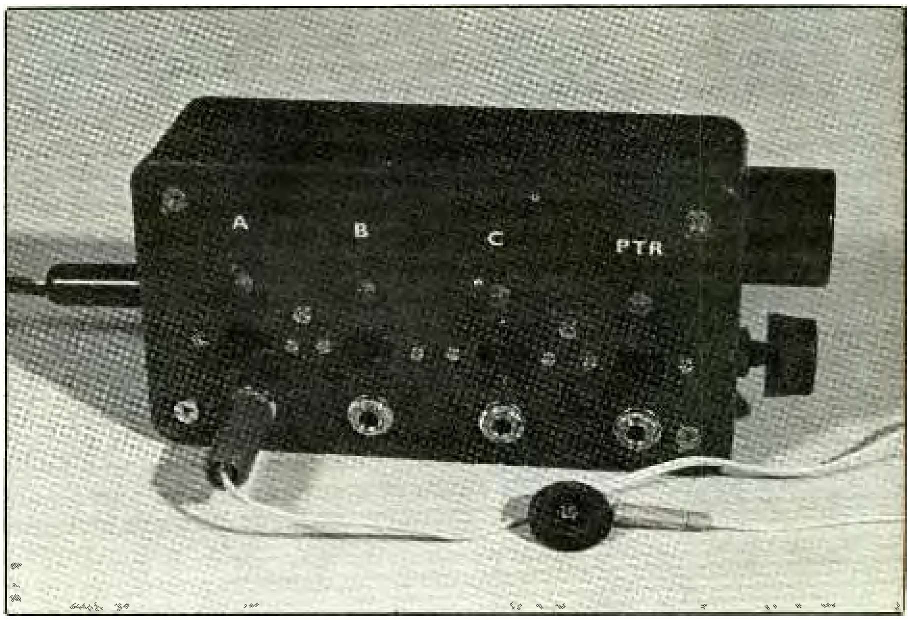
Photo Sensor Operating-Status Indicator

From data-transfer to power, this device centralizes visible and audible operating-status indication of separate components in a system without making electrical connections

By Adolph A. Mangieri



Modern electronic and computer components usually have one or more light-emitting-diode or lamp indicators to let a user know about their operating status. For a typical personal-computing system, this might mean half-a-dozen or more LEDs spread among computer, printer, modem, etc. Moreover, a printer buffer alone might have this many indicators.

Since some of these system components are not located in a user's easy line of sight, it's inconvenient to keep track of their operation. This project enables you to do so with a multi-channel LED display that, unlike a "power director" accessory, also indicates the condition of a data indicator LED, such as on a printer buffer ("Full," "Pause," etc.), not just ac power for a whole unit. In addition, it doesn't require making any electrical connections to each component since our device uses photo sensors for LEDs being monitored. Furthermore, it has individual channel sound indicators in the event you walk away from the operating station to do some work nearby, and a volume control to turn audio up for distant listening.

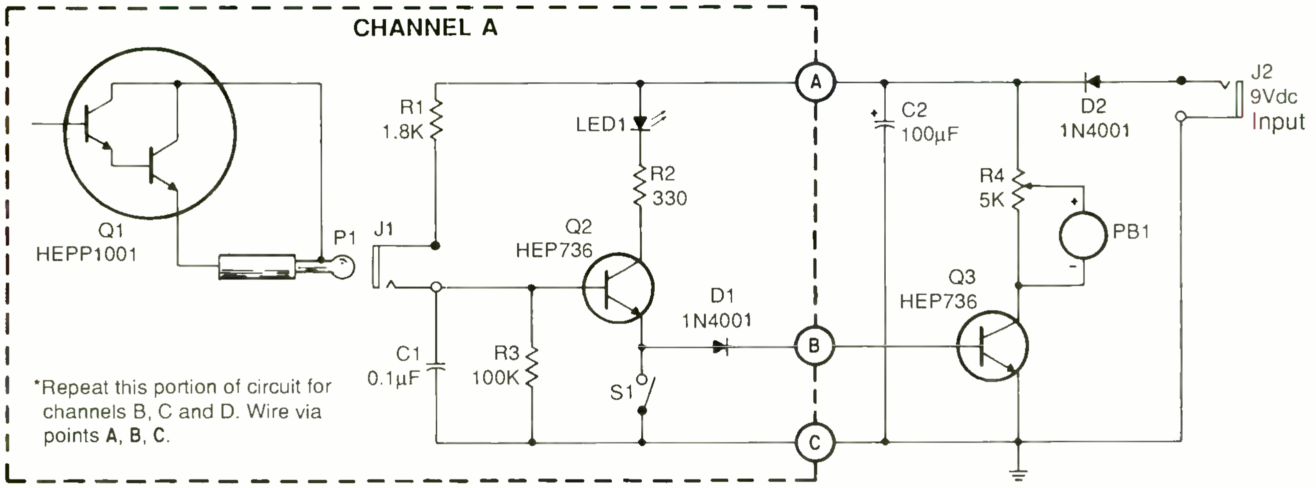
The Audible/Visible Remote Status Indicator described here consolidates a bank of LEDs that can be located directly in your field of vision if placed under the video monitor. A switch in each channel allows you to choose between audible/visible alert or visible-only alert. Each channel is driven by a photodetector that mounts over a LED status indicator on a specific peripheral.

