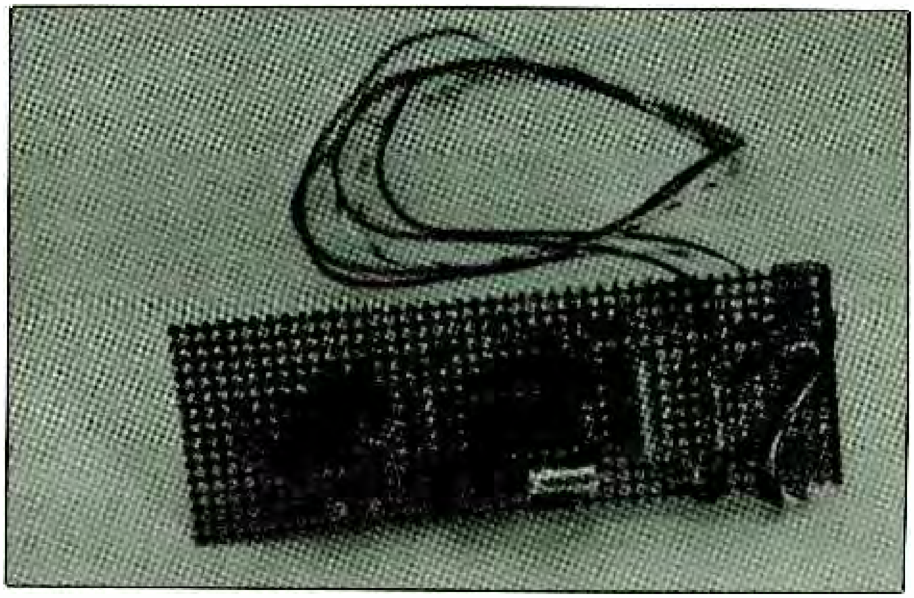
Twilight Sentry

This device visually warns a driver if his vehicle's headlights are off as night approaches

By Anthony J. Caristi



Today, many cars have all-electronic displays that light up in a brilliant display of color the instant the ignition is turned on, regardless of whether it is daylight or dark outside. Consequently, there is no visual feedback to alert drivers of these cars that their headlights have not been turned on at dusk or even after full dark. For this reason, many vehicle operators can be seen driving with their headlights off, making it more difficult for other drivers to be immediately aware of the car's presence. (Older cars, in contrast, had incandescent dashboard lighting that provided a driver with an intuitive sense of dusk's approach—if you could not read the dashboard indicators, it was time to turn on the headlights.)

Installing the Twilight Sentry in your car restores the telltale needed to alert you to turn on your headlights when twilight approaches. Completely automatic in operation, you do not even have to remember to arm the Twilight Sentry. Once installed, Twilight Sentry senses ambient light and, when the light gets to a predetermined level, starts flashing an attention-getting light-emitting diode that tells you to turn on your headlights. Turning on your headlights extinguishes the LED, eliminating any possible distraction from your driving from that quarter. The project works in both new and older cars, even those with incandescent dashboard lighting.

About the Circuit

The heart of the Twilight Sentry circuit shown in Fig. 1 is cadmium-sulfide photoresistive cell *PC1* whose resistance is inversely proportional to the intensity of the light striking its active surface. That is, when the light is bright, the cell's resistance is low, and vice-versa. By connecting *PC1* in series with *R1* and powering the circuit from an automotive 12-volt dc electrical system, the voltage across the photocell is nearly zero under bright-light conditions. As the intensity of the light diminishes, the resistance of *PC1* gradually rises.

The output of the *PC1/R1* circuit is wired in parallel with SENSITIVITY control *R2*. The output from this arrangement is used to drive the pin 1 input of NOR gate A in *IC1* (see Fig. 2 for pinouts and internal details of the integrated circuits used in this project).

Gates A and B of *IC1* make up a flip-flop or latch circuit that has two stable states that depend on the logic levels fed to the inputs at pins 1 and 6. A logic 1 pulse or voltage fed to either input causes the corresponding output (pin 3 for gate A and pin 4 for gate B) to assume a logic 0 condition and remain in this state until the circuit is toggled to its alternate state by applying a positive voltage to the opposite latch input. This latch circuit is used to "remember" that the vehicle has been started and that its headlights are still off.

