ROBOTIC LIGHT SWITCH

Flip on room lights without flipping your wig in the process

By Mike Gannon

IT IS OFTEN NEXT TO IMPOSSIBLE TO FLIP ON A LIGHT switch as you enter your apartment; for instance, imagine your arms are filled with packages when you've just returned home from a shopping spree. And just as often, many of us forget to turn out the lights as we exit a room (even though the local electric company sends us a gentle reminder of the high cost of energy each month!). But, before you start screaming about the high cost of energy, why not try this little gizmo, the Robotic Light Switch.

If there's a light in your home or perhaps at work that's turned on and off several times a day, this light-control switch can help make life a bit simpler. It will automatically turn a light on as you enter a room and turn it off as you leave. That means, no more having to juggle or drop packages as you attempt to turn on the lights. And when you leave a room, unlike us mortals, the Robotic Light Switch never forgets to turn them off!

How the system works

The operation, as you'll see in Fig. 1, is inordinately simple. A beam of light from small 12-volt lamp, LMP1, is focused on two side-by-side mounted light-dependent resistors, LDR1 and LDR2 (set and reset, respectively). The two LDR's feed a flip-flop that controls a relay through a transistor switch. The relay supplies 117 volts AC to the room light—a lamp, perhaps— through a socket, SO1.

The heart of the circuit, a 4011 quad 2-input NAND IC (U1) configured as an R-S (reset-set) flip-flop, is shown in Fig. 2 along with its truth table. Any input of about 5.4 volts or less is seen as a low by the circuit, and anything above that value is high. The LDR's, each in series with both fixed and variable resistors, provide the trigger voltage for the flip-flop. The 5000-ohm "compensation" resistors, R3 and R4, make up for a weaker illumination level that may exist across either LDR.

With no light striking the LDR's, each has a resistance of about 1 Megohm. Under strong light that resistive value drops to about 100 ohms. The 12-volt supply voltage is divided across each LDR and its associated series connected 270-ohm resistor, R1 or R2, to yield about 3.5 volts, an amount on the low side of the 5.4-volt threshold.

The LDR's are positioned in the doorjamb so that some one entering the room passes the set LDR first and then the reset LDR (with the opposite sequence occurring as the person exits). That's important to the operation of the circuit as we'll soon see.

Light striking the LDR's cause each to drop in resistance, reducing the voltage drop across them and resulting in dual

