SOLID-STATE RING COUNTERS AND CHASERS FOR LIGHT DISPLAYS

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Basic semiconductor circuits for incandescent light displays, warning and traffic lights, and illuminated advertising signs.

THIS article describes some basic semiconductor circuits for incandescent light displays, warning and traffic lights, and illuminated advertising signs. The SCR and the Triac are ideal for this type of application to switch heavy loads on and off. These solid-state switches have no contacts to bounce, stick, or wear out; they are economical, explosion-proof, and reliable.

Ring counters are used for display purposes where, out of a string of several lights, only one light (sometimes more) is kept on at any one time. There is, however, a continuous and sequential transfer from the light that is on to the next one. This can be visualized by imagining a sixty-stage ring counter where sixty lights are arranged in a circle, six degrees apart. In such a ring counter, if the trigger pulses are maintained one second or one minute apart, the movement of the light would correspond to the numeral to which the second or minute arm, respectively, points.

Chasers are similar to ring counters except that, once a light is turned on, it stays on until the rest of the lights are on, and then they all turn off and start with the first light again. In our imaginary clock, this type of operation would correspond to the hands "chasing" something, always beginning at one minute and losing it on the sixty-minute mark.

Ring Counters

A three-stage ring counter is shown in Fig. 1. More stages can be added to this circuit, as required, between the dotted lines. The components values as shown are for a load of 100 watts or less for each SCR. For heavier loads, diodes *D*1 through *D*4 would have to be changed to higher current diodes, such as the *G-E* A40B, and the value of the filter capacitor *C*1 and the commutating capacitors *C*2, *C*3, and *C*4 would have to be increased. The value of the commutating capacitors can be determined in the manner explained in the author's previous article on solid-state flashers (August issue).

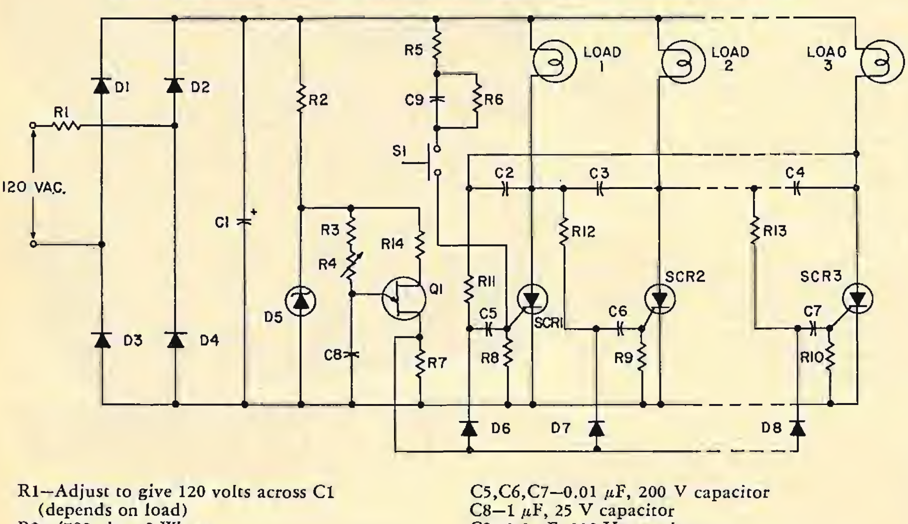
When power is first applied to the circuit, diodes *D*1-*D*4 and capacitor *C*1 supply 120 volts d.c. to the anodes of the SCR's through the loads, causing diodes *D*6, *D*7, and *D*8 to be reverse-biased. Out of this d.c. supply, zener diode *D*5 provides 18 volts to the free-running unijunction oscillator circuit. The trigger pulses from the UJT cannot turn any SCR on due to the reverse bias on the gate diodes.

To start the circuit, switch *S*1 must be closed momentarily to provide a pulse to the gate of *SCR*1 to turn it on. When *SCR*1 turns on, the reverse bias on *D*7 is removed and the next time the UJT supplies a pulse, *SCR*2 turns on causing *SCR*1 to turn off because of the commutating capacitor *C*3. Similarly, when *SCR*2 turns on, the reverse bias on *D*8 is removed and the next time the UJT fires, *SCR*3 turns on, causing *SCR*2 to turn off. Thus, every time a pulse appears at the common shift line, the power to the load transfers sequentially from one stage to the next, always in the same direction.

As the load of a ring counter is increased, the value of the commutating capacitors, (which incidentally are of the non-polarized type), the filter capacitor, and the current rating of the supply diodes must be increased. After a certain power output level, this circuit becomes impractical and uneconomical. If this is the case, a ring counter can be used to trigger Triacs much in the same way as described in the next section.

Fig. 2 shows a chaser circuit with three stages. Just like the circuit of Fig. 1, more stages may be added between the dotted lines. If in Fig. 1, the commutating capacitors were left out and some means were provided to turn all the SCR's off after *SCR*3 had been turned on, the circuit would function as a chaser.