Turning on the ignition generates a positive-voltage pulse that is delivered to pin 6 of gate B in *IC1* through capacitor *C2*. This pulse

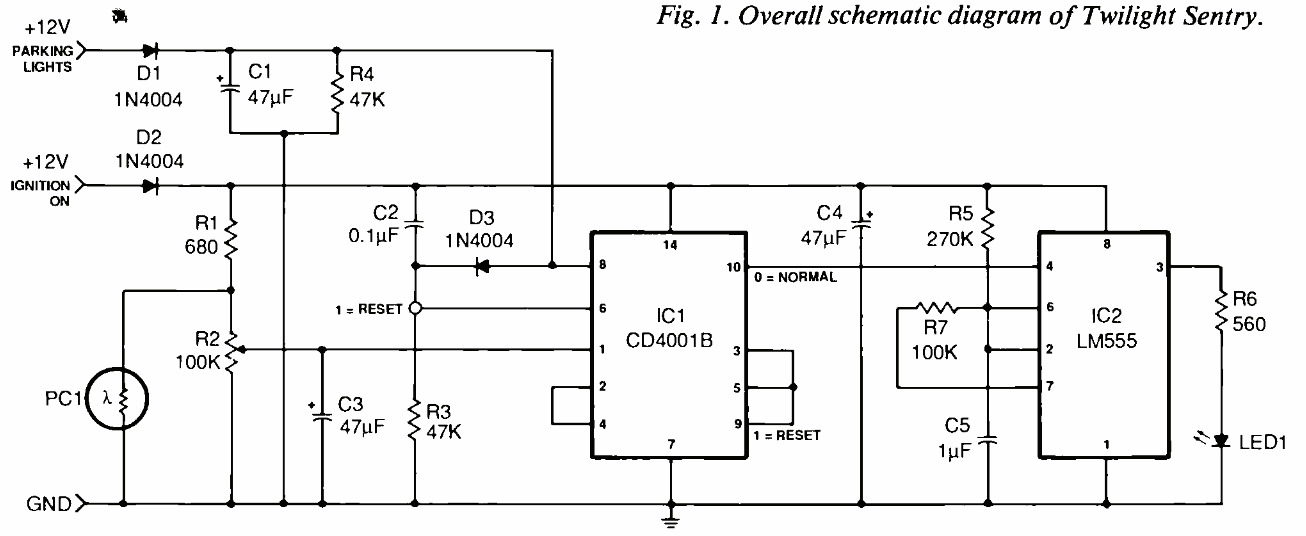


Fig. 1. Overall schematic diagram of Twilight Sentry.

puts the latch circuit into the reset mode as long as sufficient light strikes the photocell.

As dusk approaches, the voltage at pin 1 of *IC1* rises. When this potential reaches approximately 8 volts, the latch circuit toggles into its alternate state if the vehicle's headlights are still off. As the circuit switches to its alternate state, the output of gate C at pin 10 of *IC1* rises to a logic 1 because both outputs of this NOR gate are now at a zero logic level.

The positive voltage fed to pin 4 of timer *IC2* triggers this circuit into oscillation. Operation of the timer circuit is in the free-running (astable) mode. The frequency of oscillation is approximately 2 Hz. Driven by the output of *IC2* at pin 3, light-emitting diode *LED1* now flashes on and off to provide a visible indication that the vehicle's headlights are off and should now be turned on.

Turning on the headlights causes the logic 1 fed to the pin 8 input of gate C in *IC1* to generate a logic low at the pin 10 output to timer *IC2*. This shuts down the oscillator and extinguishes the LED. In addition, the latch circuit is triggered into its reset mode by means of diode *D3* so that *LED1* will not turn on if you are driving at dawn and shut off the headlights after sunrise.

Construction

Assembly of the entire project can be accomplished by wiring the components that make up the circuit on a printed-circuit board or on perforated board with the aid of suitable soldering or Wire Wrap hardware. In either case, it is a good idea to use sockets for the ICs.

You can fabricate your own pc board with the aid of the actual-size etching-and-drilling guide shown in Fig. 3. Alternatively, you can purchase a ready-to-wire pc board from the source given in the Note at the end of the Parts List.

