INFRA-RED LIGHT SWITCH

Anyone who has ever tried to switch the light on when entering a dark room with both hands full will appreciate this light switch. It operates automatically upon being triggered by your body heat.

by
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The idea behind this infra-red controlled light switch is quite simple. The body heat — which occupies the electromagnetic spectrum between light and radio waves, i.e. 0.74 to 300 μm — is picked up by a sensitive Fresnel lens. This lens, which has at its focus a double differential pyroelectric sensor, IR_1, is largely unaffected by other electrical radiation. The area served by the light switch is divided into a number of zones as illustrated in Fig. 1. When someone moves from one zone into another, there is a change of temperature, which is collected by the lens as a variation in electromagnetic energy. The sensor reacts to this change by generating a small electric signal. That signal is processed and used to operate the light switch. Instead of a Fresnel lens, it is also possible to use a simple home-made lens. More about this under *Construction*.

The circuit is suitable for operating lamps rated at up to 150 W. Depending on the setting of the presets, the light(s) will stay on for periods varying from 5 seconds to 7 minutes. If the light is required to stay on, the normal switch should be used, or an additional on-off switch provided in parallel with D_2. The latter switch should be rated at 240 V. The last solution is, in any case, to be adopted if the infra-red switch replaces the original light switch in the wall-mounted box.

An additional facility is the automatic brightness control which prevents sensor signals being processed as long as there is sufficient daylight in the room.

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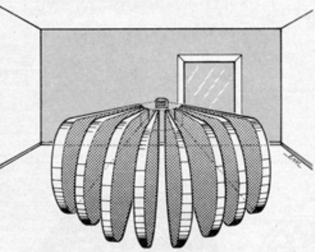

Fig. 1. This illustrates the division of a space into zones by a Fresnel or a home-made lens.

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Fig. 2. Typical field-of-view diagram in the x-x plane of dual-element sensor Type RPY97.

Circuit description

The signal provided by the sensor is so small that it must first be amplified. This is done in A_1 and A_2, which together provide a gain of 47 dB. The input amplifier is preceded by an RC filter, which removes any low frequency components. Moreover, A_1 and A_2 function as an active band-pass filter with a bandwidth of 1.5 MHz to 15 MHz.

Opamp A_3 is arranged as a comparator. The reference voltage is applied to the non-inverting input, pin 10, via divider R_3-R_4. As soon as the potential at the inverting input becomes smaller than the reference voltage, for instance, when the sensor has been triggered, the opamp toggles, its output — pin 8 — goes high, and capacitor C_6 charges quickly. Comparator A_4 then toggles, which causes T_2 to switch on. Capacitor C_6 discharges slowly through P_1 and R_{10}, and when the potential at the in-

Parts list

Resistors:

R_1 = 100 k
R_2 = 68 k
R_3;R_{10};R_{11} = 100 k
R_4 = 27 k
R_5;R_7 = 10 k
R_6;R_8 = 2M2
R_9 = 560 k
R_{12} = 3k3
R_{13} = 5k6
P_1 = 10 M preset for vertical mounting on PCB
P_2 = 250 k preset for vertical mounting on PCB

Capacitors:

C_1 = 10 µ;10 V;tantalum
C_2;C_4;C_6 = 10 V; tantalum
C_3;C_5 = 4n7;ceramic
C_7;C_8 = 100 n;400 V; 15 mm matrix
C_9 = 47 µ;16 V
C_{10} = 10 µ;100 V

Semiconductors:

D_1;D_2;D_4 = 1N4148
D_3 = zener;15 V;400 mW
D_5 = zener;8V2;400 mW
D_6 = ER900 or BR100-3
T_1 = TL081 or BP103
T_2 = BC546
Tri_1 = TIC206D
IC_1 = LM324

Miscellaneous:

L_1 = choke;40 to 100 µH;1 A
IR_1 = RPY97*
Fresnel lens Type MSFL24*
Infra-red translucent window material; 100 × 100 mm*
F_1 = miniature fuse; 1 A
Fuse carrier for PCB mounting
Two-way spring-loaded terminal strip for PCB mounting
PCB 86006; 63 mm dia.

*Available from Chartland Electronics Limited
P O Box 83
Cobham
Surrey
Telephone: (037 284) 2553
Telex: 263578 (chking g)

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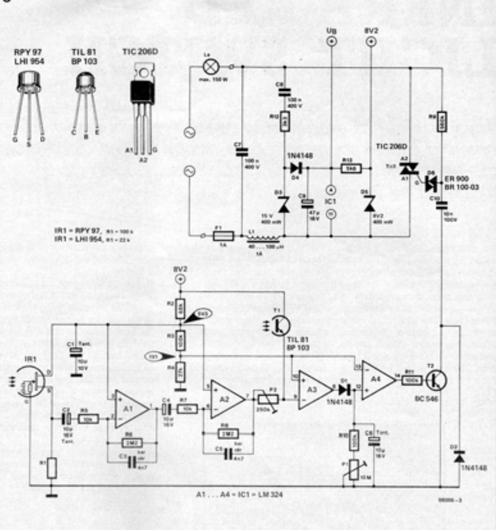

Fig. 3. Circuit diagram of the infra-red light switch.