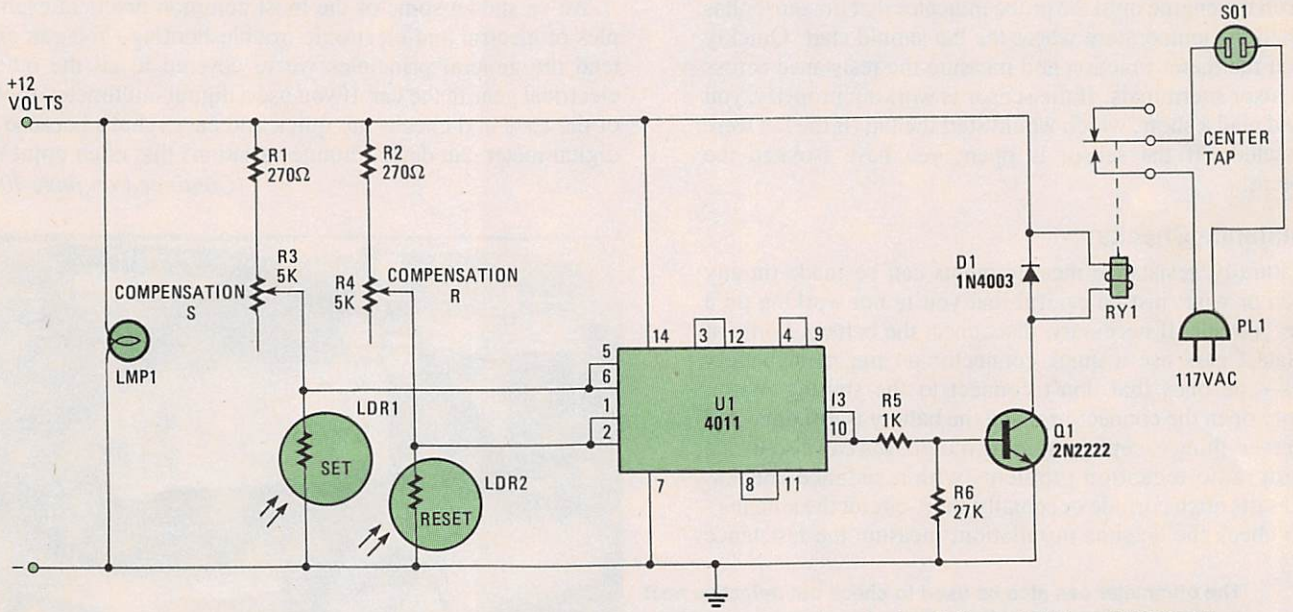


Fig. 1—Schematic diagram of the basic circuit. Note that the order in which shadow falls on LDR1 and LDR2 will determine whether the relay latches to apply voltage to SO1, or unlatches to remove it.

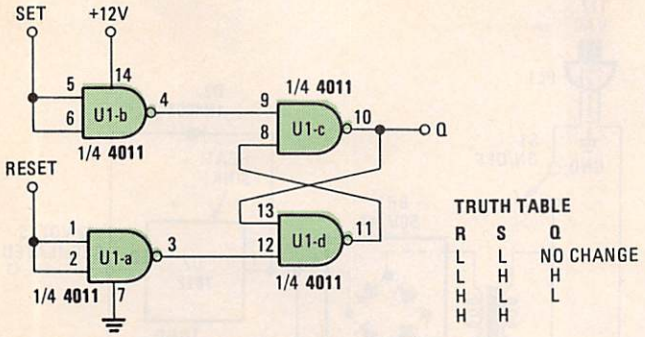


Fig. 2—The workings of the 4011 quad 2-input NAND gate integrated-circuit chip. The 4011 is configured to function as a set-reset latch (flip-flop).

low-level inputs being presented to the flip-flop. With both inputs low (as the Truth Table in Fig. 2 shows) the output remains unchanged.

When the light beam striking of the set and reset LDR's is initially blocked by somebody entering the room, both LDR's increase in ohmic value sending highs to both the set and reset inputs of the flip-flop. That invalid combination causes the output of U1 to remain unchanged. No harm is done, though, the Q output is problematic.

A fraction of a second later, illumination is restored first to LDR1 (set). And for a short period, the set input is high, while reset is low. That combination causes the output of the flip-flop to go high, energizing relay RY1 through current step-up transistor, Q1.

As the person exits the room, the opposite sequence occurs; that is, light from LMP1 strikes LDR2 first, placing a high on the reset input of the flip-flop. That causes the flip-flop to reset, pulling its output low. That low turns Q1 off and de-energizes the relay, removing power from the light.

Resistor R5 limits excessive drive current to Q1. And R6, connected in shunt across its base, ensures that the transistor remains off when the Q output is low. Diode D1 dampens or suppresses voltage spikes generated as the relay is de-energized. Without the protection of that diode, transistor Q1 would have a short life.

PARTS LIST FOR ROBOTIC LIGHT SWITCH

SEMICONDUCTORS

BR1—4 A., 50 PIV full-wave bridge rectifier (Radio Shack 276-1146, or similar)
D1, D2—1N4003 rectifier diode
Q1—2N2222 NPN general purpose silicon transistor
U1—4011 quad 2-input NAND gate integrated circuit
U2—7812 12-volt regulator

RESISTORS

(Fixed resistors are 1/4-watt, 5% unless otherwise specified)
R1, R2—270-ohm, 1/2-watt
R3, R4—5000-ohm, linear-taper potentiometer
R5—1000-ohm
R6—27,000-ohm
LDR1, LDR2—light-dependent resistor (Radio Shack 276-116, or similar)