As you install rectifier diodes and electrolytic capacitors *(C1, C3* and *C4)*, be sure to properly orient these components before soldering their leads to the copper pads on the bottom of the board. Note that though *C5* has a 1-microfarad value, which is ordinarily in the electrolytic range, this is not a polarized capacitor. It should, in fact, be a 1-microfarad ceramic capacitor. However, if you have any difficulty obtaining a nonpolarized 1-microfarad capacitor, you can substitute an ordinary electrolytic of this value.

Prepare three 5″ lengths of insulated stranded hookup wire (use stranded wire throughout this project) by stripping ¼″ of insulation from both ends of each. Twist together the fine wires at all ends and sparingly tin with solder. Plug one end of these wires into the holes labeled GND, +12V IGNITION ON and +12V PARKING LAMP and solder into place. The other ends of these wires will be connected later.

Note in Fig. 4 that though SENSITIVITY control *R2* mounts directly on the circuit board, photocell *PC1* and light-emitting diode *LED1* mount off the board in separate holes drilled in the enclosure that houses the project. You have two options for mounting the LED. You can mount it directly on the panel of the project's enclosure and run short hookup-wire leads from it to the appropriate holes in the circuit board. Alternatively, you can mount the LED remote from the project box (on or under the dashboard of your vehicle, where it will readily be seen) and run a cable from it through a hole in the enclosure and back to the circuit board. You have the same options for mounting the photocell.

If you plan on having both the LED and photocell on the enclosure, with no parts in remote locations, mount the LED on the panel facing the driver's seat and the photocell facing out through the windshield with the project sitting on the dashboard. (Before making this decision, however, see Installation below.) This way, the photocell can detect ambient light levels and the LED can perform its function as a visible alerting device.

Should you decide to mount the LED on a panel of the enclosure, trim both leads to ½" in length and form a small hook at the end of each stub. Strip ¼" of insulation from both ends of 3" lengths of red- and black-insulated wires. Twist together the fine wires at both ends of the wires and sparingly tin with solder. Connect and solder one end of the red-insulated wire to the anode lead and the black-insulated wire to the cathode lead of the LED. Then slip a 1" length of small-diameter heat-shrinkable tubing over each wire and lead, pushing them snug up against the bottom of the LED's case so that they completely cover the soldered connections and all exposed LED lead. Shrink the tubing solidly into place.

For a remotely mounted LED, follow the above procedure, except make the wires long enough to bridge the project's and LED's installation locations.

The same arrangement used for mounting the LED applies to mounting the photocell except that if the latter is to be mounted on an enclosure wall simply trim its leads to appropriate length (if needed). Since the photocell is not polarity-sensitive, there is no need to color code the wires used for its cable in remote installation. Additionally, you need use only ½" lengths of small-diameter heat-shrinkable tubing, enough to completely insulate the soldered connections when the remote cable is used.

You can use any type of enclosure for housing the Twilight Sentry as long as it can accommodate the circuit-board assembly and a three- or four-contact screw-type terminal strip (plus the photocell and LED if they are to be mounted on the box's panels). A metal enclosure is preferable to assure a good solid electrical ground between the project and your

PARTS LIST

Semiconductors
D1,D2,D3—1N4004 silicon rectifier diode
IC1—CD4001B quad 2-input NOR gate
IC2—LM555 timer
LED1—Red light-emitting diode

Capacitors (25 working volts)
C1,C3,C4—47-µF electrolytic
C2—0.1-µF ceramic disc
C5—1-µF ceramic or electrolytic (non-polarized; see text)

Resistors (¼-watt, 10% tolerance)
R1—680 ohms
R3,R4—47,000 ohms
R5—270,000 ohms
R6—560 ohms
R7—100,000 ohms
R2—100,000 trimmer potentiometer (Bourns No. 3329 or similar)

Miscellaneous
PC1—Cadmium-sulfide photoresistive cell (Radio Shack Cat. No.176-1567 or similar)
Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware (see text); sockets for ICs; suitable enclosure (see text); small-diameter heat-shrinkable tubing; small rubber grommets (see text); 3- or 4-contact screw-type terminal strip; ½" spacers; 4-40 × ¾" machine screws, nuts and lockwashers; stranded hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: etched and drilled pc board for \$7.75; CD4001B for \$2.00; LM555 timer for \$2.50. Add \$1.00 P&H. New Jersey residents, please add state sales tax.

