DMM FAULT-FINDER

By Homer L. Davidson

How many times have have you finished the last connection on your electronic project, fired it up and nothing happens? Yes, the switch is on, still nothing works. What did I do wrong? What do I do now?

Has this ever happened to you? You're mighty lucky if it hasn't happened with at least one of your projects. To many of us, who enjoy building electronic projects, it's downright discouraging. You begin to wonder if you can wire anything anymore.

Sometimes you want to throw the project in a corner or against the wall and forget it. Other times you just let it lie and hope that the next time you hook it up, by some miracle, it will work. Of course it never does and you keep remembering the dollars you have already invested in this project. Why not carefully dig in and see what went wrong...just one more time?

Maybe you made a bad solder connection. Sometimes when you're in a hurry, you can miss soldering one little old wire. Maybe one of the components is defective. It couldn't happen to you. Don't bet on it. It happens all the time...to the best of us. Just because that component or part is new, doesn't mean it can't fail before it is placed in action. OK! let's take a few measurements with that new digital multimeter you received for your birthday or Christmas and see how it works (Figure 1).

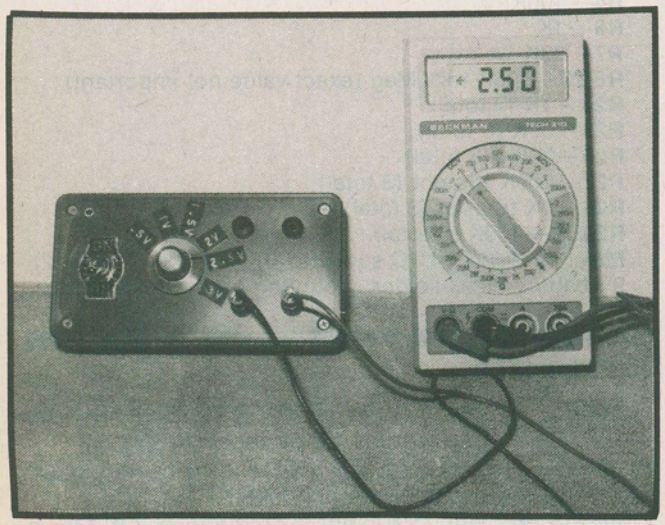

Figure 1: A digital multimeter (DMM) is the ideal test instrument to check out your project when it fails to operate.

Which Meter To Use?

There are many inexpensive digital multimeters (DMM's) to choose from with costs ranging from $29.95 to $79.95. Most meters accurately measure voltage current, and resistance. Several have autoranging and audible continuity features. Others check capacitance, transistors, diodes and even temperature. Besides accurate voltage and resistance measurements, it is recommended that you choose a DMM with transistor and diode testing capacity.

Small resistance and low voltage measurements are needed in checking out solid-state circuits. Very low voltage measurement of the transistors forward bias, between the base and emitter terminals, is a must. Measuring resistance measurements under one ohm may help locate a burned or open emitter bias resistor. Locating the open or leaky transistor or diode with a diode-transistor test is needed in checking out those solid-state projects.

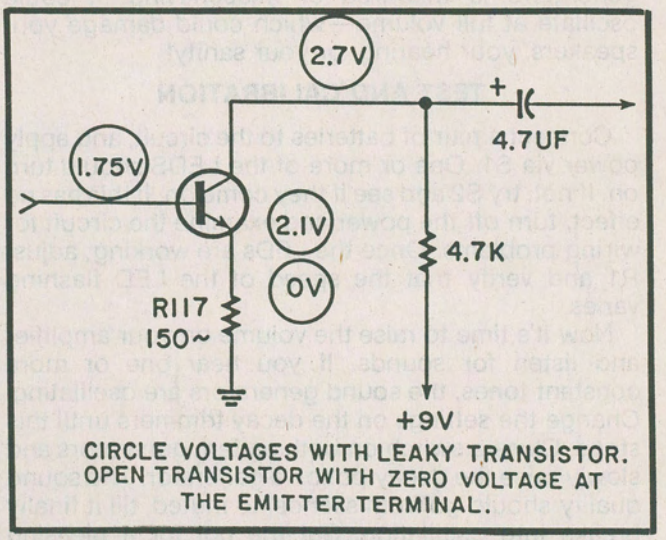

Figure 2: Low voltage measurements at transistor terminals may indicate a leaky transistor or improper supply voltage. Zero voltage at the emitter terminal indicates the transistor or emitter resistor is open.

Critical Voltage Measurements

Accurate voltage measurements at the terminals of a transistor or IC component may determine if the part is open or leaky (Figure 2). Very low voltage measurement at the collector terminal of a transistor or voltage supply terminal of a suspected IC may

indicate the component is leaky. Likewise, very low voltage at all terminals of a transistor indicates the transistor is leaky. Higher-than-normal voltage at the collector terminal and no voltage at the emitter terminal indicates that the transistor is open. No voltage at the emitter terminal will result from a open emitter resistor.

