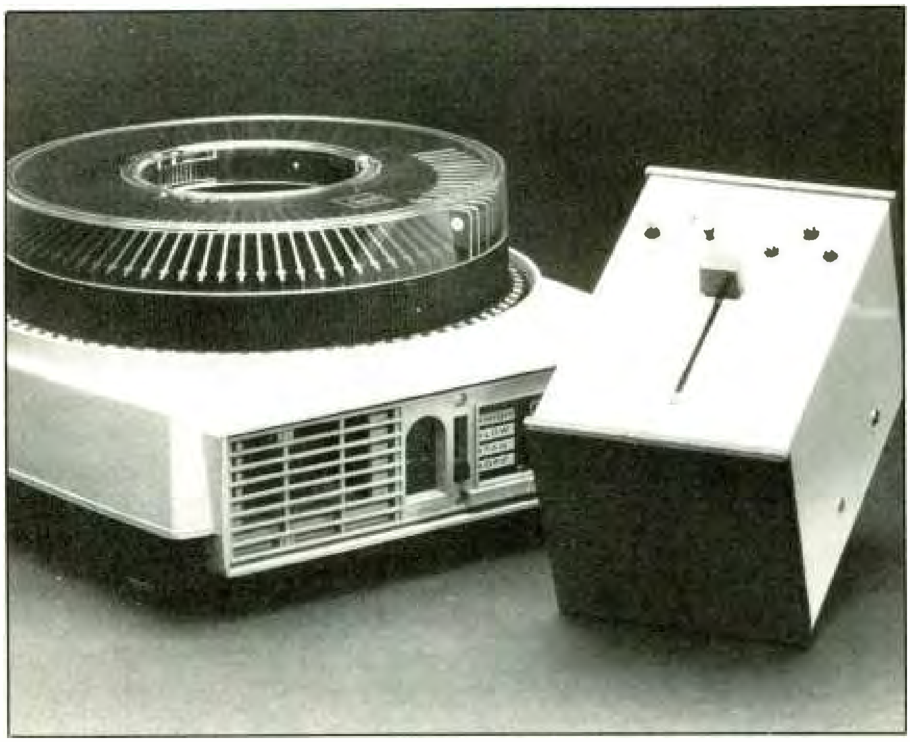
An Electronic Controller For Slide Projectors

Controls on and off of a projector only when a slide is needed and provides a fade-in/fade-out feature for smoother presentations

By David Ponting



The constant whine of the fan motor of a projector can be an irritating distraction to both narrator and audience during a slide presentation. The Electronic Controller project described here will alleviate this problem.

Our Electronic Controller for Slide Projectors is a small device that turns on the projector only when a slide is needed and changes to the next slide before it switches itself off. Additionally, it permits each slide to be faded in and out for a smoother, less jarring visual presentation. The project actually consists of two basic elements—a phase-controlled dimmer circuit for the fade-in/fade-out function and a switch-on/change-slide/switch-off control circuit. The project does not require any modification of the projector itself and is relatively easy to build using readily available components and materials.

About the Circuit

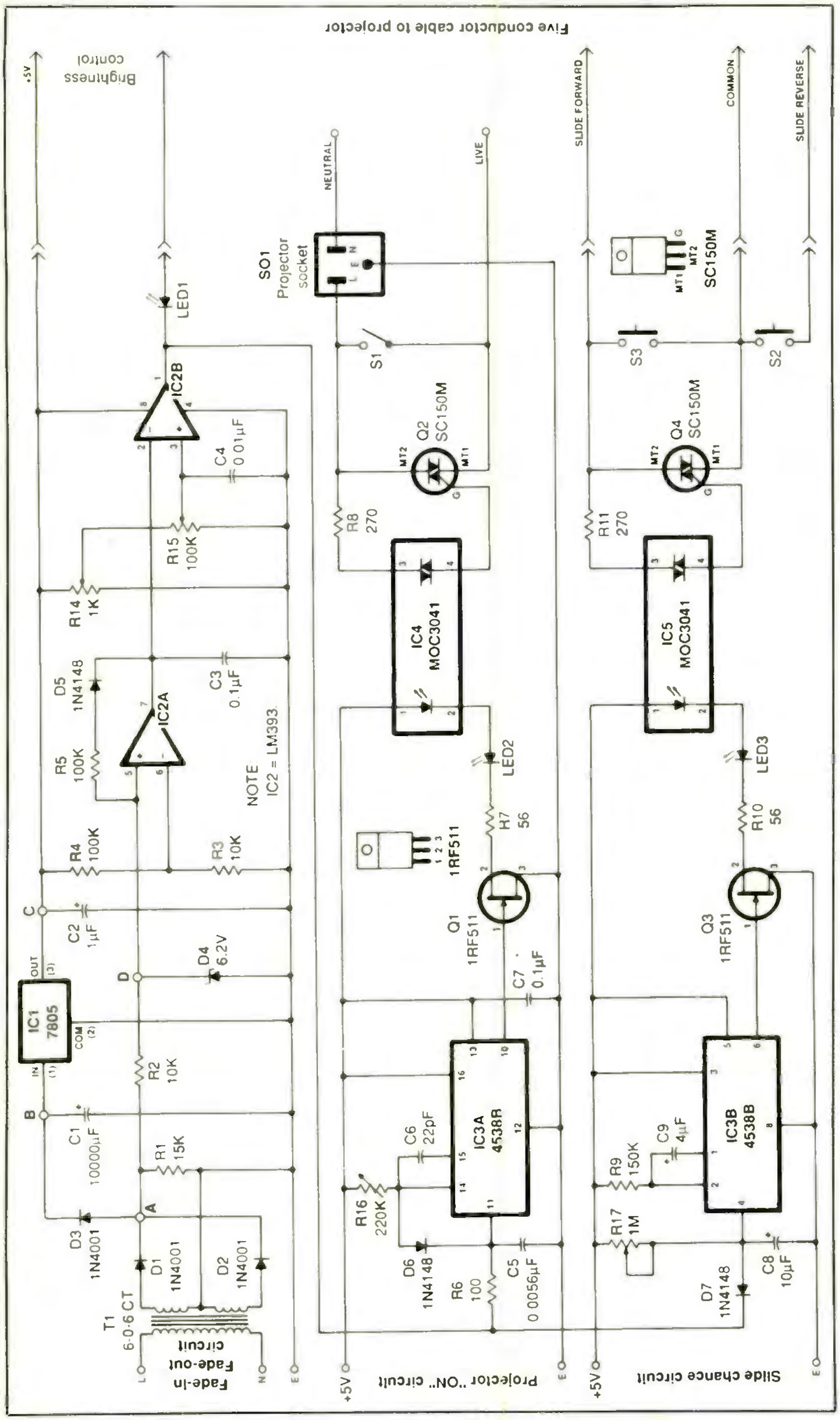
Shown in Fig. 1 is the schematic diagram for the entire Controller circuitry. The fade-in/fade-out dimmer portion of the circuit is composed of both comparators in *IC2*, optical isolator *IC6*, the last stage shown in Fig. 2(A), and each stage's associated components. Note also that the 117-volt ac-line-driven dc power supply for the entire project precedes the dimmer circuit.