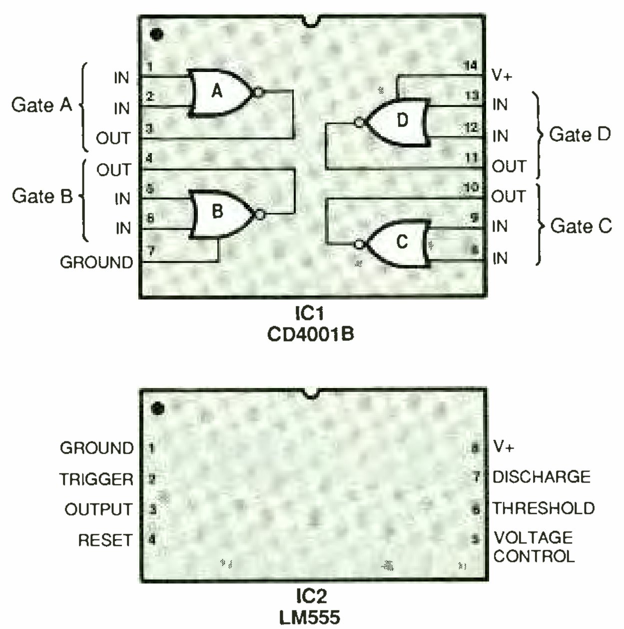


Fig. 2. Pinouts and internal details of integrated circuits used in project.

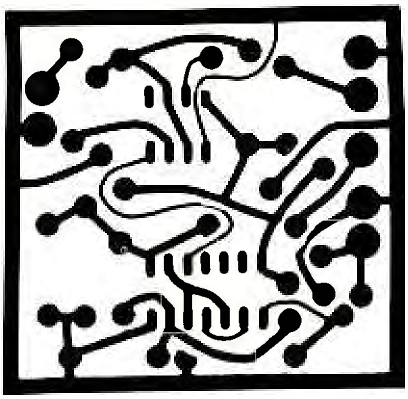


Fig. 3. Actual-size etching-and-drilling guide for printed-circuit board fabrication.

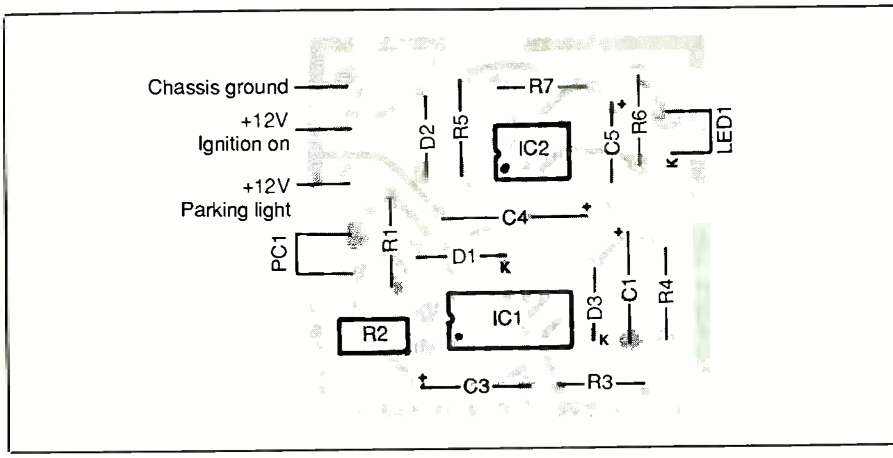


Fig. 4. Wiring guide for pc board. Use this layout as a guide to component placement and orientation if you use perforated board and soldering or Wire Wrap hardware.

vehicle's ground, but a plastic box is easier to machine.

Machine the enclosure as follows. First, drill holes for the photocell and LED, sizing each according to whether it will be used as a mounting hole for the device or as an entry hole for the device's cable. If you are mounting the LED or/and photocell on an enclosure wall, size the hole to provide a snug but not force fit. Then cut a slot and drill the mounting holes for the terminal strip.