Fig. 1. Ring counter in which each SCR is triggered in turn to operate its load.



R1—Adjust to give 120 volts across C1 (depends on load)
R2—4700 ohm, 2 W res.
R3—10,000 ohm, 1/2 W res.
R4—500,000 ohm linear pot
R5—100 ohm, 1/2 W res.
R6—1 megohm, 1/2 W res.
R7—47 ohm, 1/2 W res.
R8,R9,R10—1000 ohm, 1/2 W res.
R11,R12,R13,—33,000 ohm, 1/2 W res.
R14—330 ohm, 1/2 W res.
C1—100 μF, 200 V capacitor
C2,C3,C4—0.5 μF, 200 V capacitor
C5,C6,C7—0.01 μF, 200 V capacitor
C8—1 μF, 25 V capacitor
C9—0.1 μF, 200 V capacitor
D1,D2,D3,D4—A10B diode (G-E)
D5—Z4XL18 zener diode (G-E)
D6,D7,D8—A13F diode (G-E)
SCR1,SCR2,SCR3—Silicon controlled rectifier (G-E C20B)
Q1—2N2646 unijunction transistor (G-E)
Loads—100 W

Note: Additional stages may be inserted between dashed lines

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Chasers are primarily used in advertising signs where a string of lights is turned on sequentially to produce the effect of a "moving sign". Presently, this function is performed by a motor-driven cam, actuating heavy silver contacts, with its attendant drawbacks.

When power is turned on initially, all the SCR's will be in the "off" state. The free-running unijunction oscillator receives its power from the bridge rectifiers, *D*1-*D*4, and filter capacitor *C*1. At the end of the time delay, determined by the setting of *R*1, the UJT will fire and the pulse at base 1 will only turn on *SCR*1 (*D*5-*D*8 are reversed-biased). When the UJT fires again, *SCR*3 will turn on, thus firing Triac 1. The two new pulses will turn on *SCR*4 and *SCR*5, in that order, firing Triacs 2 and 3. The following pulse will fire *SCR*2 which will commutate off *SCR*1, *SCR*3, *SCR*4, and *SCR*5, removing the gate drive to all the Triacs. The next pulse will start the cycle again, turning *SCR*1 "on" and *SCR*2 "off."

With this arrangement, the "off" time takes two pulses; in other words, if the UJT pulses are spaced one second apart, the "off" time takes two seconds, whereas there is only one second between the time Triac 1 and Triac 2 come on. This is due to the additional stage introduced because of *SCR*2. Increasing the "off" time makes the function of the circuit more appealing to the eye. If this additional stage is not required, *SCR*1 and its associated components can be left out of the circuit to provide a starting pulse to *SCR*3. It will be noted that the circuit of Fig. 2 as shown can also be used as a 4-stage chaser by merely adding a 150-ohm resistor from the anode of *SCR*1 to the gate of another Triac. Under these conditions the "off" time will be reduced and the added Triac will turn on first, followed by Triacs 1, 2, and 3.

The circuit of Fig. 3 is an extension of the circuit shown in Fig. 2. In addition, it provides a separate timing adjustment for each stage of the chaser. Here, instead of Triacs, SCR's are used to drive the loads. When power is applied to the circuit, all the SCR's are in non-conducting state. *Q*1 starts timing and, at the end of the time delay set by *R*1, fires *SCR*4 which energizes the reed-switch coil.

The reed-switch contact then connects the d.c. supply to the remaining portion of the circuit and at the same time applies a d.c. drive to the gate of *SCR*1, turning it on. The closure of the reed contact starts *Q*2 timing which, at the end of its time delay, as set by *R*2, fires *SCR*6 which, in turn, fires *SCR*2. This sequential firing continues down the line until *Q*4 fires which causes *SCR*5 to turn on and

