DIY Kit 79C. LDR LIGHT/DARK ACTIVATED RELAY SWITCH

Note: this is Kit 79C. It is one of three kits which are part of Kit 79. However, there has been a demand for the sale of the individual kits which is what this is. The documentation below makes references to the other kits.

We wanted to do a light/dark switch as a kit. But we found there were several types of basic circuit. So rather than choose one, 2 or 3 & put each out as a separate kit we have presented here in the one kit three complete, practical, light or dark LDR (light dependent resistor) activated switches with a relay output. Each has its own features and disadvantages which will be discussed. By testing all three you will be able to decide which circuit is the best for your particular application. If your application is in very bright or very dark conditions then you can easily experiment with different resistor values to get better control over the switching range you need.

There is nothing original in these circuits. We have taken them from published material (see end of this paper for References.) But we have redesigned them each onto similar PCB's to allow easy comparison. And in addition a light/dark option has been incorporated into each. We say 'light/dark' because each circuit has a PCB-mounted switch on-board. In one switch position a light-to-dark transition will activate the relay. In the other position a dark-to-light transition is required.

So you can use the light falling on the detector to switch on a normally off circuit, or switch off a normally on circuit.

Each kit has a 12V relay rated to switch 240VAC/5A mounted on-board. Using a relay allows the light/dark switch to form a module separate from the circuit which is to be switched. The Common, Normally Open, and Normally Closed contacts are brought out to terminal blocks. Power is also brought to the kit through terminal blocks.

The kit is constructed on a single-sided printed circuit board (PCB) with a printed overlay and bottom solder mask. Protel Autotrax and Schematic were used to produce it.

ASSEMBLY INSTRUCTIONS

Before you do any construction we suggest that you connect a resistance meter to one of the LDR's - the component with the transparent face and a spiral pattern inside it - and note how the resistance depends inversely on the amount of light falling on it. Note the wide range of resistance. Play with the LDR in very bright and very dark conditions. A feel for what is happening in the LDR will help you understand the three circuits you are about to build. In the dark, the resistance is very high, typically around 1M ohm. In bright light it is low, typically 1K ohm. The peak spectral response of the LDR (VT936G from EG&G) is at 550nm. The continuous power dissipation is 80mW and the maximum voltage which can be applied to it is 100V.

Check off the components in the bag against the Component listing. It is generally easiest to solder the lowest height components first - the resistors and links. Make sure you get the diode around the correct way according to the overlay. Do not mix up the npn with the pnp transistors. Also do not mix the 4K7 with the 47K resistors.

The two terminal blocks on each board slide fit together in a tongue & groove arrangement. On the LED's the cathode or the bar on the overlay corresponds to the short lead of the LED. The LDR has a long lead. We suggest you leave it long to start with. You can always shorten it later. The LDR can go in either way.

Finally connect 12V DC power to the terminal blocks. The relay should click on or off when the potentiometer is adjusted, the switch is moved or the light falling on the LDR varies. Experimenting with each kit to see how it works.

What to do if they do not work. Poor soldering is the most likely reason that any of the kits do not work. Check all solder joints carefully under a good light. Next check that all components are in their correct position on the PCB especially the diodes.

CIRCUIT DESCRIPTION

Each circuit depends on a light sensitive device called a LDR, light dependent resistor. The resistance of the LDR depends on the amount of light falling on it. The snake-like track on the face of the LDR is a cadmium sulphide (CdS) film. On each side is a metal film which is connected to the terminal leads. If you played with an LDR & resistance meter as suggested above then you will know what it does. The CdS LDR used in these kits are relative slow response devices. This one has a time constant of about 100msec. So it is quite fast enough to switch on/off when people pass or run through it. But if you wanted to use a LDR for fast light-activated photography then other LDR materials, or a different circuit would have to be used.

The LDR and a trimpot form a voltage divider which is used to apply bias to a transistor. The more dark it is, the higher the LDR resistance. As the LDR changes resistance the change in potential is detected by the circuit and the relay is activated. What distinguishes each circuit are the stability to very small light changes, sensitivity to supply voltage and the amount of hysteresis built into the circuit.

The PCB-mounted switch in circuits A & B just interchanges the trimpot & the LDR as far as the detection circuit is concerned. So a dark activated switch becomes a light activated switch or vice versa. In circuit C as we shall see below the switch is located after the sensing circuit in association with two switching transistors. A protection diode is fitted across the relay. This is to short circuit the 'back-emf' generated by the collapsing magnetic field when the relay is turned off. Otherwise a high-voltage spike transient would enter the circuit and quickly damage the other components. In all three circuits an LED with current limiting resistor is in parallel to the relay to give a visual indication of when the relay is turned on.

Kit 79C. Note the low value of the trimpot compared to the two previous circuits. And note the placement of the light/dark switch after the sensing circuit, not before as in the previous two designs. The circuit uses two transistors Q1 & Q2 to form a Schmidt trigger. Once the circuit changes state it stays that way even if there are slight variations in the bias voltage.