Drill ⅛″-diameter holes in the board as near as possible to the upper-left and lower-right corners with the board viewed as shown in Fig. 3. Make sure these holes are far enough away from all circuit-board conductor traces so that mounting hardware will not touch any but the ground trace around the perimeter of the board.

Set the board inside the enclosure and position it so that it will not interfere with the terminal strip, LED or photocell. Mark the locations of the mounting holes and drill the holes in the marked locations. Temporarily mount the board in place on ½″ spacers and determine exactly where to drill the access hole for the adjustment slot for the SENSITIVITY control. Then remove the board and drill this hole.

If the enclosure is a metal box, deburr all holes with a file. Then line the holes through which the cable(s) to the LED or/and photocell will pass with small rubber grommets. If you are using a plastic enclosure, no rubber grommets are needed.

Mount the screw-type terminal strip in its cutout and the LED and photocell in their respective holes. Then connect and solder the LED (observe polarity) and photocell leads (or cables) to the appropriate holes in the circuit board and the free ends of the hookup wires you installed earlier on the board to the lugs of the terminal strip. Refer to Fig. 4 for wiring details.

If the LED or/and photocell are to be remotely located, loosely twist together the wires that make up each cable along its entire length. Then pass the free ends of these cables through the holes drilled for them and tie a knot in each 4″ from the free end inside the box before soldering the wires to the circuit-board assembly.

Mount the circuit-board assembly. Use ½″ spacers and 4-40 × ¾″ machine screws, nuts and lockwashers. If there is any possibility of the spacers touching any but the perimeter trace on the bottom of the board, sandwich insulating fiber washers between them and the board. Then label the screw-type terminal strip contacts as detailed in Fig. 4.

Checkout and Adjustment

Before plugging the integrated circuits into their sockets and installing the project in your vehicle, it is a good idea to check it out to make sure all components are installed in their proper locations and that they are properly oriented. Then recheck all soldered connections.

Once you are satisfied that your wiring is okay, use a meter set to measure 12 volts dc or more to check for the proper voltages. To be able to do this, you need a 12-volt dc source, which can be a bench power supply or your vehicle's battery. Connect the power supply or battery to the project via the +12V IGNITION ON and GND contacts of the terminal strip (observe polarity).

Now connect your meter's common lead to circuit ground. Touch the positive lead of the meter to pin 14 of *IC1* and then pin 8 of *IC2*; in both cases, you should obtain a reading of approximately +12 volts. If you do not obtain the proper readings, power down the circuit and recheck your work. Do not proceed until the problem has been corrected.

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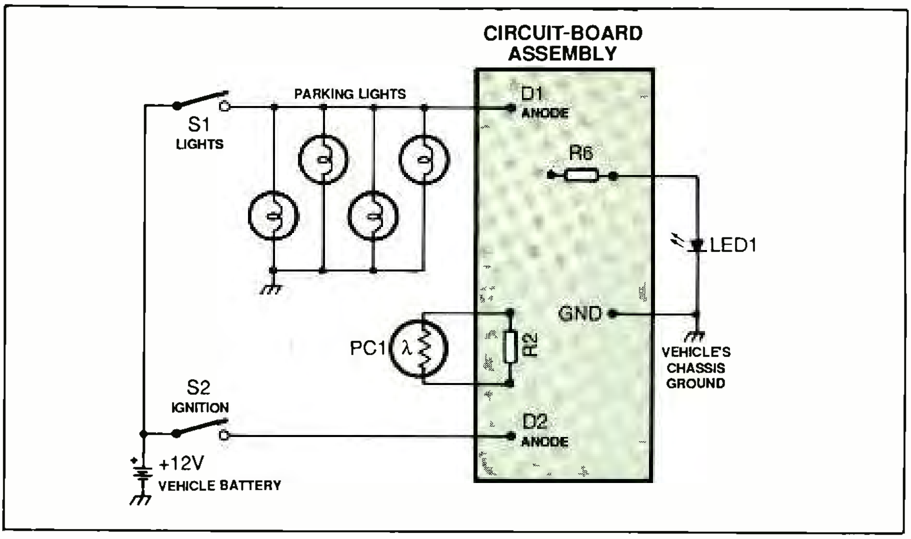

Fig. 5. Wiring diagram shows details for typical installation of Twilight Sentry in a vehicle. Photocell and/or LED can be mounted remote from main circuit.