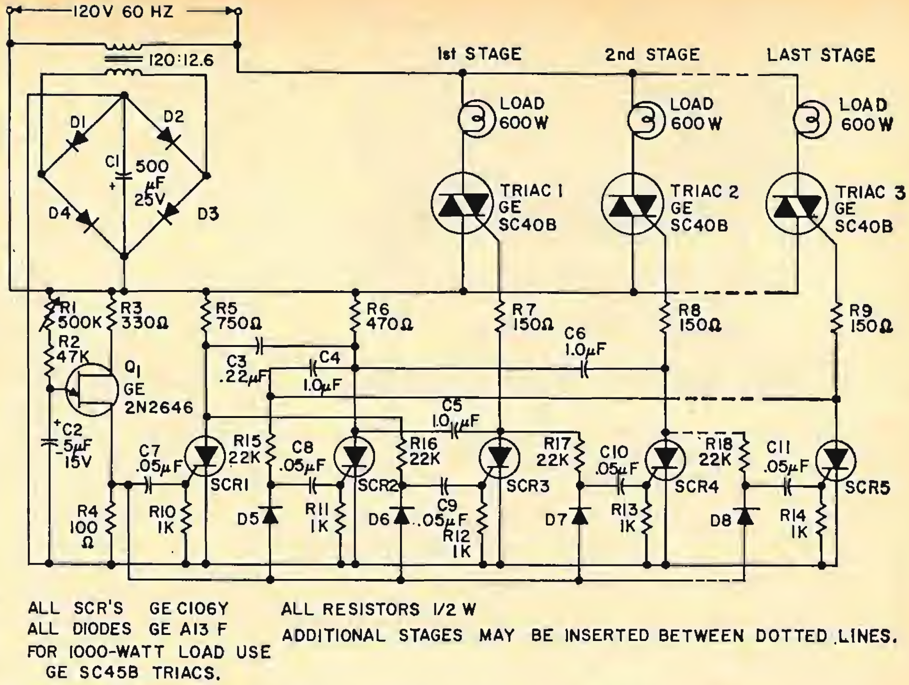
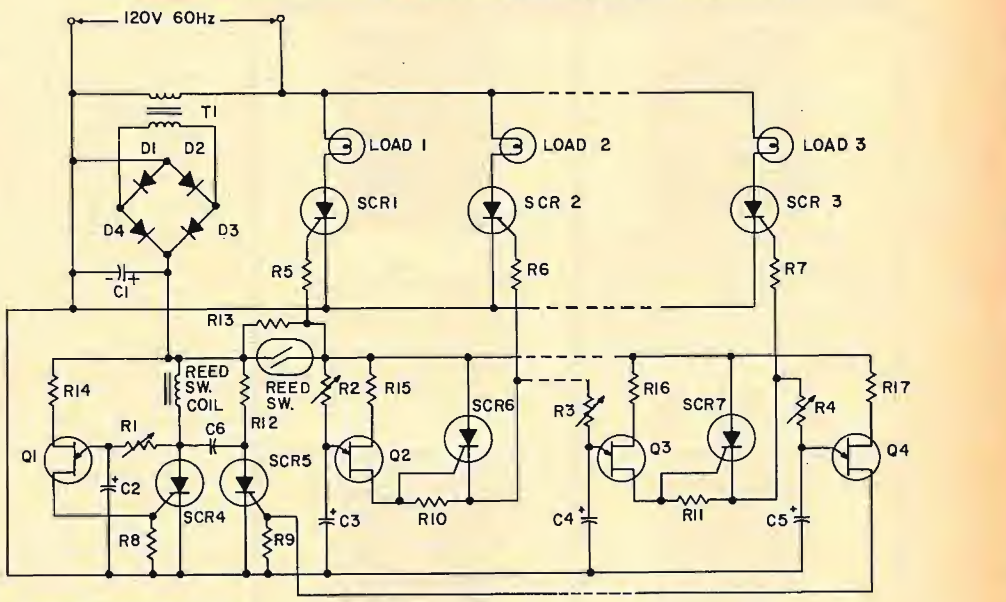


Fig. 2. A solid-state chaser circuit with only three stages is shown in diagram.

*SCR*4 to turn off. The reed-switch coil de-energizes causing all the SCR's (except *SCR*5) to turn off thus resetting the circuit. At the same time that *SCR*4 is turned off, *Q*1 starts timing and the cycle repeats.

The 1-megohm resistor (*R*13) across the reed-switch contact is to prevent *SCR*6 and *SCR*7 from triggering because of the rate of rise of voltage when the contact closes. The anodes of these two SCR's essentially see the d.c. supply voltage even when the reed switch opens but these SCR's turn off because the SCR current does go below the holding current level. It is interesting to note that the reed switch draws very little current (less than 20 mA per stage) and yet is capable of turning on and off several hundred watts of power. This, of course, is possible because of the capability of the semiconductor switches in turning on with a small signal at their gates. ▲

Fig. 3. A chaser circuit providing separate timing adjustment for each stage.



R1,R2,R3,R4—500,000 ohm pot
R5,R6,R7—750 ohm, ½ W res.
R8,R9—1000 ohm, ½ W res.
R10,R11—33 ohm, ½ W res.
R12—470 ohm, ½ W res.
R13—1 megohm, ½ W res.
R14,R15,R16,R17—330 ohm, ½ W res.
C1—500 µF, 25 V elec. capacitor
C2, C3, C4, C5—2 µF, 10 V elec. capacitor
C6—0.22µF, 100 V capacitor
Reed Sw.—Use G-E 2DR15 (1 amp) or G-E 2DR30 (3 amp)
Reed Sw. Coil—10,000 t. #39 wire (825 ohms)
D1, D2, D3, D4—A13A diode (G-E)
SCR1, SCR2, SCR3—C20B silicon controlled rectifier (G-E)
SCR4, SCR5, SCR6, SCR7—C106Y silicon controlled rectifier (G-E)
Q1, Q2, Q3, Q4—2N2646 unijunction transistor (G-E)
Loads—550 W each
Note: Additional stages may be inserted between dashed lines.