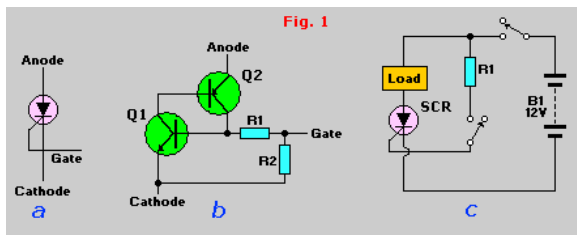


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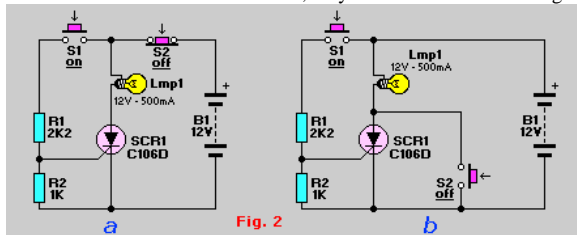
"SCR's and Triacs are high-speed, solid-state switches used in AC and DC power control applications. Find out how they work and practical applications for them."



What Exactly are Triacs or SCR's? They are similar and function similar. The difference is that triacs are usually involved with the ac side and scr's with the dc side. Triac circuits can be used to control line-voltage (AC) powered devices.

SCR's and Triacs are both members of the thyristor family. The SCR (**Silicon Control Rectifier**), is a four-layer (PNPN) sandwich of semiconductor material. Its symbol is shown in Fig. 1-a, and its equivalent circuit is shown in Fig. 1-b. The circuit is a complementary regenerative switch in which Q1's base current is derived from the collector Q2, whose base current is in turn derived from the collector of Q1. We'll discuss that regenerative action in much greater detail shortly.

Fig. 1-c show the basic circuit that lets you use the SCR as a switch in a DC power-control circuit. The circuit works as follows. When power is first applied to the SCR by closing S1, the SCR is "blocked" and appears as an open-circuit switch. That action can be understood by examining Fig. 1-b, where it can be seen that, because Q1's base is shorted to the cathode terminal via R1 and R2, Q1 is cut off through lack of base current. Therefore Q1 feeds no base current to Q2, so it is also cut off. Because both transistors are cut off, only a small amount of leakage current can flow between the anode and cathode terminals.



The SCR can be turned on (made to act like close switch or a forward-biased silicon rectifier) simply by applying a positive gate current. That can be done in the circuit shown in Figure 1-c simply by closing S2. The gate current thus applied causes the SCR to switch on very quickly.

If the externally applied gate current is sufficiently large, it will cause Q1 to start to turn on. As it does, its collector current feeds Q2's base, thereby causing Q2 to turn on and feed additional base current to Q1, and so on. The way in which the two transistors feed each other is called regenerative switching.

After the SCR turns on and is conducting significant forward current, the SCR stays on even if the gate drive is subsequently removed. Therefore, only a brief pulse of gate current will be needed to latch the SCR on. Note in Fig. 1-b that because of the presence of R1 and R2, the SCR cannot be

turned off by shorting and reverse-biasing the gate-cathode terminals of the device.

In fact, the only way of turning the SCR off is by momentarily reducing its anode current below a value known as the *minimum holding current* (I_H). So it follows that turn-off occurs automatically in a AC circuit near the zero-crossing point at the end of each half cycle.

A finite amount of internal capacitance exists between anode and gate of an SCR. Consequently, if a sharply rising voltage is applied to the anode, that internal capacitance can cause part of the rising voltage to break through the gate and thus trigger the SCR on. That "rate effect" turn-on can be caused by supply-line transients, and it sometime occurs at the moment when power is applied to the SCR's anode. Rate-effect problems can usually be overcome by wiring a simple RC "snubber" network between the anode and the cathode of an SCR; the network limits the rate-of-rise to a safe value.

Those are the basic characteristics of the SCR. As you can see, it's a fairly simple device. When choosing an SCR for a particular application, you'll usually find that the most-significant parameters are the peak voltage and current rating the gate sensitivity rating, and (occasionally) the value of the device's minimum holding-current. Table 1 lists basic specifications of several popular SCR's.

Device	PIV	Current rms / average	$V_{GT(max)}$	$I_{GT(max)}$	$I_H(max)$
C106D	400V	4A/2.5A	0.8V	0.2mA	3mA
2N3525	400V	5A/3.2A	2V	15mA	20mA
BT109	500V	6.5A/4A	2V	15mA	3mA
IR122A	100V	8A/5A	1.5V	25mA	30mA
IR122D	400V	8A/5A	1.5V	25mA	30mA
C116D	400V	8A/5A	1.5V	20mA	35mA
C128M	600V	12A/7.5A	1.5V	30mA	35mA

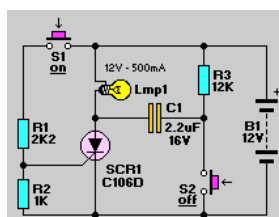


Fig. 3 - Capacitor turn-off: C1 charges via R3 so that its right side is positive. When S2 is closed, C1 dumps its charge into the SCR (which is oppositely polarized), thereby switching it off.

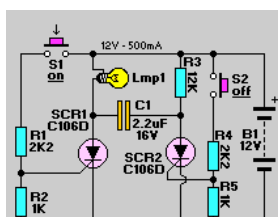


Fig. 4 - Another capacitor turn-off circuit uses a second SCR (SCR2) to control charge dumping by C1. Experiment with a lower value for R3.