The fader circuit was designed around the LM393 dual voltage comparator specified for *IC2*. This particular chip is designed to operate from a single-ended dc power supply.

In Fig. 1, operation of the dimmer circuit is as follows. The low-voltage ac output from power transformer *T1* is passed through rectifier diodes *D1* and *D2*, to emerge as half-wave pulsating dc. Resistor *R1* is included in the circuit to assure that enough current flows to switch the diodes fully on.

Diode *D3* isolates point A, the junction of the three diodes, from the smoothed dc produced by the filtering action of *C1*, at point B, so that the potential at the IN terminal of regulator *IC1* is approximately +8 volts. At the OUT terminal of *IC1*, point C, the potential is a regulated +5 volts, which is further filtered by *C2* and distributed throughout the circuit as needed.

Resistor *R2* and zener diode *D4*



PARTS LIST

Semiconductors

D1,D2,D3—1N4001 or similar 50-PIV, 1-ampere rectifier diode

D4—6.2-volt, 0.4-watt zener diode

D5,D6,D7—1N4148 or similar switching diode

LED1,LED2,LED3—T-1¾ light-emitting diode (one each red, yellow, green)

IC1—7805 fixed +5-volt regulator

IC2—LM393 dual comparator

IC3—CD4538B dual CMOS multivibrator

IC4,IC5,IC6—MOC3041 optical isolator

Q1,Q3—IRF511 (or any) n-channel power MOSFET

Q2,Q4,Q5—SC150M or similar triac

Capacitors

C1—1,000-µF, 10-volt electrolytic

C2—1-µF, 50-volt tantalum

C3,C7—0.1-µF polyester

C4—0.01-µF polyester

C5—0.0056-µF polyester

C6—22-µF, 10-volt tantalum

C8—10-µF, 16-volt tantalum

C9—4-µF, 16-volt tantalum

Resistors (¼-watt, 5% tolerance)

R1—15,000 ohms

R2,R3—10,000 ohms

R4,R5—100,000 ohms

R6—100 ohms

R7,R10,R12—56 ohms

R8,R11,R13—270 ohms

R9—150,000 ohms

R14—1,000-ohm multi-turn trimmer potentiometer

R15—100,000-ohm linear-taper slide- or rotary-type potentiometer (see text)

R16—1-megohm trimmer potentiometer

Miscellaneous

S1—Spst lever or slide switch

S2,S3—Normally-open, momentary-action spst pushbutton switch

SO1—Chassis-mount three-contact ac receptacle

T1—6.3-volt center-tapped, 100-mA minimum power transformer

Printed-circuit boards or perforated board with holes on 0.1" and suitable Wire Wrap or soldering hardware (see text); sockets for all DIP ICs and optical isolators; remote cable assembly (see Note below); suitable enclosure(s); ac line cord with plug; rubber grommets; small-diameter heat-shrinkable or other insulating tubing; heat sink (see text); spacers; machine hardware; hookup wire; solder; etc.

Note: The special seven-pin molded plug and 36" of five-conductor cable required for the remote cable assembly can be ordered as Part No. 215420 from Kodak Parts Service Dept. (716-724-7278) for $15. Alternatively, see text for details. One source for SC150M triacs is All Electronics (800-826-5432), which also sources many of the other components specified here.

Fig. 1. Schematic diagram of basic Controller circuit.

