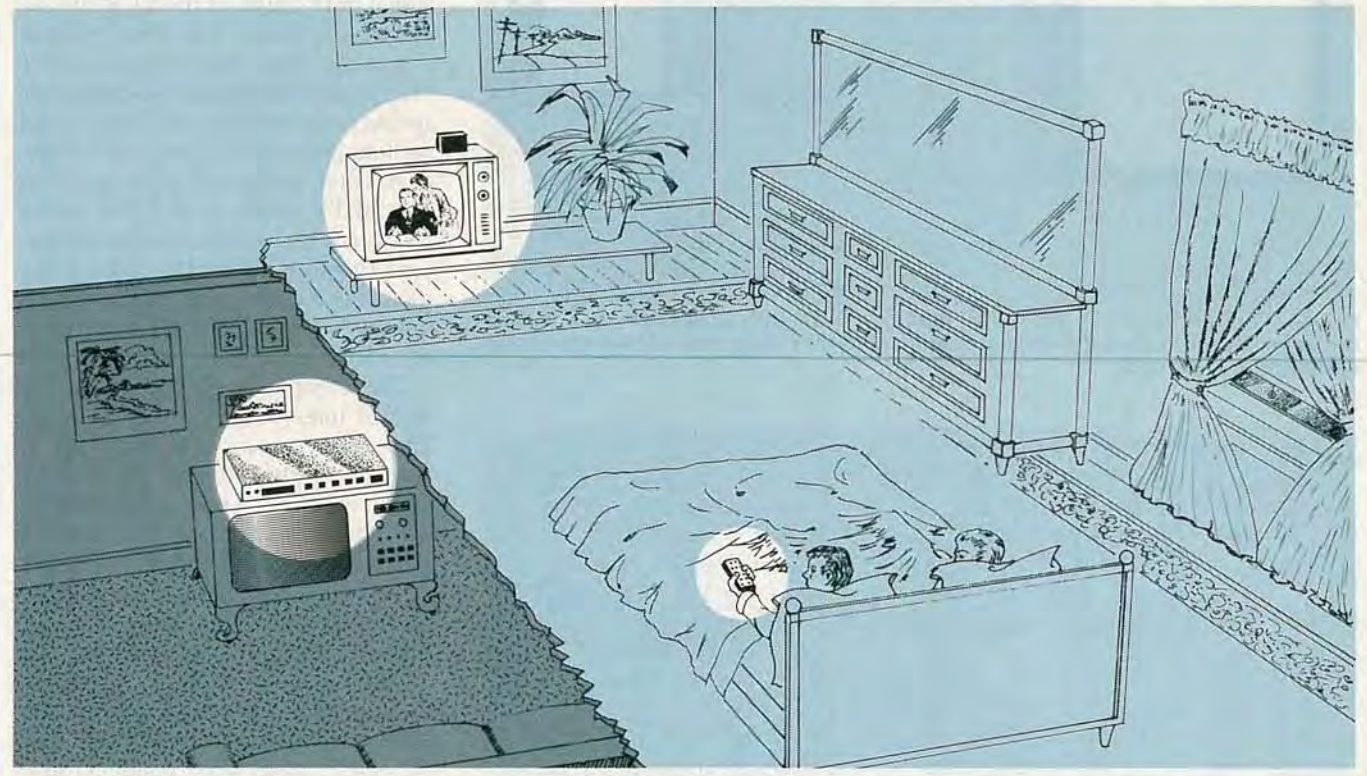
BUILD THIS

REMOTE CONTROL



EXTENDER

Control your VCR and watch video tapes from any room in your home with our VCR extender!

ROBERT A. HEIL

WHILE THE NUMBER OF FAMILIES THAT have two VCR's in their home is steadily increasing, owning two VCR's is still considered an expensive luxury for most. But now you can get the benefits of having two VCR's for a fraction of the cost with our VCR extender. Our easy-to-build device will let you watch your VCR from *any* room in your home and still maintain full remote-control capabilities. And the extender is not limited only to VCR's—it will relay *any* IR-transmitted signal. So even if you have an old manually controlled TV in your bedroom, you'll be able to use all the remote-control features of the VCR in your living room!

The extender mounts next to your TV set and can be operated via your IR remote control from a distance of 20–30 feet depending on ambient light conditions. The unit uses inexpensive, easy-to-get parts, and does not require RFI or IR shielding. Also, several extenders can be connected in parallel, so that you can extend your VCR to as many locations as you like.

