A Multiple-Application Strobe Light

This ac-operated strobe light can be adapted to a variety of practical and fun applications with simple changes in circuitry

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Strobe lights can be used to good advantage in a wide variety of applications. Among these are as photoflash strobe lights in photography, taking multiple-position photographs of a person or object in motion, providing stimulating lighting effects in a discotheque, measuring the revolutions per minute of a rotating object, alerting one to danger, a deterrent to burglars and signaling an intrusion, to name just a few. The primary difference in usage of the basic strobe-light unit is in the manner in which it is triggered.

In this article, we will describe a basic strobe light unit that you can build for low cost. Our strobe light is ac-line operated to eliminate dependency on expensive batteries and simplify circuit design. We will describe a number of triggering options to permit you to adapt the project to specific applications as well.

Only low-cost and readily available components, including the xenon flashtube, are used in the project. You have the option of wiring the project on a home-fabricated printed-circuit board or mounting the components on perforated board and wiring them together using the point-to-point technique.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the circuitry used in the basic strobe unit. The power circuit is a voltage doubler consisting of rectifier diodes *D1* and *D2* and capacitors *C1*, *C2* and *C3*. This doubler circuit produces a potential of approximately 320 volts dc.

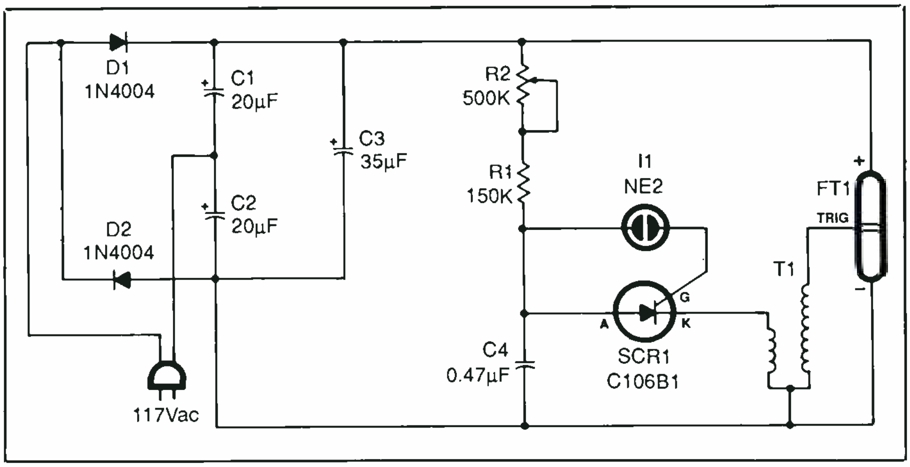

Fig. 1. Complete schematic diagram of the Multiple-Application Strobe Light circuitry.

On one half of the excursion of the ac line voltage applied to the power input to the project, current flows to *C1* and through *D1* to the other side of the ac line. The peak potential of 170 volts ac charges *C1* to a level of 165.44 volts. This level is based on the formula $E_{PEAK} = E_{rms} \times 1.414$. Plugging the figures into the equation, we obtain 117 volts rms × 1.414 = 165.44 volts peak.

During the second half of the ac line voltage excursion, current flows through *D2*, up from *C2* and back to the other side of the ac line. Capacitor *C2* now charges up to approximately 170 volts.

The charges on *C1* and *C2* arithmetically add to each other to yield an effective total of 340 volts. Capacitor *C3* smoothes the ripple to some degree, which results in an actual output voltage from the power source of approximately 320 volts dc.

Now the 320 volts dc is applied to the cathode and anode terminals of flashtube *FT1*. However, the flashtube does not instantly flash. To get it to do so, a trigger potential of about 4,000 volts must be applied to the trigger terminal of *FT1*.