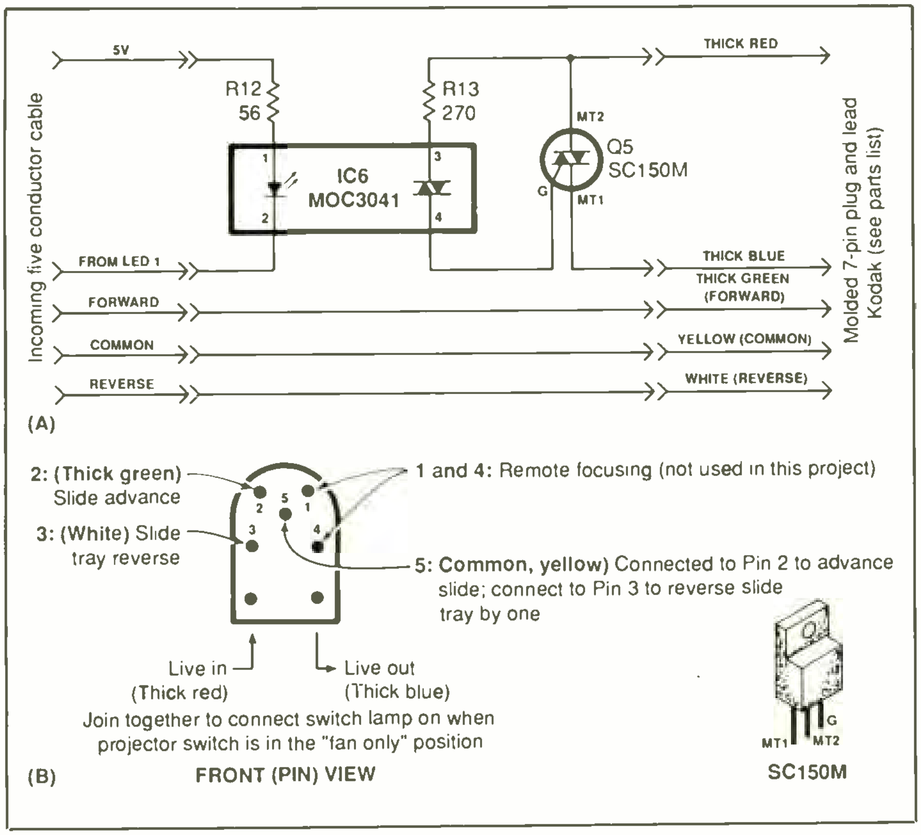


Fig. 2. Schematic diagram and wiring instructions for small junction box.

regulate the pulsating dc from point A and make it independent of any but very large variations in the ac input to the circuit.

Shown in Fig. 3(A) is the waveform that appears at noninverting (+) input pin 5 of *IC2A*. This comparator stage has an open-collector output, which means that until the inputs at pins 5 and 6 are the same, the output at pin 7 of *IC2A* is effectively an open switch.

Initially, *C3* is charged through *R5* and *D5* by the waveform at point D, shown in Fig. 3(B). This is clearly a very nonlinear charging current, but it does produce an almost ideal waveform at pin 7 of *IC2A*.

The voltage divider made up of *R3* and *R4* ensures that the inverting (−) input at pin 6 of *IC2A* is held just above 0 volt. When the pulsating dc input at pin 5 returns almost to 0 volt at the end of each half cycle, both inputs of *IC2A* become equal. At this point, the internal transistor in the output stage of this comparator switches into conduction and discharges *C3*, with the resulting waveform shown in Fig. 3(C).

The straight vertical portions of the waveform shown in Fig. 3(C) are the result of the output transistor inside *IC2A* switching on and discharging *C3*. The curved portions have the almost ideal waveshape cited above to allow the lamp in the projector to begin lighting without wasting the low end of main FADER control *R15* and to speed toward full brightness at the high end of the control, while being linear in the middle of the control's range.

Potentiometer controls *R14* and *R15* make up a pair of voltage dividers. Adjusting *R14* assures that at one end of this main FADER control *R15*, the lamp in the projector is fully off. Hence, the inputs going to pins 2 and 3 of *IC2B* are, respectively, a set potential that can be varied from about 2 volts to 0 volt by *R15*, and a sawtooth voltage of the same amplitude. With *R15* set at mid-position, the superimposed inputs are as shown in Fig. 4.

When the voltage set by *R15* rises to an amplitude that is just slightly greater than that of the sawtooth amplitude, the pulses disappear and the output at pin 1 of *IC2B* is always high. Conversely, when the voltage set by *R15* has an amplitude that is less than that of the sawtooth, the pulses again disappear but, this time, leave the output continuously low.

When the output at pin 1 of *IC2B* is zero, both *LED1*, which is in the circuit to give an indication of the lamp brightness in the projector, and the LED inside optical isolator *IC6* (see Fig. 2) will always be lit. With the LED inside *IC6* on, the internal triac is triggered into conduction and, in turn, drives external triac *Q5* into full conduction.

As *R15* is adjusted toward its alternate stop position, pulses synchronized with the 60-Hz ac line will be generated. Both *LED1* and the LED internal to *IC6* are briefly switched off during each half cycle, as are the internal and external triacs. As a result, the projector lamp will not be receive full 117-volt ac line voltage all the time. The lamp will be dimmed progressively as *R15* is adjusted toward its far end of travel.

Capacitor *C4* filters out any noise that might be picked up by the leads from *R15* from entering *IC2B* via + input pin 3. This capacitor should be placed as close as possible to the pin 3 input during assembly of the circuit.

All of the above assumes that the 117-volt ac line power to the projector is on but, at the beginning of the process, the projector is off and waiting for the command to show the first slide in the cannister or tray.

It would be an easy procedure for you to turn on the projector and then fade in the lamp. However, it is more convenient if starting to move the fade up is the way to switch on the projector. This is accomplished in this Controller by the Fig. 1 circuitry made up of *IC3A*, *Q1*, *IC4* and *Q2* and their associated components.

One-half of a CD4538B dual monostable multivibrator, shown as *IC3A*, is used here as the controlling element of the circuit for switching on the projector. Assume that the projector is off and FADER control *R15* is set so that the lamp would be off if the projector were switched on. Under these conditions, the output from pin 1 of *IC2B* would be high.

As soon as the fader starts to move up, however, a series of initially narrow pulses are initiated, the first of which can be used to trigger *IC3A*. When this stage is triggered, its output at pin 10 goes high. This causes *Q1* to switch into conduction, in turn causing the LED inside optical isolator *IC4* to light. When this occurs, the triac internal to *IC4* switches on and drives external triac *Q2* into conduction. The result is that 117-volt ac line power is applied to the projector through ac receptacle *SO1*.

