Besides acting as a full-range light dimmer, this versatile device can be remotely operated by any audio signal for many control functions.

MULTIPURPOSE ELECTRONIC CONTROL

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THE compact, multipurpose electronic control described in this article is essentially a 200-watt, full-range lamp dimmer with the added provision that a low-level audio-control signal can also proportionately control the lamp brilliance. In this latter mode, less than 50 mw. of input signal can directly control 200 watts of lamp, giving a gain of 4000. Fig. 1 illustrates some of the many operations that can be performed with this unit. Package and component modifications can give a one-kilowatt control capability at the expense of size.

By connecting the audio input of the control to the speaker terminals of a public address system (Fig. 1C), display-lamp brightness will smoothly follow music.

If two controls are used, one on the left channel of a stereo speaker system and the other on the right (Fig. 1D), an interesting test instrument results. The control can provide a dynamic and vivid indication of the balance and separation of the two stereo channels. This is done by placing the controls in proximity to each other and terminating one in a red lamp and the other in a yellow one. The state of the two stereo channels can then be continuously monitored.

Extension of these "stereo lamps" yields a color-organ type of device with a different twist—the colors produced correspond to the *position* of a particular solo instrument, not the pitch. One method (Fig. 1E) is to use red bulbs for the left channel, blue bulbs for the right channel, and green bulbs for *both* channels. (Half the green bulbs are tied to each side.) When this is done in a suitable reflective display, you can watch as well as hear music. Actually, a two-tone display works just as well as the three and can produce much deeper colors.

If the input sensitivity is set quite low, the light output will follow the input intensity variations, giving a fairly linear indication of the input signal strength. If the input is overdriven, the control will provide a discrete on-off type of indication that depends only upon the presence of an input signal and not its amplitude. (See Fig. 1F.) The control can then be used as a telemetry indicator or a visual alarm in high-noise areas.

A new, low-cost ($1.60) SCR together with a low-cost ($2.40) miniature, molded, full-wave bridge rectifier assembly make the circuit possible. The compact package is obtained by using a large SCR and operating it without a heat sink. The power levels inside this control are well within the manufacturer's specifications for no heat sink operation, even at moderately high temperature.

The schematic is shown in Fig. 2 and the circuit is best explained by breaking down the control into two parts—the dimmer portion and the audio-control portion.

Full-wave proportional control of a load by using SCR's can only be obtained by using two SCR's, or else by inverting the alternate a.c. half cycles with a bridge rectifier. The latter method is chosen since only one SCR and no gate transformers are required. This method also guarantees that reverse breakdown of the SCR cannot occur; there is never anything but forward voltage applied to the SCR.

Pulse the gate of an SCR, and it turns on and stays on until the voltage across it drops to zero (as happens every a.c. "zero"). If the SCR is turned on late in each half cycle, very little power gets to the load. Pulsing the SCR gate in the middle of each a.c. half cycle allows about half the available power to reach the load. Pulsing the gate early in each half cycle allows nearly full power to reach the load. By controlling when in each half cycle a gate pulse is produced, the load power can be directly and proportionately regulated. In this control, load power is variable from a minimum of 5% to a maximum of 95% of the available load power.

The required gate pulses are produced by a resistor, a capacitor, and an avalanche diode. In operation, *R*3 charges *C*3 until *C*3 reaches the breakdown voltage of avalanche diode *D*4. The avalanche diode then snaps on and empties the capacitor into the gate of the SCR, turning it on. Increasing the value of *R*3 causes the capacitor to charge slowly. The SCR turn-on is later in each half cycle and very little power gets to the load. This gives a low lamp brilliance. A lower-valued *R*3 will result in a fast capacitor charge and early turn-on, giving high load power and high brilliance. *R*3 is made variable to vary the output power.

As the SCR turns on, it eliminates the voltage supply for the *RC* network and discharges the capacitor (*C*3) completely *via* diode *D*2. This insures zero capacitor charge at the beginning of each half cycle and locks the capacitor's timing to the line frequency.