This low-cost project works with any LED and incandescent-lamp status indicator. Since it requires no direct electrical connection to the equipment, it doesn't void existing warranties. It can be equipped to handle any number of channels.

About the Circuit

Shown in Fig. 1 is the schematic diagram of the circuit for Channel A of the project, along with the common audio stage. Highly sensitive Darlington phototransistor *Q1* positions over a remote light-emitting diode or incandescent-lamp status indicator. When *Q1* is illuminated by the light from the LED or lamp, it conducts and drives the base of high-gain transistor *Q2*. Load resistor *R1* limits collector current to a safe level when *Q1* is illuminated by intense light.

Capacitor *C1* bypasses stray ac noise pickup on the cable that connects *Q1* to the Status Indicator. Resistor *R3* siphons off the dark current of *Q1* to prevent partial turn-on of *Q2* when *Q1* isn't being illuminated. Light-emitting diode *LED1* turns



PARTS LIST

Semiconductors
D1,D2—1N4001 silicon rectifier diode
LED1—Light-emitting diode
Q1—ECG 3035 or HEP P1001 Darlington phototransistor
Q2,Q3—ECG 123AP, HEP 736 or similar high-gain npn silicon transistor
Capacitors
C1—0.1-µF, 25-volt disc
C2—100-µF, 25-volt electrolytic
Resistors (¼-watt, 10% tolerance)
R1—1,800 ohms
R2—330 ohms
R3—100,000 ohms
R4—5,000-ohm panel-mount miniature volume control
Miscellaneous
J1,J2—⅛-inch miniature phone jack
P1—⅛-inch miniature phone jack
PB1—Piezoelectric buzzer (Radio Shack Cat. No. 273-065 or equivalent)
S1—Spst miniature slide or toggle switch
Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; small enclosure (see text); twisted-pair earphone extension cord (Radio Shack Cat. No. 33-176 or similar); materials for fabricating detector housing (see text); lettering kit; clear spray acrylic; machine hardware; hookup wire; solder; etc.

Note: This list includes components for assembling a single-channel Remote Status Indicator. For additional channels, duplicate all components except C2, D2, J2, PB1, Q3 and R4.

Fig. 1. Schematic diagram of project showing one LED "channel" and the common audible-alert circuit. Additional channels are identical to that shown in the boxed are and connect into the circuit via points A, B and C in identical manner.

on when *Q2* is switched on by *Q1*'s emitter current. Resistor *R2* safely limits current through *LED1*.

When AUDIO switch *S1* is set to open (off), *Q2*'s emitter current passes through Channel A isolating diode *D1* to the base of audio driver transistor *Q3*, which switches on and causes the supply voltage to appear across VOLUME control *R4*. Piezoelectric buzzer *PB1* now sounds at an output level determined by the setting of *R4*. With *S1* closed, *Q2*'s emitter current is diverted to ground, preventing *PB1* from sounding and providing only visible LED alert.

Circuitry of any additional channels added to the basic Fig. 1 circuit is connected via points A, B and C in exactly the same manner as shown. Isolating diodes (*D1*) connect directly to the base of *Q3* via point B. These diodes are wired in an OR logical arrangement such that *PB1* sounds if any one or more status LEDs light while the channel's AUDIO switch is open.

