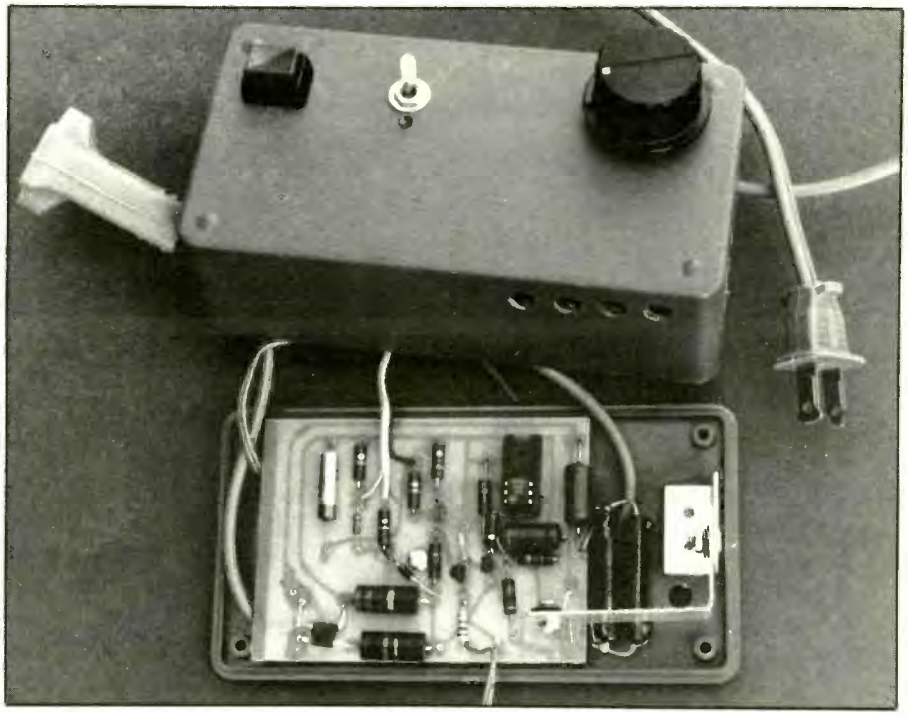
A Solid-State Light Dissolver

Controller smoothly dims or brightens lights automatically with the flip of a switch

By Imre Gorgenyi*



Light controllers are always popular projects not only because they are practical projects, but also because they are fun to use imaginatively. A good light controller, like the Solid-State Light Dissolver described here, will smoothly dim or brighten lights with the flip of a switch. In addition to automatic, flicker-free fade-in or fade-out of lights, the Light Dissolver provides full manual control and an instant-on feature. Also, you can tailor its circuit to suit specific needs simply by changing the value of resistors.

As designed, the Light Dissolver can handle up to 300 watts of lighting (resistive, or incandescent) or a small ac motor, such as a fan. To provide maximum safety and assure long operating life, the project must be housed inside a plastic—not metal—box with adequate ventilation.

Uses

By now, you probably have a good idea of some of the uses to which the Light Dissolver can be put. Here are a representative few:

•You can permanently wire a Light Dissolver for simple fade-in/out of lighting in any room.

•A very practical application is to use a Light Dissolver to slowly fade out lights when you leave your home, garage, workshop, etc. You will never trip over unseen obstacles in the dark again. For this application, use a 2- to 5-minute fade-out.

•Another application is to have adjustable background lighting for viewing TV, working at a computer video terminal, or setting a "mood." Once the desired level is manually set, flip the switch to on and the light will come up to the preset level.

•You can also use the Light Dissolver as a speed controller for a small dc motor. The motor's speed will come up slowly, instead of abruptly the way it does with HIGH/MEDIUM/LOW fan switches.