The circuit shows the parts used. *Rect*.1 is a 1.5-amp., full-wave bridge rectifier the size of a mica capacitor, which inverts the alternate line half cycles. *SCR*1 is a 5-amp. (if heat-sinked) device in a power-transistor type of case. The load terminals are in series with the SCR which is powered by *Rect*.1. The combination of *R*3, *C*3, and avalanche diode *D*4 provides the SCR gate turn-on pulses. *D*4 breaks down whenever the voltage across its terminals exceeds 30 volts. Varying *R*3 controls the lamp brilliance from a dull orange glow to full on. (*D*3 is always forward-biased during dimmer-only operation and does not affect the circuit performance.)

Capacitor *C*1 prevents the fast turn-on transient of the SCR from traveling back into the power line to become radio noise. Resistor *R*1 forms a permanent load for *Rect*.1, preventing stray capacitance and long cables from affecting performance.

The audio circuitry consists of an input-sensitivity control *R*4 and a high-ratio, step-up transformer *T*1. The secondary voltage of *T*1 is rectified by *D*1 to provide a continuously varying d.c. voltage of 0-40 volts magnitude in proportion to the input audio. This voltage is filtered by capacitor *C*2. This capacitor determines the time constant of the audio control and may be varied to suit individual taste. The larger *C*2 becomes, the more gradual the attack and decay of the output.

The rectified and filtered audio voltage is used to forward-bias avalanche diode *D*4, causing it to turn on earlier than normal, in direct proportion to the audio voltage present. This earlier turn-on causes the load lamp to brighten, again in proportion to the audio input. Diode *D*3 blocks the reverse audio bias from SCR gate. Capacitor *C*4 is a commutating capacitor required to start SCR turn-on in lieu of a momentarily reverse-biased *D*3. This completes the circuit.

If *Rect*.1 is changed to a 6-amp unit (*Motorola* MDA-952-3), and a 3-inch square aluminum heat sink is added to *SCR*1, then 600 watts of load power are permissible. For 1-kw. control, use a MDA-962-3 unit and add a 5-inch square heat sink to an 8 amp. SCR. Remember that the SCR case is electrically hot.

Operation depends upon the application. Some connection possibilities are shown in Fig. 1. The "Brightness" control should smoothly vary the light output from a dull orange glow to full brilliance, increasing in a clockwise direction. Likewise, the "Sensitivity" control increases audio sensitivity in the same manner. Since the audio is used only to bias a diode and not to provide gate current for the SCR, sensitivity is quite good. Whisper-level audio from a 16-ohm source will be enough to excite the control.

The control will only operate on 100- to 125-volt, 60-cycle a.c. lines. (For 50-cps operation, change *C*3 to .12 μf. The circuit will not function at 400 cps.) The circuit will not operate most motors due to the inverted waveform, although some small universal motors will work. Fluorescent lamps will *not work* with this control and permanent damage to both the control and the lamp may occur if this is tried. Do not exceed more than 200 watts of load, unless the control has been modified as previously described.

The choice of lamp load depends upon application. Conventional light bulbs, up to 200 watts, work fine. All three-way bulbs whose top rating is 200 watts or less also work equally well. The control will not excite a neon lamp or an electroluminescent panel because they draw too little current (if they are connected in parallel with a 10-watt conventional bulb, they will operate properly).

For audio control of lamps, a good choice is a 25-watt bulb. This size combines a large amount of light output with a minimum of thermal inertia (reluctance to turn off).