Using the extender unit, remote-control signals can be sent to the VCR via the existing coaxial cable (if you have cable television), as shown in Fig. 1, or by using ordinary two-conductor speaker wire or zip cord. The latter will eliminate the need for the two additional filters that are required for the coaxial-cable system but, of course, will require two lines—one for the out-going IR signals, and a second for the returning video or RF.

Circuitry

Refer to the schematic in Fig. 2 for the description of the basic circuit. A signal from an IR remote control enters phototransistor Q1, where it is converted from IR radiation to a frequency pulse and then passed to decoupling-capacitor C1. Resistor R1 keeps Q1 from saturating too quickly from visible light. Because the IR signals from a remote control are not that strong, Q1 is kept constantly conducting, via IR-LED2, which was added to increase the range during extreme low-light conditions. IR-LED2 is positioned directly behind Q1 and aimed at the base, where it emits a small amount of IR radiation, ensuring that Q1 will continue to conduct without IR or visible light.

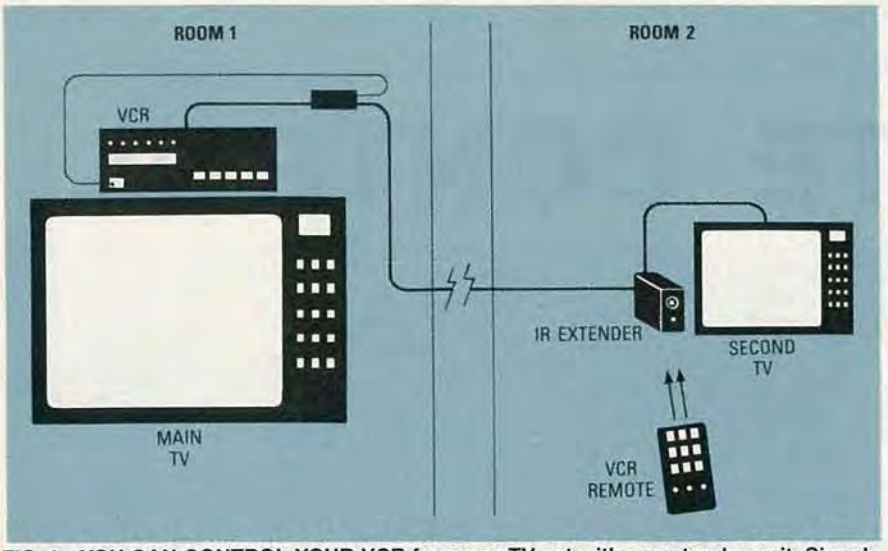


FIG. 1—YOU CAN CONTROL YOUR VCR from any TV set with an extender unit. Signals can be sent to the VCR via the existing coaxial cable or by using ordinary two-conductor speaker wire or zip cord.

