Photo A.** Front view.*

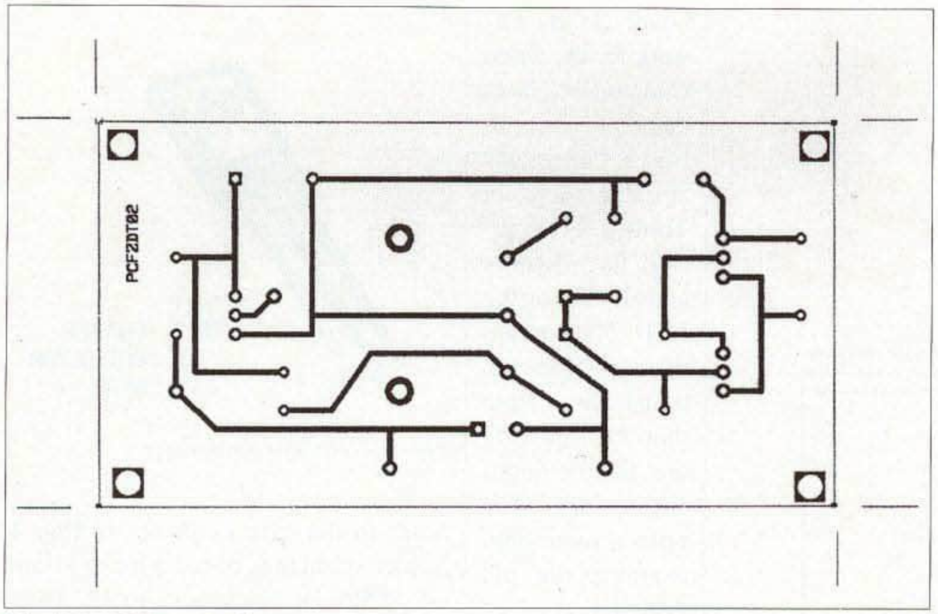


*Fig. 2. 1x PCB artwork.*

measurement adapter is composed of two basic parts. The first is a +125 VDC power supply. The second is a 10 mA current source that is connected from the +125 V to the DUT. The other terminal of the DUT is connected to ground. T1 is a 1k to 8 ohm audio transformer. This transformer is used in reverse (the 8 ohm winding drives the 1k winding instead of vice versa).

This allows T1 to generate +125 V at its 1k to center-tap winding. This center tap is connected to ground. The voltage at the green wire of T1 is 180 degrees out of phase with the red to white winding. The feedback drives the base of Q1 through C2. Q1 provides an additional 180 degrees of phase shift, causing a 360 degrees total phase shift along with a loop gain greater than 1.

This results in sustained oscillation (with some clipping). R1 is necessary to start the oscillator. D1 protects the base of Q1 from negative high voltages. D2 and D3 form a full-wave rectifier with