The trigger potential is applied between the cathode and trigger terminal of the flashtube. When it is applied, the trigger voltage causes the xenon gas inside the flashtube to ion-

PARTS LIST

Semiconductors

D1,D2—1N4004 or similar silicon rectifier diode

SCR1—C106B1 (TO220 case) or Radio Shack Cat. No. 276-1662 or similar (TO92) silicon-controlled rectifier

Capacitors

C1,C2—16- to 20-μF, 200-volt electrolytic

C3—22- to 25-μF, 400-volt electrolytic

C4—0.47-μF, 200-volt Mylar or ceramic disc

Resistors

R1—150,000 ohms, ¼-watt, 10% tolerance (see text)

R2—500,000-ohm linear-taper panel-mount potentiometer

Miscellaneous

FT1—50-watt-second straight xenon flashtube/reflector/lens assembly

I1—NE-2 neon lamp

T1—Trigger transformer

Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; suitable enclosure (see text); spst slide or toggle switch, fuse holder and 1-ampere slow-blow fuse (optional—see text); pointer-type control knob for R2; ac line cord with plug; fast-setting epoxy cement or silicone adhesive (see text); ½-inch spacers (4); machine hardware; hookup wire; solder; etc.

Note: Flashtube assemblies and trigger transformers are available from: DC Electronics, P.O. Box 3203, Scottsdale, AZ 85271-3203.

ize and create a low-impedance path through which the charges on the capacitors can be instantly dumped to ground. In doing so, the ionized gas inside the flashtube produces a brilliant flash of light.

Resistor *R1*, potentiometer *R2* and capacitor *C4* make up an RC time-constant circuit that is controlled by *R2*. The potentiometer is connected here in the rheostat configuration. Increasing the resistance in the circuit by adjusting *R2* in the appropriate direction slows down the flash repetition rate, while decreasing the resistance speeds up the flash rate.

When *C4* begins to charge, it soon reaches the ignition potential for neon lamp *I1*. Then, when the neon gas inside *I1* ionizes, it creates a low-impedance path for the charge on *C4* to the gate of silicon-controlled rectifier *SCR1*. Thus, the charge on the capacitor discharges to ground through the SCR and primary of trigger transformer *T1*.

The brief discharge pulse through the primary of *T1* is inductively coupled into the secondary winding, where it is stepped up to about 4,000 volts and used to trigger the flashtube. When discharge of *C4* occurs, the capacitor begins to charge for the next triggering cycle. This action will repeat for as long as ac line power is applied to the project.

When operation of the circuit is as described above, the project serves as a free-running strobe flash with a flash rate governed by the setting of potentiometer *R2*. In this configuration, the circuit can be used as a device to signal for help or to warn of a possible hazard in the vicinity of the flashing light.

Figure 1 does not show a switch or fuse in series with the ac line cord. These are options you might wish to incorporate into your project. If you do decide to use them, the switch comes first and is followed by the fuse (use a 1-ampere slow-blow fuse here) between the upper conductor of the line cord and the point where it is shown connected to the junction between *D1* and *D2*.

Now that we have covered basic operation of the Multiple-Application Strobe light, let us briefly discuss some of the possible applications for the project:

• *Discotheque Lighting*. By adding a footswitch in series with *I1* in the basic circuit, as shown in Fig. 2(A), you can manually control the on/off flash for discotheque lighting. You can also use a foot-controlled rheostat in place of potentiometer *R2* to control the repetition rate of the flash as the circuit operates as a free-running strobe.

• *Position-Action Photography*. Another possible use for the basic strobe circuit is as a device for controlling position photography, like the dropping of a white ball in a dark room with the camera shutter open. For this application, set the strobe rate with *R2* to catch the ball in a series of positions as it falls and bounces.

With a little ingenuity, you can make a setup with a normally-open pushbutton switch, as shown in Fig. 2(B), to start the strobe automatically upon action impact. Fig. 2(C) illustrates switch closure upon impact.

• *Photoflash Strobe Slave*. A photoflash strobe slave for backlighting or highlighting in photography is yet another possible application for the basic strobe light. In this application, you use the flash from the camera to trigger the strobe light in the project. To set up the basic circuit for this application, you can modify the project by adding a light-activated silicon-controlled rectifier (LASCR) to trigger the strobe action.

