Experimenting With an Infrared Receiver Module

By Forrest M. Mims III

The Technology of infrared remote control has been available since 1962. In that year, highly efficient near-infrared-emitting diodes were developed. Only in recent years, however, have infrared remote controllers become widely available. Their most popular application is the control of home-entertainment equipment, such as TV receivers, videocassette recorders and audio components and systems.

A spin-off from the widespread acceptance of infrared remote control is the availability of inexpensive infrared receiver modules. One such module is the Sharp Corporation's GP1U52X. This receiver module is now available from Radio Shack (Cat. No. 276-137; $3.49). This time around, we'll take a close look at this impressive receiver module and some of the ways you can put it to use.

Much of what we'll discuss will apply to any of the infrared receiver circuits and modules used in remote-ly controlled television receivers, videocassette recorders, audio gear and other appliances. Therefore, if you have access to a discarded appliance that can be operated by an infrared remote controller, you may be able to salvage the receiver circuit from it and try it in place of the GP1U52X module.

The Receiver Module

Though the GP1U52X is not as sensitive as a receiver that you can assemble from a photodiode and high-gain operational amplifier, it has surprisingly high sensitivity. As Fig. 1 shows, the GP1U25X is smaller than a receiver you can assemble on your own. Moreover, it is a complete system that includes a bandpass filter, demodulator and output comparator.

Designed to be powered by a 5-volt source, the GP1U52X is rated for a maximum power supply potential of 6.3 volts. The upper limit is determined by a miniature 47-microfarad capacitor that is rated at 6.3 volts contained inside the module. The module is specified for a maximum current consumption of 5 milliamperes.

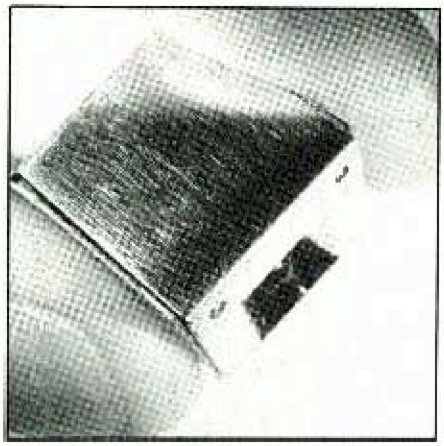

Fig. 1. Photo of the GP1U52X infrared receiver module.

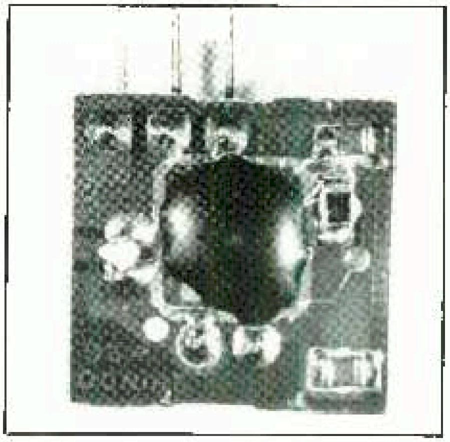

Fig. 2. The hybrid circuit board inside the GP1U52X module.

Shown in Fig. 2 is the bottom side of the tiny hybrid circuit-board assembly inside the GP1U52X module. The black blob of epoxy in the center of the board covers the single integrated-circuit chip that incorporates the receiver's amplifier and signal-processing circuitry. Two ceramic chip capacitors are soldered to the upper-left and lower-left corners of the board. A single chip resistor is located just above the lower chip capacitor.

Shown just above the encapsulated chip on the board are the two soldered pins that provide connections to the on-board photodiode. The two soldered pins on the right side of the epoxy blob are those for the 47-microfarad capacitor.

How the Module Works

Information about the GP1U52X module beyond what is supplied by Radio Shack was not possible to obtain for this column. Based on a close examination of a disassembled module and Radio Shack's block diagram, from which Fig. 3 is adapted, it's possible to figure out how the module works.