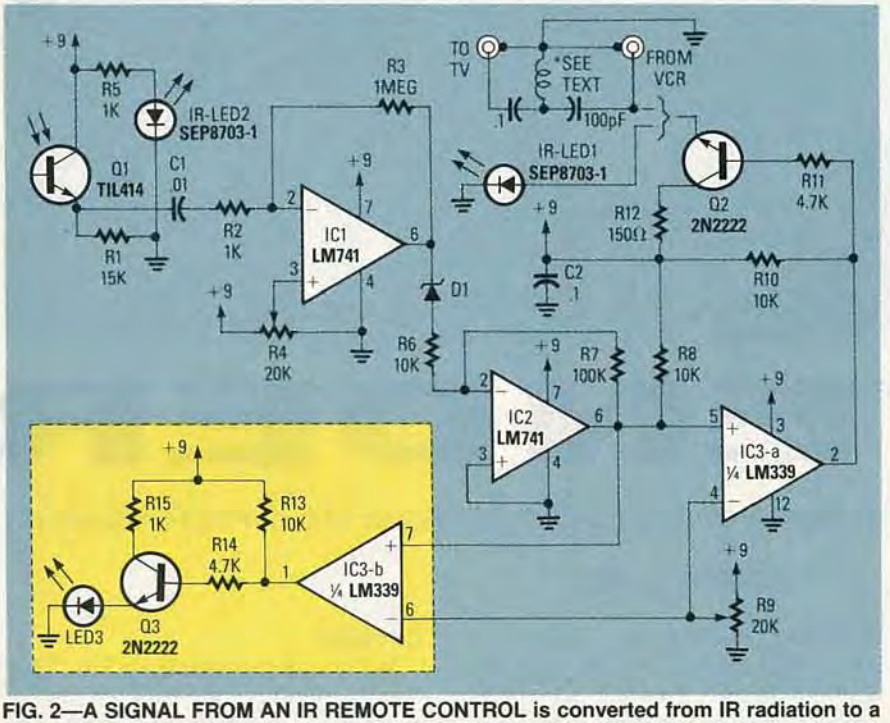


FIG. 2—A SIGNAL FROM AN IR REMOTE CONTROL is converted from IR radiation to a frequency pulse that can be transmitted through coaxial TV cable or any other two-conductor wire to another room, where it's converted back into an IR signal.

The signal from C1 is amplified by a factor of 1000 by IC1, with gain set by R2 and R3. It is then passed to D1, a 5.1-volt Zener diode, which is used as a voltage shifter. The anode stays low until the input voltage at pin 2 of IC1 rises higher than the reference voltage at pin 3, which is set by R4. When that happens, the output of IC1 goes high and avalanches D1, producing a voltage rise at the anode along with the signal. The signal is then passed to IC2 where it is amplified by a factor of 10. Pin 3 of IC2 is tied to ground. That allows any signal higher than ground to be amplified and sent to pin 5 of IC3 via pull-up resistor R8. IC3 is a comparator, in which the output goes high when the reference voltage at pin 4 (set via R9) is exceeded by the smallest amount.

IC1 and IC2 are independent 741 op-amps. Separate op-amps were used because IC1 is referenced at pin 3 while IC2 is tied to the ground rail at pin 3. Dual or quad op-amps share a common bias network and power-supply leads—that produces noise at the reference point, so very small signals could not be detected. But by using two independent op-amps, the noise level is reduced and the circuit sensitivity is increased.

The output of IC3 (pin 2) is pulled up by R10 and sent through R11 to the base of Q2, which then passes the signal to IR-LED1 at the VCR by one of two methods. The first method passes the signal directly to IR-LED1 via a suitable length of two-conductor speaker wire or zip cord. The second method passes the signal, via a high-pass filter, right onto the existing coaxial TV cable, to IR-LED1 at the other end. R12 sets the maximum current through IR-LED1, which retransmits the IR signal to the receiving unit's (the VCR, stereo receiver, etc.) IR window.

The components enclosed in the dashed lines in Fig. 2 are optional. That circuit causes an LED to flash on and off rapidly when the IR-extender circuit is activated by a signal from an IR remote control. The circuit is useful in that LED3 will only flash if a signal is being received from a remote control—that way you know if the IR signal is reaching the extender. The circuit works as follows: When the signal from pin 6 of IC2 exceeds the reference voltage set by R9, the output of IC3 causes Q3 to conduct, driving LED3. That can be either a red or green non-IR LED, and R15 sets its current (brightness level).

Construction

A foil pattern is provided in PC Service, and is available separately. (See Parts List.) If you wish to hard-wire the circuit, place the external components as close together as possible to keep stray capacitance to a minimum.

The Parts-Placement diagram is shown in Fig. 3. Be sure that pin 1 on all three IC's faces Q1, and mount Q1 with enough lead length (approximately ¾-inch) so that it will be able to protrude through a hole in the project box. The flat side of Q1 (the collector) is connected to +9-volts DC. Mount IR-LED2 so that it can be positioned directly behind Q1 (that way it can emit a small amount of IR into the base of Q1 during low-light conditions), as shown in Fig. 4. The flat sides (the cathode) of D1, D2, and D3 are attached to ground.