Power for the circuit is supplied by a commonly available 9-volt dc, 150-milliampere plug-in wall transformer, whose output plugs into the project via *J2*. Diode *D2* protects the circuit from damage that might otherwise result if the power supply were to be connected into the circuit in reverse polarity.

Construction

Since this is basically a steady-state dc circuit, there's nothing critical about component layout and wire routing. Therefore, any traditional means of assembly can be employed to wire the circuit. You can design and fabricate a printed-circuit board or use perforated board and suitable Wire Wrap or soldering hardware to wire the circuit. The prototype was built using perforated board and was mounted inside an all-plastic project box, but you can use a box that has an aluminum front panel. The four-channel version of the circuit easily fits into a standard 4½ × 2½ × 1½-

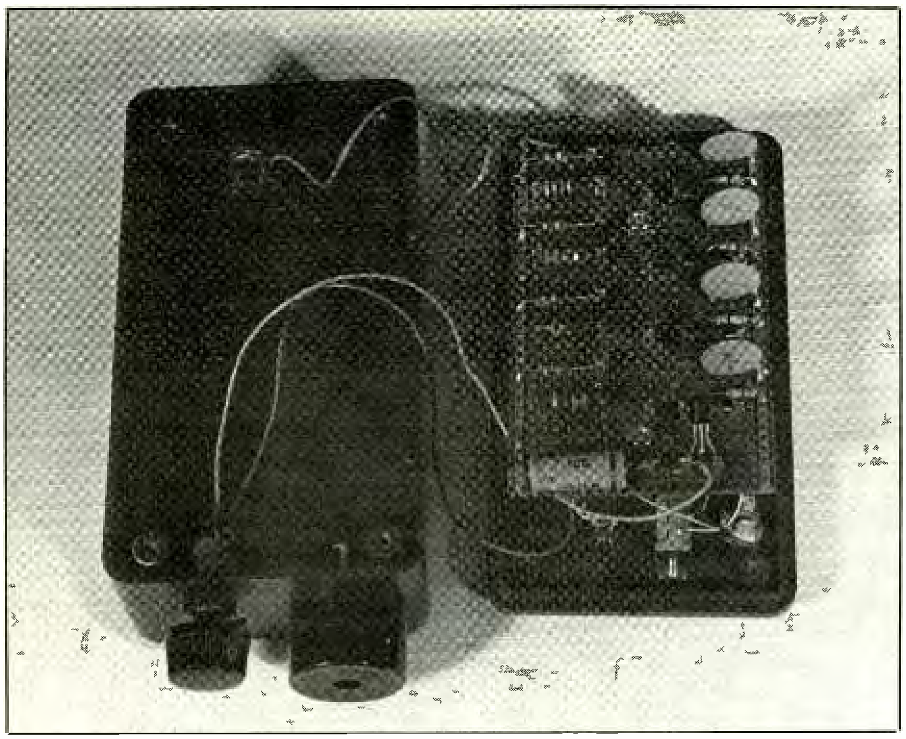


Fig. 2. Interior view of author's prototype. Circuit was assembled on perforated board using solder clips and was housed inside standard plastic enclosure.

inch project box, as shown in Fig. 2. If you add more channels, use a larger project box.

Take care to properly base or polarize the diodes, transistors, LEDs and electrolytic capacitor before soldering them into place. Except the Darlington phototransistors, LEDs, jacks, buzzer, switches and VOLUME control, all components mount on the circuit board. After wiring the board, set it aside.

Now machine the enclosure. Drill two holes for mounting the circuit-board assembly to the front panel. Lay out the front panel to determine where to drill the mounting holes for the LEDs, input jacks and switches. If you wish, you can use miniature toggle switches instead of the slide types shown in the photo of the prototype to eliminate having to cut rectangular slots and drilling two mounting holes for each switch.

If you use the box mentioned and limit your project to only four channels, drill holes for mounting the miniature VOLUME control potentiometer, buzzer and POWER jack *J3* on the side of the enclosure.