Pulsed infrared signals are detected by a silicon PIN photodiode. The photodiode is encapsulated in a near-infrared-transmissive epoxy material that absorbs visible light. The diode's package includes a small molded lens that increases the infrared gathering power of the device and provides some degree of directional sensitivity.

The photodiode transforms the signals it receives into a photocurrent that is amplified by an op amp. A limiter restricts the peak level of the signal. The bandpass filter is tuned for a maximum frequency response of 40,000 pulses per second (pps). Signals within about 4,000 pps of the bandpass frequency are passed on to an integrator and then a comparator that acts as a threshold circuit. If the signal that appears at the input of the comparator exceeds a preadjusted value set to exceed the noise level, the comparator switches on when a 40,000-pps signal is received by the photodiode.

Ideally, the bandpass filter would block all out-of-band signals. In practice, however, out-of-band signals of sufficient amplitude do get through. More about this later.

If a series resistor is used to restrict the flow of current to a few milliamperes, the comparator's output can directly drive a low-current LED or piezoelectric buzzer. Or it can trigger a driver transistor that, in turn, can drive a relay, lamp, motor or other external device.

Using the Receiver

If you've ever designed and built a lightwave receiver using individual components, you'll find that the GP1U52X is

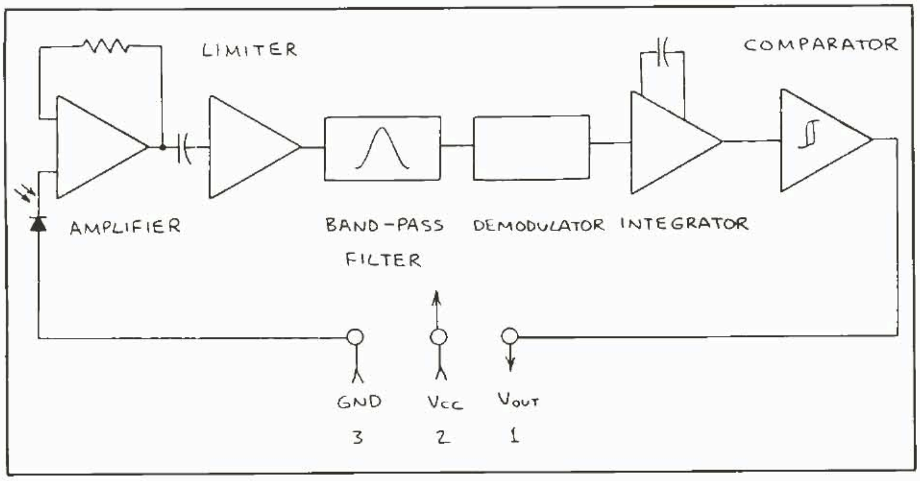

Fig. 3. Block diagram of GP1U52X infrared receiver module.

amazingly easy to use. As you can see by referring to the outline view of the module in Fig. 4, the module has only three pins. Pin 1 is the device's output, pin 2 its positive supply and pin 3 its ground.

Shown in Fig. 5 is a simple method that can be used to verify operation of the module. The LED connects directly to the module's output pin in the polarity shown. Series resistor *R1* limits current through the LED to 2.5 milliamperes.

A piezoelectric buzzer can be substituted for the LED in Fig. 5 to give an audible output. The buzzer should be the kind with a self-contained oscillator and not just the piezoelectric element. Correct polarity must be observed when connecting the buzzer into the circuit. A buzzer I tried consumed only 1.5 milliamperes when it was emitting a tone.

Figure 6 shows how to insert a transistor driver between the receiver and buzzer. Since the series resistor remains unchanged, current consumption of the buzzer is unchanged. In both circuits, you can insert a 10,000-ohm potentiometer or trimmer resistor between the series resistor and positive supply line to provide a means for controlling volume.