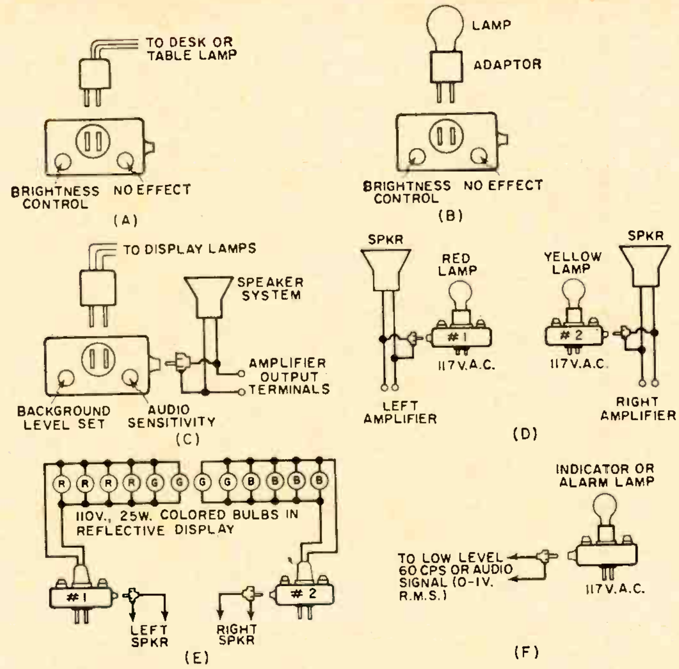


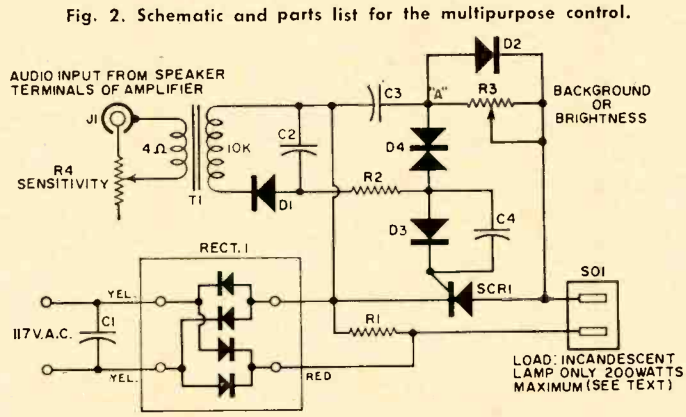
Fig. 1. (A) Conventional dimmer. (B) Variable brightness aisle marker. (C) Lamp brightness varies in proportion to audio volume. (D) Stereo test set. (E) Stereo color display where color varies with instrument position. (F) A telemetry indicator or an annunciator for high-noise areas may be made either proportional or on-off depending on sensitivity control setting.

There may be some variation in the exact value of *C*3 and *C*4 required due to slight manufacturing differences in trigger diode *D*4. In addition, the tolerances in some diodes are rather wide, varying from as low as 20 volts to as high as 40 volts. *C*3 should be a value that allows the load to just extinguish completely at the minimum brightness setting of *R*3. The change in capacitance might be $\pm$.02 μf. A disc ceramic capacitor of low value could be used to trim *C*3.

*C*4 should be the minimum capacitance that reliably allows audio control of the lamp brightness. Certain trigger diodes might require a value of *C*4 as high as .002 μf.

Frequency-sensitive filters can be added to the audio input to make the control sensitive only to some desired portion of the audio spectrum. ▲

Fig. 2. Schematic and parts list for the multipurpose control.



R1,R2—39,000 ohm, ½ w. res.
R3—250,000 ohm potentiometer
R4—250 ohm potentiometer
C1—.02 μf., 600 v. paper cap.
C2—.04 μf., 600 v. disc cap. (two .02 μf. in parallel)
C3—.1 μf., 400 v. paper cap.
C4—100 pf., 600 v. disc cap.
T1—Audio output trans: pri; 4 ohms; sec; 10,000 ohms or higher. (Stancor TA-33 or equiv.)
SO1—Type "S" power socket (Amphenol 61-S or equiv.)
D1,D2,D3—100 ma., 200 p.i.v. diode. (Motorola 1N4003 or equiv.)
D4—30 v. trigger diode (Transitron ER-900, TI TI-43, or G-E ZJ-238)
SCR1—Silicon controlled rectifier 2N3228 or 2N3528
Rect.1—1.5 amp, full-wave rectifier (Motorola MDA-942-3)