The Schmitt trigger uses positive feedback to avoid chattering of the relay. When Q1 turns on, Q2 makes sure that Q1's base-emitter voltage becomes more positive. Q1 on turns Q2 off. The key to the Schmitt trigger operation is R4, the common emitter resistor. The current flow through it causes a voltage drop which reduces the voltage applied across each base-emitter junction.

Consider the two extreme situations. Suppose it is dark. The LDR has a high resistance. Q1 is off & Q2 is on. Current flows through R3 (1K), Q2 then R4. Now suppose it was light. Q1 is on & Q2 off. The current flows through R2 (10K, 10 times R3), then Q2 then R4. But in this case the voltage drop across R4 will be ten times smaller.

Now let us look at what happens at the transition. Suppose it is dark. As the light increases and the resistance of the LDR decreases Q1 starts to turn on and the voltage across R4 decreases as the larger current from Q1 is replaced by the smaller current from Q2. Since the R4 potential drop is decreasing the voltage drop across Q1 increases. This is positive feedback. Q1 is turned on harder. Very quickly Q1 is fully-on & Q2 fully-off. A similar story applies the other way.

Q3 & Q4 do the actual switching of the relay. Q2 & Q3 operate together. When Q1 is off both Q2 & Q3 are on. Q4 acts as an inverting switch. When Q3 is on, the base of Q4 goes high turning Q4 off. The SPDT switch connects the relay to the collector of either transistor giving the light/dark switch choice. R5 & R7 provide a load for each transistor when they are not connected to the relay. Because they are large (47K) compared to the relay coil resistance (usually in the 200 - 400 ohm range) the relay can be connected in parallel with either of them.

Note that the trimpot does not have to be readjusted when the light/dark switch is moved because of its position after the sensing circuit, nor before it like in the previous circuits.

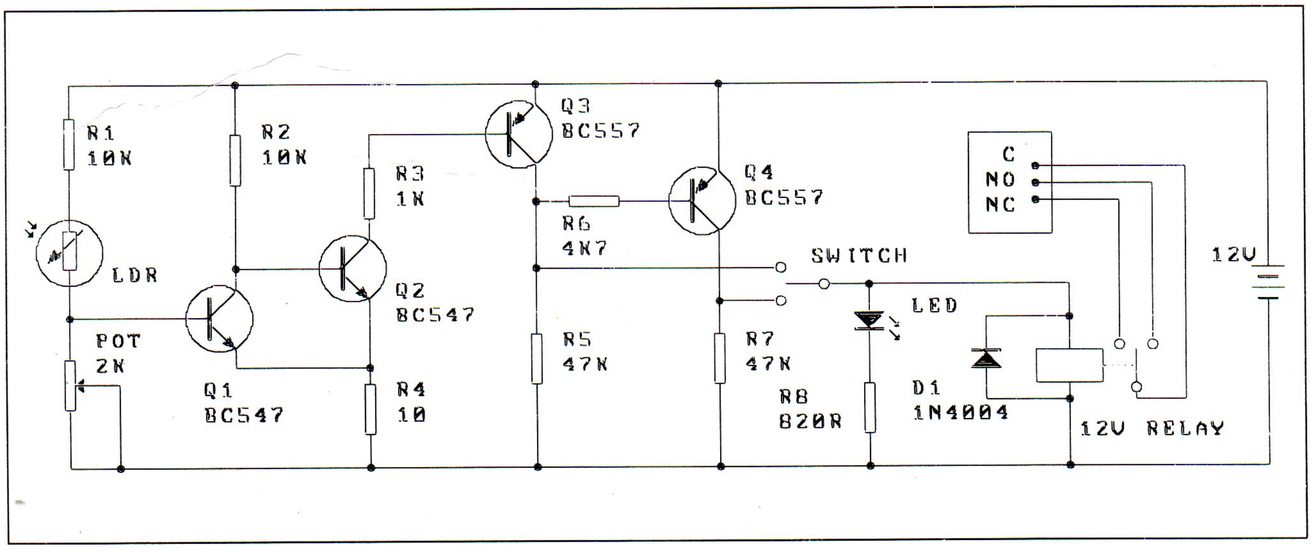
References:

Optoelectronics Circuits Manual by R. M. Marston, published by Heimann Newnes, 1988, Chapter 5.

The circuit for Kit 79C was originally published in *Electronics Australia*, February 1992 and is used here with permission. The PCB was redrawn.

K79C Components

Resistors 5% 1/4W:			
1K	R3	brown black red	1
4K7	R6	yellow violet red	1
10K	R1 R2	brown black orange	2
10R	R4	brown black black	1
47K	R5 R7	yellow violet orange	2
820R	R8	grey red brown	1
2K Koa trimpot (202)			1
BC547			2
BC557			2
1N4004 diode			1
5mm red LED			1
Relay 250VAC/5A Goodsky			1
LDR			1
SPDT PCB-mounted switch			1
3 pole terminal block			1
2 pole terminal block			1
Kit 79C PCB			1



Kit 79C Schematic