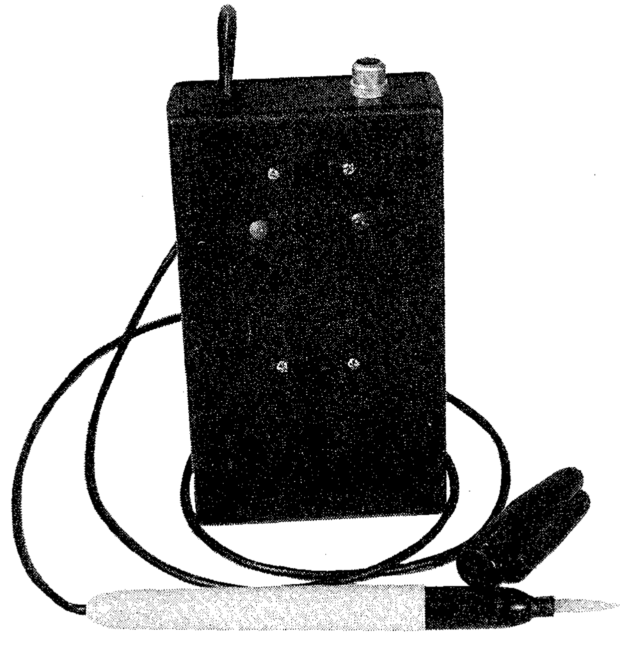
INFRARED LOGIC PROBE



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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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. Connector 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 oscillations. 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 multivibrator 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

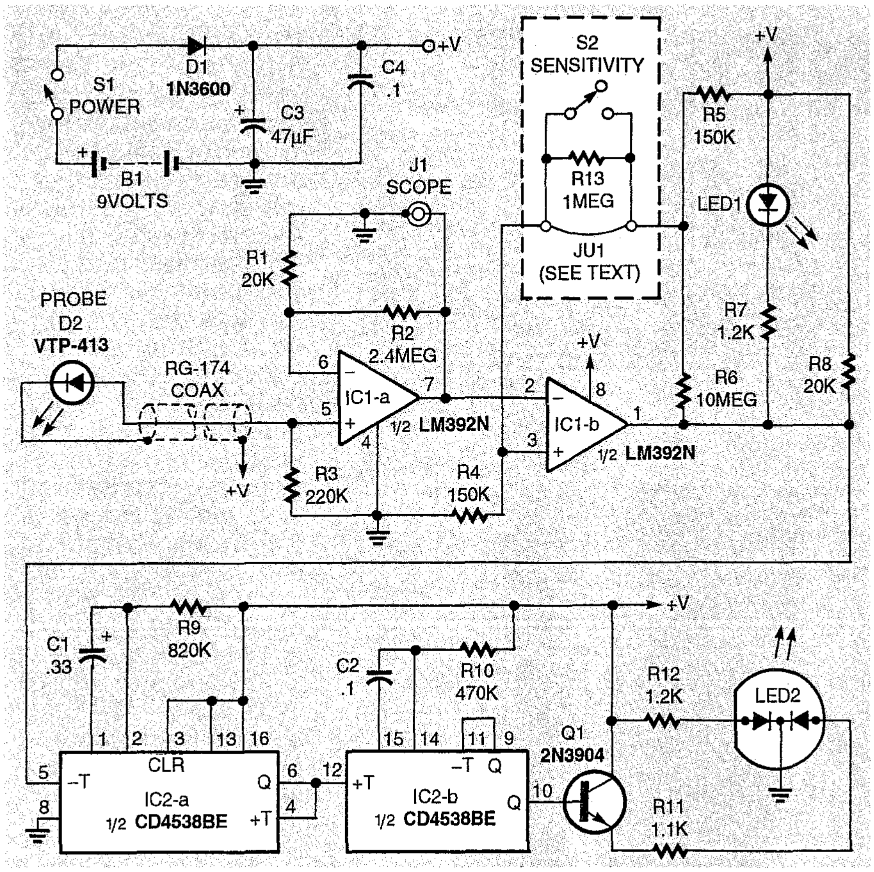


FIG. 1—SCHEMATIC FOR THE IR LOGIC PROBE. Infrared light detected by photodiode D2 is amplified by IC1-a, half of an LM392N op-amp.

