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Learn How SCRs and Triacs Fail and How You Can Test Them with your Z Meter

SCRs and triacs are used in a variety of consumer and industrial applications. In consumer electronics, SCRs are found in television shutdown and regulator circuits. Triacs are often used in consumer products to turn AC line voltages on and off. In industry, SCRs and triacs are used as voltage regulators, controlled duty cycle rectifiers, and motor speed controls, as well as in other voltage control applications. SCRs and triacs belong to a family of components called thyristors. A thyristor is a solid state device that is used as a switch. These solid state switching devices have become increasingly popular due to their long life and fast switching action.

Characteristics of SCRs and Triacs

One of the most common members of the thyristor family is the Silicon Controlled Rectifier (SCR). An SCR is also sometimes called a reverse blocking thyristor. Figure 1 shows the schematic symbol for an SCR. Notice that the symbol looks much like a diode with the addition of a third lead. The third lead is the gate lead and is used to trigger the SCR.

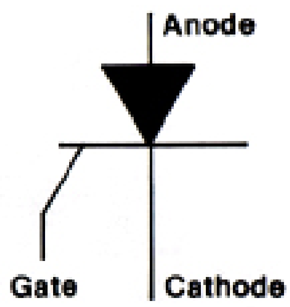

Fig. 1: Schematic symbol for an SCR.

An SCR, like a switch, is either on or off. When the SCR is off, it acts like an open circuit. When it is on, it acts like a diode. Like a diode, current flows through an SCR in one direction only.

For some applications, current flow is needed in both directions. Triacs are used in these applications. A triac is sometimes called a Bidirectional Silicon Switch. Figure 2 shows the schematic diagram for a triac. A triac, like an SCR, is either on or off. When the triac is off, no current can flow through the device in either direction. When the triac is on, current flows in either direction.

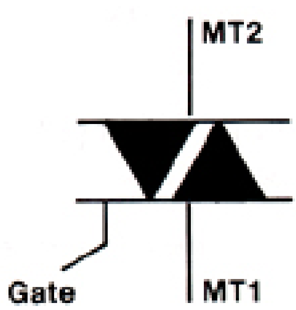

Fig. 2: Schematic symbol for a triac.

The main terminals on an SCR are called the anode and the cathode, just like a diode. The main terminals on a triac are called Main Terminal 1 (MT1) and Main Terminal 2 (MT2). The leads are designated this way since the triac acts like two opposing diodes when it is turned on and neither lead always acts like a cathode or an anode.

Unlike an SCR, a triac can operate in any of four configurations, called quadrants. Figure 3 shows these quadrants and how they are defined. In quadrant 1 and 2, the MT2 lead is positive with respect to MT1, and current flows in one direction. In quadrant 3 and 4, MT2 is negative with respect to MT1 and current flows in the reverse direction. As can be seen, quadrant 1 and 3 have the polarity of the gate voltage, the same as MT2 voltage. These two quadrants are the most stable and easiest to trigger. Manufacturers normally recommend that triacs operate in quadrants 1 and 3, if at all possible.

SCRs and triacs both have control gates. The control gate is used to turn the SCR or triac on. There are two different types of gates: sensitive gates and normal (non-sensitive) gates. Sensitive gate SCRs get their name from the fact that they are very sensitive to the amount of current and voltage applied to the gate lead. They require as little as 0.8 volts to turn them on versus 3 volts or more for a normal SCR. Sensitive gate SCRs are typically used in low current applications where only a small gate current is available.

For many applications, sensitive gate SCRs are too sensitive for reliable use. Internal currents can accidentally trigger the SCR into conduction. This can have serious consequences. To prevent this from happening, SCRs have been developed with an internal bleeder resistance built into them. This type of SCR is sometimes called a “shorted emitter”, non-sensitive gate, or a Normal Gate SCR. These types of SCRs require more gate current to turn on. In many applications, the necessary gate current is easily obtained and, thus, the reliability of turn-on outweighs the additional gate current needed.