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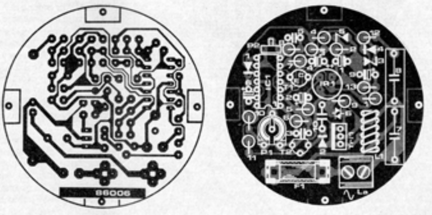

Fig. 4. The printed-circuit board for the infra-red light switch is available through our READERS SERVICES.

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verting input of A_4 rises above the level of the reference voltage, the comparator toggles again, and T_2 is switched off.
The length of time the light remains switched on depends on the time-constant P_1-R_{10}-C_6.
When T_2 is switched off, one terminal of C_{10} is open-circuited, and nothing will happen, because the triac gets insufficient gate current. As soon as T_2 is on, however, C_{10} is connected to earth and begins to charge. After a short while, the voltage across it is sufficient to switch on diac D_6. Capacitor C_{10} then discharges via the diac and the gate of Tri_1, which causes the triac to conduct. The potential across Tri_1 is, therefore, shaped as shown in Fig. 6, and is reminiscent of that produced by a dimmer switch. The resemblance does not end there, because, just as in the case of dimmer control, the lamp never gets the full mains voltage. This is in any case necessary to ensure that the circuit gets sufficient power.
If the room in which the switch is installed is open to daylight, it would, of course, be nonsense to have the light switched on every time someone moved across the field of the sensor during the day. This is, therefore, prevented by the automatic brightness switch. This consists of phototransistor T_1 and potentiometer P_2 with which the sensitivity of the circuit is set. When a certain amount of light falls onto T_1, it conducts, which results in a larger potential at the inverting input of A_3 than at the non-inverting input. The comparator output then remains low, which prevents T_2 from conducting, so that the triac cannot fire. Note that a higher resistance of P_2 corresponds to a higher sensitivity of the circuit and that, therefore, even a small amount of incident light may prevent the triac from switching on. If the brightness control is not required, merely omit T_1 and replace P_6 by a wire link.
The remainder of the circuit forms a simple power supply that is stabilized by zener diodes D_3 and D_5.
Choke L_1 and capacitor C_7 prevent switching pulses generated by the triac from reaching the mains supply.

Construction

The circuit is best constructed on the PCB shown in Fig. 4, since this has been designed for fitting into a round electrical junction box. It may be necessary to file the edges of the board to make it fit snugly into the box. Be careful, however, not to take too much off, particularly around C_7 and C_8.
The sensor may be fitted well away from the circuit, in which case a simple cable is needed to connect the two. Alternatively, it may be fitted onto the PCB, in which case the entire unit should, of course, be installed in a suitable position as suggested in Fig. 1.
The sensor or the entire unit, whichever construction is chosen, is best placed at a height of about 2 m (6 ft 6 in) at a downward angle of about 14° from the vertical in such a position that the door opening is fully covered. It should not be placed in direct sunlight, nor above heating appliances. Note that the unit is not really suitable for use in the open.
As stated earlier, the sensor may be fitted behind a proper Fresnel lens or a home-made one as shown in Fig. 5. A Fresnel lens is composed of a number of smaller lenses so arranged that they give a very short focal length. Such lenses are used in headlights, camera viewfinders, and spotlights, to name but a few. If you opt for a home-made lens, this is best constructed from some flexible cardboard into which a number of longitudinal slits are cut as shown in Fig. 5. These apertures should then be covered with clingfilm or similar foil. The reason for this is that the sensor should be open to infra-red light, but not to draughts or similar air currents. As the lens is bent into a semicircle, the open sides should also be made airtight.

Finally

When planning the installation, bear in mind that the sensitivity of the sensor is greatest for movements in parallel with it, and least for movements towards it. The sensitivity is greatly enhanced when a Fresnel lens is used. Further information on this, as well as on the sensor, may be found in the July 1985 issue of ***Elektor India***.
WARNING. Remember to switch off the mains when working on the PCB and when wiring the switch into the domestic light system. Remember that touching the mains can be fatal! ◼

Fig. 5. Suggested construction of a cardboard lens.

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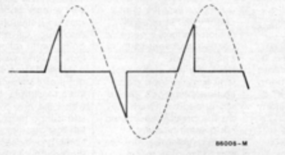

Fig. 6. Waveshape of the potential across the triac.