SOLID-STATE FLASHERS 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.

Flashers are widely used in traffic control, mostly as hazard warning signals where one or two lights alternately flash on and off at a predetermined rate.

A.C. Flasher

Most flashers available today have a motor-driven cam, actuating heavy silver contacts. The arc generated the instant the contacts open and close, the high in-rush current obtained by switching a tungsten lamp, and the mechanical wear of the contacts limit the operating life of this system.

The circuit of Fig. 1 illustrates a basic a.c. flasher with no moving parts. It is basically a free-running unijunction oscillator triggering a transistor flip-flop which, in turn, alternately fires two Triacs capable of handling 1-kW load each. If a single lamp output with only "on-off" performance rather than two alternately flashing lamps is desired, Triac 2 can be omitted, but the connection noted in Fig. 1 should be made.

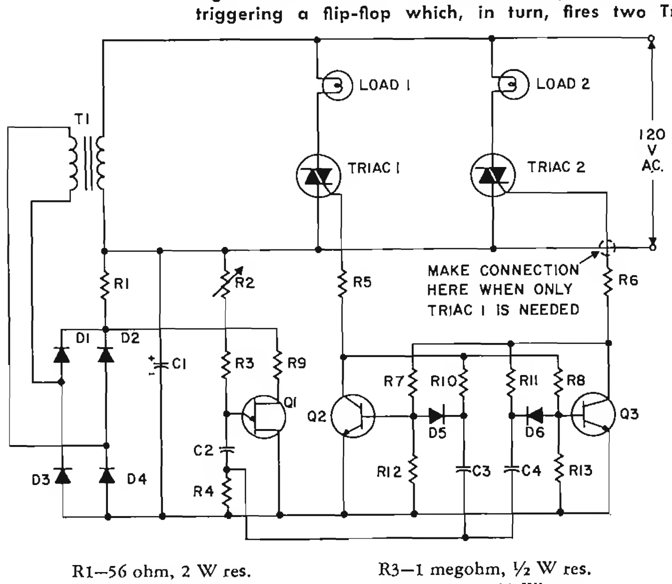
The operation of the circuit is as follows: transformer *T*1, diodes *D*1 through *D*4, resistor *R*1, and capacitor *C*1 provide the d.c. supply to the free-running unijunction oscillator *Q*1 and to the transistor flip-flop *Q*2,*Q*3. Because of the ripple on base 2 of unijunction *Q*1, *C*2 can reach the peak-point voltage of *Q*1 only at the beginning of the half cycles, thus firing *Q*1 early in the half cycle. The synchronization of the unijunction transistor minimizes the effect of radio-frequency interference. The frequency of oscillation of *Q*1 is determined by the actual setting of control *R*2.

Collector-gate resistors *R*5 and *R*6 form a divider network with *R*1, supplying about 6 volts d.c. to the flip-flop. Suppose initially *Q*2 is "on" and *Q*3 is "off." In this case, the collector of *Q*2 will be at a negative potential with respect to the gate and lower terminal (1) of Triac 1 while the collector of *Q*3 will be at the same potential as the gate and terminal 1 of Triac 2. The negative potential at the gate will cause electron current to flow out of the negative side of the d.c. supply, through transistor *Q*2 (from emitter to collector), *R*5, through the gate and terminal 1 of Triac 1 to the positive side of the d.c. supply. Current flow into the gate of Triac 1 will cause it to conduct, energizing load #1. Since the gate and terminal 1 of Triac 2 do not see a different potential, there will be no current flow to or from the gate and therefore Triac 2 will remain off.

The timing capacitor, *C*2, charges through *R*2 and *R*3 and when the voltage across it reaches the peak-point voltage of the unijunction transistor, *Q*1, it discharges, producing a negative-going pulse across resistor *R*4. A negative-going pulse at the junction of *C*3 and *C*4 will change the state of the flip-flop, turning *Q*2 "off" and *Q*3 "on," causing Triac 1 to stop conducting and Triac 2 to conduct. In this manner, the Triacs will turn on and off alternately every time the unijunction fires.

It should be noted that the on-time is equal to the off-time with the connection of the unijunction as shown in Fig. 1. This does not permit the variation of one of the timings without changing the other one as well. To obtain independent timing for the "on" and "off" functions, diode gating similar to the arrangement in Fig. 2 is necessary.

Fig. 1. An a.c. flasher circuit using unijunction oscillator triggering a flip-flop which, in turn, fires two Triacs.



R1—56 ohm, 2 W res.
R2—2 megohm trimmer
R3—1 megohm, ½ W res.
R4—100 ohm, ½ W res.
R5,R6—33 ohm, ½ W res.
R7,R8,R9—680 ohm, ½ W res.
R10,R11,R12,R13—10,000 ohm, ½ W res.
C1—500 μF, 25 V elec. capacitor
C2—2 μF, 200 V capacitor
C3,C4—0.05 μF, 200 V capacitor
D1,D2,D3,D4—A13F diode (G-E)
D5,D6—1N4009 diode (G-E)
T1—120:12.6 V stepdown trans.
Triac 1,Triac 2—G-E SC45B for 1 kW load; G-E SC40B for 600 W load
Q1—2N2646 unijunction transistor (G-E)
Q2,Q3—2N3416 transistor (G-E)

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Such a.c. flashers are quite popular when it comes to handling hundreds of watts of power. At lower power levels, or in some applications where there is no a.c. power available, such as automotive or portable flashers, d.c. flashers come in handy.