How SCRs and Triacs Fail

An SCR or triac operates in one of two states: it is either on or off. In the off state, a properly operating SCR or triac blocks the flow of current through it. In the on state, a good SCR allows current to flow in one direction only. A good triac allows current to flow in both directions when it is turned on.

Common failures in SCRs and triacs are: 1. No turn-on 2. Leakage or direct short 3. Leakage at higher working voltages 4. triac only: Short in one direction, normal operation in the other direction.

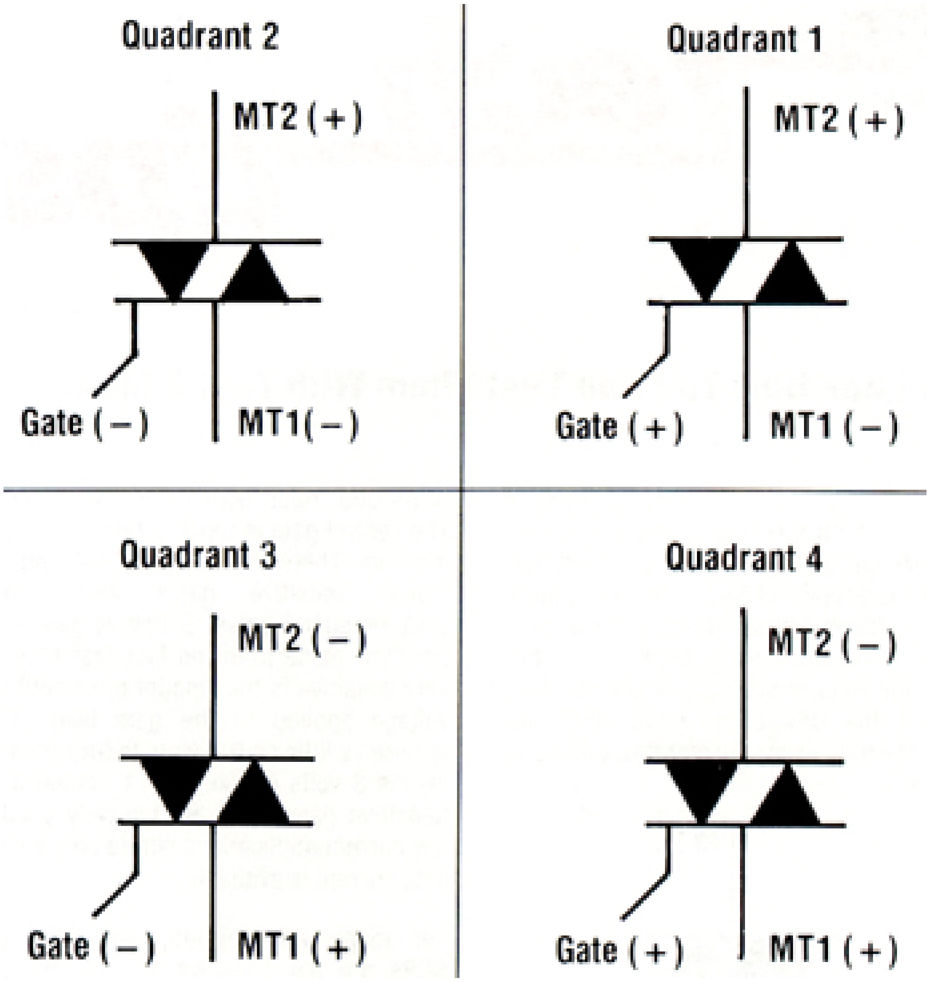

Fig. 3: A triac can operate under four different voltage polarity conditions. Quadrant I and III re the most common.

SCRs and triacs fail to turn on when either the gate junction is damaged or the lead from the external connection to the gate junction is damaged. In either case, an external control voltage applied to the gate lead will not turn the device on and no current will flow.