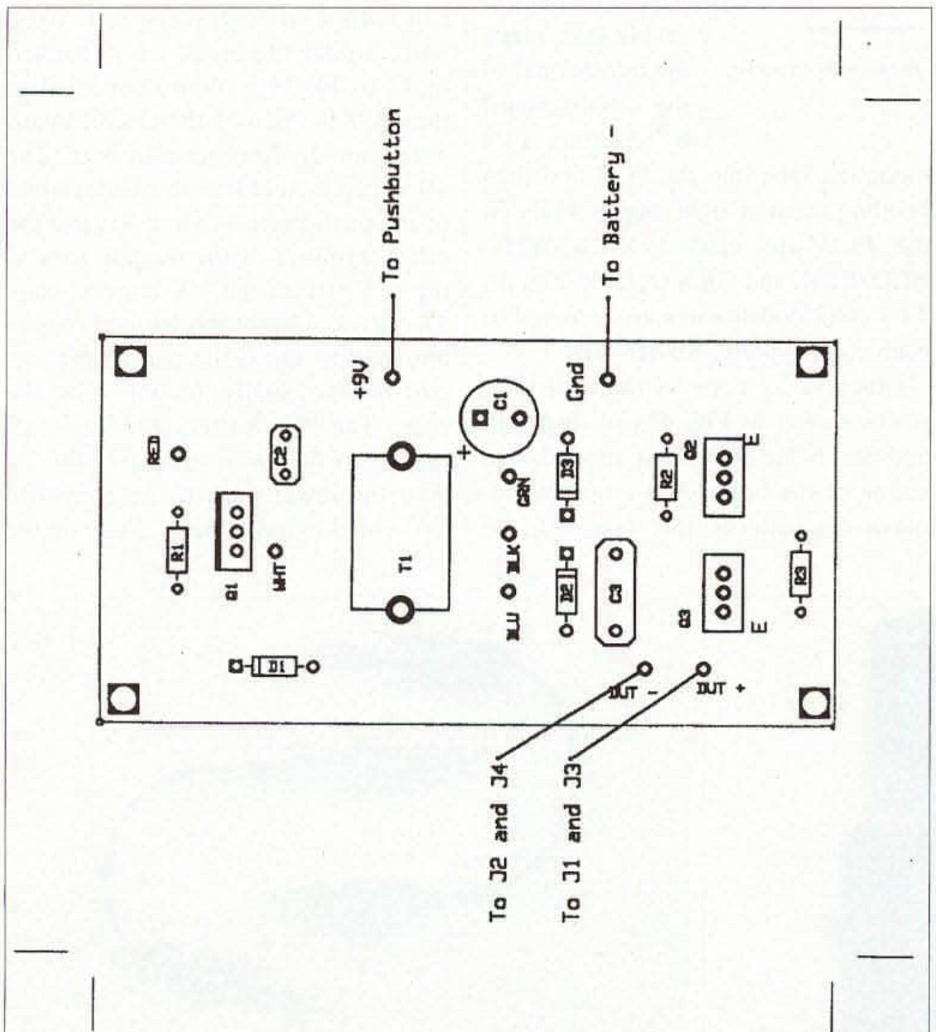


*Fig. 3. Component placement diagram.*

| Part | Description | P/N |
|---|---|---|
| R1 | 1k 1/4W 5% | |
| R2 | 27k 1/4W 5% | |
| R3 | 100Ω 1/4W 5% | |
| C1 | 100µF 35V electrolytic | |
| C2 | 10nF | |
| C3 | 100nF 250V film | |
| Q1 | TIP31 | |
| Q2, Q3 | MJE340 | Mouser 511-MJE340 |
| D1, D2, D3 | 1N4007 | |
| T1 | Audio transformer 1k CT to 8Ω | Radio Shack 273-1380 |
| S1 | N.O. push-button | |
| Case | | Radio Shack 270-1803 |
| Red tip jack | | Mouser 530-105-0802-1 |
| Black tip jack | | Mouser 530-105-0803-1 |
| Red banana jack | | |
| Black banana jack | | |
| 9V battery holder | | |
| 9V battery clip | | |
| 9V battery | | |
| 2-sided adhesive tape | | |
| Hookup wire | | |
| Black test cable | Black banana plug to alligator clip cable | |
| Red test cable | Red banana plug to alligator clip cable | |

***Table 1.*** *Parts list.*

reference to T1's center tap. The output voltage of D2 and D3 is filtered by C3. Q2, Q3, R2, and R3 form a current source with a short circuit current of 10 mA. The current source allows the testing of reverse breakdown voltages without having to constantly change a series resistance for a given test current.