To implement the LASCR modification illustrated in Fig. 2(D), replace the existing NE-2 lamp in the project with the LASCR. Be sure to place a shroud around the LASCR. A good choice for a shroud is a common plastic insulator "boot" from a small alligator clip. Trim the front end of the boot to permit the LASCR to force-fit into this end and use the narrow end through which a wire normally enters as the viewing orifice for the LASCR. Of course, you must point the LASCR toward the flash on the camera for proper circuit action to take place.

A photoresistive cell, shown in Fig. 2(E), also works well for this application, though it is a bit slower to respond. As with the LASCR, the photocell replaces the NE-2 lamp. It must similarly be shielded with a shroud as well.

• *Rpm Indicator*. The basic strobe

circuit operated in its free-running state can also be used as an indicator of revolutions per minute made by a rotating member. Strike a white chalk line on the rotating member. Start the member rotating and point the strobe at the member. Slowly adjust the setting of *R2* until you "freeze" the white chalk line (make it appear to be stationary). Then read the revolutions per minute pointed to by the knob on the potentiometer. Of course, this function is predicated upon an accurately calibrated series of markings on the panel behind the control knob.

In this application, the fastest repetition rate is determined by the value of *R1*. If you wish a higher flash rate than is possible with the basic project, reduce the value of *R1* to 100,000 ohms. With the 150,000 value specified for this resistor, you can measure the shaft rotation of 1,750 rpm of an ac-operated motor. Bear in mind, though, that the speed of an electric motor can vary by as much as ± 50 rpm. Hence, if the strobe is set for an rpm of exactly 1,750, the white mark will tend to drift slightly.

• *Intrusion Detector or Deterrent.* For this application, place a normally-closed spst switch in series with the NE-2 lamp in the basic circuit. Open the switch to place the free-running strobe light in its standby state. When an intrusion is detected by the closure of the switch, the strobe light will begin flashing. If it flashes inside the protected premises, the light serves as a warning to you that an intrusion is taking place. If it flashes outside the protected premises, the light will signal a potential intruder to the fact that his presence has been detected. Hopefully, he will then hightail it for safer pickings.

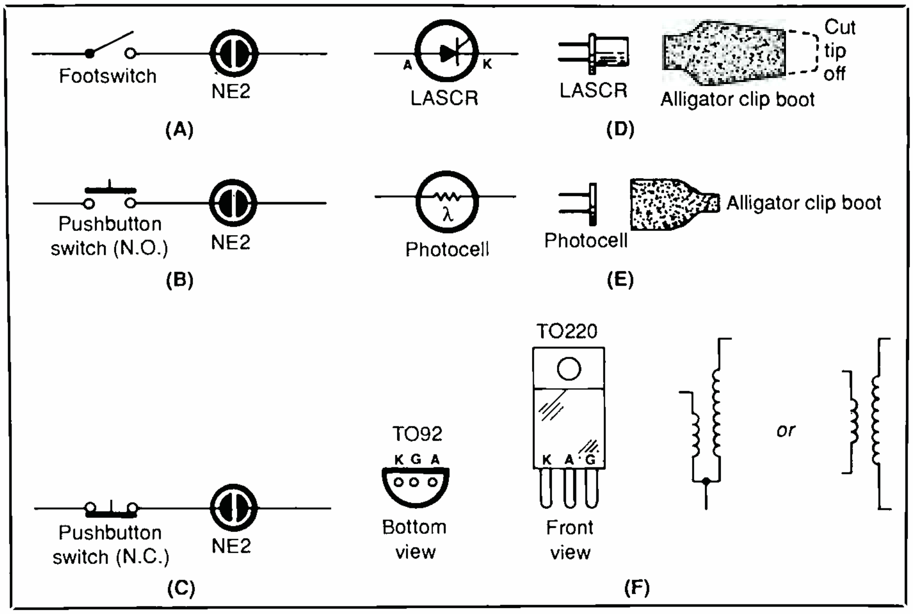

Fig. 2. Some simple changes that can be made to the basic strobe-light circuit to adapt it to specific applications: (A) a footswitch controller for discotheque applications; (B) switching arrangement for position action photography and (C) closed activated switch arrangement for same; and (D) and (E) photoflash strobe slave using a light-activated silicon-controlled rectifier (LASCR) and photoresistive cell. (F) shows the pinouts for the SCR in plastic TO92 and tab-mount TO220 packages and the two possible configurations for the trigger transformer.