D.C. Flashers

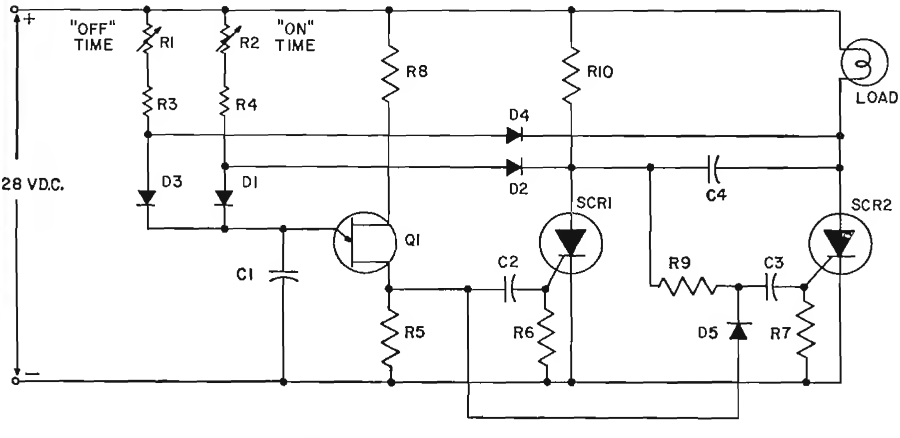
These d.c. flashers are nothing more than SCR flip-flops. Fig. 2 shows such a circuit with variable "on-off" adjustments. The arrangement of diodes *D*1 through *D*4 makes it possible to adjust both "on" and "off" times of the load independently. The circuit is a capacitor-commutated SCR flip-flop. The SCR's conduct alternately and are triggered by the pulses out of base 1 of unijunction *Q*1.

In this type of circuit it is important that at the start, when power is first applied to the circuit, some means be provided to ensure the triggering of only one SCR. The network of *R*9, *C*3, and *D*5 takes care of this situation. When power is applied, both SCR's are off. Because of the positive potential on the anode of *SCR*1, *R*9 will apply the same potential to the cathode of *D*5, thus reverse-biasing it. When a pulse appears at base 1 of *Q*1, only the gate of *SCR*1 will receive this pulse and only *SCR*1 will be turned on. Capacitor *C*4 will now charge through the load with positive on the side connected to the anode of *SCR*2 and nearly ground potential at the anode of *SCR*1. With *SCR*1 on, the bias on *D*5 is removed, and the junctions of *D*1 and *D*2 are clamped to nearly 1 volt because *D*2 is now forward-biased. Capacitor *C*1 now starts charging through *R*1, *R*3, and *D*3. At the end of the time-delay, which is adjusted by setting *R*1, the unijunction will produce another pulse, turning *SCR*2 on. This corresponds to connecting *C*4 across *SCR*1 so that it is momentarily reverse-biased. The momentary reversal of anode potential turns *SCR*1 off. With *SCR*2 on, diode *D*4 is forward-biased and therefore *C*1 starts charging through *R*2, *R*4, and *D*1. With this arrangement, the off time (*SCR*2 "off") is determined by the setting of *R*1 and the on time is determined by the setting of *R*2.

*SCR*2 should be selected so that the maximum load current is within its rating. Since *SCR*1 is used for commutating *SCR*2, it can have a lower rating than *SCR*2. It will be noted that the more current through the load, the larger the value of *C*4 would have to be. The minimum value of *C*4 can be determined from the formula $C4 \geq (1.5\ t_{off} I)/E$ where *C*4 is in μF, t_{off} is the turn-off time of the SCR (in μsec), *I* is the maximum load current (including possible overloads) in amperes at time of commutation, and *E* is the minimum d.c. supply voltage.

If the anode of *SCR*1 had a lamp in its circuit as a load, rather than *R*10, the circuit as shown would not function properly because when *SCR*1 is on, the trigger pulse is coupled to both gates and *SCR*1 would not have sufficient time to turn off due to the short time-constant involved. With the component values shown in Fig. 2, however, triggering *SCR*1 and *SCR*2 at the same time is not objectionable because the time-constant *R*10-*C*4 is much longer than the trigger pulse width, so that *SCR*1 remains reverse-biased long enough after the end of the trigger pulse to assure commutation of *SCR*1. To be able to drive equal loads in the anodes of the SCR's, the *SCR*1 gate in Fig. 2 would need a bias similar to *SCR*2 gate bias. If this is the case, some additional starting means would have to be incorporated in the circuit. ▲

Fig. 2. The d.c. flasher using SCR flip-flops along with variable time adjustments.



R1,R2—500,000 ohm linear pot
R3,R4—750,000 ohm, ½ W res.
R5—100 ohm, ½ W res.
R6,R7—1000 ohm, ½ W res.
R8—270 ohm, ½ W res.
R9—4700 ohm, ½ W res.
R10—250 ohm, 5 W res.
C1—0.47 μF, 50 V capacitor
C2,C3—0.22 μF, 50 V capacitor
C4—4 μF, 50 V non-polarized capacitor
SCR1,SCR2—Silicon controlled rectifier (G-E C106F)
D1,D2,D3,D4,D5—A13F diode (G-E)
Load—1.4 A lamp (G-E 50C)
Q1—2N2646 unijunction transistor (G-E)