

LIGHT OPERATED SWITCH

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THE circuit to be described was designed to operate a bench light when the daylight fell below a certain level. The unit was to switch sharply and accurately at the same light level each time, to avoid repeated setting and interactions between the light sensor and the switched light when switching begins.

CIRCUIT DESCRIPTION

To ensure accurate switching an amplifier with high impedance must be used to amplify current taken from the voltage developed across the light dependent resistor (Fig. 1). A common collector amplifier is used, the first transistor (TR1) is a silicon device to prevent leakage current affecting the voltage across the l.d.r. (X1); all leakage current passes through R1. Transistor TR2 need not be silicon, an OC71 would do, but an OC200 is used to prevent variations in switching due to temperature variations. Theoretically the input impedance of the stage is $h_{FE}^2 R_1$ so that for circuit used the input impedance should be of the order of 160 megohms for an h_{FE} of only 40.

Transistor TR3 is the power switch and is an *npn* device, in order to improve the switching time positive feedback is applied by R4. The feedback resistor couples the collector of TR3 to the base of TR1.

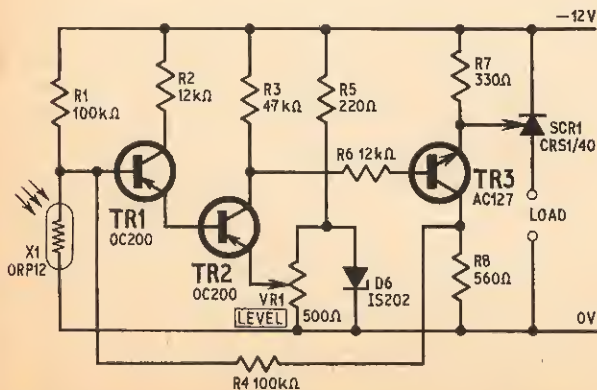


Fig. 1. Circuit diagram of the light operated switch for use with a 12V supply and 12V load

When light is falling on the l.d.r. TR3 is off and the only effect of R4 is to shunt the l.d.r.; once the voltage at the l.d.r. rises to a sufficient level, due to failing light causing its resistance to rise, TR1 starts to conduct and the collector voltage of TR3 begins to rise. This voltage rise at TR3 collector is fed back via R4 and since the impedances around the base of TR1 are large in value then the voltage drop across R4 is small and the base voltage of TR1 rises causing TR1 to switch fully on. The regenerative effect ensures rapid switching.

Zener diode D6 is used to supply a constant voltage to the emitter of TR2; this stabilises the switching voltage required at the base of TR1. If a Zener diode is considered an expensive luxury, then it is possible to change VR1 to 100Ω and omit D6. This will reduce the accuracy of the switching and the level at which the device switches will be more dependent on variations of supply voltage.

POWER SWITCHING

The switching operation is performed by a thyristor with a voltage rating of 350 volts or more at 0.5A. Resistor R7 may need to be changed if the specified thyristor is not used.

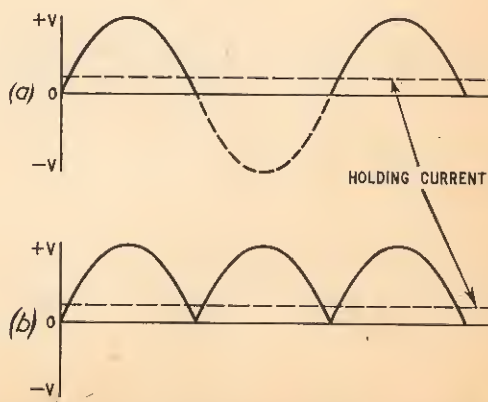


Fig. 2(a). Current supplied to load when a.c. is applied directly across the thyristor. (b) Current supplied to load when full wave rectified

To switch on the thyristor it is necessary to supply a pulse of current to the gate of the device, this is done by switching TR3. To switch off the thyristor the load current must be reduced to a low level, typically 10mA. If the thyristor is fed from an a.c. source the load current is reduced to zero every half cycle. Unfortunately such a system would supply half wave rectified power (see Fig. 2a) to the light and this causes a flickering effect which can be disconcerting. This may be avoided by full wave rectifying the mains before feeding it to the thyristor (Fig. 2b). A full wave rectified mains supply circuit is shown in Fig. 3.