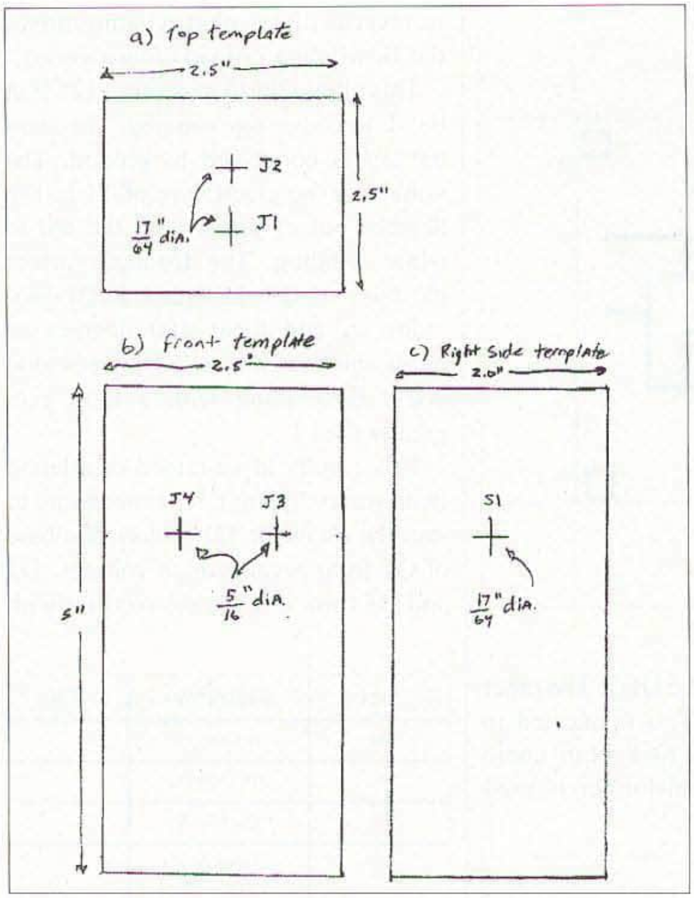


*Fig. 4. Drill template: (a) top template, (b) front template, (c) right side template.*

## Construction

**Fig. 2** shows the 1x printed circuit board (PCB) artwork for the tester. Component placement is given in **Fig. 3**. Part values are referenced in **Table 1**. First, install the resistors and diodes in the PCB. Then mount the capacitors and transistors. Note that Q2 and Q3 are facing opposite directions. For proper mounting, examine the pin designations of the MJE340 in **Fig. 5** and the emitter (E) marking in the component placement diagram in **Fig. 3**. After Q2 and Q3 are installed, mount the transformer to the circuit board by inserting T1's mounting tabs into the PCB and then bending them at right angles. Pads on the PCB are marked RED, WHT, BLU, BLK, and GRN (refer to **Fig. 3**). T1's color coded wires are soldered to each corresponding solder pad.

Obtain a 1x copy of the drill templates shown in **Fig. 4**. Cut them out and tape to the case. Next, mark the location of the holes with a punch. Remove the patterns and then drill the holes in the case as shown in **Fig. 4**. Solder six inches of red wire to J1 and six inches of black wire to J2. Then, mount these connectors in the appropriate holes in the case. Mount J3 and J4 to their holes in the lid. Examine **Fig. 3** for the connections of the test jacks. Solder the red wire attached to J1 to J3.

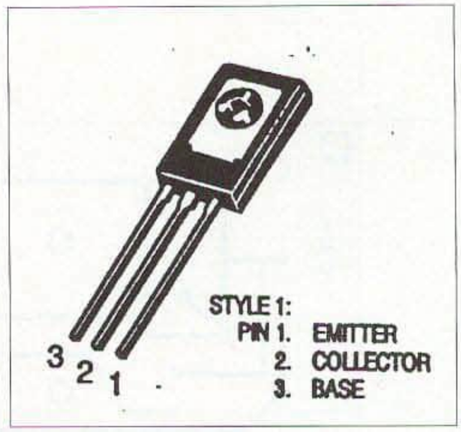


*Fig. 5. Transistor designations.*

Next, J3 is connected to the DUT + pad with a six-inch piece of hookup wire. Solder the black wire attached to J2 to J4. J4 is then connected to the DUT (–) pad of the circuit board with another short piece of wire. The +9 V pad is soldered to one terminal of the push-button switch S1, and the other terminal of the switch goes to the red wire of the 9 V battery snap. The black wire of the battery snap is attached to the GND pad of the circuit board. Finally, mount S1 to the case. The 9 V battery holder is attached to the reverse side of the lid near the lower part of the case with two-sided adhesive tape. Snap on the