•Being more imaginative, you can use two Light Dissolvers with two slide projectors to give really professional presentations. Connect a Light Dissolver to each projector and set one Dissolver for fade-out, the other for fade-in. A 1- or 2-second period for the fade-in and fade-out

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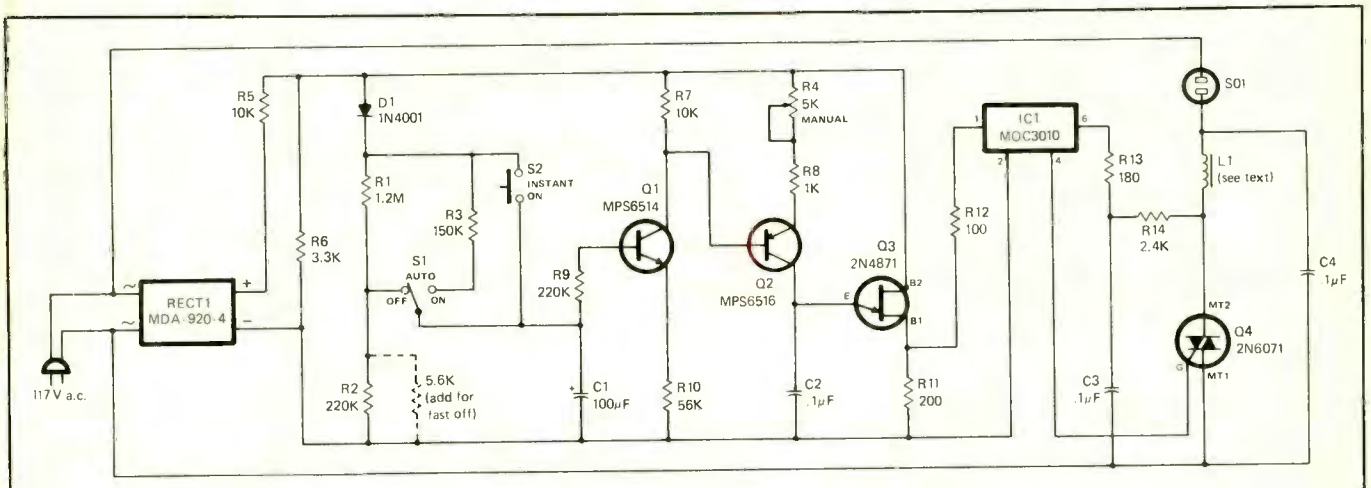

PARTS LIST

Semiconductors

D1—1N4001 rectifier diode
IC1—MOC3010 triac driver (Motorola)
Q1—MPS3904 or MPS6514 npn transistor (Motorola)
Q2—MPS3906 or MPS6516 pnp transistor (Motorola)
Q3—2N4871 unijunction transistor
Q4—2N6071B (200-volt, 4-ampere) or MAC222-4 (Motorola) triac
RECT1—MDA-920-4 bridge rectifier (Motorola)

Capacitors

C1—100-μF, 25-volt electrolytic
C2—0.1-μF, 50-volt disc
C3,C4—0.1-μF, 200-volt disc

Resistors (½- or ¼-watt, 10%)

R1—2.2 megohms
R2,R9—220,000 ohms
R3—150,000 ohms
R7—10,000 ohms
R8—1000 ohms
R10—56,000 ohms
R11—200 ohms
R12—100 ohms
R13—180 ohms
R14—2400 ohms
R5—10,000 ohms, 2 watts
R6—3300 ohms, 2 watts
R4—5000-ohm potentiometer

Miscellaneous

L1—Coil; two in parallel—see text (Radio Shack No. 273-102 or similar)
S1—Dpst slide or toggle switch
S2—Normally-open, momentary-action pushbutton switch
SO1—Ac receptacle (see text)

Printed-circuit board or perforated board and push-in solder terminals; socket for IC1 (optional); heat sink for Q4 (see text); control knob for R4; suitable enclosure (Radio Shack No. 270-223 or similar); 1"×½" bracket; ¼" spacer; silicone heat-transfer paste; ac line cord or extension cord (see text); machine hardware; hookup wire; solder; etc.

Fig. 1. This is the overall schematic diagram of the Light Dissolver. Note that the common lines for the ac line and control circuits must be kept isolated. This task is accomplished with opto-isolating triac driver IC1.

periods is best. In operation, have the fade-in projector start its action about midway through the fade-out projector's period. This will momentarily superimpose the frame from the two projectors on the screen and eliminate the annoying blackout on the screen between slide changes.