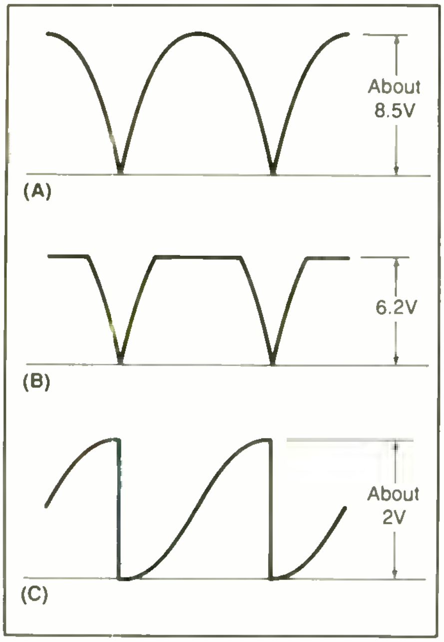


Fig. 3. Waveforms that appear at various points in fade-in/fade-out circuitry: (A) pulsating dc with an amplitude of about 8.5 volts at point A; (B) truncated pulsating dc with an amplitude of 6.2 volts at point D; and (C) waveform at pin 7 of IC2 of about 2 volts.

Of course, at this stage, you do not want the timer to time out and switch off the projector until the projection lamp has been faded up, the first slide has been viewed, the lamp has fully faded down and the change mechanism has advanced to the next slide. Early timing out is prevented by *D6*. The first pulse comes in, triggers the onset of the output pulse and *C6* starts to charge through trimmer potentiometer *R16*. However, each succeeding incoming pulse short-circuits *C6* via *D6*, and so discharges the capacitor.

When the lamp is fully on, pin 1 of *IC2B* is low. Hence, *C6* will not charge at all. This capacitor will be permitted to charge fully only when *R15* has been returned to its fully faded-out position and all incoming pulses have ceased. Only then can the timed output pulse really begin. Provided this pulse is long enough in duration to permit a third part of the circuit to change the slide (this time interval can be adjusted by setting *R16*), the desired purpose is achieved.

The remainder of the circuit, built around the second multivibrator stage inside the CD4538 and shown as *IC3B* in Fig. 1, is used to change the slide before the projector finally switches off. Initially, with the projector off, the output at pin 6 of *IC3B* is low while the input at *D7* is high.

With the first negative-going pulse from pin 1 of *IC2B* at pin 4 of *IC3B* through *D7*, *C8* immediately discharges through *D7*. Further pulses keep the capacitor discharged. With *IC3B* configured so that it will trigger only on a rising input, the output at pin 6 remains low and will not trigger to a high state until *C8* is again permitted to fully recharge.

Full recharging of *C8* does not occur until the projector lamp fader has been returned to its fully faded-out position. Only then will *C8* recharge through *R16*. As the potential across *C8* rises through the input threshold of *IC3B*, the output pulse begins. The slight delay before the output pulse goes high allows the projector lamp to be completely out so that changing of the slide will not be seen on-screen.

Use of optical isolator *IC5* and triac *Q4* permits the slide-forward/reverse connections in the projector to be made without having to use a relay. The slide-change mechanism advances the slide tray by one.

In summary, as the fader is first operated, the projector switches on and the lamp is brightened to full. When the slide is no longer required, the fader completely fades out the lamp in the projector, at which time the slide changes and the projector switches itself off.

Spurious spikes are prevented from falsely triggering *IC3A* by *R6* and *C5* in the projector switch-on circuit. Decoupling by *C7* helps in preventing similar false triggering. This latter capacitor should be placed as near as possible to pins 8 and 16 of *IC3A* during construction.

Slide or toggle switch *S1* and push-button switches *S2* and *S3* permit you to manually set up and operate the system. As mentioned above, *LED1* gives an indication of the brightness of the lamp in the projector. Power to the projector is visually indicated by *LED2* lighting, while a slide change is indicated by *LED3*.

A lightweight five-conductor cable of reasonable length (up to 100 yards is possible with this Controller) operates the projector from a remote point. By including optical isolator *IC6*, as shown in Fig. 2, close to the projector, this control cable does not have to carry 117-volt ac line power. Inserted in the cable close to the projector, a small box serves as the junction that allows three of the cable's five conductors to join directly to the common conductor (yellow insulation), forward thick conductor (green insulation) and reverse conductor

