# PHOTOELECTRIC SENSOR

## DETECTS (AND COUNTS) ENTRANCES & EXITS

***In/out detection system counts events (up and down) and can be used to control lights, appliances, etc.***

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MOST photoelectric entry detectors are unidirectional. They can detect when an individual enters a given area but not when he leaves. A more practical system, from both a security and a convenience point of view, would be able to detect motion in both directions. A store owner would then know whether or not all customers who entered his premises had left by the close of the day. In the home, such a system could be used to automatically turn on and off lights as you enter and leave a room.

The in/out detection system described here is a relatively simple and inexpensive approach that takes advantage of readily-available TTL IC's. It not only turns on the room lighting (or any other electrical device) when the first person enters the monitored area, it also keeps tabs on the number of people entering and leaving the area. The system turns off the electrical device only after the last person has passed the sensor while exiting the area.

The basic circuit is designed to count up and down a maximum of nine events. However, it can easily be modified to count 99, 999, etc., events simply by adding extra IC's and diodes. Additionally, the system can accommodate two or more sets of sensors should you have more than one doorway to monitor.

**About the Circuit.** In the circuit shown in Fig. 1, the UP and DOWN sections of the system operate in an identical manner, the only difference being in the direction of the count. Since operation is identical, we will discuss the sequence of events in only the UP section.

When an external light beam shines on *LDR1*, the resistance of this light-dependent resistor is a low 100 ohms (approximately). Consequently, the input to pin 13 of *IC1* is low, making the output of this inverter stage, at pin 12, high. Now, when the beam to *LDR1* is broken, the light-dependent resistor's characteristic resistance rapidly increases to several megohms, placing a relatively high positive voltage at the pin-13 input of *IC1* to generate a low output at pin 12. The steep edge of the rapidly falling voltage at pin 12 is differentiated by *C1*, *R2*, and *R3* to produce a sharp negative pulse whose width remains constant regardless of how long the light path to *LDR1* is broken.

Resistor *R2* also serves as a "pull-up" for the input of *IC2*, a timer integrated circuit that is connected as a one-shot multivibrator. When triggered, *IC2* generates a positive-going pulse at its pin-3 output. This pulse is then inverted by another inverter stage in *IC1*, after which it is passed to the "count-up" input (pin 5) of up/down counter *IC4*, registering a one-count increase. With each successive breaking of the beam to *LDR1*, the system registers another up-count (to a maximum 9 count, after which the system automatically resets to 0).

The same inverted signal that is applied to the pin-5 input of *IC4* is also applied to the reset input (pin 4) of *IC3*, another timer integrated circuit connected as a one-shot multivibrator. This inhibits the output of *IC3* and prevents any possibility of generating a false down-count in the system. Bear in mind that *LDR1* and *LDR2* in the finished project are mounted physically close to each other so that a common light beam can be used for both. This means that when an opaque body passes between the beam and *LDR1*, a discrete interval later it passes between *LDR2* and the beam. Hence, if *IC3* were not inhibited, the system would count up and almost immediately count down as the beam to first one and then the other LDR is broken. The system must, therefore, respond to the count generated by the first LDR to be activated—in this case, *LDR1*—for true bidirectional performance.

The four outputs from *IC4* are coupled through isolating diodes *D1* through *D4* and current-limiting resistor *R10* to the base of transistor *Q1*. The transistor is held in cutoff whenever all the outputs of *IC4* are low and conducts whenever any one or more outputs are high. When *Q1* is conducting, relay *K1* is energized and operates whatever external device is connected to its contacts.

As noted earlier, the basic system is configured for a maximum count of 9 in either direction. If you wish to increase the count range, you can add one or more 74192 up/down counter IC's to the basic circuit as shown in Fig. 2. Each added 74192 IC will then provide a *one-decade* increase in range. For example, two 74192's increase the maximum count to 99, three 74192's to 999, etc. When up/down counters are added, the "carry" and "borrow" pins (pins 12 and 13) of each preceding counter become the inputs to the next counter in line. Note also that all "clear" inputs (pin 14) of the counters must connect to CLEAR switch *S1*.

