

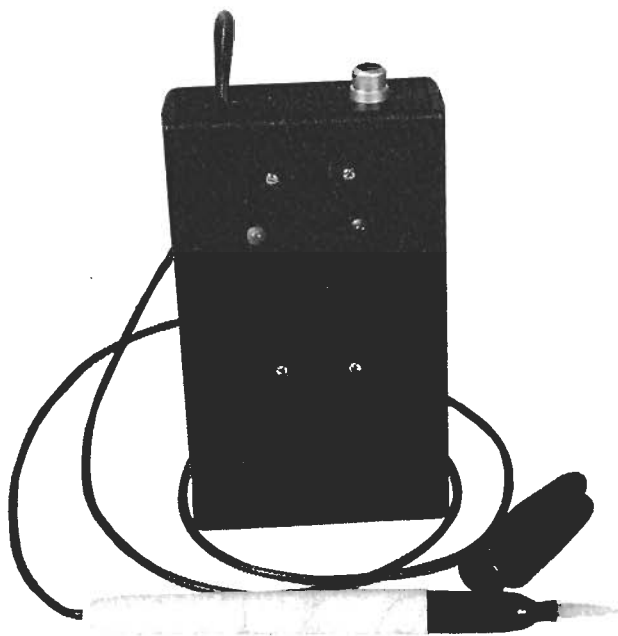
IF YOU HAVE EVER TRIED to test an infrared LED with a fluorescent phosphor card, you'll be happy to know that there's a better way. This project, called the infrared logic probe, combines an infrared photodiode sensing circuit and a logic-probe pulse detecting circuit. The device is handy for checking just about any infrared emitting source.

The infrared logic probe consists of two sections: a probe and a PC board containing the electronics. The probe is packaged in a felt-tip pen case. The electronics are packaged in a plastic case and connected to the probe through a thin coaxial cable. The circuit will detect 0.3-milliwatt continuous levels and pulses as narrow as 40 microseconds at a frequency of 7.1 kilohertz. The probe's tip is small enough to fit in a slotted optical switch and other hard-to-reach optical sensing devices. Sensitivity to ambient light is not a problem, but the probe can be sensitive to sunlight or incandescent light that is rich in infrared. The photodiode is packaged in a visible-light rejecting case with a peak spectral response of 925 nanometers and a usable range of 725 to 1150 nanometers.

Circuit description

The schematic for the IR logic probe is shown in Fig. 1. Infrared light detected by photodiode D2 is amplified by IC1-a, half of an LM392N op-amp. Resistors R1 and R2 set the voltage gain of IC1-a. The value of R2 can be changed to decrease the sensitivity of the circuit if your application demands it. Con-

INFRARED LOGIC PROBE



***Here's a device to help you
troubleshoot infrared
emitters. You can't buy it
anywhere—you have
to build it yourself!***

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ductor J1 provides an output to an oscilloscope for the display of the amplified photodiode signal. This is handy when checking the pulsed emitters found in most remote controls.

Voltage comparator IC1-b squares up signals from IC1-a to digital logic levels for IC2-a. Resistors R4 and R5 set the reference voltage at the non-inverting input to one half of the supply voltage, and R6 provides hysteresis to prevent oscilla-

tions. Resistor R8 pulls up the comparator's output for a near rail-to-rail voltage swing for IC2-a. LED1 and current-limiting resistor R7 indicate the presence of steady-state infrared and also function with pulsed emitters, if the duty cycle is appropriate.

Monostable multi-vibrator IC2-a conditions pulse trains with any period shorter than the time constant of R9 and C1 into a low-frequency waveform with a very high duty cycle. Monostable IC2-b triggers on the waveform from IC2-a. This provides pulses for LED2 that are constant in frequency and duty cycle, regardless of the high input frequency to IC2-a. Any frequency input to IC2-a with a period longer than the time constant of R9 and C1 creates IC2-b output pulses with the same width as before at the input frequency. Resistor R10 and C2 set the output pulse width for IC2-b.

Tricolor LED2 (a dual red/green device) functions as a pilot lamp and indicator for pulsed infrared sources. LED2 will always glow red and pulse amber (red + green) when infrared pulses are detected. Transistor Q1 is

an emitter-follower buffer that allows IC2-b to drive the green diode. Resistors R11 and R12 limit current for LED2.