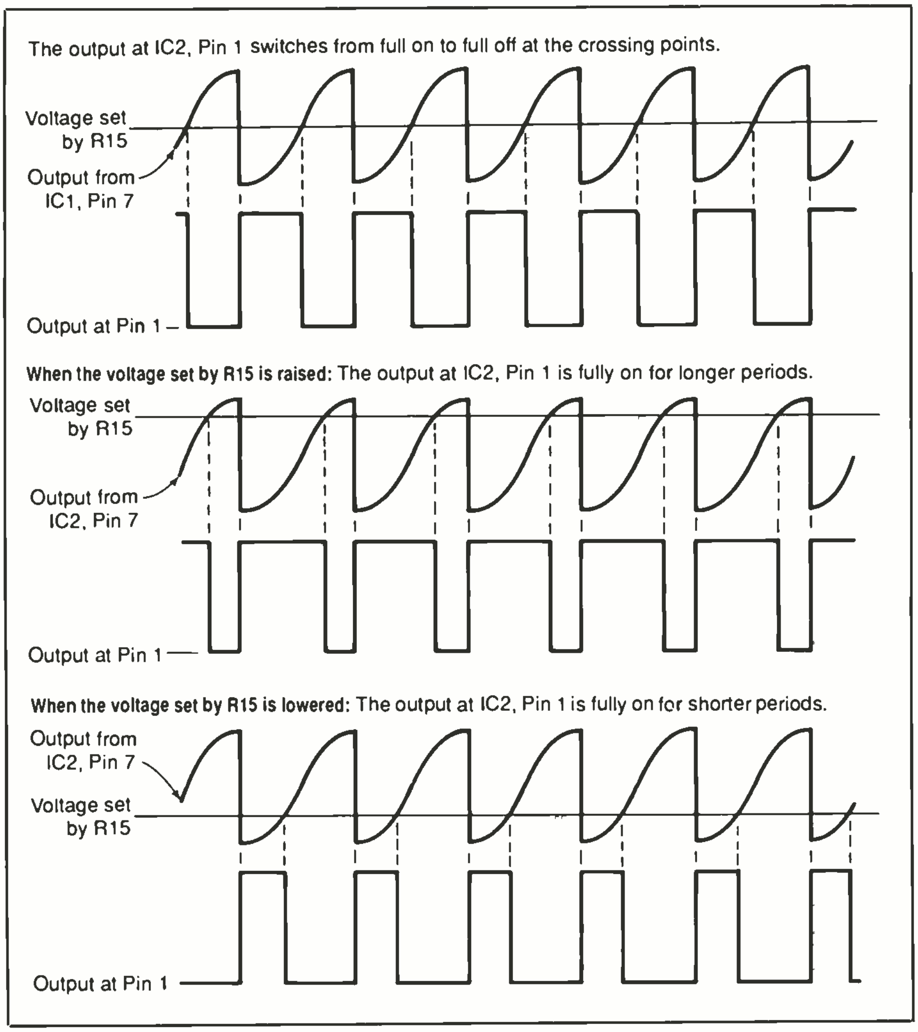


Fig. 4. Pulse waveforms at pin 1 of IC2 for various settings of fader control R15: (top) at mid-position; (center) near top of control; and (bottom) near bottom of control.

(white insulation) of the projector's molded plug and cable.

The timing sequences for the complete Controller circuit are shown in Fig. 5. Figure 5(A) details the timing for switching on the projector and fading the projector lamp to full brightness. Figure 5(B) details the timing for fading the projector lamp to full off, changing the slide and switching off the projector.

Construction

There is nothing critical about assembling the Controller circuitry, other than to observe the normal precautions about isolating the 117-volt ac from the low-voltage dc portions. Therefore, you can use printed-circuit boards on which to mount and wire together the circuitry or perforated board that has holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware. Whichever way you go, be sure to use sockets for all DIP ICs and optical isolators.

If you wish to wire your circuitry on printed-circuit board, use the actual-size etching-and-drilling guides shown in Fig. 6. Then wire first the main and then the smaller boards exactly as shown in Fig. 7. (If you opt for point-to-point wiring on perforated board, use the wiring guides shown in Fig. 7 as rough layouts for the components.)

When wiring the board, install and solder into place first the sockets for the ICs and optical isolators. Do *not* plug the ICs into their respective sockets until you have conducted preliminary voltage checks and are certain that everything is okay. If you cannot locate six-pin sockets for the optical isolators, carefully cut down sockets with more pins or substitute Molex Soldercon® socket strips.

With the sockets in place, install and solder into place the resistors and trimmer controls, then the diodes and capacitors. Note that most resistors and diodes mount vertically on the board. Make certain that you properly orient any electrolytic capacitors and all diodes before soldering their leads into place.

Next, install and solder into place regulator *IC1* and then the power MOSFETs, followed by the triacs. Again, make absolutely certain that each of these devices is properly based before soldering any leads into place.

Note that a number of components associated with the large main circuit-board assembly mount off the board. These include the power transformer, all three switches, the three LEDs and slide potentiometer *R15*. To make connections to these components, you must install suitable length wires at the indicated locations. Make these wires about 4 inches long. Strip ¼ inch of insulation from both ends of each. If you are using stranded hookup wire, tightly twist together the fine wires at both ends of all wires and sparingly tin with solder. Then plug one end of each wire into the indicated hole and solder into place.

Keep in mind that two copper conductors on the smaller junction-box pc board, both associated with triac *Q5*, carry about 3 amperes of 117-volt ac line power. These are indicated by extra-heavy traces in the smaller guide in Fig. 6. Strengthen these traces by soldering along their lengths thick pieces of heavy-duty bare copper wire before installing and soldering triac *Q5* into place.

You can use any enclosure you wish to house the large circuit-board assembly. It must be large enough to accommodate the assembly and power transformer and have enough panel space on which to mount the switches, control and LEDs. Machine the enclosure as needed (see lead photo for a suggested panel layout), including drilling the hole for entry of the five-conductor control cable. If you do not have the proper tool to make the long, narrow slot for the slide control, substitute a rotary control. Of course, doing this sacrifices some of the "feel" for smooth fades in and out.

After machining the enclosure, deburr any holes drilled through metal to remove sharp edges. Line the ac line cord and control-cable entry holes with rubber grommets and mount the switches, slide (or rotary) control and five-pin connector in their respective locations. Mount the power transformer with suitable hardware. Solder the transformer's secondary leads in the appropriate holes in the circuit-board assembly.

Trim 1½ inches of outer plastic jacket from the five-conductor cable and strip ¼ inch of insulation from all conductors. Tightly twist together the exposed wires of each conductor and sparingly tin with solder.

Pass this end of the cable through its rubber-grommet-lined entry hole and secure a large plastic cable tie tightly around it about 4 inches from the end inside the enclosure to serve as a strain relief. Plug the conductors into the holes labeled +5V, FROM LED1, SLIDE FORWARD, COMMON and SLIDE REVERSE. Make a note on a slip of paper of the color coding used for each conductor connection. then mount the circuit-board assembly with ½-inch spacers and 4-40 × ¾-inch machine screws, lockwashers and nuts.