An adequate light source for the system can be obtained by using a low-voltage power transformer with an appropri-

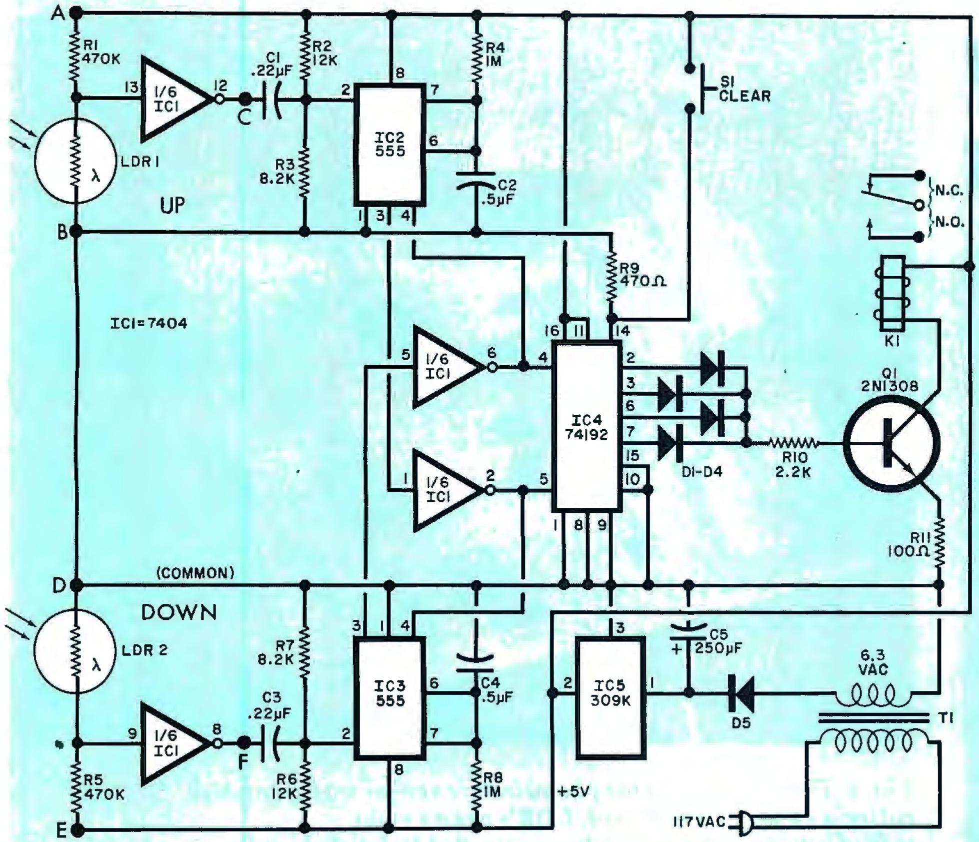


*Fig. 1. Any sudden change in light on LDR1 causes an output pulse which is counted to drive relay K1. Two one-shots are cross-coupled so that only the first one activated is counted.*

## PARTS LIST

C1, C3—0.22-μF capacitor
C2, C4—0.5-μF capacitor
C5—250-μF, 25-volt electrolytic capacitor
D1 through D5—1N4001 rectifier diode
IC1—7404 hex inverter IC
IC2, IC3—555 timer IC
IC4—74192 up/down counter IC
IC5—309 5-volt regulator IC
K1—3-volt, 25-mA relay (Calectro No. D1-965 or similar)
LDR1, LDR2—Light-dependent resistor with 1-megohm maximum, 100-ohm minimum resistance (Radio Shack No. 276-116 or similar)
Q1—2N1308 or similar transistor
The following resistors are ½-watt, 10%:
R1, R5—470,000 ohms
R2, R6—12,000 ohms
R3, R7—8200 ohms
R4, R8—1 megohm
R9—470 ohms
R10—2200 ohms
R11—100 ohms
S1—Spst momentary-action pushbutton switch
T1—12-volt, 300-mA power transformer
Misc.—IC and transistor sockets (optional); heat sink for IC5; perforated board; suitable box to house circuit; line cord; hookup wire; chassis-mounting ac receptacle; sheet of insulating plastic; materials for making light source (see text); rubber grommet; machine hardware; solder; etc.