If the unit is required to switch off when the light level increases, C1 should be omitted from the supply circuit (Fig. 3). For most uses it is better that the light should remain on, independent of changes in light level, this allows the l.d.r. to be placed on the workspace to be illuminated. Also if the l.d.r. is placed in a window headlamps from cars passing may cause the unit to switch unless it locks on.

Capacitor C1 will maintain the current to the load above the thyristor holding current (see Fig. 2), the

value given is sufficient for use with a load of up to 200 watts, for greater loads a value must be determined by trial and error. The current rating of C1 is important, this can be calculated by:

$$\text{max. surge current} = \frac{\text{load power}}{\text{supply voltage}}$$

RELAY OPERATION

A relay may be used in preference to a thyristor for switching the load as shown in Fig. 4. If a relay is used its coil resistance must be greater than 150Ω to prevent the current through TR3 becoming excessive. If the coil resistance is less than this, but the relay only requires 100mA or less to operate, then R6 may be replaced by a resistor of sufficient value to limit the current through TR3 to 100mA or less. The relay should be wired to latch on (see Fig. 4).

When a relay is used it is not necessary to rectify the mains before supplying the load as the contacts will pass the full waveform to the load; this represents a considerable saving in cost of diodes. Diode D7 protects TR3 from the back e.m.f. generated when the relay is

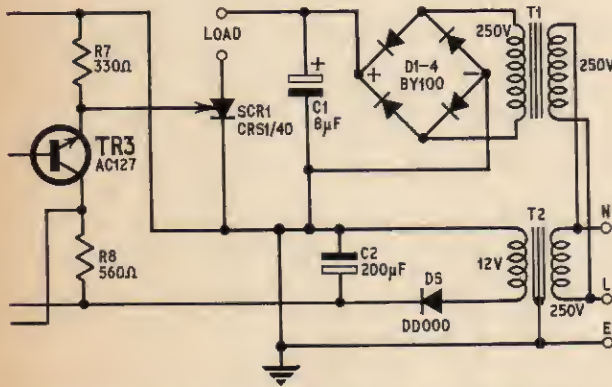


Fig. 3. Circuit of a mains supply using two transformers and full wave rectification of the 250V load supply

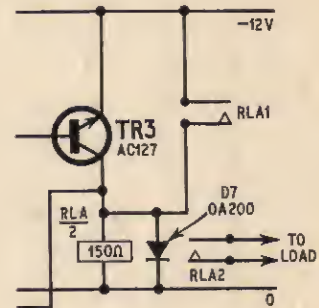


Fig. 4. Modified circuit using a relay to switch the load

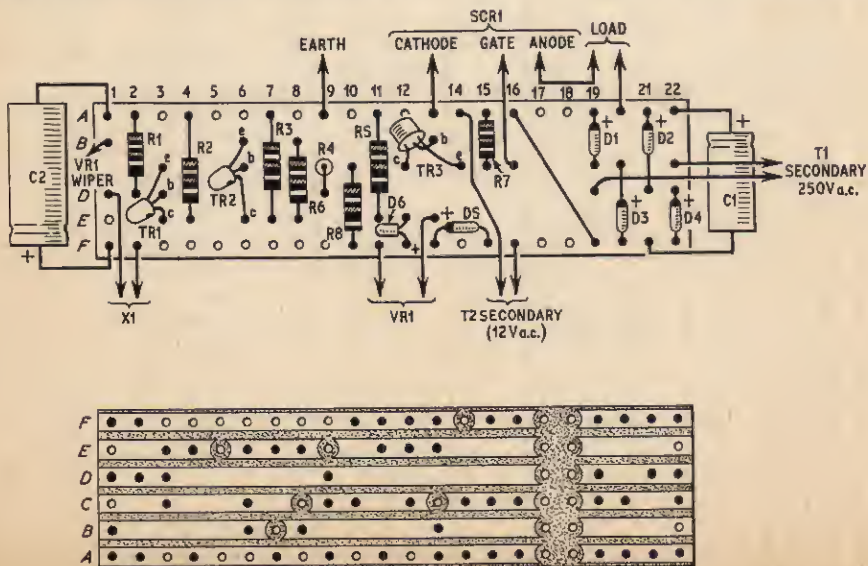


Fig. 5. Veroboard layout and wiring of the mains supply and mains load switching light operated switch (see text)