Another common failure is leakage. The leakage through the SCR or triac may be of a low level or it may be large enough to act like a direct short. A leaky, or shorted, SCR or triac causes loss of control of the device it is connected to. Typical symptoms of a shorted SCR or triac are incorrect voltages in a regulator circuit or a motor controller that allows the motor to run at full speed with little or no control of the speed.

The third failure occurs when a relatively small amount of current flows through the SCR or triac only when a high voltage is applied between the main leads. This leakage current may be small or it may be so large as to act like a direct short. Low voltage tests of such an SCR or triac will indicate that the device is good. Only when a high voltage is applied will the device fail.

Triacs also exhibit a fourth type of failure. This failure results when the triac becomes shorted in one direction only. This type of failure allows current to flow in one direction, even when the triac is turned off. In the off mode, the defective triac acts like a diode.

How a Z Meter and the SCR250 Dynamically Test SCRs and Traics

Any Sencore Z Meter, along with the SCR250 SCR and Traic Test Accessory, can be used to test SCRs and triacs. The Z Meter supplies a high voltage across the cathode and anode lead for an SCR, or across the MT1 and MT2 lead, for a triac. The high voltage checks for failures of the third type described earlier. The Z Meter supplies a high enough voltage to locate SCRs and triacs that leak or short only at their working voltage. In addition, the Z Meter's digital meter monitors the amount of current flow through the SCR or triac. This measures the leakage current and also tells you when the SCR or triac is conducting.

The SCR250 SCR and Triac Test Accessory provides a controlled gate voltage to the SCR or traic. The SCR250 allows you to safely apply the gate voltage to the device under test. It also supplies the correct voltage polarities to test triacs in quadrants 1 and 3.

Fig. 4: The SCR250 can be mounted on top of a Z Meter using Velcro strips supplied with the SCR250.

Preparing the Z Meter and SCR250 to Test SCRs and Triacs

The SCR250 SCR and Traic Test Accessory is an accessory to the Z Meters. It can be used with any Sencore Z Meter to safely test SCRs and triacs for proper turn-on and leakage.

First, connect the SCR250 up to the Z Meter. Velcro strips are provided if you want to secure the SCR250 to your Z Meter (Figure 4). If you are not using the Z Meter and SCR250 in portable applications, you can simply set the SCR250 to the side of the Z Meter.

Connect the cable, coming out the back of the SCR250, to the BNC connector on the front of the Z Meter. Check the condition of the battery on the SCR250 by pressing the PUSH FOR BATT TEST button on the front of the SCR250. The BATT OK light should light. If it does not light, replace the three AA batteries located in the battery compartment in the rear of the unit.

Next check the setting of the leakage range switch on the Z Meter. On the LC102 AUTO-Z, the leakage range is automatic and no setting is required. On all other Z Meters, a leakage range switch selects one of two leakage ranges. Set the LEAKAGE RANGE switch to the 10K uA range. If low leakage measurements are needed for critical thyristor applications, use the 100 uA range.

Now connect the SCR or triac to the test leads supplied with the SCR250. Figure 5 shows how to connect up the test leads in relation to the schematic designations of the SCR and triac. Each lead on the SCR250 is color coded and labeled for easy identification.

NOTE: Some stud mount SCRs have a large red cathode wire. Connect this cathode wire to the black cathode wire on the SCR250 test leads. These and other large SCRs and triacs also often have two small wires coming out the side of the case. The white wire is the gate lead and the red wire is the cathode potential wire. Disregard the small red wire when testing these SCRs and traics. Connect the blue gate lead from the SCR250 to the white gate lead on the SCR or triac (Figure 6).