The suspected transistor may be tested with low bias voltage measurements between the base and the emitter terminals. An NPN transistor has a forward bias of .6 volts. You can expect a .3 volt bias with a PNP transistor. You will note that most schematics indicate these bias voltage differences between the two elements. If no bias voltage is found, you may assume that the transistor is leaky or open. When the bias voltage is much higher than normal, the transistor is usually open or has a high resistance junction between the two elements.

Critical voltage measurements within the circuit often indicates a leaky component, defective power supply circuits or a weak battery. Check the battery after removing it from the circuit. Very low voltage at the supply pin of a suspected IC may indicate a leaky IC or a defective power source.

Accurate Resistance Measurements

Correct resistance measurements in solid-state circuits will show if a component is open or leaky. Improper wiring connections will usually show up with accurate resistance measurements. A small coil, transformer winding or low-ohm resistor will often open with ohmmeter continuity tests. Leaky transistors or ICs can usually be located with accurate resistance measurements.

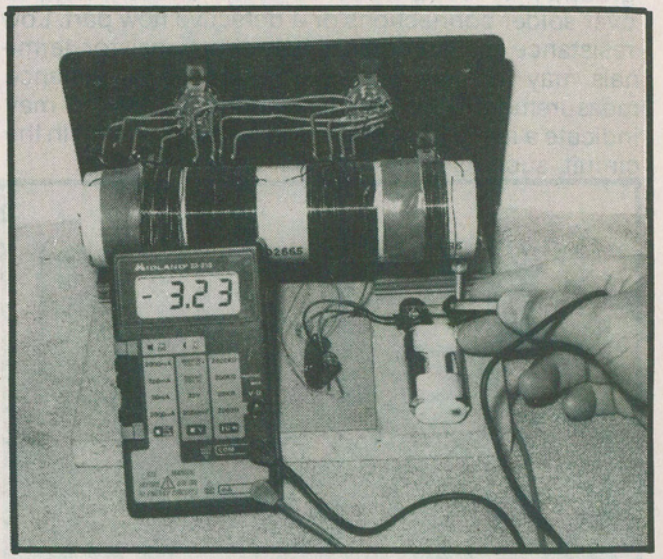

Figure 3: Take accurate current measurements when the batteries last for only a few hours or the battery voltage is low. Remove one end of the battery to take measurements.