Ideally, the LED will glow or the buzzer will sound when a train of 40,000 pps of near-infrared pulses is received by the module's photodiode in Figures 5 and 6. Actually, the receiver will trigger on almost any light signal. Therefore, you will

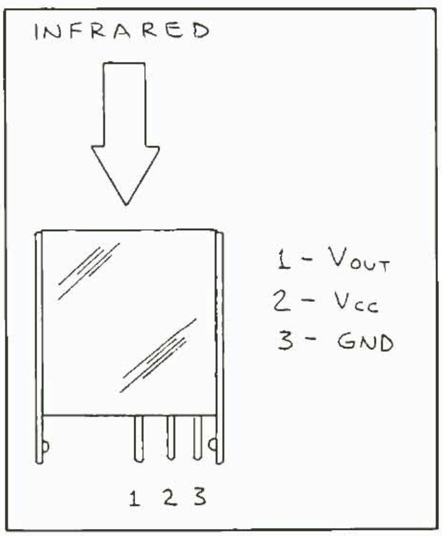

Fig. 4. Pinouts of the GP1U52X.

observe occasional flashes from the LED or hear "chattering" or "beeps" from the buzzer when the receiver is illuminated by ordinary room lighting. Before getting into why the receiver falsely triggers, though, let's try some simple experiments with the basic circuits given in Figures 5 and 6.

If you have an infrared remote-control unit for a TV receiver or VCR, point it at the receiver module and press any of its buttons. The LED will probably flash or the buzzer will beep in response.

If you use the Fig. 6 circuit, the sound of the buzzer may be annoying. As already noted, you can reduce the level of the buzzer's sound by placing a 10,000-ohm potentiometer between *R2* and the positive power-supply line. You can also reduce the sound level by placing some tape over the buzzer's sound-venting hole.

I happen to own a VCR made by Sharp, the company that makes the GP1U52X receiver module. When I pointed the VCR's infrared remote-control unit at the module, with the latter connected as shown in Fig. 5, and pushed some of its buttons, the LED rapidly blinked on and off. The receiver was quite sensitive to the signals sent by this "transmitter." Indeed, the receiver would respond even to stray reflections when the transmitter was pointed anywhere in my office and shop.

I opened the remote-control unit and found that a 1.5-ohm resistor was connected between the unit's single LED and ground. An oscilloscope connected across this resistor revealed periodic bursts of a dozen or so pulses were generated. Each pulse had a duration of 15 microseconds.

Since both the IR transmitter and the receiver module were made by Sharp, I wasn't surprised to find that the pulses within each burst had a pulse repetition rate of approximately 40,000, which, of course, is the center frequency of the receiver's bandpass filter.

As measured across the 1.5-ohm resistor, the amplitude of each pulse was 0.4 volt. From Ohm's law (I = E/R), this gives a peak current per pulse of 0.4/1.5, or 267 milliamperes.

Incidentally, the number of pulses within each burst and their relative positions were constant for a specific key on the remote-control unit. Pressing different keys altered the pulse pattern within a burst. A microprocessor connected to the receiver decodes the pulses within the bursts to determine which key has been pressed.

False Triggering

Before looking at a circuit for a transmitter you can build, let's examine the

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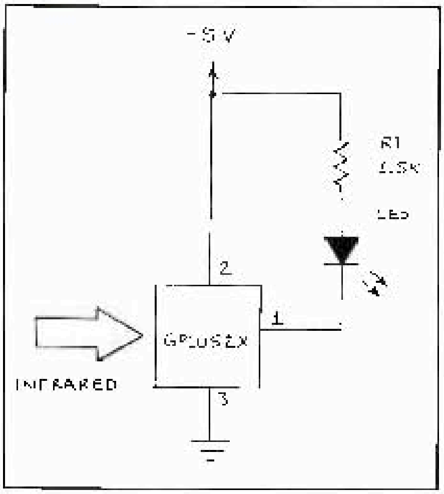


Fig. 5. Adding a LED to the GP1U52X's receiver module's output.

GP1U52X's susceptibility to false triggering. After you make the connections shown in Fig. 5 or Fig. 6, you'll probably observe occasional random flashes from the LED or beeps from the buzzer even when no infrared signal is present. These flashes are caused by stray illumination from room lights or sunlight entering a window.

If your work area is lighted by a fluorescent source, the output LED may flash rapidly or even appear to glow continuously. It will flash only occasionally if you prevent excessive stray light from striking the photodiode.