After cleaning the enclosure, label the front panel. If you use a dry-transfer lettering kit, protect the legends with two or more light coats of clear acrylic spray. Allow each coat to dry before spraying on the next.

Secure the LEDs in their holes in the front panel with panel clips or fast-setting clear epoxy cement. Identify and label the anode leads of the LEDs. Then mount the switches, jacks, VOLUME control and buzzer.

Solder color-coded hookup wires to the lugs of the panel-mounted components. Place a 1-inch-long, small-diameter plastic tube on the anode leads of all LEDs. Tie these leads together and attach to the bundle a 3-inch hookup wire. Solder the connection and push the tubing up against the bases of the LEDs.

Prepare as many 4-inch-long hookup wires as you have LEDs by stripping ¼ inch of insulation from both ends. Trim the cathode leads of all LEDs to ½ inch long and form a small hook in each. Crimp one wire to each cathode lead and solder. Slide 1-inch lengths of small-diameter plastic tubing onto the free ends of the wires and push them over the connections until they're flush against the bases of the LEDs.

Place the circuit-board assembly near the enclosure. Referring to Fig. 1, wire the free ends of the wires coming from the panel-mounted components into their respective points in the circuit. Mount the circuit-board assembly to the front panel with ½-inch spacers, 1¼-inch machine screws, nuts and lockwashers. Leave enough slack in all wires to allow the board to be dismounted for easy troubleshooting should that become necessary.

Checkout & Use

The power supply you use with this project can be a plug-in wall-type capable of delivering a minimum of 30 milliamperes dc current per channel. You can use an unfiltered dc transformer or a 9- to 12-volt unit with filtered output.

First determine whether or not the supply has a built-in filter capacitor. Identify the polarity of the output connector using a dc voltmeter or a multimeter set to the dc-voltage function. Connect a 1,000-ohm resistor across the output connector and measure the voltage across it. Then connect a 100-microfarad electrolytic capacitor across the resistor, properly polarized, and again measure the voltage. If the voltage increases by about 40 percent with the capacitor in place, the supply doesn't have a built-in filter capacitor; you must supply it inside the project.

If you use a 6-volt unfiltered dc supply, increase the value of *C2* to 330 microfarads and verify with your meter that the potential across the capacitor is between 8 and 10 volts. If you use a 12-volt filtered supply, change the value of *R2* to 470 ohms.

With power applied, verify that *LED1* (for all channels) is off and that no tone sounds with *S1* set to both positions. Connect a jumper wire across the lugs of a miniature phone plug and plug it into the CHANNEL A INPUT jack. The LED for that channel should light in both positions of *S1*. Also, the tone should be heard from the buzzer only when *S1* is open (audio on). Repeat this test for all remaining channels.

If the LED in a particular channel doesn't come up to full brightness, *Q2*'s dc gain is too low. Replace *Q2* with any high-gain (200 or greater beta) general-purpose npn silicon transistor and *Q3* with any medium-gain (100 or greater beta) or high-gain npn silicon transistor. Later, when you're using a phototransistor pickup, if any channel's LED lights dimly when the pickup is in total darkness, the dark current of *Q1* is too high and the value of *R3* must be reduced until the LED extinguishes.

You can use any high-sensitivity npn-type Darlington phototransistor for *Q1*. Pretest each phototransistor by making temporary connections from it to a suitable length of two-conductor cable wired at its remote end to a miniature phone jack. Plug this into any CHANNEL input jack.

Position the sensitive surface of the transistor over any lighted LED and turn off room lights. That channel's LED should now light and a tone should be heard from the buzzer when *S1* is open. Slowly move the phototransistor away from the lighted LED source and observe how the channel LED in the project gradually dims. Moving the transistor well off to the side should cause the channel LED to extinguish. During these tests, make sure you do not touch the phototransistor's bare wire leads.

A high-sensitivity phototransistor works well with red and yellow LEDs and some of the brighter green LEDs. For equally bright red, yellow and green LEDs, the red variety has the best ability to irradiate the phototransistor, green the least. This is due to the much higher infrared output of the red LED and closer match with the spectral response of the phototransistor.

Perform a test on a neon lamp and note the difference in the audio tone heard from the buzzer. In this case, the light radiating from the neon lamp is modulated at the line frequency rate that, in turn, modulates the audio tone. You may also find a LED used as an indicator on a particular piece of gear energized by half-wave rectified ac that produces similar audio modulation.