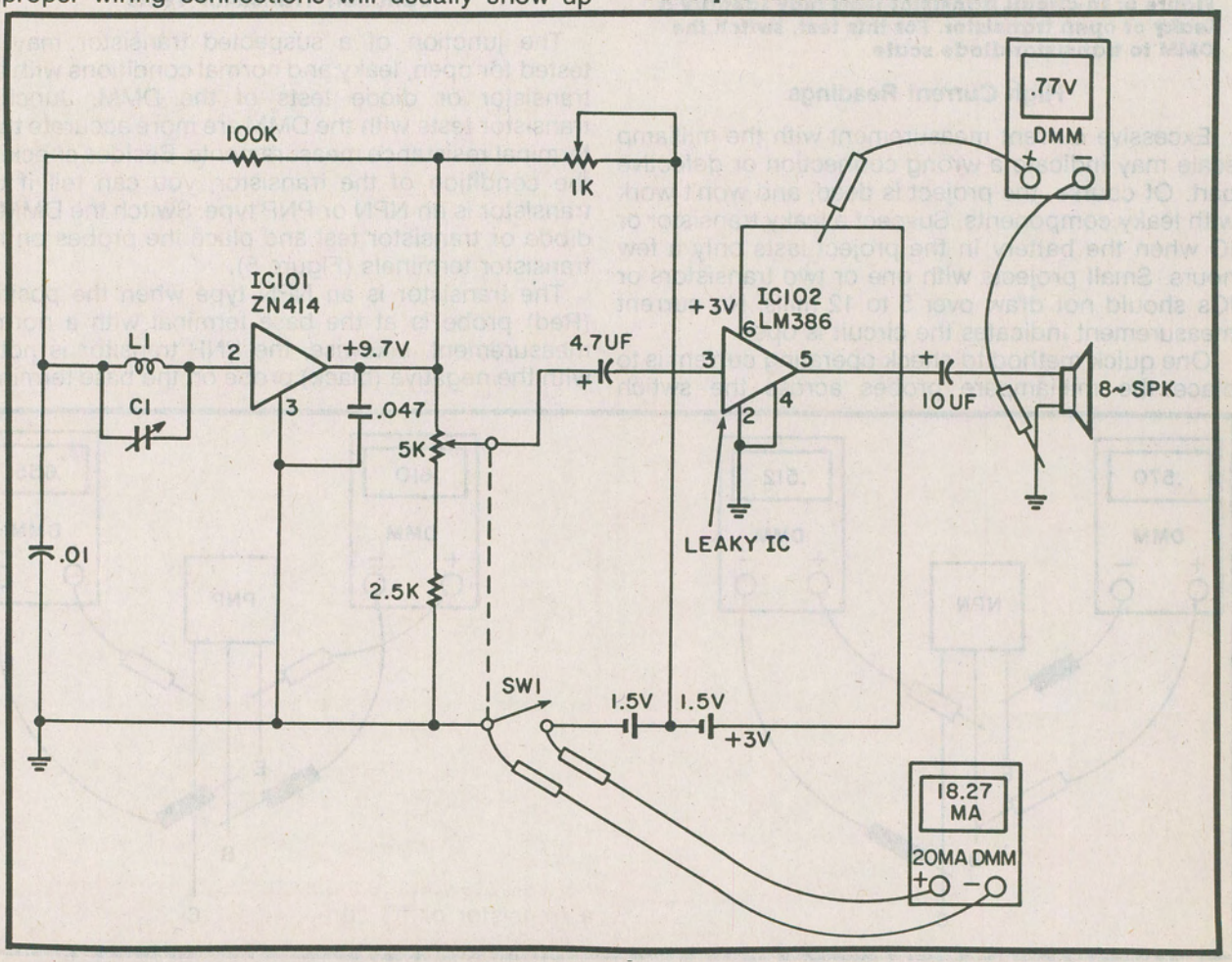

Figure 4: Accurate voltage measurements at each IC terminal can indicate a leaky IC or part tied to it. Disconnect the suspected leaky pin and take low resistance measurements to ground.

When checking out defective audio output circuits, critical resistance measurements will generally locate a defective component. After replacing the component, accurate resistance measurements to chassis ground may locate a poor soldered junction, slopped over solder connections or a defective new part. Low resistance measurements between transistor terminals may locate a leaky transistor. Low resistance measurement from one IC terminal to ground may indicate a leaky IC or a low resistant component in the circuit. such as a resistor, coil or diode.

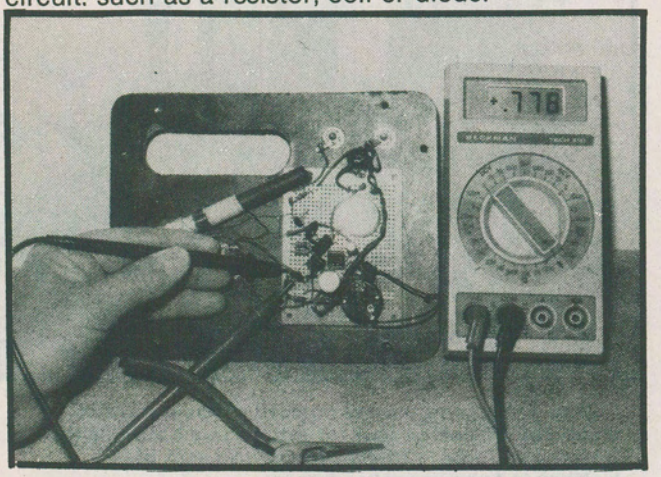

Figure 5: In-circuit transistor tests may identify a leaky or open transistor. For this test, switch the DMM to transistor-diode scale.

High Current Readings

Excessive current measurement with the milliamp scale may indicate a wrong connection or defective part. Of course, the project is dead, and won't work with leaky components. Suspect a leaky transistor or IC when the battery in the project lasts only a few hours. Small projects with one or two transistors or ICs should not draw over 5 to 12 mills. No current measurement indicates the circuit is open.

One quick method to check operating current is to place the milliampere probes across the swtich terminals with the switch turned off. Now read the total operating current. If the switch terminals are difficult to get at, or there's no switch in the circuit, insert the milliamp meter probes in series with the batteries or power supply source. Simply rotate the battery terminals on the 9 volt battery 180°, with one terminal connected and take a current measurement between battery terminal and battery plug (Figure 3). Place a thin piece of cardboard between the batteries and place the meter probes on the front and the back terminals of the batteries (on each side of the cardboard). Remember, when taking current measurements, place the meter probes in series with the voltage source.

Suspect an open circuit or improper voltage source if you got a no-current measurement. Check for a poor switch contact, disconnected wires or a dead battery or power supply. First, measure the voltage applied to the circuit. Often higher voltage will be measured with little or no current flow. Very low voltage may indicate a leaky component pulling heavy current. (Figure 4). Cut the wire or foil feeding the suspected transistor or IC, when more than one is in the schematic, to isolate the leaky component. Place the current meter leads across each end of the cut wire or foil to accurately measure the working current.

Junction Transistor Tests

The junction of a suspected transistor may be tested for open, leaky and normal conditions with the transistor or diode tests of the DMM. Junction transistor tests with the DMM are more accurate than terminal resistance measurements. Besides checking the condition of the transistor, you can tell if the transistor is an NPN or PNP type. Switch the DMM to diode or transistor test and place the probes on the transistor terminals (Figure 5).

The transistor is an NPN type when the positive (Red) probe is at the base terminal with a normal measurement. Likewise, the PNP transitor is noted with the negative (black) probe on the base terminal.