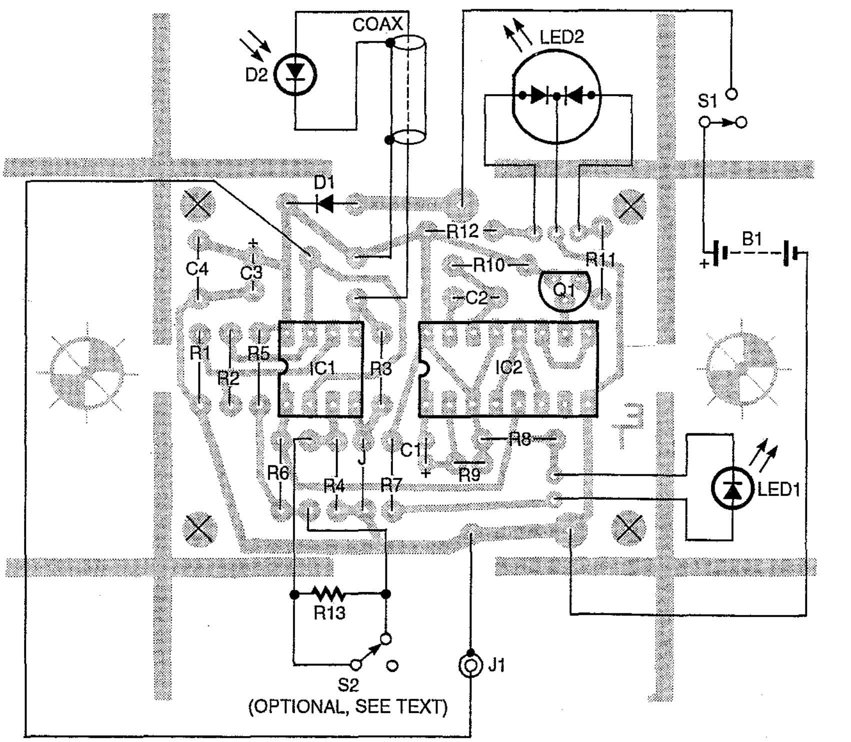


FIG. 2—PARTS-PLACEMENT DIAGRAM. Sockets for mounting the integrated circuits are recommended.

and high-efficiency LEDs.

Switch S2 (and R13) is optional. The probe will operate properly with a wire jumper in place of S2 for most emitters (remote controls) found on consumer electronic equipment. For certain devices such as slotted optical switches, CD laser diodes, and reflective sensors, more sensitivity might be desirable. If you plan to use the probe for LEDS that operate below 0.5 milliwatts, install S2 and R13—if not, you can install a wire jumper on the board instead of the switch.

Construction

The circuit can be built on a PC board or point-to-point wired. You can make your own PC board from the foil pattern provided here, but point-to-point wiring is practical because of the low component count. The photograph and parts placement diagram within this article will help. Sockets for the ICS are recommended. Figure 2 is the parts-placement diagram.

If you are using the same case as the prototype (see the Parts List), place the unpopulated PC board on the bottom half of the enclosure, centered and positioned about 5⁄16-inch from the battery compartment wall. Mark the four mounting holes and then drill them for 2-56 hardware.

Mount the components on the board, taking care not to make any solder bridges or poor connections. Note that R9 must be mounted vertically. Again, if you are using the recommended case, cut the leads on the LEDs to approximately 5⁄8-inch, and solder them to the board straight up. (If you are using a case with a different height, cut the LED leads to a length so that they will just extend through holes drilled in the top of the case after the board is mounted in the case.) Next solder 6-inch lengths of No. 24 wire for the switch/switches (remember that S2 is optional), jack J1, and the negative lead of the battery snap, to the points indicated in Fig. 2. Do not connect the switches and jack now. Mount the board to the bottom of the case with short 2-56 machine screws and nuts.