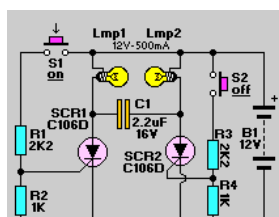


Fig. 5 - Same circuit as Figure 4, but with two lamps.

Basic DC Circuits:

SCR's are used in both AC and DC power-control circuits; let's look first at some basic DC circuits. Two ways of using the SCR as a pushbutton-controlling power-switch are shown in Figure 2. In both circuits, the SCR (and thereby the lamp) can be latched on by momentarily closing S1, thereby feeding gate drive to the SCR via R1. In both circuit the gate is tied to the cathode via R2 to improve stability of the circuit.

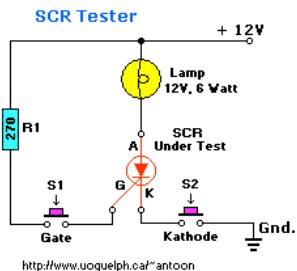
Of course, after the SCR turns on, it can be turned off again only by momentarily reducing anode current below the device's I_H value. In Fig. 2-a the SCR is turned off by momentarily opening S2; in Fig. 2-b is that done by using S2 to short the anode and cathode terminals of the SCR momentarily.

Figure 3 shows another way of turning the SCR off. Here, after the device turns on, C1 charges up to almost the full supply voltage via R3 and the anode of the SCR. When S2 is subsequently closed, it clamps the positive end of C1 to ground, and the charge on C1 forces the anode of the SCR to swing negative momentarily, thereby reverse-biasing the SCR and causing it to turn off. The capacitor's charge bleeds away rapidly, but it has to hold the SCR's anode negative for only a few microseconds to ensue turn-off. Note that C2 must be non-polarized type.

A variation of the capacitor turn-off circuit is shown Fig. 4. A slave SCR (SCR2) replaces the turn-off switch (S2) in Fig. 3. The master SCR (SCR1) is turned off by briefly turning on SCR2 via S2. The slave SCR turns off after S2 is released, because the anode current provided by R3 is lower than SCR2's holding current.

Testing an SCR:

This simple SCR tester can be made with only a couple components. It will provide a visual 'go' or 'no-go' indication on the cheap--it is simply a voltage source, a lamp, and a resistor through which gate current is supplied.



This handy tester will provide a visual "on" or "off" switching and latching indication. When finished, you can test all those possible 'duds' in your junkbox and dump some of those in the garbage. If the scr is latching and can hold the latch it is most likely okay.

Look at the circuit diagram, it shows a 3-amp, 50-volt SCR (under test) and a test circuit. Points "Gate" and "Kathode" are temporary connections, so that they can easily be opened. I used toggle switches for each, but use whatever you feel comfortable with, a simple jumper wire would do the trick. I use this gadget in my shop and so have it mounted in a small case. This circuit can even be bread-boarded for your purpose.

When "Kathode" is closed, the lamp doesn't light. When "Gate" is **also** closed, the lamp lights to its full intensity. The lamp remains lit even if "Gate" is opened again. But when "Kathode" is opened, even momentarily, the lamp does not close again when "Kathode" is closed. That illustrates the "ON" and "OFF" operation of the SCR.

I tested the following SCR types:

C106D1 (400V/4A)	T106Y1 (30V/4A)
C106F (50V/4A)	C106F1 (50V/4A)
C106B (200V/4A)	CSM2B2 (100V/4A)
T106D1 (400V/4A)	NTE5402 (100V/0.8A)
TIC106M (600V/8A)	NTE5457 (400V/4A)
TIC126M (600V/25A)	CR6AM-8 (400V/10A)
MCR106-3 (100V/4A)	NTE5455 (200V/4A)

In all cases the tester was accurate in telling 'good' from the 'bad'.

TRIACS:

I decided to experiment the tester on TRACS since they operate on the same principle. The pin-out of a Triac is usually MT1, MT2, and Gate. Hookup the probes as follows: The 'K' probe to 'MT1', the 'A' probe to 'MT2' and the 'G' probe to 'Gate'. I used a 9Volt and a 12Volt power-supply for bench testing purposes. Execute the tests the same way as a SCR. The lamp should only be on when the K switch is on and G switches on **momentarily**. In any other condition the lamp should remain off. If not, the Triac will almost certainly be defective. Keep the tests on any Triac as short as possible.

I tested the following Triacs with good results:

Q4006L4 (400V/8A)	- Tested Good (was new)
Q6006LT (600V/10A)	- Tested Defective (was defective)
Q6010L5 (600V/10A)	- Tested Good (was new)
L4004F31 (400V/4A)	- Tested Defective (was defective)
MAC15A (400V/15A)	- Tested Good (was new)
NTE5610 (800V/8A)	- Tested Good (was new)

Again, in all cases the tester was correct. I compared the results of the two defective Triacs with the results of a very expensive commercial SCR/Triac tester. On the commercial tester you can set the actual VRM (volt) of a Triac and check for leakage and what not but I found the end result the same; "is it good or bad" and is it "switching or not".

Suggested Reading:**Copyright and Credits:**

"Using Triacs and SCR's" by Ray Marston, *Radio Electronics Magazine*, September 1987.

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