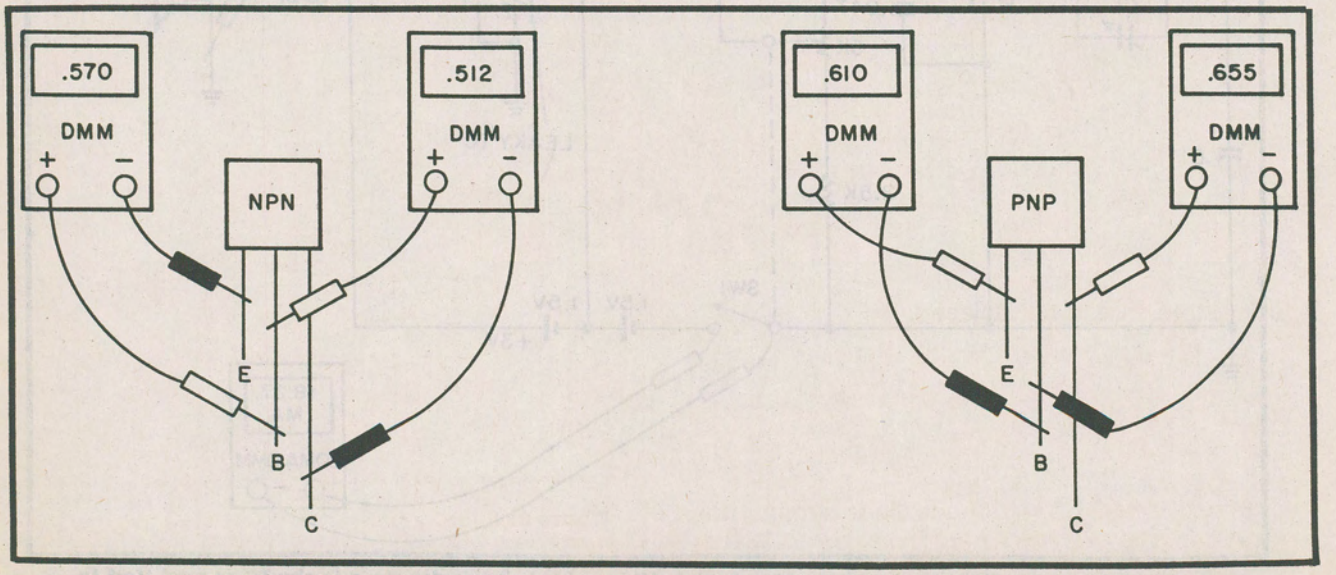

Figure 6: The type of transistor may be identified with transistor-diode junction tests of the DMM. Check the NPN or PNP transistor.

The transistor is normal if the two resistance measurements between the base and the remitter, and the base and the collector terminals are close (Figure 6).

Remember, the transistor junction may be open from the base to either collector or emitter elements. Be very careful in taking transistor tests. You may find the transistor open between two elements or all three. Figure 7 shows a transistor that is normal between the base and the collector, but open between the base and the emitter.

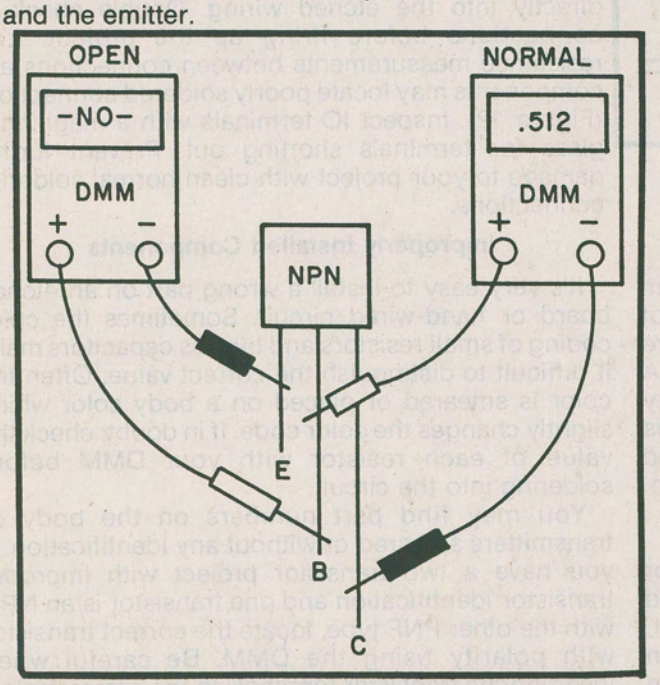

Figure 7: You may find the transistor open or leaky between any two elements. Here the transistor is open between emitter and base terminals.

A very low resistance measurement between any two terminals may indicate the transistor is leaky. Often the leakage exists between collector and emitter terminals (Figure 8). Reverse the ohmmeter terminals when a low measurement is found between two elements. A leaky transitor will now have a low measurement in both directions. Always replace the transistor if leakage is suspected.

Remove the suspected transistor and take another measurement when it is out of the circuit. Usually a transistor with a dead short between emitter and collector will test the same when out of the circuit. An erractic or intermittent transistor will produce erratic measurements with in-circuit tests. Sometimes when the transistor is removed from the circuit, after testing leaky or open in the circuit, it may test normal. Such transistors should be replaced.

Checking Those Diodes

Most diodes can be checked with the diode test of a DMM. Although diodes may be checked in-circuit with the DMM, remove one terminal for accurate leakage tests (Figure 9).

Often the positive or cathode diode terminal may be indicated with a white ring or beveled end. A shorted or leaky diode will show a reading in both directions. A normal diode will indicate in only one direction.