Note: Instead of making direct cable connections to the circuit-board assembly, you can mount a female DIN-type five-pin connector in a suitable hole in the enclosure and wire from it to the circuit-board assembly. Then terminate one end of the control cable in a matching five-pin male DIN-type connector, as illustrated in the cover photo.

Tightly twist together the wires in each conductor of the ac line cord and sparingly tin with solder. Pass this end of the line cord through its rubber-grommet-lined hole and tie a strain-relieving knot in it about 4 inches from the end inside the enclosure. Separate the conductors a distance of about 1½ inch and slip over each a 1-inch length of small-diameter heat-shrinkable tubing. Twist together one line-cord conductor and one power transformer primary lead and solder the connection. Do the same for the other line-cord conductor and transformer primary lead. Then slide the tubing over the connections to completely insulate them

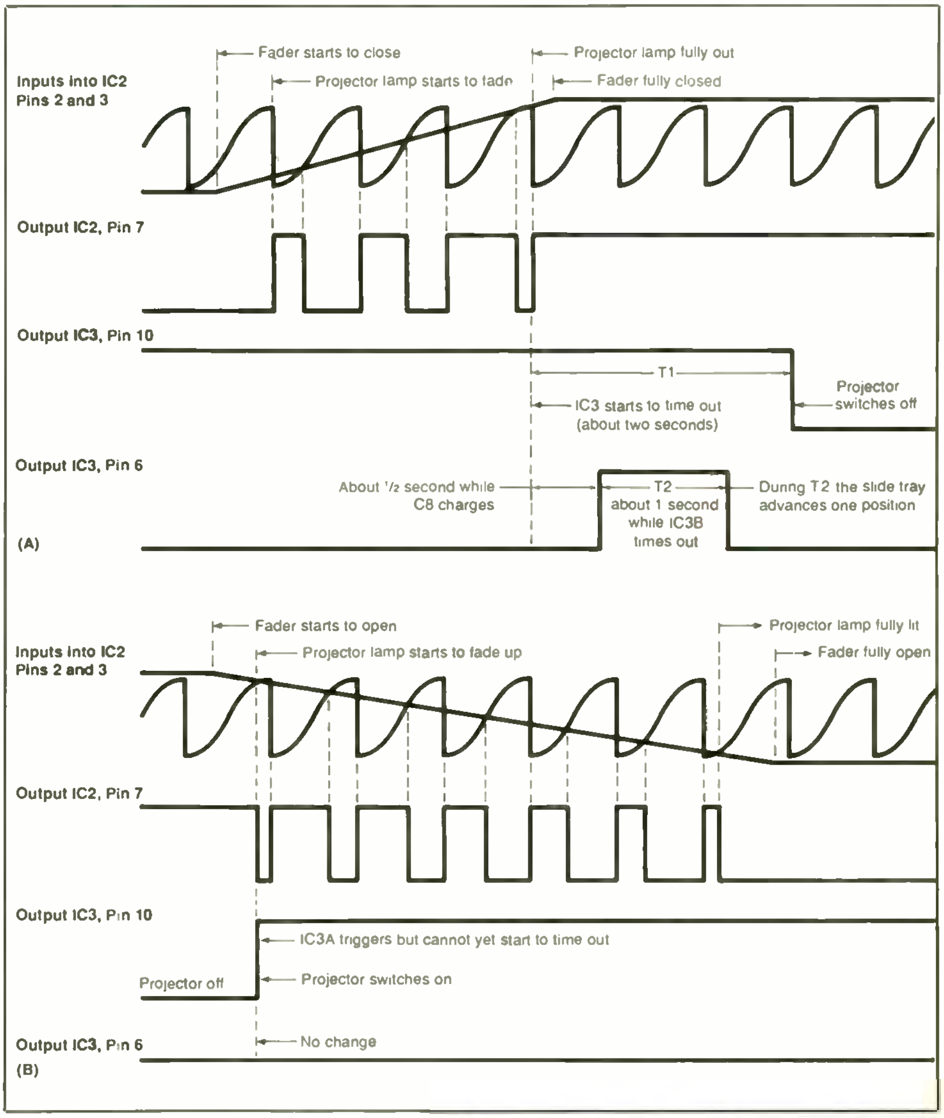


Fig. 5. Timing diagrams for (A) fading out lamp, changing slide and switching off projector and (B) switching on projector and fading up lamp. Waveforms are not to scale.

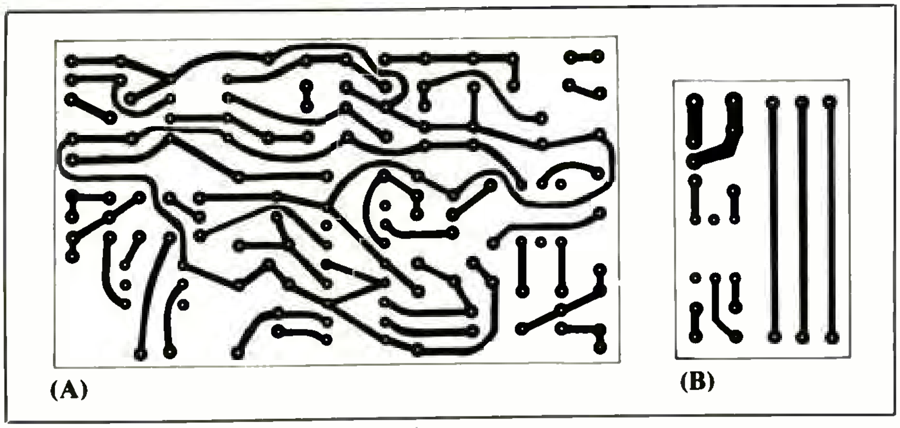


Fig. 6. Actual-size etching guides for (A) main and (B) junction-box circuits.

and shrink it into place.