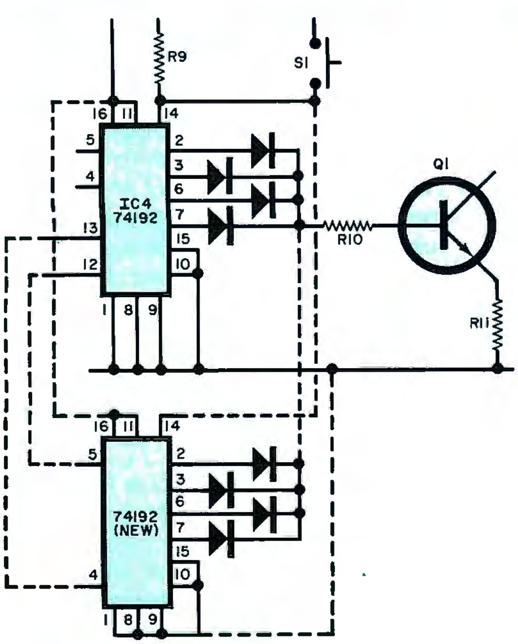


*Fig. 2. Count can be increased by adding another up/down counter.*

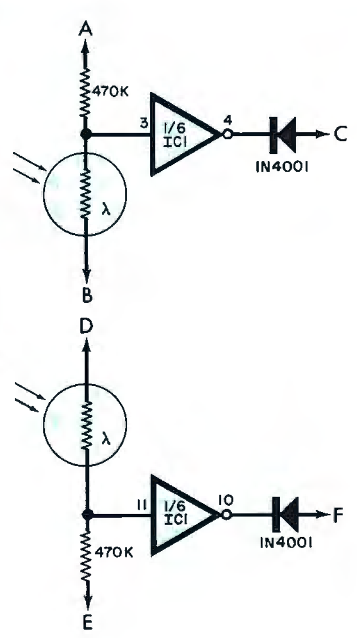


*Fig. 3. Second pair of counting inputs can cover another entry.*

ate panel lamp connected across its secondary winding. By wiring a 100-ohm potentiometer in series with one of the transformer's secondary leads and the lamp, you can vary the intensity of the beam to suit conditions. The lamp can be set into an ordinary flashlight reflector to focus the light into a narrow beam.

If it is necessary to cover a second doorway, the system will accommodate an extra pair of UP/DOWN counting inputs, connected as described in Fig. 3. This will use up the remaining two inverters in the 7404 hex inverter used for *IC1*. In the event that more than two doorways must be covered, extra UP/DOWN counting inputs can be used, provided that you add as many inverter pairs as there are LDR pairs.

**Construction.** There is nothing critical about circuit layout or lead routing. The entire circuit can be assembled on a 5" × 4" (12.7 × 11.4 cm) piece of perforated board, as shown in Fig. 4. It is