Check the diode by placing the DDM test probes on each terminal. You should get a low resistance measurement with the negative (black) probe on the positive terminal and the positive (red) probe at the negative terminal of the diode (Figure 10). Now, reverse the two probes and make another test. No measurement indicates the diode is normal. Suspect a leaky diode if the resistance is low in both directions.

RF and zener diodes may be checked in the same manner as a fixed diode. Usually, zener diodes are found to be leaky, not open. An RF diode will have a higher resistance than silicon diodes. Leaky, high voltage diodes found in a TV chassis can not be tested succesfuly, unless a dead short exists.

Locating Leaky ICs

Integrated circuits are difficult to test except for voltage and resistance measurements. Open components inside the IC may not indicate with voltage and resistance checks. Sometimes accurate voltage and resistance measurements at each IC terminal will locate the leaky IC. Signal in and signal out tests witha scope are the best methods to locate a defective IC component.

You can check the suspected IC in your dead project with accurate voltage and resistance measurements (Figure 11). The most critical voltage test is at the supply terminal. All IC components have one terminal tied directly to the battery or power supply source. A leaky IC will have lower voltage at the supply terminal. Suspect a leaky IC when voltage is lower at any terminal than shown on the schematic.

After locating a low voltage measurement, take a low-ohm measurement from the IC pin to ground. Remove the suspected terminal from the pc wiring.

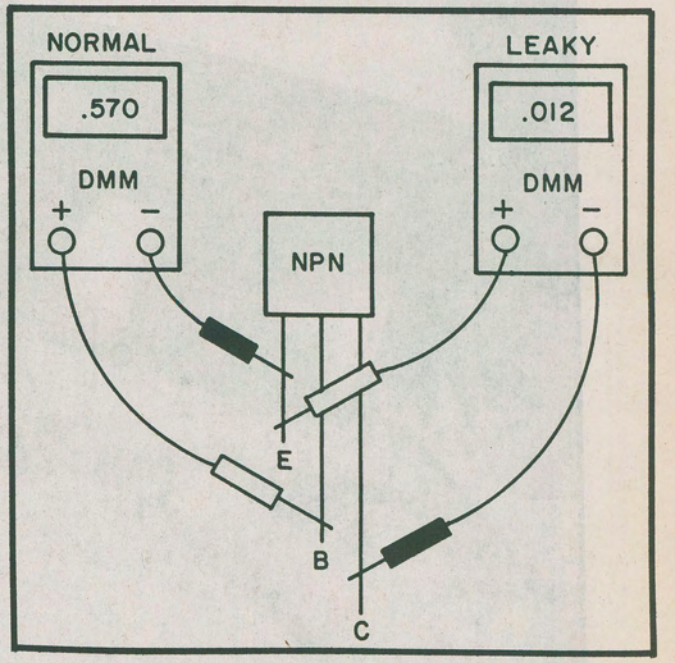

Figure 8: A leaky transistor will have a low-ohm measurement in both directions. Here an NPN transistor is leaky between emitter and collector terminal.

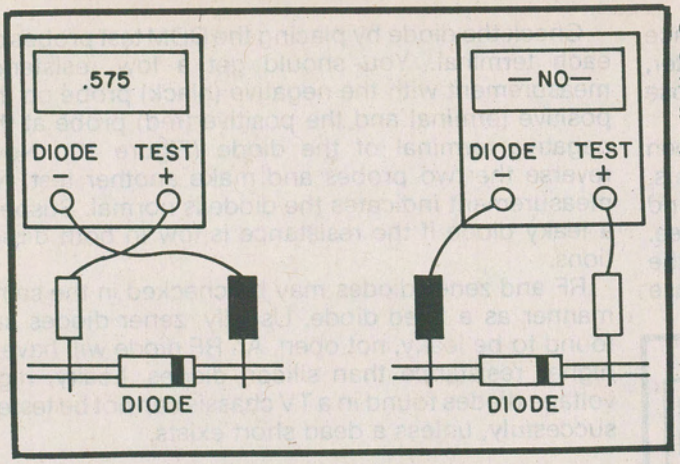

Figure 9: A normal diode will have low resistance in one direction and no reading with reversed test probes. A leaky diode will have low resistance in both measurements.

Always check the circuit to make sure a low ohm resistor, coil, transformer winding or diode is not shunted from this terminal to ground. Now, measure the resistance between the terminal and ground. A low resistance (under 1000 ohms) indicates a leaky IC. Supply insert another IC if the component is plugged into the IC socket. Often ICs are damaged when removed from the circuit with a soldering iron.

Poorly Soldered Connections

Improper soldered contacts may cause dead or intermittent project operation. The cold soldered connection may have a high resistance joint. Sometimes a poorly soldered connection between component terminal and etched wiring will result in erratic operation. Always apply the solder to the wire connections, not to the end of the iron. Solder should flow into the joint for a good clean connection. Make sure each wire is connected to the right component or joint.

Of course, too much solder around transistor or IC terminals may slop over, tying terminals and components together. Remember to use a heat sink on transistor terminals when soldering into the circuit. Use IC sockets instead of soldering ICs directly into the etched wiring. Double check all connections before firing up the project. Low resistance measurements between connections and components may locate poorly soldered connections (Figure 12). Inspect IC terminals with a magnifying glass for terminals shorting out. Prevent further damage to your project with clean normal soldering connections.