Since the receiver's circuitry contains a bandpass filter, you're probably wondering why it responds to ambient light. To understand why this occurs, let's begin by looking at sunlight since it isn't even modulated.

A photodiode's photocurrent is linear over six or seven decades of light intensity. Therefore, a photodiode can be operated in the presence of considerable background illumination. A pulsed signal will be detected so long as it produces a pulse of photocurrent that exceeds the steady photocurrent produced by a CW (continuous-wave) source such as sunlight or a battery-powered incandescent lamp. In other words, the receiver module can function in the presence of some sunlight.

What we're concerned about here is false triggering. Why does the module emit output pulses when it is illuminated by stray sunlight? The answer is that the amplified photocurrent has a noisy upper fringe. When a noise spike exceeds the system's threshold, the output LED flashes.

Incandescent and fluorescent lights are modulated by the alternating nature of the household ac line current that powers them. You can easily prove this by connecting a solar cell to the input of an audio amplifier. When you point the cell toward these light sources, the speaker driven by the amplifier will emit the familiar 60-Hz hum. Light from a fluorescent lamp switches on and off more frequently than does that from an incandescent lamp. Therefore, the hum or buzz produced by fluorescent lamps is more intense than that from incandescent lamps. The hot filament of an incandescent lamp remains heated and continues to glow during the zero-crossing of the applied current. This "thermal-lag" effect reduces the modulation depth caused by alternating current.

Both incandescent and fluorescent lamps will cause the receiver module to trigger. Since the bandpass filter in the receiver's circuitry is designed to pass signals that have a rate that is within 4,000 pps on either side of the 40,000-pps center frequency, why does the system trig-

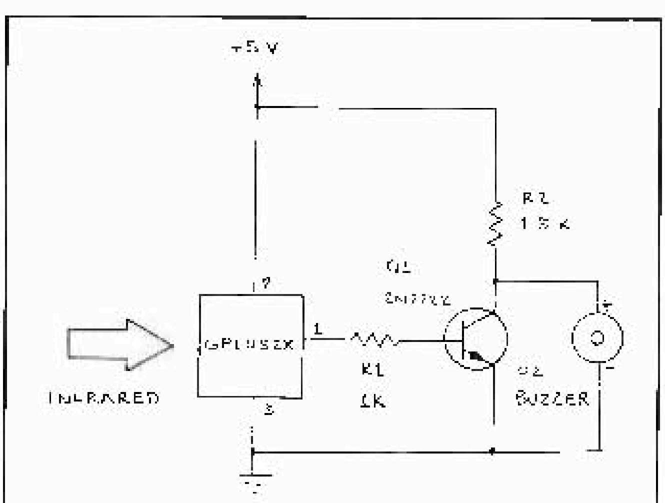
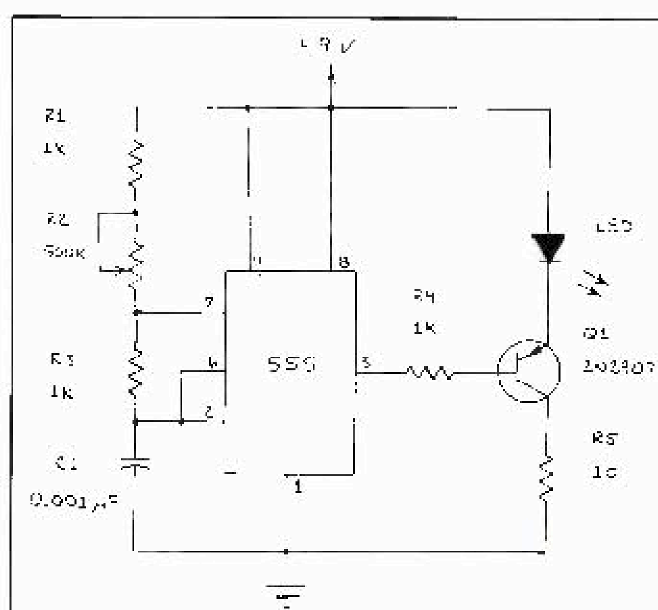


Fig. 6. An infrared receiver with a piezoelectric-buzzer output.