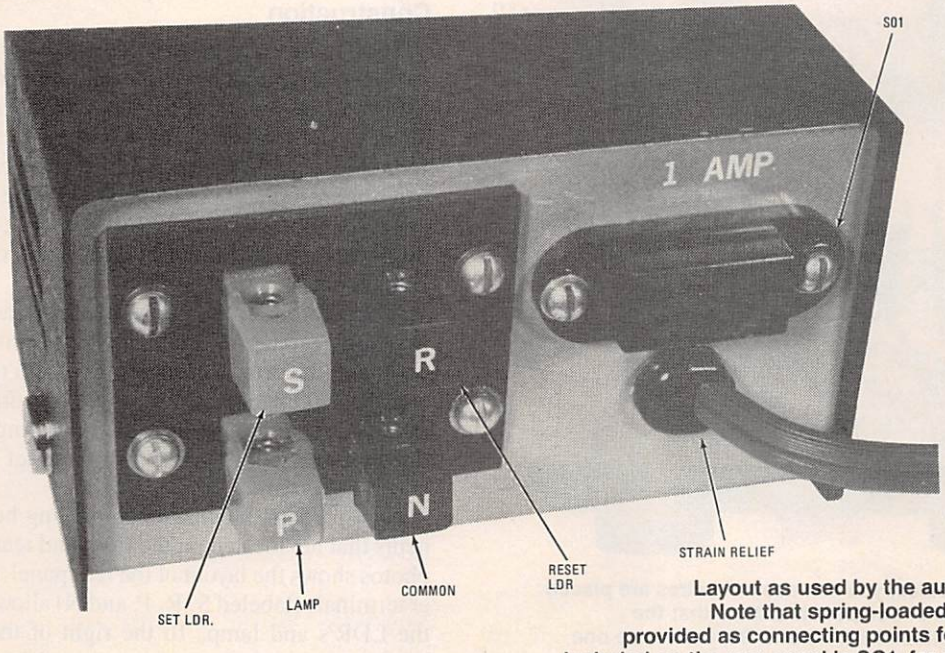
CAPACITORS

C1—3000-μF, 25-WVDC, electrolytic
C2—10-μF, 25-WVDC, electrolytic

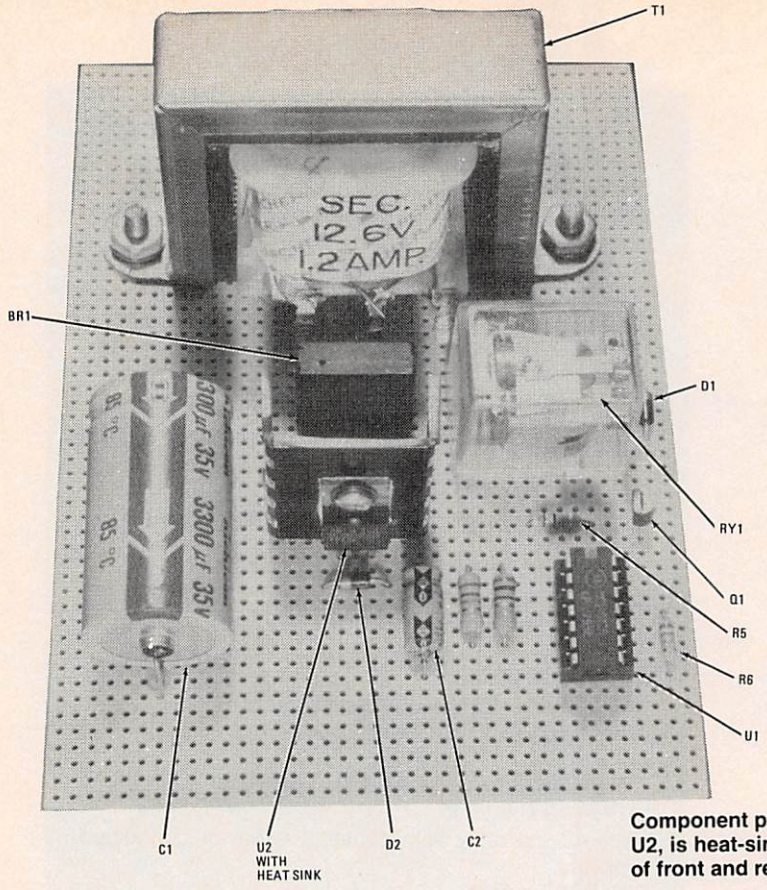
ADDITIONAL PARTS AND MATERIALS

LMP1—12-volt lamp
RY1—12-volt relay with contacts rated for connected device.
S1—SPST switch
T1—Power transformer: 117-volt primary, 12.6V, 1.2A secondary
Heat sink for TO-220 package, lamp reflector, wire, perfboard, stand offs, solder, hardware, etc.