The power source for the circuit is a 9-volt battery. Diode D1 protects the circuit from accidental voltage reversals when you install the battery. Power supply noise is decoupled by C3 and C4. Alkaline batteries will provide many hours of operation, because the circuit has low-power integrated circuits

PARTS LIST

All resistors are 1/2 watt, 5%.

R1, R8—20,000 ohms
 R2—2.4 megohms
 R3—220,000 ohms
 R4, R5—150,000 ohms
 R6—10 megohms
 R7, R12—1200 ohms
 R9—820,000 ohms
 R10—470,000 ohms
 R11—1100 ohms
 R13—1 megohm (optional, see text)

Capacitors

C1—0.33 μ F, 50 volts, electrolytic
 C2—0.1 μ F, 50 volts, Mylar
 C3—47 μ F, 16 volts, electrolytic
 C4—0.1 μ F, 25 volts, ceramic disk

Semiconductors

IC1—LM392N dual op-amp/comparator National Semiconductor
 IC2—CD4538BE dual monostable multivibrator
 Q1—2N3904 NPN transistor
 D1—1N3600 or NTE-519 silicon diode
 D2—Vactec VTP-413 photodiode (Allied Electronics)
 LED1—High-efficiency yellow LED
 LED2—Tricolor LED (Digi-Key P391 or equivalent)

Other components

S1—SPST slide switch
 S2—SPST slide switch (optional, see text)
 J1—Chassis mount phono jack
 B1—9-volt alkaline or lithium battery

Miscellaneous: One 8-pin low profile IC socket, one 16-pin low-profile IC socket, 4 feet of RG-174 coaxial cable, 9-volt battery connector, Pac Tec HM-9VB or Radio Shack 270-293 plastic project case, 2-56 hardware, clear casting resin and catalyst or clear RTV silicone sealer, 5-minute epoxy, Sanford *Sharpie* fine-point permanent marker pen (use a dried up one if you have one), small piece of 1/10-inch thick clear Plexiglas, denatured alcohol, black paint, foam rubber, No. 24 hook up wire, solder.

closure's removable end plate: one 1/8-inch hole for the probe's cable and one 1/4-inch hole for phono jack J1. Install J1 in the end plate and place the plate into the enclosure. Solder the wires to the jack, observing polarity and taking care not to melt the plastic end plate.

Next use the drill guide in Fig. 3 to mark and drill the holes in the enclosure's top. (The drill guide matches the PC board layout, so it can be used for any case.) Remember, S2 is optional, so don't drill holes for

mounting it if you're not using it. The rectangular holes for the switches can be made by drilling a pilot hole in the center and carefully cutting away the plastic with a sharp hobby knife. Mount the switches and solder the wires to them. Figure 4 shows the inside of the completed unit.

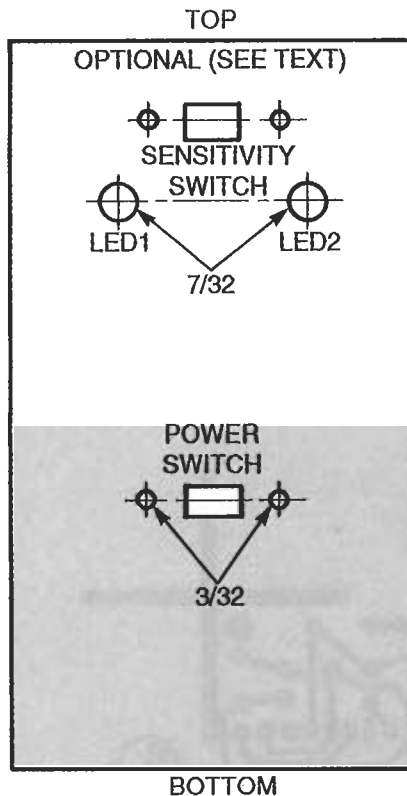


FIG. 3—DRILL GUIDE. S2 is optional, so don't drill holes for mounting it if you're not using it.