Shown in Fig. 3 are mountings for side- and top-view photodetectors. Install side-viewing plastic transistors, such as the ECG 3035 and HEP P1001, in standard 1/16-inch-thick × 5/8-inch-diameter fiber washers with 1/4-inch holes in them. Strip about 1/8 inch of insulation from the ends of as many 3- to 5-foot lengths of twisted-pair earphone cables as you have designed inputs to the project for. Twist together the fine wires at both ends and tin with solder.

Carefully identify and clip off the base leads of the phototransistors. Separate the two remaining leads of the transistor a bit, but leave them full length. Clip a heat sink onto one lead close to the transistor's case, and lap-solder a conductor at one end of the cable to the outer side of this lead. Do the same for the other lead and cable conductor. Repeat for all cables and phototransistors.

After soldering the cables to both leads of the transistors, use short lengths of electrical tape between them to insulate them from each other. Use an ohmmeter to identify the conductors at the other end of the cables that go to the emitters and collectors of the transistors. Label each accordingly. Then terminate the free ends of the cables in mini phone plugs.

Place the viewing side of the phototransistor so that it faces downward in the washer's central hole. Cement a 5/8-inch-diameter covering disk atop the washer. Make sure this disk is fully opaque to light. Use a putty-like cement, such as black epoxy putty or automobile body filler, so that it fills the gap between washer and disk when the transistor's leads are sandwiched between them. Use only enough cement to fill the gap, and take care to avoid forc-

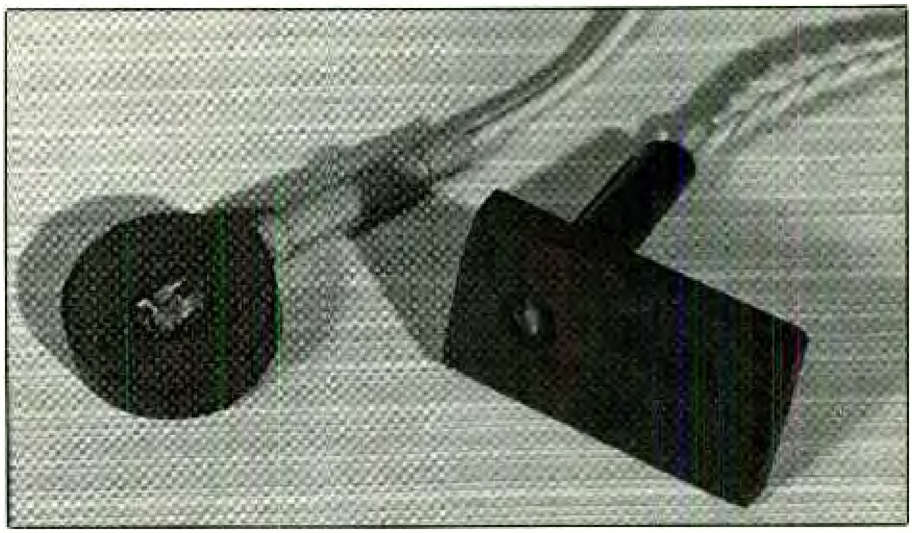


Fig. 3. Mounted side-viewing (left) and top-viewing (right) photo-Darlington transistor sensors.