Construction

The easiest way to build this project is to wire its circuitry on a printed-circuit board you fabricate yourself, using the actual-size etching-and-drilling guide shown in Fig. 3. Alternatively, you can replace the pc board with a perforated board and use suitable Wire Wrap or soldering hardware to permit interconnecting the components.

If you decide to use a pc board, it is a good idea to locate the capacitors before actually fabricating the board. Slight adjustments might have to be made in the spacing of the copper pads for each capacitor, depending on the physical sizes of the actual capacitors you will be using. Also, you may have to rearrange the pads for the SCR, depending on the type of package in which the one you use is housed. Additionally, after etching and drilling the pc board, drill a hole near each corner away from any copper traces to facilitate mounting the wired board inside an enclosure.

As you can see in Fig. 1, this is a very simple circuit. Wiring of the printed-circuit board is very easy. The only thing you must keep firmly in mind is that the diodes and electrolytic capacitors must be properly oriented and the SCR must be properly based before soldering their leads or pins to the copper pads on the bottom of the board. Note in Fig. 2(F) that you can use an SCR that comes in either a miniature TO92 plastic package or a metal-tab-mount TO220 package. Depending upon which you use, you must follow the appropriate pinout, which is different for the two package styles.

Begin wiring the board by installing and soldering into place the rectifier diodes in the orientations shown in Fig. 4. Then install and solder into place fixed resistor *R1*, followed by the capacitors (observe orientation for *C1*, *C2* and *C3*. Then install and solder into place the SCR (observe basing) and neon lamp.

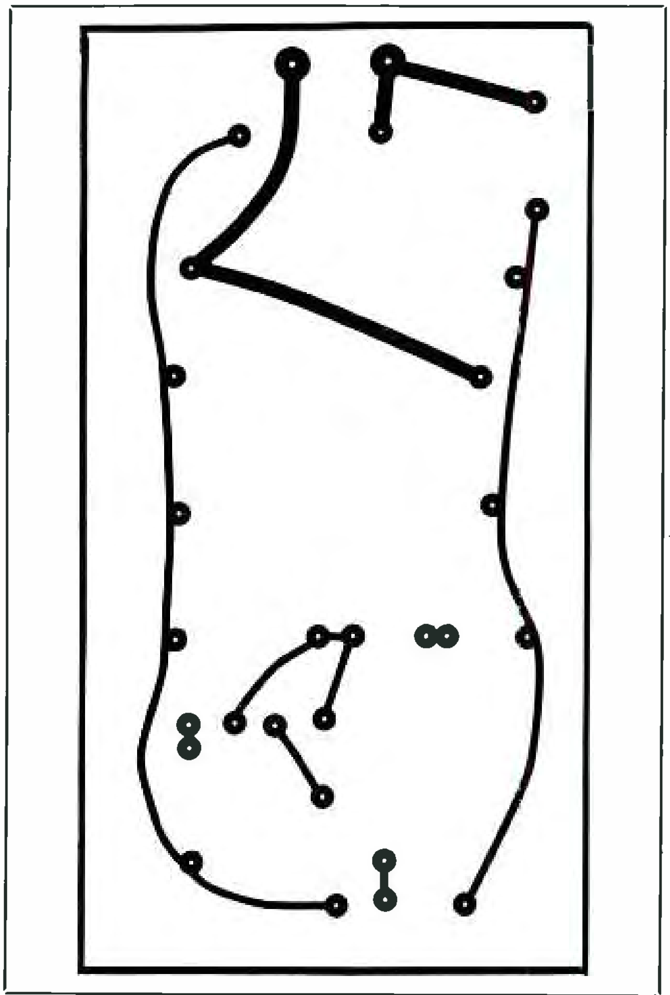

Fig. 3. Actual-size etching guide for pc board.