Drill two holes in the en-

PARTS LIST

All resistors are ⅛ 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 µF, 50 volts, electrolytic
C2—0.1 µF, 50 volts, Mylar
C3—47 µF, 16 volts, electrolytic
C4—0.1 µF, 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 ⅛-inch hole for the probe's cable and one ¼-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.

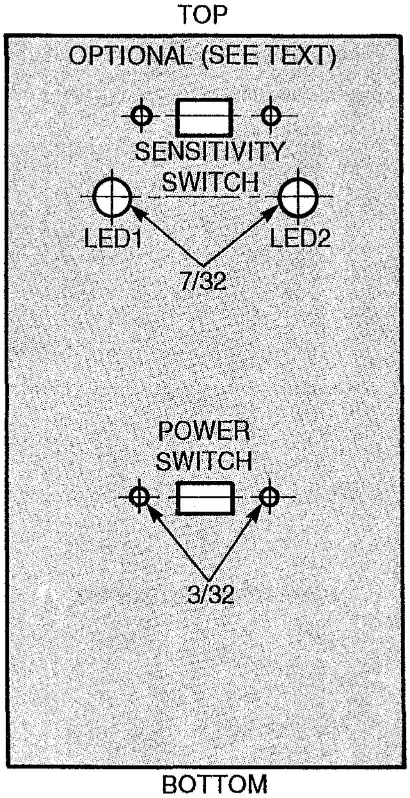


FIG. 3—DRILL GUIDE. S2 is optional, so don't drill holes for mounting it if you're not using it.

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, ⅛-inch wide and 1¼-inches long.

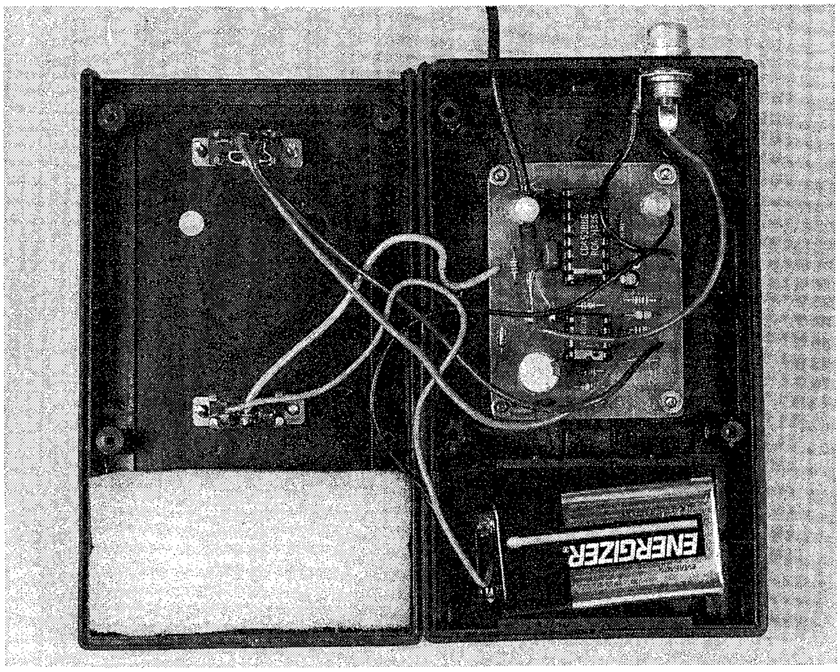


FIG. 4—THE INSIDE OF THE COMPLETED UNIT. You can use the same case (see the Parts List) or any other that will accept the board and a 9-volt battery.