The IR probe

The prototype's photodiode probe case was made from a fine-point (not extra-fine point) Sanford *Sharpie* felt-tip marker pen. Figure 5 shows a cutaway view of the probe. To disassemble the pen, first pull out the writing tip with pliers. Grasp the pen's upper portion (the part that is the same color as the ink) and the pen's gray barrel. Then pull the pen apart with a twisting, bending motion. Wear rubber gloves to improve your grip on the pen. Discard the ink cartridge and wash the pen's interior with denatured alcohol to remove any remaining ink. Denatured alcohol will also remove the embossed lettering on the outside of the pen's barrel.

To make the "light pipe" that conducts light into the probe's interior, cut a small piece of 1/10-inch thick clear Plexiglas, 1/8-inch wide and 1 1/4-inches long.

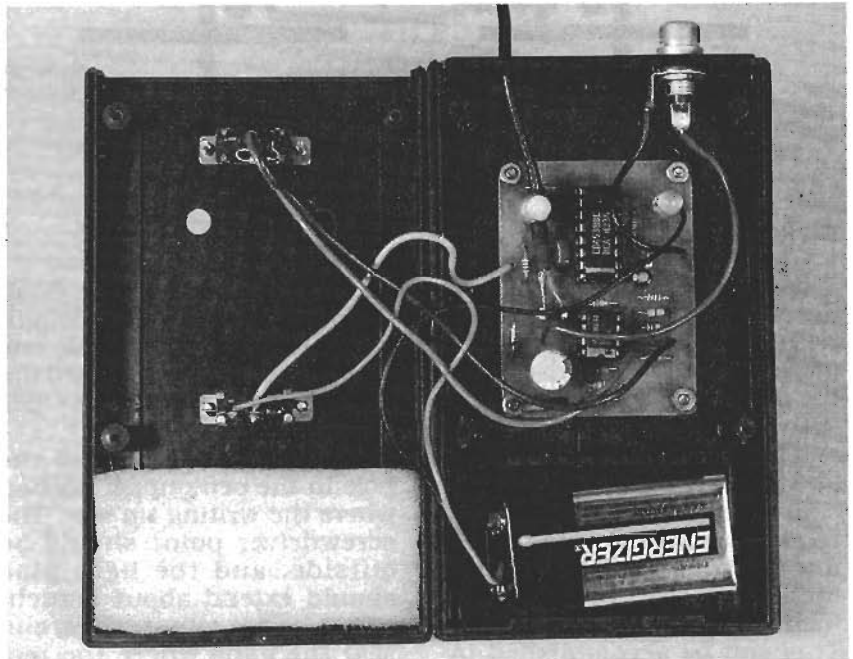


FIG. 4—THE INSIDE OF THE COMPLETED UNIT. You can use the same case (see the Parts List) or any other that will accept the board and a 9-volt battery.

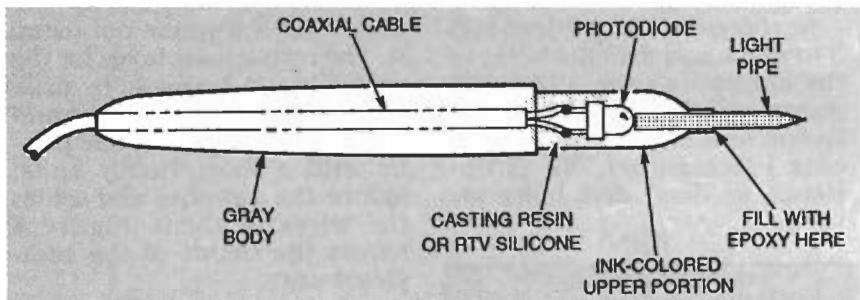


FIG. 5—CUTAWAY VIEW OF THE PROBE. The probe case was made from a fine-point felt-tip marker pen.