Relay RY1 can be installed in a wall box to control a prewired lighting fixture. (Check local wiring codes before making any such modification.) By using two separate lamps to trigger the LDR's, the circuit can be made to function as an industrial control, responding to objects moving along a conveyor belt.



Layout as used by the author for his rear panel. Note that spring-loaded speaker terminals are provided as connecting points for the LDR's and lamp. Included on the rear panel is SO1, for room light connection.



Component placement on the perfboard. Note that the regulator, U2, is heat-sinked. Ample room is allowed for clearance of front and rear panel-mounted components.

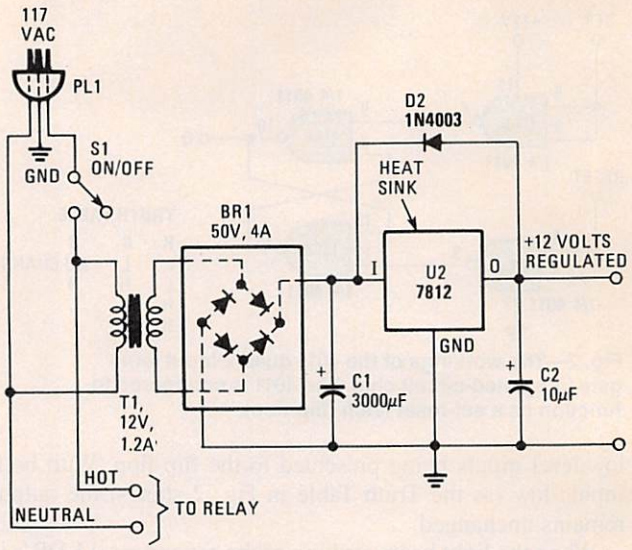
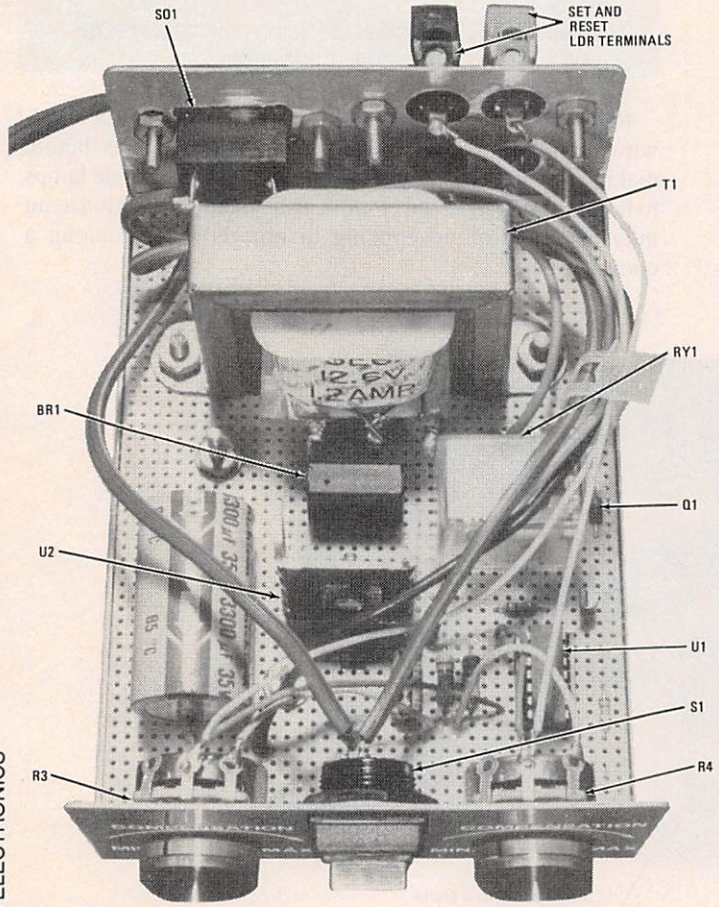


Fig. 3—Recommended power supply features current limiting, so no fusing is required. A tap from the transformer's primary is routed to relay RY1 to power room lights.