•If you have only one slide projector, you can still spice up your presentations with a Light Dissolver. Just have the Dissolver control a 150-watt lamp directed at the screen to cast a colored light between slides. When you advance the projector, simultaneously push the instant-on button on the Dissolver. (Use the Dissolver's manual control to set the desired light level.)

Many other applications for the Light Dissolver should come to mind. We have presented here just a few ideas to get you started.

About the Circuit

Shown in Fig. 1 is the overall schematic diagram of the Dissolver. Dimming action is controlled by varying the amount of current passed through triac *Q4* and, thus, the lamp plugged into ac receptacle *SO1*. The triac is a solid-state device that can be triggered into conduction in both directions by a low-level, short pulse applied to its gate (G). It can be shut off only by removing the voltage at main terminal 1 or main terminal 2 (MT1 or MT2). Since the ac line voltage passes through zero (effectively removing the voltage) 120 times every second, there is no need for a manual device, such as a switch, to interrupt the voltage. This being the case, we only have to add to our circuit the elements required to turn on the triac.

Since the voltage on the ac line passes through zero every half cycle, the duration of the current going through the load at *SO1* depends on just where in the cycle *Q4* is triggered

into conduction. Early triggering produces bright light, while late triggering allows the lamp to shine less bright. The task of triggering *Q4* into conduction at the desired point in the cycle falls to the circuit made up of bipolar transistors *Q1* and *Q2* and unijunction transistor *Q3*.

Unijunction transistor *Q3* operates as a relaxation oscillator whose output pulse frequency depends on how fast capacitor *C2* recharges after firing. Transistors *Q1* and *Q2* furnish the charging current, with the *R3/C1* and *R1/R2/C1* time-constant networks controlling the turn-on and turn-off times.

You can tailor the circuit to your specific needs in either or both of two ways. If you want the lamp to turn on faster, simply change the value of *R3*, either by using a lower-value resistor or by paralleling the 150,000-ohm resistor with another resistor. Similarly, if you want a faster turn-off, you can do the same with *R2*.

There are two common lines in this circuit. One is connected to the negative (−) side of rectifier assembly *RECT1* and serves the control circuitry. The other is connected to the ac power line and serves as the return path for the load current. It is essential that these lines be kept isolated from each other. While you can use a power or small pulse transformer to provide isolation, an opto-coupled triac driver, shown in Fig. 1 as *IC1*, offers a neater solution.

Inside *IC1* are a light-emitting diode (LED), a detector and a small triac. In the Fig. 1 circuit, the low-level pulses coming from *Q3* make the LED in *IC1* emit short bursts of light that are picked up and converted into electrical current pulses by the internal detector. This small current triggers the internal triac, which then outputs pulses to the gate of power triac *Q4*, triggering it on so that it delivers current to the lamp.

Potentiometer *R4* serves as a master control of the pulse rate and provides both manual control and a limit in the brightness of the lamp plugged into *SO1*. Momentarily pressing *S2* causes the lamp to instantly turn on.

Choke *L1* suppresses any spikes produced by the power triac and limits its interference with AM radio reception. No safeguards against interference need be made for FM and TV reception, since these media are immune to this type of noise.

Construction

This is a relatively simple circuit to build and, thus, lends itself to just about any wiring technique. If you wish, you can fabricate a printed-circuit board for the project, using the

Fig. 2. Use the actual-size etching-and-drilling guide at the left to fabricate a printed-circuit board for the project. Then mount all components (except R4, S1, S2 and SO1) exactly as detailed in the diagram shown at the right.