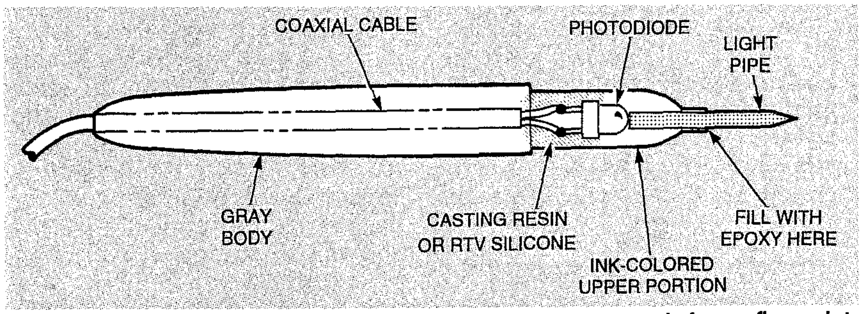


FIG. 5—CUTAWAY VIEW OF THE PROBE. The probe case was made from a fine-point felt-tip marker pen.

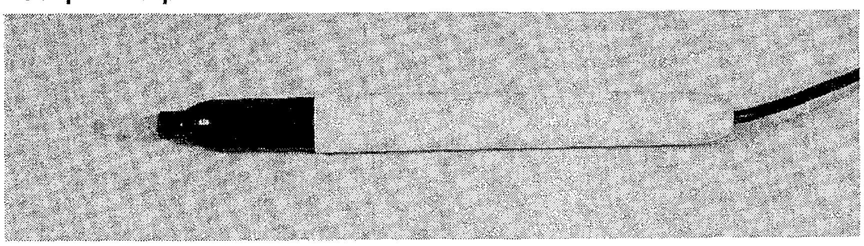
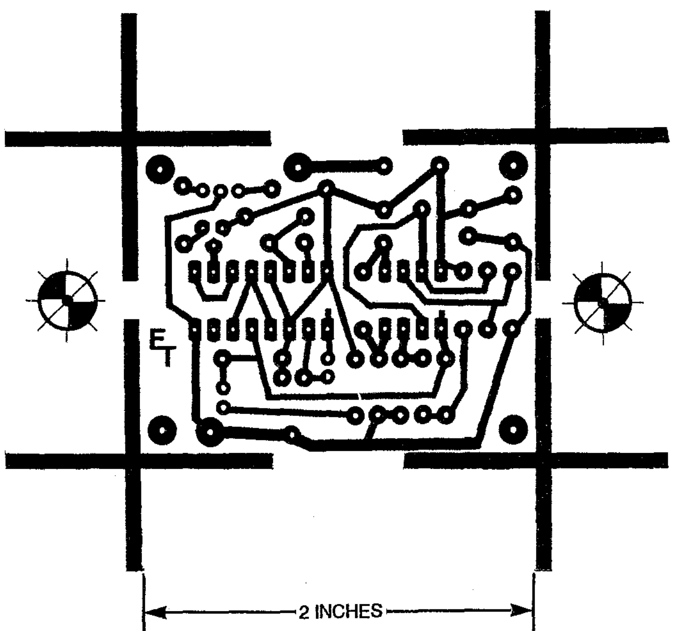


FIG. 6—THE COMPLETED PROBE. Use the pen's original cap to protect the light pipe from breakage.



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 1⁄10-inch thick clear Plexiglas, 1⁄8-inch wide and 1¼-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 ½-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 ¼-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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the Twin-T is imperfectly balanced, it gives a feeble output at its center frequency, and its output phase depends on the direction of the imbalance. In other words, if the imbalance is caused by low values of R3 + R5, the output phase is inverted with respect to the input.

The twin-T network in Fig. 13 can be adjusted by R5 so that a small phase-inverted output at a center frequency of 1 kHz can be produced. Consequently, overall phase inversion takes place around the feedback loop, and the circuit oscillates at 1 kHz. Potentiometer R5 can be adjusted so that oscillation is barely sustained. Under this condition, sinewave amplitude is limited to about 5 volts RMS by the onset of operational amplifier clipping. The output has less than 1% THD.