Improperly Installed Components

It's very easy to install a wrong part on an etched board or hand-wired circuit. Sometimes the color coding of small resistors and bypass capacitors make it difficult to distinguish the correct value. Often the color is smeared or placed on a body color which slightly changes the color code. If in doubt, check the value of each resistor with your DMM before soldering into the circuit.

You may find part numbers on the body of transmitters smeared or without any identification. If you have a two transistor project with improper transistor identification and one transistor is an NPN with the other PNP type, locate the correct transistor with polarity using the DMM. Be careful when inserting the transistor terminals in the correct holes.

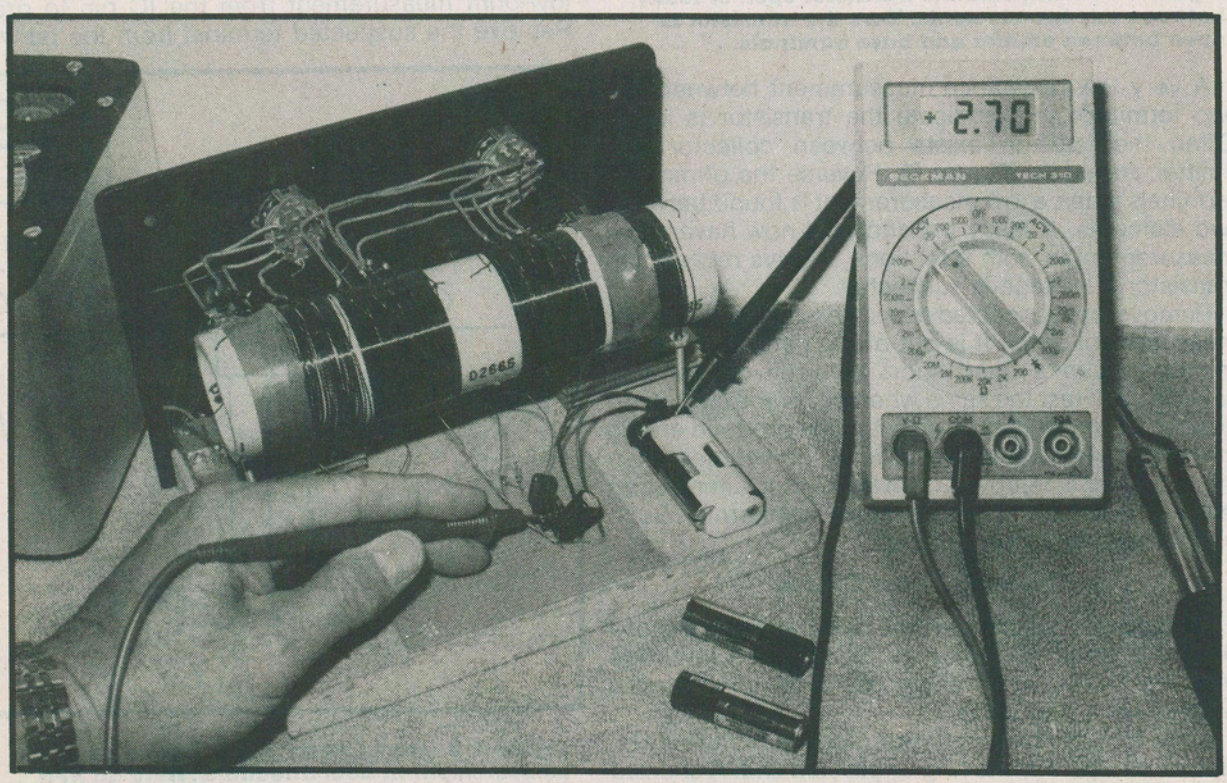

Figure 10: Diodes may be checked in the circuit for normal tests. Remove one end of the diode when leakage is noted for accurate leakage measurement.