With all circuitry in place, you can see how wires are placed from front to rear panel components. Note that the compensation potentiometers, R3 and R4, each have one end-terminal left floating.

You can also place the lamps and LDR's sufficiently high on the doorjamb leading to your home workshop. In that way, only "big people" can trigger the circuit. That way, little tykes are protected from injury by power tools, like saws and drills, which they may attracted to.

A suitable power supply for the circuit is shown in Fig. 3. That circuit can provide up to .8 A—an ample amount for handling additional lamps, plus a heavy-duty relay. The circuit, without the lamp and relay, draws only about 100 mA. Because the 7812 regulator has a current-limiting feature incorporated into it, a fuse is usually not needed, but feel free to include one if desired.

Construction

The circuit may be built using the construction method most convenient for you. The author's prototype was built on a piece of perfboard about 4 × 5-7/8 inches. (Refer to the photos.) Perfboard with suitable spacing for IC sockets should be used. Be sure to allow sufficient clearance for the panel-mounted components when laying out the board. The power switch (S1) as well as LMP1, R3, R4, the AC socket (SO1), and the set and reset LDR's are, of course, off-board components.

Wire the circuit-board components according to Fig. 1. Next connect the AC source to the circuit using a 3-wire line cord with the ground lead going to both the transformer case and the circuit box. (The usual precautions apply.) In any event, observe the hot and neutral wiring even if a two-wire line cord is used. And use a strain relief where the line cord enters the circuit box.

Next prepare the chassis by drilling holes for the components that are located on the front and rear panels. One of the photos shows the layout of the rear panel. Push-button speaker terminals (labeled S, R, P, and N) allow easy connection of the LDR's and lamp. To the right of the terminal block is

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socket SO1, below which is the line cord with strain relief.

The circuit board should be mounted in the cabinet on stand-offs to avoid short-circuiting. Now wire the chassis-mounted components to the board. The photo of the top-view of the unit shows the circuit board wired to the chassis-mounted components. Next prepare the lamp and LDR blocks, which are "custom-made" to suit your own application.

The LDR block requires that wells about 3/4-inch deep be drilled to block out stray light, when the LDR's are in place. Two holes can be drill side-by-side into the doorjambs or a block of wood to accommodate the LDR's. Space the holes at least 1-inch apart center-to-center so the LDR's can distinguish shadow edges, but not so far apart that the lamp does not shine on them evenly.

A low-current lamp of about 75 mA provides sufficient illumination for a distance of up to six feet. The reflector from a flashlight can serve to focus the light on the LDR's. The bulb must be carefully positioned in the reflector for best effect.

Installation, Test, and Adjustment

Place the circuit box in a protected area near an electrical outlet and the light it must control. Attach the lamp and LDR block on opposite doorjambs. If possible, try to attach the lamp block to the hinged side of the door. Passing too close to the lamp block can cause shadows on the LDR block to have ill-defined edges.

The set LDR's should be placed so that upon entering the room, it is the first to have its light source interrupted. Using four-conductor cable, connect one lead wire of the two LDR's to the circuit board through terminal S and R (set and reset). Connect the lamp to the circuit board through 2-conductor speaker wire with the positive lead going to the P terminal on the rear panel. The other end of both LDR's and the lamp are connected to the common N terminal.

Once done, close off all windows and doors, making the room as dark as possible. Set each compensation control to minimum and connect a voltmeter across each LDR and measure the voltage. If the LDR's receive an optimum amount of light, your readings should be between 2.5 and 4.5 volts, and no further adjustment will be required. But, if either of the LDR's is above 4.5 volts, adjust the corresponding compensation control until a 4.5 volt reading is obtained.

Finally, with everything in place, pass though the doorway as you normally would. The lights should turn on as you enter the room and extinguish as you exit. Of course, if the circuit doesn't work as expected, it will be necessary to trace back through your wiring to find the problem. Look for solder bridges, mis-wired components, and so on.

If it does work as desired, your Robotic Light Switch is complete and ready to go to work. As an added benefit, the small lamp also serves as a marker or night light for the entryway. ■