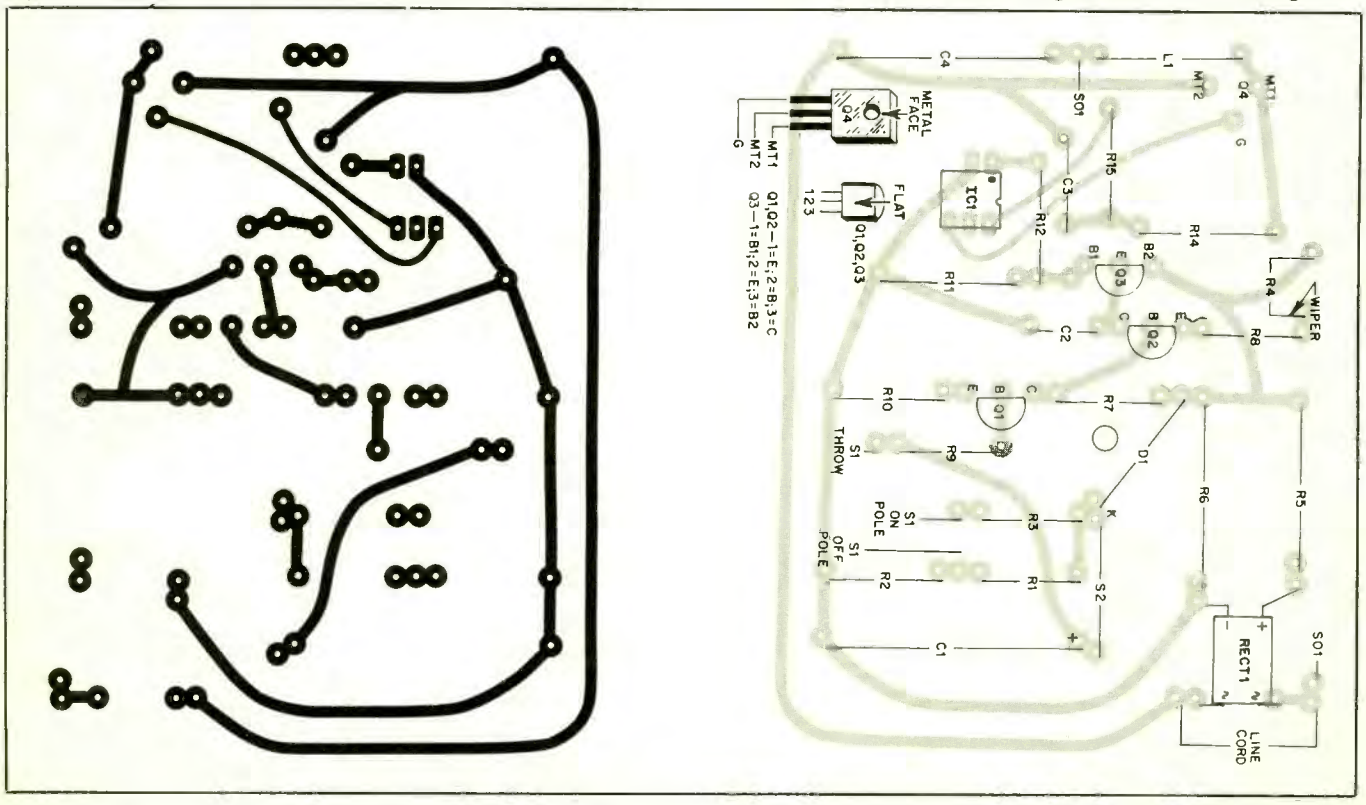

Fig. 3. Note in this close-up view how two chokes are wired in parallel for L1 and the L-bracket heat sink used for Q4 (upper-left), use of a 16-pin socket for IC1 (lower-left), and single screw that mounts the board on the box (center).

actual-size etching and drilling guide shown in Fig. 2. If you do use the pc-board approach and decide to use a socket for *IC1*, be sure to drill a small hole for pin 3 of the socket. (You will not be able to find a six-pin socket in any of the catalogs or electronics parts stores. So you will either have to use a 14- or 16-pin socket carefully trimmed to size or two strips of three Molex Soldercons.) If you forego using a socket, you can simply clip off pin 3 of *IC1* and eliminate the need for an extra hole in the board.

Mount the components on the pc board exactly as shown in the components-placement diagram in Fig. 2, making sure that the leads of the transistors go into the proper holes (see the detail drawings at the lower-left of the components-placement diagram). Note also the orientations of *D1*, *C1* and *RECT1*.