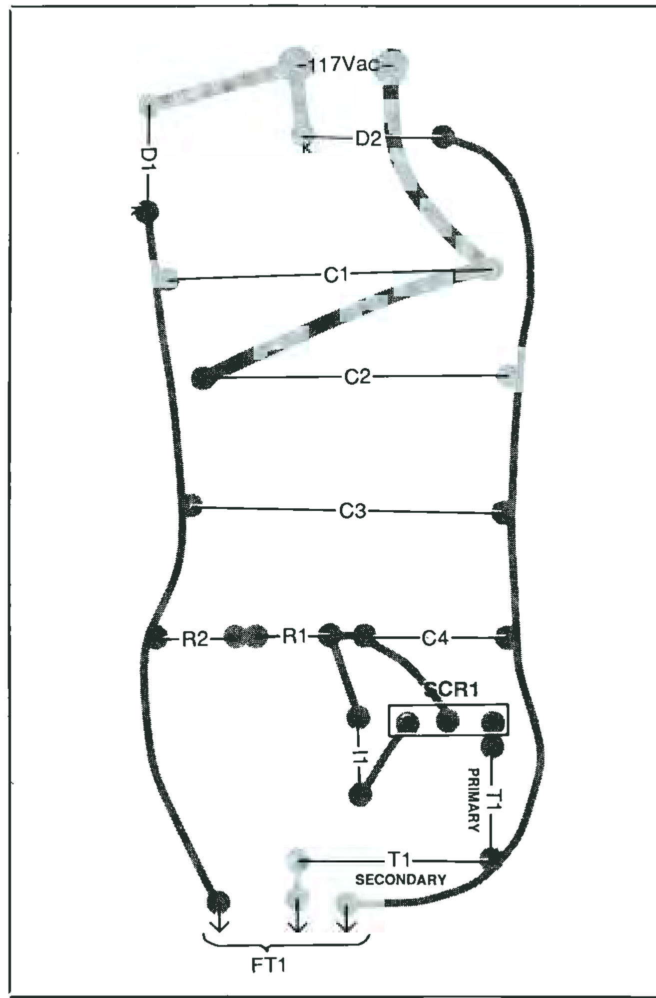

Fig. 4. Wiring diagram for printed-circuit board.

Now install and solder into place the trigger transformer. This transformer can have primary and secondary windings that are electrically isolated from each other or that share a common line at one end, as illustrated at the right in Fig. 2(F). Neither is preferable from an operating point of view, though the common-line configuration makes installation of this component a bit easier. This version simply plugs into the T1 holes in the board (make sure the installation is correct) and solders into place.

If your transformer has four separate leads, twist together the lower primary and secondary winding leads and treat the two as one. If necessary, slightly enlarge the appropriate pad hole to accommodate both leads.

As you can readily see in Fig. 4, the flashtube in its reflector/lens assembly mounts off the board. Before you attempt to wire the flashtube into the circuit, make sure you clearly identify its anode, cathode and trigger leads. Place a piece of tape on each lead and label it accordingly. Do not wire the flashtube into the circuit-board assembly until after the former is mounted in the selected enclosure.

You can house the project in any enclosure that will accommodate the circuit-board assembly, flashtube assembly and potentiometer control without crowding and the fuse holder and switch if you decide to use these. The chosen enclosure can be plastic, metal or a mixture of the two. Machine it as needed. That is, drill mounting holes for the circuit-board assembly, the potentiometer, switch and fuse holder and an entry hole for the ac line cord. Also, make the cutout in which the flashtube assembly will mount.

If you use a metal enclosure or machine any metal portion of your selected enclosure, deburr all holes and the flashtube cutout to remove sharp edges and line the entry hole for the line cord with a small rubber grommet.

Mount the flashtube assembly in

its cutout, using either a fast-setting clear epoxy cement or silicone adhesive. Allow the cement or adhesive to fully cure before attempting further work on the flashtube assembly.

Meanwhile, feed the free end of the ac line cord into the enclosure through its hole and tie a strain-relieving knot in it about 5 inches from the end inside the enclosure. Tightly twist together the fine wires in both conductors and sparingly tin with solder.