If you are going to use the existing coaxial cable in your home to transmit

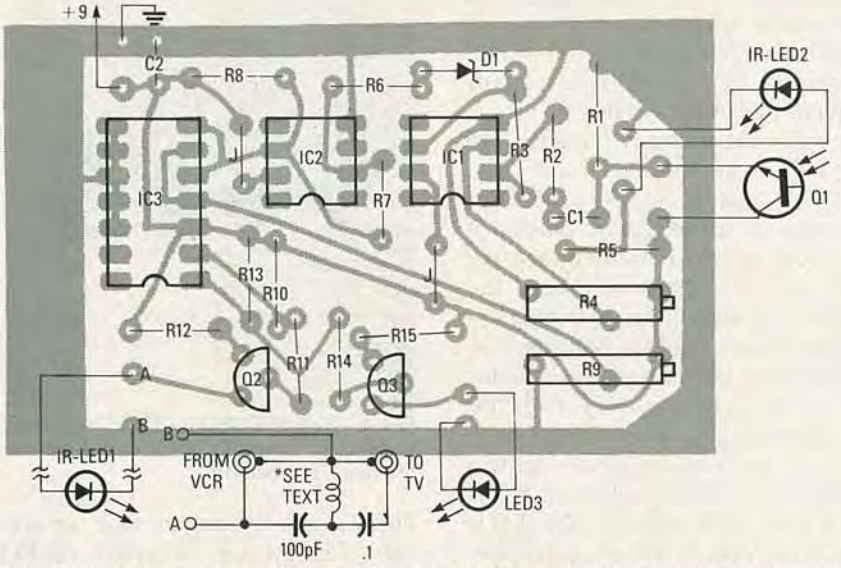


FIG. 3—PARTS-PLACEMENT DIAGRAM. Mount Q1 so that it can protrude through the project box. Either IR-LED1 *or* the filter circuit attaches to pads A and B.

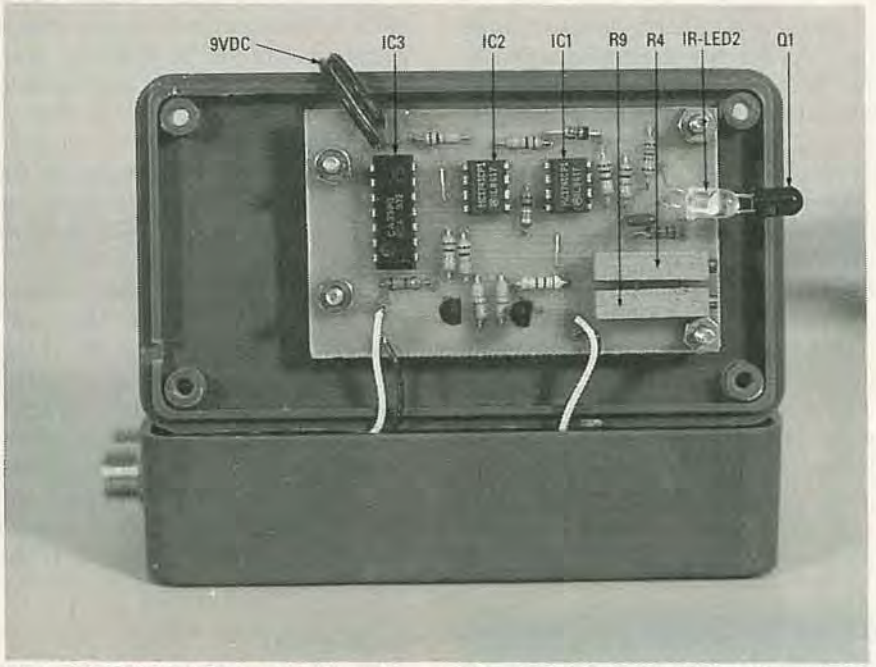


FIG. 4—MOUNT IR-LED2 so that it can be positioned directly behind Q1 as shown. That way it can emit a small amount of IR into the base of Q1 during low-light conditions.

PARTS LIST

All resistors ¼-watt, 5%.
R1—15,000 ohms
R2, R5, R15—1000 ohms
R3—1 megohm
R4, R9—20,000 ohms, 20-turn potentiometer
R6, R8, R10, R13—10,000 ohms
R7—100,000 ohms
R11, R14—4700 ohms
R12—150 ohms

Capacitors
C1—0.01 μF, disc capacitor
C2—0.1 μF, disc capacitor

Semiconductors
IR-LED1, IR-LED2—SEP 8703-1, infra-red light-emitting diode
LED3—light-emitting diode, red or green
Q1—TIL 414 phototransistor
Q2, Q3—2N2222, NPN transistor
D1—5.1-volt Zener diode
IC1, IC2—LM741 op amp
IC3—LM339 comparator

Other components
T1—120-volts AC/9-volts DC, wall transformer
Miscellaneous: 4-40 hardware, standoffs, tape, speaker wire, etc.
Note: The following two filters are needed only for transmitting through coaxial TV cable (see text).