Choke *L1* consists of two 100-μH r-f coils. Place the two chokes side by side and wrap a couple of turns of the leads of one around the leads of the other so that the chokes are in parallel. Solder the connections and clip off the excess lengths from the twisted leads. Then bend the unclipped leads and install the choke pair on the board via the *L1* holes (see Fig. 3 for mounting details).

Mount the transistor about ¼" and the *Q4* triac about ⅜" above the top surface of the board. Make sure the rear (metal) face of *Q4* is oriented away from *L1* and parallels the long edge of the board.

Prepare seven 6" lengths of hookup wire by stripping ¼" of insulation from each end. Plug one end of these wires into the holes labeled *R4, S1* and *S2*. The other ends of these wires will be connected later.

You have two choices with regard to the ac receptacle into which the lamp load plugs. One is to use a chassis-mount receptacle and run lamp cord between it and the appropriate points on the board; the other is to use a cut-off section of extension cord that enters the cabinet through a side wall (see lead photo). The latter is easier and has the advantage of providing you with an essentially no-cost ac line cord.

Disassemble the box in which the project is to be housed and temporarily set aside the top panel. Machine the box as follows. First, drill three or four ¼" holes through the long wall at the lower-right corner and two more holes through the short wall adjacent to where the first set of holes are drilled. These serve as a vent for heat in the area occupied by triac *Q4* when the project is assembled. Drill the hole for the line cord through the long wall opposite that in which the vent holes are drilled. If you use the latter type of receptacle discussed above, drill a second hole in this wall to permit its cord to enter the box and connect to the board.

Off-the-board components *R4, S1* and *S2* mount on what was originally intended as the bottom of the box. Drill the mounting holes for these components, locating them where there will be no interference with the components on the pc board. If you have decided to use a chassis-mount ac receptacle, machine a slot in which it will mount on the blank short wall. Mount the components in their various locations, and place a control knob on *R4*'s shaft.

Turn over the box and place the pc-board assembly alongside it and, referring back to Fig. 1, connect and solder the free ends of the hookup wires to the appropriate lugs on *R4, S1* and *S2*.

If you are using the chassis-mount ac receptacle, clip 6" from the free end of the line cord and separate the two conductors thus obtained. Strip ¼" of insulation from both ends of both conductors. Tightly twist together the fine wires and sparingly tin with solder. Then plug one end of each wire into the holes on the board labeled *SO1* and solder. Connect and solder the free ends of these wires to the lugs of *SO1*. Prepare the free ends of the conductors of the remaining

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length of line cord. Pass this cord through its entry hole in the box and tie a knot in it about 6″ from the prepared end. Solder the conductors to the LINE CORD pads.

If you have decided to use the extension cord instead of the chassis-mount ac receptacle, cut it apart about 12″ from the socket end and prepare all conductors at the cut ends. Pass the free ends of both pieces through their respective holes in the box and tie a knot about 6″ from the prepared ends of both. Connect and solder the conductors to the appropriate *SO1* and LINE CORD pads on the pc board.

Retrieve the lid of the box and determine where to drill the mounting hole for the pc board. Drill this hole and then mount the board in place using a ¼″ spacer and 6-32 × ½″ machine hardware.

Bend a 4″ × ½″ strip of $\frac{1}{16}$″-thick aluminum into an L shape, locating the bend 1½″ from one end of the strip. Drill a ⅛″ hole centered and ⅜″ in from the ends of each leg. Spread some heat-transfer silicone paste over the metal face of *Q4* and mount the L-bracket heatsink to the triac (use the long leg of the bracket) with machine hardware. Loosely mount a 1″ by ½″ L bracket on the other end of the heat sink, facing its free leg in toward the pc board. Mark the mounting hole on the box lid.

Remove the L bracket from the heat sink and carefully drill a hole through the marked location. Mount the L bracket via its short leg to the box lid with machine hardware. Then secure the bracket to the heat sink with machine hardware. This done, mount the lid on the box and affix four rubber feet to it near the securing screws. The project is now ready to be put into service. **ME**