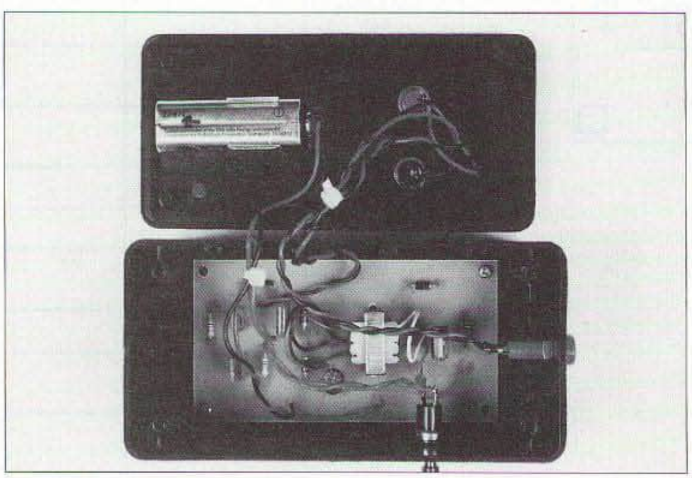

***Photo B.** Inside view.*

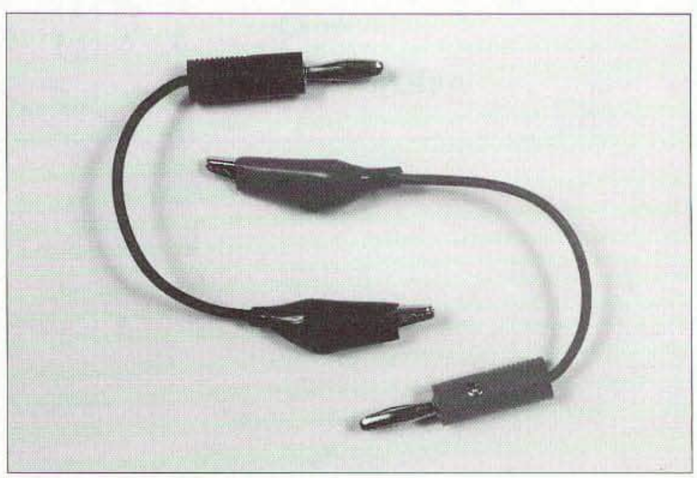

***Photo C.** Test leads.*

battery connector and install the battery into its holder.

### Testing

To improve safety, it is suggested that a resistor of 1 megohm be placed across capacitor C3 to function as a bleeder.

To test the circuit, attach a voltmeter across capacitor C3 and press S1. The meter should read approximately +125 V. If there is no voltage across C3, verify the correct attachment of T1's color-coded wires to their respective circuit board pads.

Also, check the correct installation of Q1 and D1.

Note: Because transformer color coding varies by manufacturer, proper phasing may be achieved by reversing a pair of colored leads, e.g., RED-WHT or BLU-GRN.

Once C1 has a charge of +125 V, the current source can be tested. Plug a voltmeter into J1 and J2.

To connect the DUT to the reverse breakdown voltage measurement adapter, either purchase or construct two test leads. One test lead has a red banana plug and alligator clip, while the other test lead has a black banana plug and alligator clip. Insert the red banana plug into J3 and insert the black banana plug into J4. Clip a 1k resistor between the alligator clips. After S1 is pressed, the meter should read between 8 V and 10 V.

This voltage drop corresponds to a current of 8 to 10 mA, thus verifying the operation of the current source. If the voltage drop is too high or is zero, there may be a problem with the correct installation of Q2, Q3, R2, and R3. Once the adapter is operational, mount the circuit board to the inside of the case using small self-tapping screws. Then attach the lid with the four screws provided with the case.

### Operation

Set the multimeter to read DC volts. Verify that the meter is plugged into the tip jacks, J1 and J2. Be sure that the banana plugs with alligator clips attached are plugged into J3 and J4.

To measure the breakdown voltage for a zener diode, attach the red alligator clip to the cathode (black band of the diode) and connect the black alligator clip to the anode.

Then press S1 and observe the meter. The zener voltage can be read directly from the meter. If the meter reads +125 V, then the reverse bias voltage is greater than this instrument can measure. This may occur if the DUT is not an actual zener diode, but a regular diode with a peak inverse voltage (PIV) greater than +125 V.

The unit will also measure forward voltage drops for any diode. In this case, the red clip is attached to the anode of the DUT and the black clip is attached to the cathode (black band). Pressing S1 will send 10 mA through the DUT, and the meter will show the forward bias voltage drop for the diode being tested.

This device can also be used to determine various properties of bipolar junction transistors (BJTs).

For NPN transistors, use the following instructions to measure the reverse breakdown voltages. In order to read the collector-emitter breakdown voltage (Vceo), clip the red test lead to the collector and the black test lead to the emitter of the BJT. When S1 is pressed, the collector-emitter breakdown voltage will be displayed.

To measure the emitter-base breakdown voltage (Vebo), clip the red lead to the emitter and the black lead to the base. Press S1 and read the result from the meter.

The collector-base breakdown voltage (Vcbo) can also be measured by connecting the red lead to the collector and the black lead to the base. Next, press S1 and examine the meter for the result. To determine the breakdown voltages for PNP transistors, measure similarly to the NPN transistors, except switch the polarity of the test leads.

Remember, the circuit can only measure reverse breakdown voltages of +125 V or less. Have fun building and operating the reverse breakdown voltage measurement adapter!