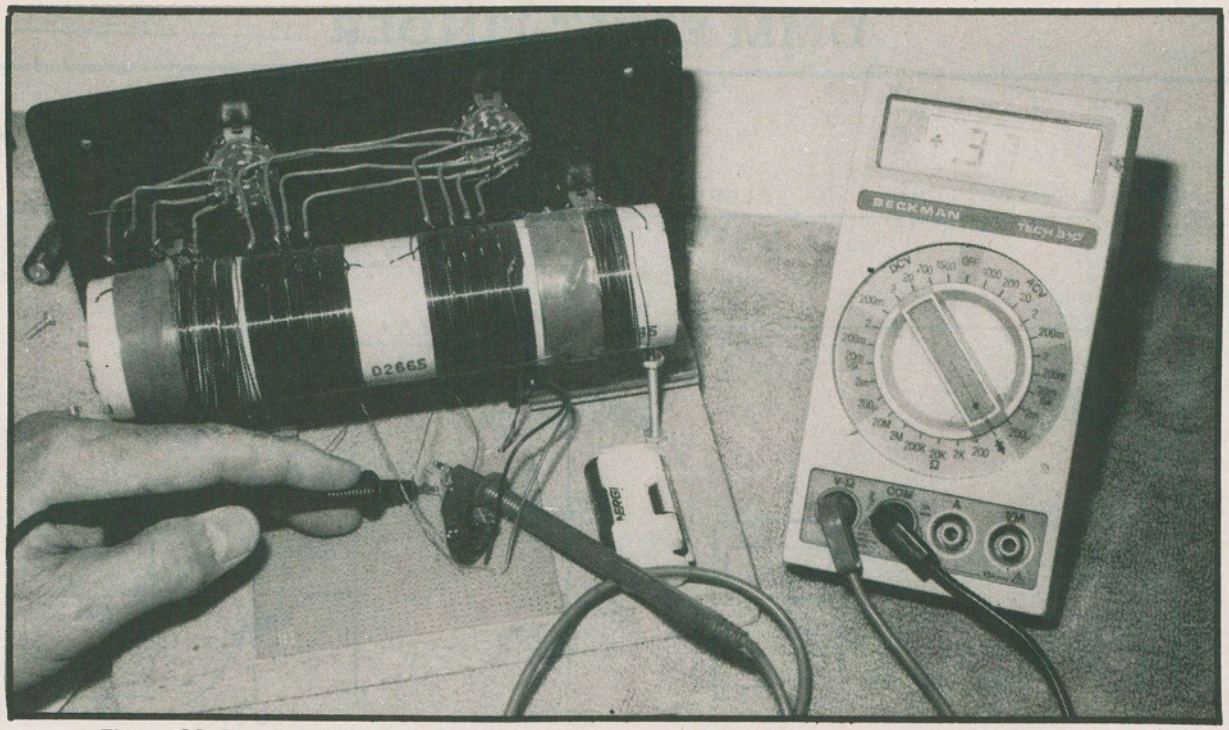

Figure 11: Low voltage measurements on the suspected IC may indicate a leaky IC. Check the battery or power supply with the IC removed from the circuit.

Have the bottom view of the transistor handy at all times. Besides having a project that will not work, connecting the wrong terminals may destroy the new component.

Defective New Components

Do not overlook a possible defective component. Try to test each part before installing it in your project. You will know if the part is defective or breaks down after it's installed in the circuit. Make sure that the part is good before installation.

Transistor, diodes and resistors are easily checked with the DMM. IC components may be checked in the circuit with accurate voltage and resistance measurements (Figure 13). Small capacitors may be checked with a capacitor tester or with a DMM which also incorporates a capacitor checker. Variable resistors may be checked from center terminal to each outside terminal with high resistance measurements. Low-ohm continuity tests on coils, transformers and relays will indicate if the part is open. Check for broken wire leads at the component lugs or terminals.

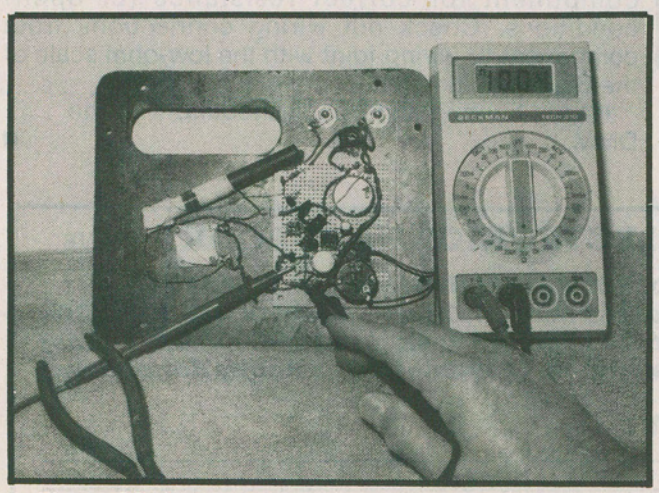

Figure 12: Low resistance measurements between wiring and parts may locate a poorly soldered connection. Check each resistor for correct resistance. Remove one end of the resistor.

Before installing a variable capacitor in a project, take a high resistance measurement (20K) between the ground and the rotor or stator terminals. Sometimes in shipment, the metal plates are damaged or pressed together. The normal variable capacitor has infinity between terminals. You can not tell if the capacitor is shorted when installed with the coil shunted across the capacitor terminals in the circuit, because the coil will show zero resistance.

Improper Schematic

Missing lines or improper connections in a schematic diagram may prevent the project from operating. Mis-labeled parts can cause problems in getting the project to work. A ground or tie wire left out of the schematic will produce many problems. Wrong polarity symbols for battery terminals (interchanged) can hook up the battery backwards in the circuit. Although magazines and books check and proof read all material, little errors somehow can creep in. Check with the magazine, book or manufacturer for possible wiring defects after going over the wiring many times. Most magazines re-run corrections of mistakes made in the project content.