de-energised. Contacts RLA1 latch the relay on and the circuit must then be disconnected from the supply to turn the load off. For non-latching operation RLA1 contacts can be omitted.

CONSTRUCTION

The circuit is assembled on a single piece of Veroboard as shown in Fig. 5. Transformer T1, VR1, X1 and the thyristor can be mounted around the Veroboard in a small metal case. When a mains supply is used an adequate earth must be provided to the Veroboard and the metal case.

COMPONENTS . . .

Resistors

R1	100k Ω
R2	12k Ω
R3	4.7k Ω
R4	100k Ω
R5	220 Ω
R6	12k Ω
R7	330 Ω
R8	560 Ω
All $\pm 10\%$, $\frac{1}{2}$ W carbon.	

Capacitors

C1	8 μ F elect. 250V
C2	200 μ F elect. 15V
} not required for relay version	
} for mains supply version only	

Semiconductors

TR1	OC200
TR2	OC200
TR3	AC127
D6	1S202 (4.7V Zener diode)
SCR1	CRS1/40 not required for relay version
D1-4	BY100
D5	DD000
} or mains supply version only	
or DD003	

Miscellaneous

X1	ORP12 photocell
VR1	500 Ω carbon potentiometer
RLA	12V 150 Ω relay with two pairs of normally open contacts, one pair rated at 250V 1A (see text —for relay version only)
T1	Mains isolation transformer —100W
T2	Mains transformer: secondary 12V 0.5A
} for mains supply version only	
Veroboard, case	

If a battery is used to supply the circuit, components D1-5, C1 and C2 can be omitted from the Veroboard and the connections to T1 secondary (12V a.c.) connected to the supply—make sure that the negative line is applied to the strip A on the board. The breaks at 14F and 17-18A should not be made when a battery supply is used. All wires carrying mains voltage should be insulated and of sufficient size to carry the load current.

Once complete the unit can be tested by connecting a load and varying the light falling on X1; VR1 is used to set the switching level.

LOAD POWER

Load power is limited by T1 rating, D1-4 rating and the thyristor rating. Using the components specified the load power is limited to 100 watts by T1. When a battery supply is used the load power is limited only by the thyristor and for a 12V supply would be 12 watts, this power could be increased by using a thyristor with a higher current rating.

When switching inductive lamps the thyristor should be able to pass the cold resistance current—normally about twice the normal current.

If the relay circuit in Fig. 4 is used, T1 can be omitted and the supply fed from T2 and D2 or a battery. The relay contacts RLA2 should be rated at 250V a.c. 1 amp for a 100W load or at higher current ratings for increased loads.

APPLICATIONS

The switch unit is very versatile and may be used for a number of jobs; the switch will operate mains lamps or car parking lights. When used for the second of these a non-latching relay should be employed and the l.d.r. sited away from the switched lights and from any other source of artificial light. If protection against shadows falling across the l.d.r. or momentary illumination is required a capacitor can be placed across the l.d.r. the value of which is best found by trial and error—too large a value should be avoided as this would slow down the switching speed—10 μ F is a good value to use as a starting point.

The switch may also be used as a burglar alarm; if the unit is arranged so that a thief interrupts a beam of light falling on the l.d.r., the switch will power an alarm that can be locked on to indicate an intruder. The light beam may be made invisible by the use of an OCP71, in place of the ORP12, and an infra red light source. Any bulb with an infra red filter may be used and the beam focused on the sensitive section of the OCP71.