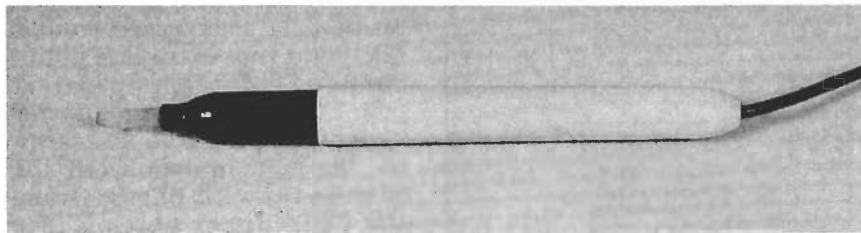
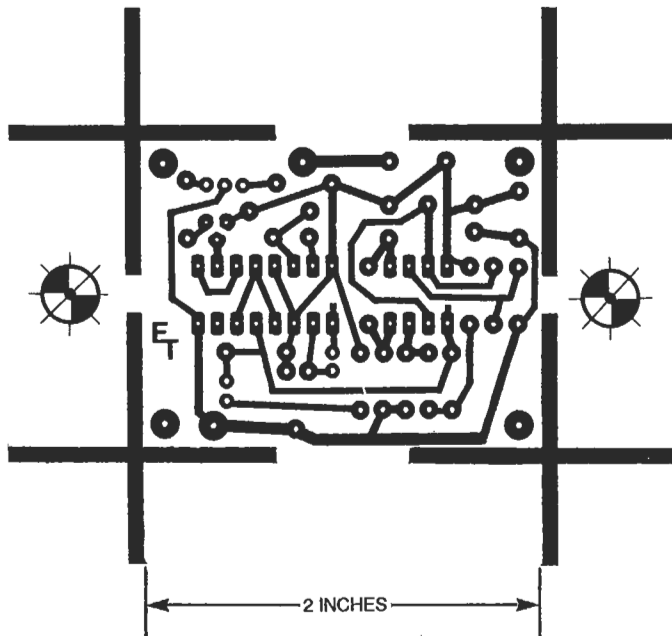


FIG. 6—THE COMPLETED PROBE. Use the pen's original cap to protect the light pipe from breakage.



IR PROBE FOIL PATTERN.

This can be accomplished by deeply scribing the sheet on both sides and clamping the piece to be cut off in a vise. Snap the piece off and cut it to length with diagonal cutters. File one end to a screwdriver-shaped tip, and then dress also clean up the

To make the "light pipe" that conducts light into the probe's interior, cut a small piece of $\frac{1}{10}$ -inch thick clear Plexiglas, $\frac{1}{8}$ -inch wide and $1\frac{1}{4}$ -inches long. This can be accomplished by deeply scribing the sheet on both sides and clamping the

piece to be cut off in a vise. Snap the piece off and cut it to length with diagonal cutters. File one end to a screwdriver-shaped tip, and then dress up the sides with the file.

Tap the light pipe into the hole in the pen's upper portion where the writing tip was. The screwdriver point should be outside, and the light pipe should extend about $\frac{1}{2}$ -inch. Mix some five-minute epoxy and seal the gaps where the rectangular light pipe enters the round hole in the pen's upper

portion.

Prepare one end of the probe's coaxial cable by stripping about an inch of the jacket off and separating the braid with an awl. Place a length of heat-shrink tubing over the cut jacket for a neat appearance. Drill a hole in the end of the marker's gray barrel large enough to admit the coaxial cable.

The photodiode's leads must be bent to extend from the center of the device. Mark the photodiode's cathode lead (it's the shorter lead), and then cut both leads down to a $\frac{1}{4}$ -inch length from the back of the device. Solder the leads of the coaxial cable to the leads of the photodiode; use the cable's braid for the cathode and the center conductor for the anode. Make sure the leads cannot short together!

Mix about an ounce of clear casting resin (available at an art supply store) according to the directions on the package. (Alternatively, you can use clear RTV silicone sealant.) Place the probe's upper portion in a vise with the open end facing upwards. Insert the photodiode in the open end, and push it down until its lens touches the light pipe. Pour the resin (or RTV silicone) in the open end and completely fill the void, encapsulating the diode in the marker's upper body. The coaxial cable should be positioned in the center of the upper body while the resin hardens overnight.

When the resin (or RTV silicone) has cured, apply black paint to the resin around the cable. This prevents infrared light from entering through the probe's gray barrel. When the paint dries, slide the barrel over the cable, and push the two sections of the probe together. Sand the light pipe with 400-grit sandpaper to finish the surface. Use the pen's original cap to protect the light pipe from breakage when it is not in use. Figure 6 shows the completed probe.

Final assembly & testing

Pass the free end of the probe's coaxial cable through the hole in the enclosure, and

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