Fig. 7. Schematic diagram of a 40-kHz infrared transmitter.



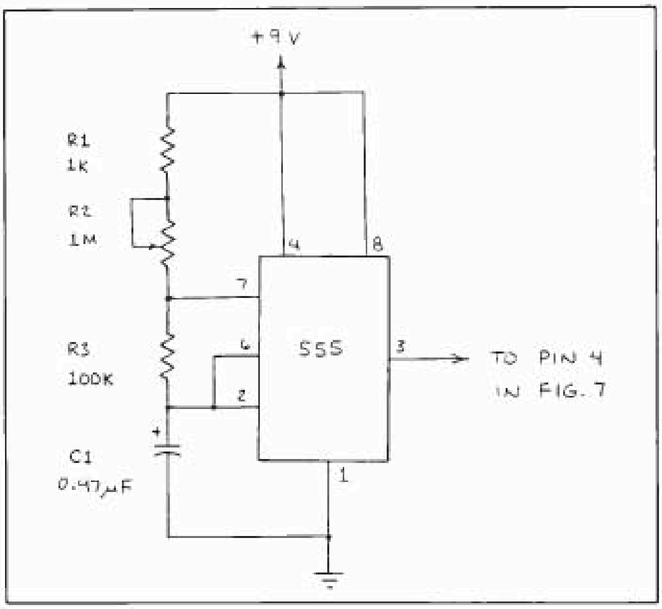
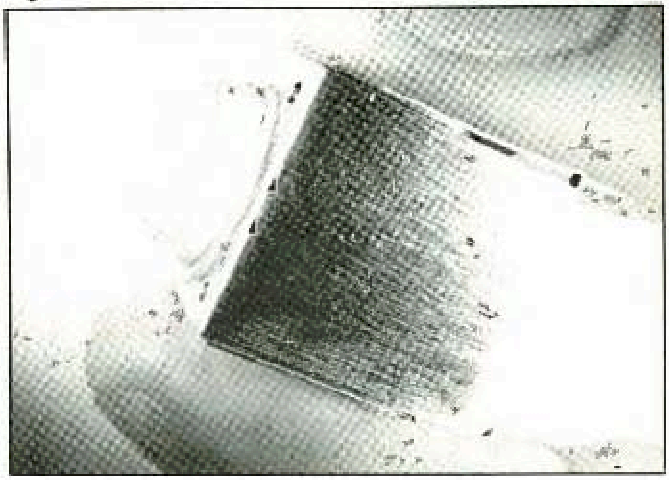


Fig. 8. An automatic switcher circuit for the Fig. 7 transmitter.

Fig. 9. The GP1U52X receiver module with a clear plastic foot "lens."



ger on a 60-Hz signal? Obviously, the receiver's bandpass filter is not perfect. Stray signals that fall well outside its nominal passband will be detected, especially when the photodiode is pointed toward them.

False triggering can be reduced by placing a near-infrared filter between the photodiode and light source. For this application, glass absorption filters work best. Several layers of developed color photographic film will function as a near-infrared filter if you have this handy.

Another way to reduce false triggering is to place a collimator tube over the photodiode. This collimator will then reduce the stray light that strikes the detector and gives the detector a much more directional response. A short length of 0.25-inch-diameter heat-shrinkable tubing works well. Cut a slit part or the way up one end of the tubing to allow it to fit over the photodiode's leads.

Incidentally, materials that block visible light may be nearly transparent to the near-infrared radiation the photodiode is designed to detect. Before using heat-shrinkable tubing as a collimator, I used an infrared viewer to check its ability to block near-infrared radiation. When observed through the viewer, an operating near-infrared LED appeared like a brilliant searchlight. However, the beam was completely blocked by the heat-shrinkable tubing.

This test can also be accomplished with a LED pulse modulated at an audio frequency and a photodiode connected to the input of a small audio amplifier that, in turn, drives a small speaker. Position the photodiode so that it can readily receive the signal from the LED. Then place the collimator material you're testing over the LED. If the material does indeed block infrared radiation, the tone produced by the receiver will be greatly or even totally attenuated.