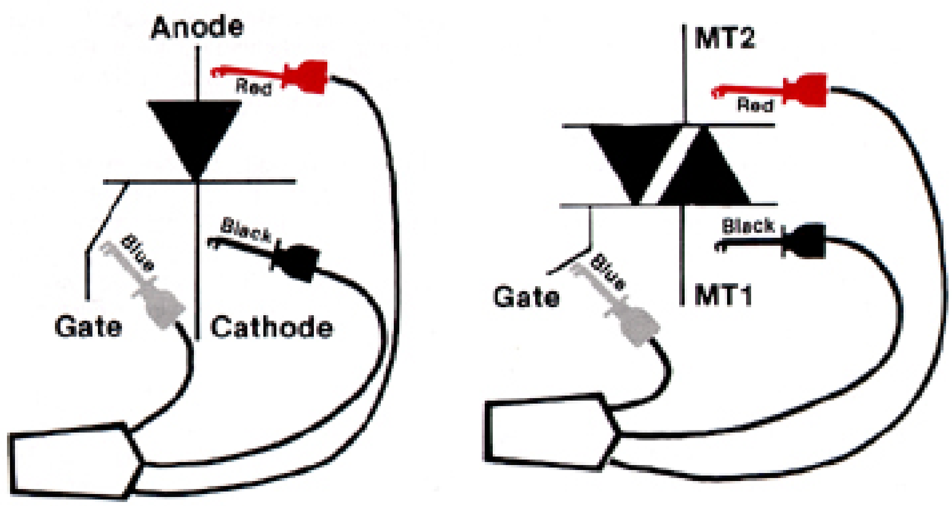

Fig. 5: Connect the SCR250 to the SCR or TRIAC using the convenient color coded and labeled connections on the SCR250 test leads.

How to Test SCRs

As we learned earlier, there are two types of SCR gates: sensitive gates and normal gates. The SCR250 provides a separate test for each type. If you know that the SCR you want to test is not a sensitive gate type, then press the NORMAL GATE SCR button. If you don't know what type of SCR you have, then press the SENSITIVE GATE SCR button. The SENSITIVE GATE test provides a lower gate current and this procedure ensures that an unknown sensitive gate SCR will not be damaged.

Next, set the Z Meter LEAKAGE VOLTAGE switch to the working voltage of the SCR. On the LC102 AUTO-Z, program in the working voltage on the keypad.

You are now ready to perform the SCR "turn-on" test. This tests the ability of the SCR to conduct when a controlled voltage is applied to the gate. First, press the GATE CURRENT button to the ON position. This applies the correct current to turn the SCR on. If the SENSITIVE GATE button was previously selected, a lower level gate current is supplied to the SCR.

Now, press the Z Meter LEAKAGE button. This applies the selected high voltage between the anode and cathode leads of the SCR. The Z Meter then measures the current flow through the SCR and displays the results on the digital readout. A good SCR will show flashing 888's on the Z Meter display.