Figure 14 is a schematic for a simple twin-T oscillator that will have lower output distortion. Diode D1 provides distortion-generated automatic gain control. To organize this circuit, set the wiper of potentiometer R7 to the output of the operational amplifier, and adjust R6 so that oscillation is just sustained. A sinewave output of about 500 millivolts, peak-to-peak, will be produced. Ω

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to those found on the schematic Fig. 1. The cores and bobbins for this transformer are from Philips (Ferroxcube) Components, Saugerties, NY). The cores are No. E187 made from 3E2A ferrite material. The plastic molded bobbins are Part No. E187PCB1-8. These parts are available from the source given in the Parts List.

Transformer T1: Wind the first 30 turns trifilar (three wires in parallel) from No. 30 AWG magnet wire and the remaining 30 turns as single wire turns. Solder the ends of the windings to the pins, insert the E-core, and tape the assembly together securely.

Transformer T2: The core of transformer is No. 4162S from Samhwa USA, Chatsworth CA, with matching seven-segment bobbin, cup and primary bobbin. These parts are also available from the source given in the Parts List.

Start winding the secondary bobbin by securing the magnet wire to a pin insulated on the bobbin end and wind between 300 and 400 turns of No. 37 AWG magnetic wire on each of seven segments. Snap the cup in place and solder the output leads. Fill the cup with epoxy or RTV silicone when you are satisfied that the transformer has been wound correctly.

Wind eight turns of No. 30 twisted wires on the primary bobbin and tape the windings in place. Form the air gap of the primary section with 0.005-inch thick Milar tape and form the air gap for the secondary section with 0.010-inch thick Milar tape. Tape or clamp the two sections together with a heavy rubber band. Ω

VIDEO NEWS

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Digital Camcorders Here

If you have a couple or three thousand dollars to spend on really top-notch video reproduction, you now can buy a digital camcorder using the standard DV (digital video) format from either Sony or Toshiba, with JVC waiting in the wings. In this column we've carried a lot of information about that DVC format (now called DV). The available camcorders produce breathtaking pictures and are ideal for professional or "prosumer" videographers.

Panasonic's model has three CCD pickups, while Sony has two models, one with three pickups and one with a single CCD. The Sony model has a digital interface and utilizes an optional feature of the DV system—a cassette with a built-in chip that stores data on tape specifications and records the date of recording and provides easy access to any scene. EN

IR LOGIC PROBE

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prepare the cable ends in the same manner as before. Solder the leads of the cable to the circuit board as shown in Fig. 2. Attach a 9-volt battery to the connector and turn on the power. The unit can be tested with an infrared remote control or an infrared LED and current-limiting resistor connected to the output of a pulse or function generator. (The IR LED can be coupled to the probe's tip with a length of ¼-inch heat-shrink tubing for test purposes.)

The tricolor LED should glow red; if not check D1 and the battery or its polarity. Point the IR LED at the probe's tip and make sure both LED indicators are functioning. If there is no indication, check the photodiode's polarity, IC1, and its associated components. If the tricolor LED does not flash amber, check IC2 and its associated components. Connect an oscilloscope to J1, and verify that a waveform is present.

Once the circuit has been checked out, join both halves of the enclosure. Be sure that the battery wires do not tangle around the LED indicators. A piece of foam rubber cut to fit the bottom of the battery compartment will keep the battery from rattling around in the case.

Using the probe

If light from windows and incandescent lamps interferes with the probe's operation, either remove the source of interference or move the work area. Ambient room light should not create problems, especially if its source is florescent fixtures.

The probe's plastic light pipe is most sensitive at the screwdriver-shaped tip. The light reflects within the walls of the light pipe (as in fiber optic cable), conducting the light to the photodiode. The probe will indicate if high-frequency pulsed IR LEDs are working, but the photodiode will integrate the pulses to a steady-state level. Ω