Next, wire the LEDs into the circuit, making certain that you make the correct connections to the anode and cathode leads. Insulate all connections with heat-shrinkable or other plastic tubing. Then wire the switches and slide (or rotary) control into the circuit.

Plug the LEDs into their respective holes in the top panel of the enclosure. If the LEDs do not remain in place by friction, secure each with a small daub of silicone adhesive or fast-setting epoxy cement.

Machining of the smaller junction box in which the smaller circuit-board assembly is to mount requires drilling of only three holes. One hole is needed for mounting the circuit-board assembly inside the smaller enclosure. Then one hole is required for entry of the control-cable from the main unit and another for exit of the cable that goes to the projector. After all holes are drilled, deburr them to remove sharp edges and line the cable holes with rubber grommets.

Prepare the unfinished end of the control cable as detailed above. Pass the cable through its hole in the enclosure and, again, use a large plastic cable tie to provide strain relief. Plug the conductors into the appropriate holes in the small circuit-board assembly (observe the same color coding used for the connections to the main circuit-board assembly) and solder each into place.

The seven-pin molded plug and 36 inches of seven-conductor cable required for connection from the small branching box to the slide projector can be obtained from Kodak (see Note at end of Parts List). All you need do to wire this into the circuit is to prepare its unfinished end as described above for the control cable. Pass this end into the enclosure through its grommet-lined hole, use a large plastic cable-tie strain relief and wire it to the small circuit-board assembly as detailed in Fig. 2.

A less-expensive solution is to use two plugs, both available from your local Radio Shack store. Cat. No. 270-041A is a round five-pin plug that fits into the top section of the socket on the projector, and Cat. No. 270-017 is a multiple-pin plug that can be machined to fit a number of formats, including the two-pin format on the projector.

If you go the less-expensive route, you must fabricate the cable assembly yourself. This is simple enough to accomplish, using the details given in Fig. 2 for wiring the cable to both the circuit-board assembly and the connectors.

Exercise care when fitting the small circuit-board assembly into its enclosure. If you use a plastic box for the enclosure, make sure that no entry/exit conductors on either side of the board can touch any others. Also, fit a small heat sink onto the triac on this board. Secure the board to the enclosure via the hardware that secures the heat sink into place.

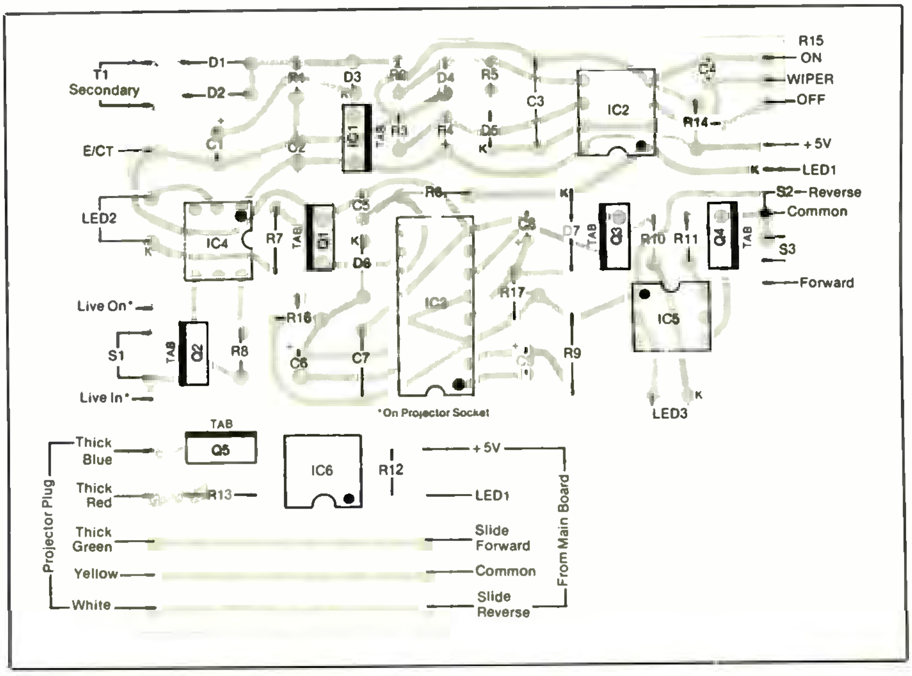


Fig. 7. Wiring diagrams for (A) main and (B) junction-box circuit boards.

If you use a metal enclosure for the junction-box assembly, make certain that the inside of the box is well-insulated from any part of the circuit-board assembly. The recommended triac on this board has an isolated metal tab that can be used to secure the circuit-board assembly into place. Additionally, the metal box will provide the required heat-sinking.