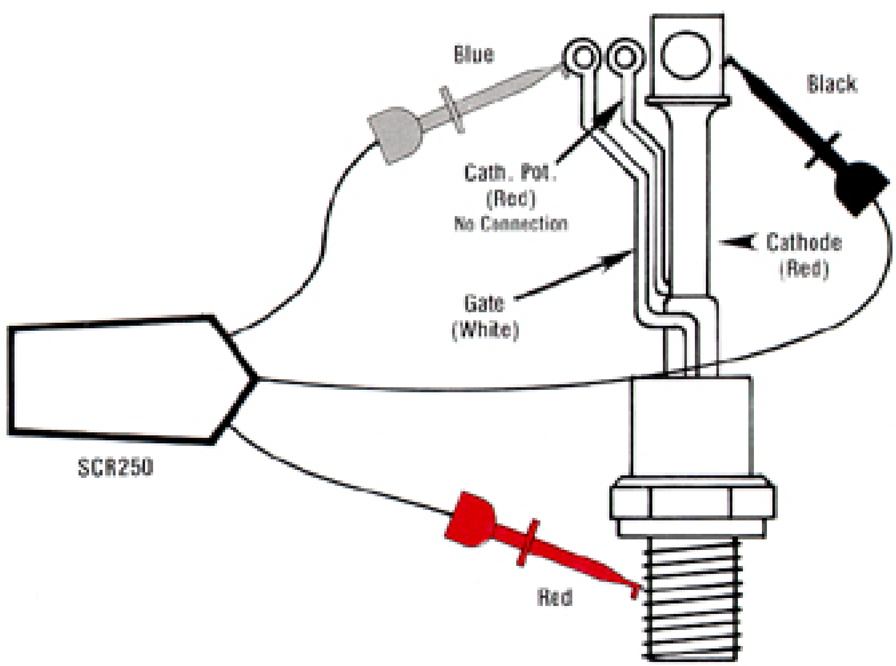

Fig. 6: Connect the SCR250 test leads up to large stud mount SCRs following the color coding shown here.

This indicates that the SCR is turned on and maximum current is flowing from the cathode to the anode. If flashing 888's are not obtained, the SCR has not turned on.

NOTE: If you have an unknown type SCR and previously selected the SENSITIVE GATE SCR button, press the NORMAL GATE SCR button and perform the "turn-on" test again. If you do not obtain a flashing 888 reading on the Z Meter, when the LEAKAGE button is pressed, the SCR is bad and should be replaced.

The final SCR test is the "Leakage" test. This measures any leakage current flowing through the SCR when it is turned off. The Z Meter applies the full working voltage to the SCR to check both for a shorted SCR and for leakage that occurs only when the SCR is at its rated voltage.

First, set the GATE CURRENT button to the OFF position. Next, press the Z Meter LEAKAGE button. The Z Meter digital display should show less than 10 microamps of leakage current. If the display reads more than 10 microamps, or it displays flashing 888, the SCR is leaky and should be replaced.

How to Test Triacs

The SCR250 and a Z Meter are designed to test triacs for proper turn-on and leakage in the quadrant 1 and 3 mode. Once you have connected the triac to the SCR250 test leads, press the POSITIVE GATE BIAS button. This prepares the triac to be tested in the quadrant 1 configuration.

Next, set the Z Meter LEAKAGE VOLTAGE switch to the working voltage of the traic. On the AUTO-Z, program in the working voltage on the keyboard entry.

You are now ready to perform the triac "turn-on" test. This tests the ability of the triac to be turned on when a controlled current is applied to the gate. First press the GATE CURRENT button to the ON position. This applies the gate current to the triac.

Next, press the Z Meter LEAKAGE button. This applies the working voltage between the MT1 and MT2 leads of the triac. The Z Meter then measures the current flow through the triac and displays the results on the digital readout. A good traic will show flashing 888 on the Z Meter display. This indicates that the triac is turned on and maximum current is flowing through the device. If flashing 888s are not obtained, the triac is not being turned on and is defective.

Next, do the "leakage" test. This shows if any leakage current will flow through the triac when it is turned off. The Z Meter applies the selected working voltage to the triac when it is turned off. The Z Meter applies the selected working voltage to the triac to check both for a shorted triac and for any leakage that could occur only when the traic is operated at its rated voltage.

Set the GATE CURRENT button to the OFF position. Next, press the Z Meter LEAKAGE button. The triac should show less than 10 microamps of leakage current. If more than 10 microamps of current is displayed on the Z meter display or you get a flashing 888 display, the triac is leaky and should be replaced.

The previous test checks the triac in the quadrant 1 mode. To check the triac in the quadrant 3 mode, press the NEGATIVE GATE BIAS button and repeat the "turn-on" and "leakage" test.

A Final Tip on Thermal SCRs and Triacs

Occasionally you may come across a thermal SCR or triac. If you suspect the device to be thermal, simply heat up the device using a heat gun. Leakage currents go up in these devices when they get warm. If a moderate amount of heat causes an overrange reading when the "leakage" test is being performed, suspect a thermal SCR or triac and replace it.

For more information,
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