Conclusion

You have heard it said many times, double check all wiring connections. Remember, even the most experienced builder can make mistakes in wiring an electronic project. Take voltage and resistance

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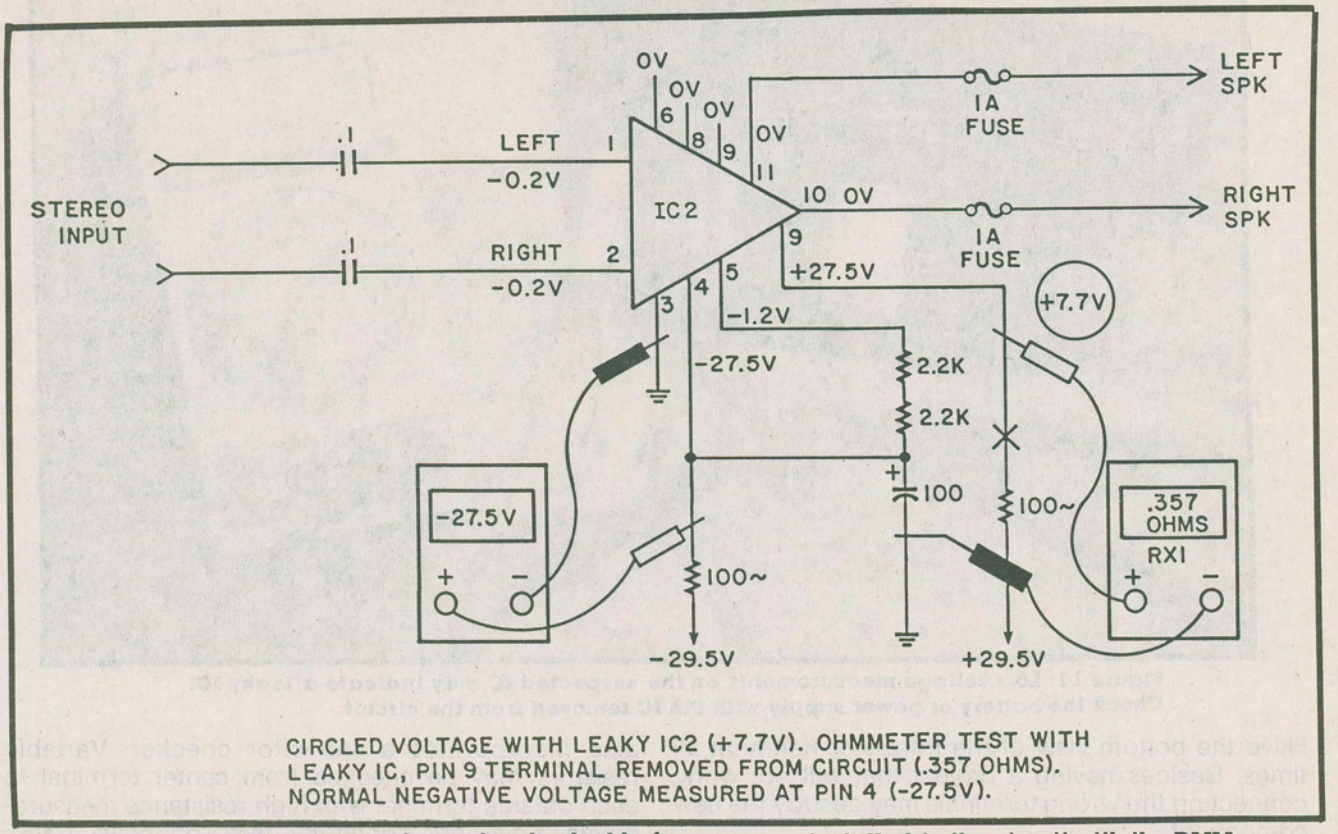

Figure 13: Most components can be checked before they are installed in the circuit with the DMM. Correct voltage and resistance tests at each terminal of an IC may locate the leakage.

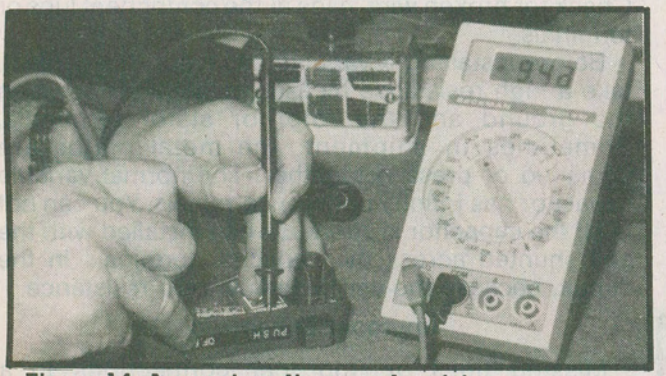

Figure 14: Accurate voltage and resistance measurements upon the various components may locate the defective part or improper wiring. Check and compare these measurements with those found upon the schematic.

measurements to locate the possible defective component or wiring error (Figure 14). Next, take a milliampere measurement for excessive current.

Check the suspected transistor or diode with the transistor-diode test of the DMM. Make sure that all diode and/or transistors are installed properly. Take low voltage and resistance measurements at each IC terminal. Take resistance and continuity tests on each component for correct resistance (or open) conditions. Check out wiring connections from component to wiring joint with the low-ohm scale of the digital multimeter.

Happy hunting and troubleshooting with the DMM. ■