Parts for the first filter
1 0.1-μF disc capacitor, 1 100-pF disc capacitor, 1 inductor (see text), 1 chassis-mount F connector, 1 cable-mount F connector, a piece of coaxial TV cable, cardboard, 2 washers, copper tape or aluminum foil.

Parts for the second filter
1 0.1 μF disc capacitor, 1 100-pF disc capacitor, 1 inductor (see text), 2 chassis-mount F connectors.
Note: An etched and drilled PC board is available postpaid for $7.50 in U.S. funds from Fen-Tek, P.O. Box 5012, Babylon, NY 11707-0012. NY residents must add sales tax.

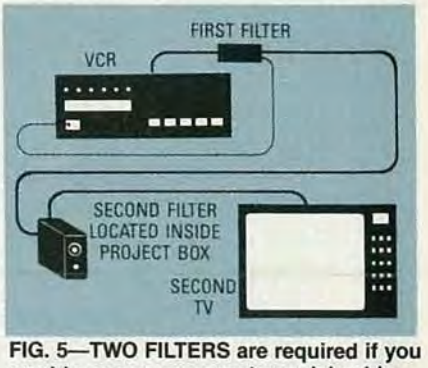


FIG. 5—TWO FILTERS are required if you want to use your current coaxial cable.

the signals, then two filters are required to decouple the DC voltage and to attenuate the transmitted signal. That keeps the TV tuner or VCR from receiving any harmful DC voltages. The only consequence of doing it that way is that there is an interchanging between the control signal and the video signal that takes place in the coaxial cable when the extender is activated; that results in a small amount of interference that is visible on the TV screen when a command is being sent.

Both filters must be installed between the last output stage and the tuner of your second TV, as shown in Fig. 5. (If you have an amplifier to boost your VCR output, then the amplifier becomes the last output stage.)

The first filter, located after the last output stage, can be constructed in two ways: The first way—and also the easiest—is to purchase a Radio Shack high-pass filter (PN 15-579). Remove the rubber gromet and slide back the case, as shown in Fig. 6. Take a 4- to 5-foot length of small-gauge two-conductor speaker wire or zip cord, and scrape away enough potting material at the filter's F connector to attach one wire to the center pin and the other to the ground side (see Fig. 6). Run the

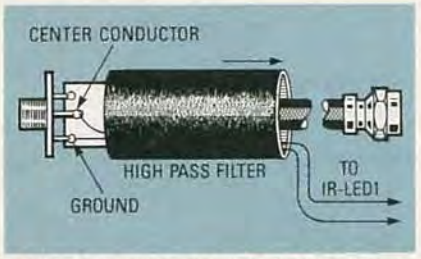


FIG. 6—A RADIO SHACK HIGH-PASS FILTER (PN 15-579) can be used for the first filter if you don't want to make your own.

wire through the case and then slide the case back over the filter. Use RTV silicone to reseal the area where you removed the grommet. Attach IR-LED1 to the other end of the wire. Remember that the wire that you attached to the center pin of the F connector is positive for IR-LED1.

For those true do-it-yourselfers, the other way is shown in Fig. 7. Because solder will not easily adhere to metal plating, file or sand away a small amount of the metal plating on the F connector and washer before soldering. When the filter is finished, wrap a piece of cardboard around it and tape in place. (The cardboard found on a blister pack works well.) The filter should then be wrapped with copper tape or aluminum foil for RF shielding. Make sure that a small piece of copper tape or aluminum foil is in contact with the washers at both ends of the filter to effectively complete the ground shield. You can also build the filter in a small metal case.

The inductors can be obtained in an inductor assortment from Radio Shack (PN 273-1601), or by making your own. If you purchase the inductor assortment, the ½-inch enameled wire-wound inductors have a value of 10 μH. Combined with a 100-pF capacitor, the filter should have a cutoff frequency of about 5 MHz.

If you wind your own inductor, use 22-gauge enameled copper wire, and wind 6½ turns on an 8-32 screw. Remove the screw and coat the outside of the windings with non-conductive RTV silicone. That will keep the windings from deforming during assembly. Scrape and tin both ends of the inductor. The value of the inductor should be approximately 100–200 nH. (It is much more difficult to make a 10-μH coil by hand, and because a 100- to 200-nH coil will do the job, that's what we'll make.) When that is combined with a 100-pF capacitor, the cutoff frequency should be about 35–50 MHz. The formula used for calculating the cutoff frequency is: $F = 1/2\pi\sqrt{LC}$.