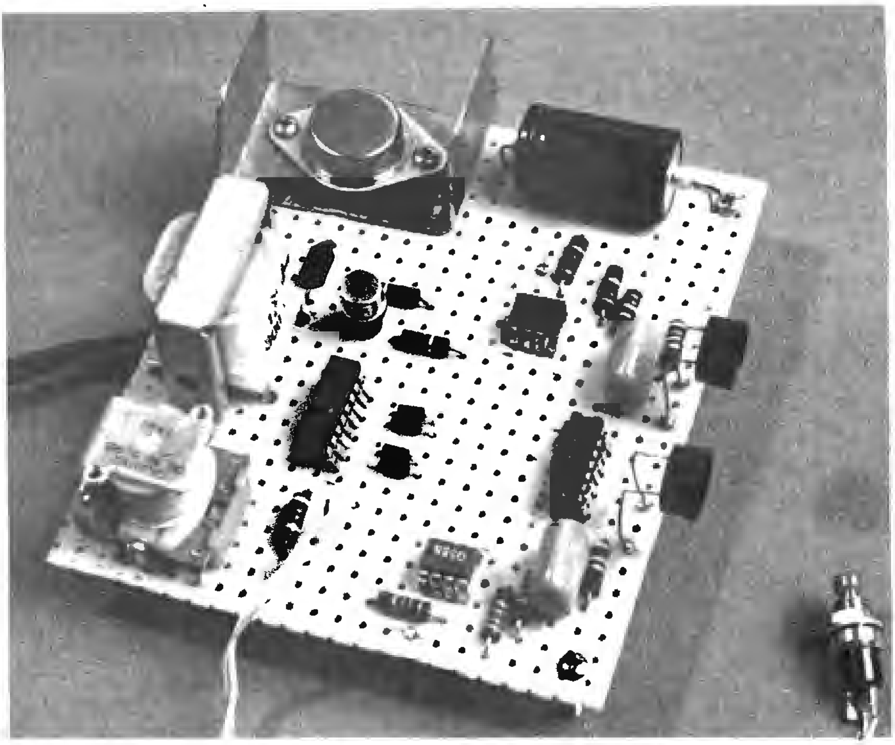

*Fig. 4. The prototype of the photoelectric sensor was assembled entirely on perforated board. LDR's are on right side of board. CLEAR switch is connected by twisted leads.*

advisable to use sockets for the IC's and transistor. Note also the need for a heat sink with *IC5*.

Light-dependent resistors *LDR1* and *LDR2* should be mounted about 1" (2.54 cm) apart so that a single light beam will suffice for both. If you are using extra UP/DOWN counting inputs, mount their LDR's on a small piece of perforated board. Cut holes in a small box to allow light-beam access to the LDR pair, mount the LDR board inside the box, and interconnnect this assembly with the main board via twisted cable.

The box that houses the main circuit board should be large enough to accommodate the main circuit board, a chassis-mounting ac receptacle, and CLEAR pushbutton switch *S1*. Drill holes in the box as required to mount all components in place and to provide light-beam access to *LDR1* and *LDR2*. Mount *S1* and the receptacle in their respective holes. You can use ordinary hookup wire to interconnect *S1* with the circuit board, but it is advisable that you use a length of regular line cord to interconnect the relay contacts and the receptacle. Slip the free end of the line cord through a rubber-grommet-lined hole in the case and solder it to the appropriate points in the circuit. A sheet of insulating plastic should be placed between the box and the bottom of the board before the latter is finally bolted down. This will obviate the possibility of the live ac on the primary side of *T1* from shorting out against the metal box.

**Testing the Circuit.** Plug the system's line cord into a convenient ac receptacle and direct a beam of light onto *LDR1* and *LDR2*. The relay should immediately energize. Depressing the CLEAR button (*S1*) should cause the relay to immediately deenergize. Now, block the light beam by passing your hand in front of first *LDR1* and then *LDR2*. The relay should again energize. With the relay still energized, passing your hand in front of first *LDR2* and then *LDR1* should cause *K1* to drop out.

Pass your hand several times from *LDR1* to *LDR2*. The relay should immediately energize on the first pass and remain energized with each successive pass. Now pass your hand an equal number of times from *LDR2* to *LDR1*. The relay should remain energized for all but the last pass. On the last pass, the relay should deenergize. This procedure checks the up and down counting operation of the circuit.

The relay specified for *K1* in the Parts List can safely handle up to 3 amperes of current. If you wish to operate a device that requires a greater amount of current, you will have to substitute a low-voltage, low-current relay whose contacts can handle the current drain. Alternatively, you can use the specified relay to drive a higher-current relay. ◇