Checkout & Use

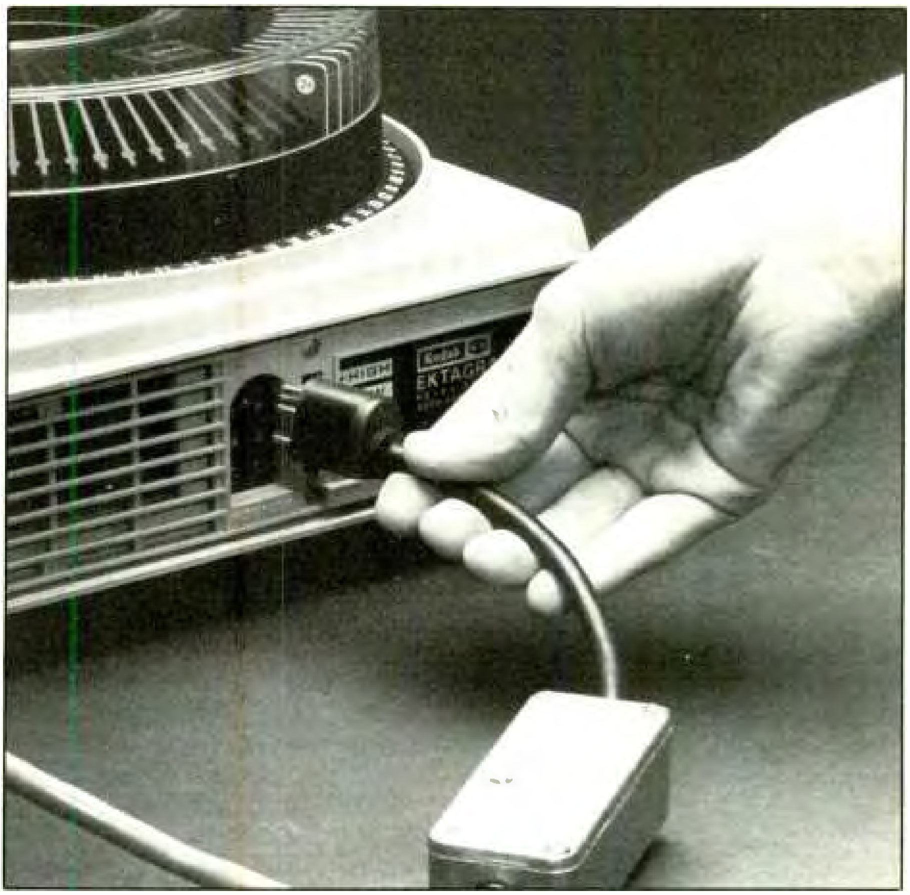
Make sure no DIP IC or optical isolator is plugged into any socket on either board. Clip the common lead of a dc voltmeter or multimeter set to the dc-volts function to circuit ground. Plug the line cord of the Controller into a convenient ac outlet and touch the "hot" probe of the meter to pin 8 of the *IC1* socket and note the reading obtained. It should be +5 volts. If it is not, touch the "hot" probe to OUT pin 3 of *IC1* and note if the reading is +5 volts. If you still do not obtain a reading of +5 volts, touch the "hot" probe to IN pin 1 of *IC1*. Now the reading should be approximately +8 volts.

Switch your multimeter to the ac-volts function. Touch the "hot" probe to the junction between *R2* and *D4*. The meter should give a reading of approximately 6 volts ac.

If you fail to obtain the correct reading at any of the points cited, unplug the project from the ac outlet and correct the problem. Do not proceed until you do obtain the correct reading at each point.

Using the "hot" probe of the meter, check the voltages at pins 3 and 16 of the *IC3* socket and pin 1 of the *IC4*, *IC5* and *IC6* sockets. In all cases, the correct reading is +5 volts. Failure to obtain the proper reading at any socket pin requires remedial work to rectify any wiring or component-installation error.

Once you obtain the proper readings at all points cited, unplug the project from the ac line and disconnect the meter from it. Carefully plug the ICs and optical isolators into their respective sockets. Make sure each is in its proper socket and is properly oriented and that no pins overhang the sockets or fold under between devices and sockets.



Small junction box plugs into connector on slide projector via a multiple-conductor cable. This box must be located as near as possible to the projector but can be tethered to main control unit via a cable up to 100 yards long.

Set *R16* and *R17* to about mid-position. Plug the projector into an ac outlet, plug the cable coming from the small branching box into the projector and plug the control cable into the main unit. Plug the main unit into an ac outlet. The projector fan may start operating and the lamp light (though not at full brightness) in the projector at this point.

Operate the slide control up and down to see if this action dims and brightens the projector lamp. If it allows the lamp to go out completely, the projector mechanism should advance to the next slide and switch off.

Adjust the setting of *R16* until the slide-advance process is completed before the projector switches off. Leave the slide control in a position that leaves the projector lamp just glowing dimly.

Adjust the setting of *R14* to brighten the projector lamp, and move the slide control until the lamp just glows again. Repeat the process as many times as necessary until the slide control is at the "out" end of its travel. Now adjust the setting of *R14* to completely fade out the lamp, at which time, the slide should change and then the projector switch off.

If *R14* is set too critically, switching on an electrical appliance close to

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Slide Projector *(from page 43)*

the control unit might trigger on the projector and change a slide. If this occurs, back off on the setting of the trimmer potentiometer just a bit. The only loss in doing this will be that the projector will not switch on at the very bottom of the travel of the slide control.

You may be concerned that the projector will not have time to cool down if it is switched on and off in normal operation. This is not the case, however. In tests with a number of different slide projectors, no excessive temperature was reached. If the projector is on for a long period of time, the temperature tends to stabilize after about 4 minutes. If the projector is used intermittently for short periods, it never gets hot enough to reach even this stabilized temperature.

Provided the time period is adequate between the end of T_2 and the end of T_1 in Fig. 5(A) (this can be adjusted with *R16*), consecutive slides can be shown without the projector turning off between each slide. If the projector is still running when the slide-type FADER control is opened again, it will continue running without a break and maintain the correct sequence of events.

Although the Electronic Controller described here was designed specifically to work with Kodak Ektagraphic slide projectors, almost any other projector can be controlled by it. Even a projector that uses a low-voltage lamp powered by an internal transformer can be faded in and out with no change in component values in the circuitry.

With a low-voltage, high-wattage lamp, the triac specified for *Q5 must* be bolted to a sizable heat sink, perhaps the metal body of the projector itself. However, provided a break in the supply to the lamp can be found, the circuit will yield good control of the brightness of the lamp and all other slide functions.

Photos by Teresa Hernandez