The second filter is located inside the extender box as shown in Fig. 8. Be sure to attach the output wires from the PC board to the side that is coming from the other filter and not the one to the TV set. Label the two F connectors as in and out to make installation easier. If you have a TV set that uses a 75- to 300-ohm matching transformer, then the second filter can be omitted. In that case, just solder a bus wire from the center pins of both F connectors, and attach the positive output lead for IR-LED1 to that bus wire. Then bus-wire the grounds together on the F connectors and attach them to the PC board's ground.

If you decide to use the two-wire system, you can install a terminal

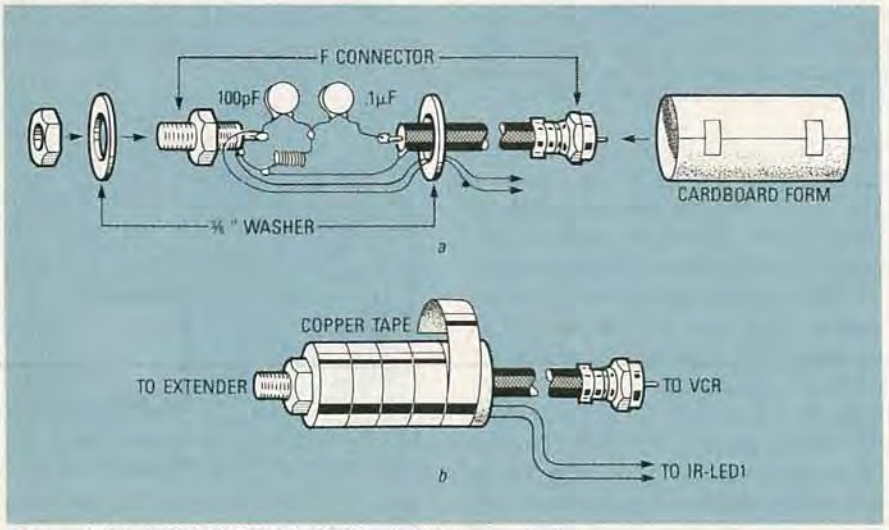


FIG. 7—YOU CAN MAKE YOUR OWN FILTER by first building the assembly shown in (*a*), and then wrapping it with copper tape or aluminum foil (*b*).

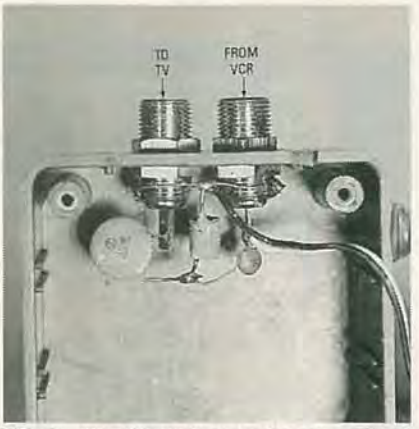


FIG. 8—THE SECOND FILTER, if required, is installed inside the project box across the two F connectors.

block inside the project case, or you can solder the wire directly to the PC board. Just make sure that the grounded lead gets soldered to the cathode of IR-LED1.

The easiest way to mount IR-LED1 on an appliance is to position it so that it covers ¼ of the IR receiving window on the device that you wish to control. Use a piece of clear tape to secure it to the unit. That way you can still use your remote control in the same room as your receiving unit. Be sure to insulate the legs of IR-LED1 so that they don't short out.

The PC board is installed inside a small plastic project box, and mounted on ¼-inch stand-offs. If you do not have stand-offs, then 3 nuts on top of each other can be used instead. The hole for Q1 in the front of the project box is not critical. Just be sure that Q1 fits through the opening and slightly protrudes outward. A smaller hole must be drilled for LED3, if you decide to use it.

Calibration

Apply power and make sure that nothing gets too hot. If anything does, then recheck your connections. Then, connect a voltmeter across IR-LED1. Adjust R9 until the output drops to approximately 0.004 volts. Then attach the voltmeter to pin 3 of IC1. Adjust R4 for 4.55 ± 0.05 volts. Remove the test lead and reconnect it across IR-LED1. Again, adjust R9 until the output goes high, and then back off slowly until it drops to approximately 0.004 volts. If you used the optional LED circuit, then there is no need to connect a voltmeter across IR-LED1, because LED3 will light when the output of IR-LED1 is high, and it goes out when it's low. **R-E**