If you are using the optional switch and fuse, mount the switch and fuse holder via their respective holes. Strip ¼ inch of insulation from both ends of two 3-inch long hookup wires and prepare the exposed ends as detailed above if you are using stranded hookup wire. Crimp and solder one line cord conductor to either lug of the switch. Then crimp and solder opposite ends of one wire to the other lug of the switch and one lug of the fuse holder. Plug one end of the remaining wire into the hole in the circuit-board assembly that connects to the trace that goes to the anode of *D1* and cathode of *D2* and solder it into place.

If you are not using the optional switch and fuse holder, simply plug the free ends of the ac line cord into the holes labeled 117 VAC on the board in Fig. 4 and solder into place.

Mount the potentiometer in the hole you drilled for it and place on its shaft a pointer-type control knob. Then loosely mount the circuit-board assembly into place inside the enclosure using ½-inch spacers and 4-40 × ¾-inch machine screws, nuts and lockwashers. Crimp and solder the free end of the wire from which ¼ inch of insulation was removed to either outer lug of the potentiometer. Thread the free end of the other wire through the other outer lug and crimp it to the center lug of the potentiometer. Solder the connections at both lugs.

Strip ¼ inch of insulation from both ends of two 4-inch-long hookup wires. Then strip an additional ⅜ inch of insulation from one end of one of these wires. If you are using stranded hookup wire, tightly twist together the fine conductors at all wire ends and sparingly tin with solder. Plug one end of these wires into the holes labeled R2 and solder into place. Use ends from which only ¼ inch of insulation was removed, and locate the wire from which the additional amount of insulation was removed in the hole nearer the edge of the board.

You will now perform a voltage check on the circuit prior to connecting the leads from the flashtube assembly to the circuit-board assembly. Before you do, however, it is imperative that you understand that you will be dealing with potentially lethal ac line voltage and high dc voltages. Exercise extreme caution when working on the powered circuit.

With the foregoing admonition firmly in mind, connect the common lead of a dc voltmeter or multimeter set to the dc-volts function to a convenient circuit ground point, such as the negative (−) lead of *C3*. Connect the "hot" lead of the meter to the positive (+) lead of *C3*, and set the meter to a range that permits safe measurement of at least 250 volts dc and turn on the meter.

Place a 1-ampere slow-blow fuse in the fuse holder if you are using the fuse and plug the line cord from the project into an ac receptacle. Flip the switch to "on" and observe the display of the meter. If you wired the circuit properly, you should obtain a reading of approximately +230 volts.

If you do not obtain the appropriate meter reading, power down the circuit and rectify the problem before proceeding. Make sure all connections have been soldered on the bottom of the board. Check to make sure that the rectifier diodes and electrolytic capacitors are properly polarized.

When you are certain that the project has been properly wired, disconnect line power from it and allow the charges to bleed off the electrolytic capacitors. Then dismount the circuit-board assembly from the enclosure. Plug the free ends of the wires coming from the flashtube assembly into the appropriate holes in the board and solder them into place. Remount the circuit-board assembly, and assemble the enclosure.

Plug the line cord into an ac outlet and observe project operation. Do *not* look directly into the flashtube as the project is operating. Rather, face the flashtube away from your line of sight. Slowly adjust the setting of the potentiometer from one extreme to the other and observe that the flash rate changes with different settings. If it does, the project is complete and you can put it into service.

If you built the project to permit you to make measurements of rpm, you will have to calibrate the pointer range for the knob on the potentiometer control. To do this, you will need a tachometer of known accuracy and a motor whose speed can be varied over the entire range of the project.

Start the motor running at a low speed and use the reference tachometer to take an rpm reading. Adjust the speed of the motor and the strobe rate of the tachometer for a reference rpm of, say, 100. Then, without changing the speed of the motor, freeze the white reference mark on its shaft with bursts of lights from the project. Make a pencil mark on the panel at the position the index on the potentiometer's knob points and write in the rpm figure obtained with the reference tachometer. Do this for a sufficient number of motor speeds in multiples of 100 yield a useful range of indexes on the panel behind the project's control knob for the entire range of the potentiometer.

If you plan to use the project in an application other than as a variable-flash-rate free-running strobe, as described above, make whatever changes are required at this time. **ME**