When you do obtain the proper readings, power down the project and plug the ICs into their respective sockets, taking care to observe proper orientations. Handle *IC1* as you would any other CMOS-type static-sensitive device. As you plug each IC into its socket, make sure that none of its pins overhang the socket or fold under between IC and socket as you push it home.

Now check actual circuit operation, once again using the power supply or vehicle battery as a power source. Do this in a location where the ambient lighting is subdued. First set SENSITIVITY CONTROL *R2* fully counterclockwise. Then with some light striking the photocell, connect the power supply's or battery's ground or negative lead to the GND contact and the positive lead to the +12V IGNITION ON contact of the screw-type terminal strip on the project. The LED should be off.

Simulate a dusk condition by shielding most of the light from the photocell. In bright light, you will have to exclude almost 100 percent of the light. Adjust *R2* clockwise until the LED begins to flash. Then use a short wire or a paper clip to jumper from the anode of *D1* to the anode of *D2*. The LED should now turn off.

If you fail to obtain the proper results during your tests, you must troubleshoot the circuit and rectify the problem. You can check the latch circuit by measuring the potential at pin 13 of *IC1*, which should be about 12 volts when you first apply power to the circuit with *R2* set fully counterclockwise. Setting *R2* to its fully clockwise position and with no light falling on the photocell, the potential at pin 3 of *IC1* should drop to zero and remain there.

Measure the voltage across the photocell to be sure that it is near zero under bright-light conditions. It should rise to no more than about 8 volts as the photocell is darkened.

You can check operation of the *IC2* oscillator by measuring the voltage at pin 4. When power is first applied to the anode of *D2* and with light striking the photocell, you should measure 0 volt. With *R2* set fully clockwise and the photocell in darkness, the measurement should rise to about +12 volts and the LED should flash.

If the logic levels at pin 4 of *IC2* are correct but the LED fails to flash, carefully check your wiring, the component values of the *IC2* oscillator circuit and the polarity of the LED. If necessary, try a new LED.

Installation

Figure 5 shows a simplified installation diagram to use to wire the Twilight Sentry into your vehicle's electrical system. Since the photocell is extremely sensitive, you may want to mount it in a location that is somewhat sheltered from direct light. Whatever location you choose, however, make sure that the photocell is protected from the elements and that there is no possibility that the connections can be accidentally shorted to any metal part of your vehicle.

Voltage to drive the anode of *D2*, via the +12V IGNITION ON contact of the terminal strip, must be obtained from a point in your vehicle's electrical system that is at +12 volts with the ignition on and at 0 volt with the ignition off. Use a voltmeter to locate such a point. Since the circuit draws very little current, you can use the power lead of any ignition-on accessory, including your car radio or a windshield-wiper motor.

The anode of *D1* must be driven, via the +12V PARKING LAMPS terminal-strip contact, from one of the running lights of your vehicle. You can tap off the parking or tail lights. Do not use the headlight circuit, since the high-low beam switch may cause the LED to flash when it should not. Use the dc voltmeter to make certain that you have selected the correct wire in your vehicle to which to make this connection. You should obtain a reading of +12 volts when the lights are on and 0 volt when the lights are switched off.

Be sure to connect circuit-board common to the chassis of your vehicle, via the GND contact of the terminal strip, to assure a good ground.

After installing the Twilight Sentry in your vehicle, make a final adjustment of the SENSITIVITY control. This must be done under actual twilight conditions, at the level of light you want the warning LED to flash. Set *R2* fully counterclockwise (least-sensitive position). Start your vehicle's engine and make sure all lights are off. Now very slowly adjust *R2* clockwise until the LED begins to flash. This will be the ambient light level at which the project will provide a visible warning. After making this adjustment, turn on your vehicle's headlights and note that the LED should now extinguish.

After installing the Twilight Sentry in your vehicle, inform all other drivers who use your car of its function. You will now have peace of mind knowing that you and other drivers who use your vehicle will never inadvertently drive without lights at dusk. **ME**