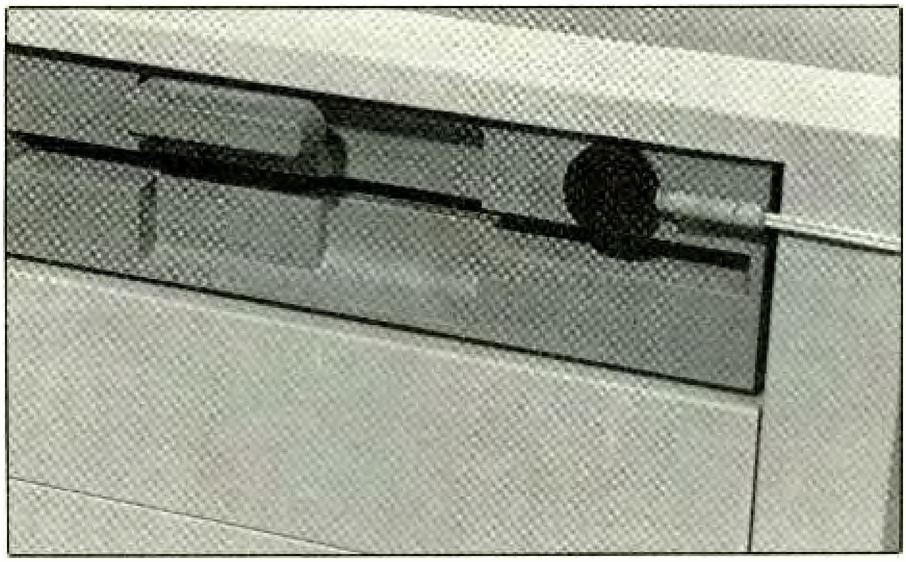


Fig. 4. Example of installation of photosensitive sensor over a floppy-disk drive's activity LED indicator.

ing excess cement into the washer's central hole and over the viewing surface of the transistor.

Lift the assembly from your work surface and check to make sure that the viewing surface doesn't project below the bottom surface of the washer. If it does, gently press it until it's flush with the bottom surface or is slightly recessed. Wipe from the perimeter of the assembly any excess cement and allow to set overnight.

For top-viewing detectors, such as the ECG 3036, drill a tight-fitting hole through a block of opaque plastic. Cement the detector into the hole with epoxy cement. Adjust the size and shape of the blocks of plastic to suit the particular installation.

For remote LEDs that project beyond the front surface of their mounting panels, mount the detector in a thicker block of plastic or cement additional washers to the detector assemblies.

Secure the phototransistor detectors over the LEDs in the equipment with which they are to be used with double-sided tape or a non-hardening putty like weather-strip caulking cord. If you use the latter, roll a pellet of the putty to form a thin strand. Then form the strand into a circle around the sensor window.

Turn on the equipment with which the project is to be used so that the target LED is lit. Without touching the panel with it, position the sensor assembly over the lighted LED, moving it about until that channel's LED is illuminated on the project. Gently push the sensor into place to secure it to the equipment over the status LED. Do the same for all sensors.

When you're finished installing the sensors, label the front panel of the Status Indicator to reflect what equipment each channel's LED is monitoring. This way, you'll know at a glance the operating status of any given device in your system. Label the channels with a lettering kit, but omit any protective spray coating to permit the labels to be removed and replaced as you reconfigure your system.

You'll probably want to know when floppy-disk or hard-drive accesses are occurring. Modern drives run quietly, so brief disk access may go unnoticed. Though software utilities are available to sound the computer's speaker during disk access, the Remote Status Indicator provides a better alternative. It doesn't use up needed RAM in your computer or add to the items in your AUTOEXEC.BAT file.

Just follow the procedure previously cited. Place a photodetector pickup over the floppy-disk (and/or hard disk) drive's LED. While the drive is running, carefully position the sensor so that its channel's indicator on the project lights. On subsequent disk accesses, adjust the level of the buzzer's tone to a comfortable level. If minimum level is excessive, tape over the hole in the buzzer. You can also operate the project with the audio-tone function disabled.

The utility of this project becomes more apparent when a device is farther away, of course, whether it's an external drive or whatever. For example, some printers don't have activity LEDs up front where they can easily be seen from your work position. If you forget to shut it off at the end of a long computing session, the photo sensor device will remind you. A status sensor placed over the printer's READY LED will also eliminate your having to remember whether or not you turned on your printer.

Keyboard NUM LOCK, CAPS LOCK and SCROLL LOCK status indicators are useful, but if you're a touch-typist, you may not notice their state as you type away while looking at source material. When using a word processor, it's easy to hit the wrong key and find that SCROLL LOCK or CAPS LOCK somehow kicked in and ruined your text. I chose to monitor the SCROLL LOCK LED because it's this function that has given me the most grief and, thus, required close watching. Monitoring keyboard keys requires that their LEDs be mounted separate from the keys themselves, of course.

Summing up, this project is an easy-to-build, low-cost accessory that can make it more convenient to operate a variety of systems from computer systems to remote-controlled stereo systems. ME