Near-IR Transmitter

Many different near-infrared transmitters will activate the GP1U52X module. In Fig. 7 is shown the schematic diagram of a simple transmitter designed around a 555 timer configured as an astable oscillator. This oscillator delivers a train of pulses to *Q1* at a frequency determined by the setting of *R2*. When *Q1* is switched into conduction, the LED receives a pulse that has a duration of a few microseconds and peak current of 350 milliamperes. I measured the current by connecting an oscilloscope across *R5*.

Potentiometer *R2* in Fig. 7 can be adjusted to provide a pulse repetition rate of 40,000 (the center frequency of the GP1U52X). This adjustment is best accomplished by connecting a frequency counter across *R5* or *C1* and observing its display as *R2* is adjusted. Alternatively, you can point the LED at the receiver (built using the circuit shown in Fig. 5 or Fig. 6) and adjust *R2* for best results. The optimum 40,000-pps setting can be found by permitting only a small amount of the radiation emitted by the LED to reach the receiver's photodiode.

The duration of the pulse from the LED can be increased by increasing the resistance of *R3*. This is best done by first connecting an oscilloscope across *R5* and observing the change in pulse duration on its CRT screen as you try different values of resistance for *R3*. However, keep in mind that increasing pulse duration also increases the transmitter's current consumption.

You can easily add a switching circuit to the Fig. 7 transmitter circuit that will automatically transmit bursts of 40,000-pps pulses. To do this, first disconnect pin 4 of the 555 in Fig. 7. Then adjust the

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setting of *R2* in Fig. 8 to control the rate at which the bursts are transmitted. For a very slow transmission rate, increase the value of *C1*.

Getting Greater Range

The reception range of the GP1U52X receiver module can be increased with the aid of an external lens. Assuming the lens is properly focused, doubling the diameter of the lens will approximately double the receiver's reception range.

An ultra-simple lens that increases the receiver module's range to some degree is illustrated in Fig. 9. The "lens" is a plastic foot, a clear dome with a coating of adhesive applied to its flat side. The lens is simply pressed into place. Clear plastic feet are available from Radio Shack (Cat. No. 64-2365) and other electronics parts distributors.

For greater range, you can use a larger lens. Inexpensive plastic Fresnel lenses and magnifiers are available in various sizes from office-supply dealers and variety stores. Many kinds of lenses are also available from surplus parts/equipment dealers and from Edmund Scientific Co. (101 E. Gloucester Pike, Barrington, NJ 08007).

You can also increase the receiver's range by narrowing (concentrating) the transmitter's beam with a lens. However, narrow transmitter beams are difficult to aim with good accuracy over long distances. This is especially true when the beam is infrared radiation that is invisible to the human eye.

Going Further

You can easily adapt an infrared receiver module like Sharp's GP1U52X for simple on/off remote-control applications. To control large loads, use a relay in place of the piezoelectric buzzer in Fig. 6. Depending on the relay chosen for this application, it will probably be necessary to reduce the value of *R2*. Of course, be sure to observe proper safety precautions if you use the relay to switch 117-volt ac line current.

There are many applications for infrared remote-control receiver modules beyond straightforward remote control. They can be used as receivers in break-beam intrusion alarms. Unfortunately, false triggering can prove to be a problem here. One possible solution is to connect the receiver's output to a missing-pulse detector designed around a 555 timer. This will reduce the impact of false triggering, but the circuit may fail to warn of an intrusion if the break occurs at the same time as a noise pulse.

Another possible application for infrared receiver modules is pulse-frequency-modulated voice communications. The GP1U52X module seems to be particularly well-suited for this application because its 40,000-pps center frequency is well above the range of human hearing and, thus, simplifies demodulation of the received signal.

For additional information about missing-pulse detectors, see books and applications notes for the 555 timer chip. I show a sample circuit on page 12 of my *Engineer's Mini-Notebook: 555 Timer IC Circuits* (Radio Shack, 1984).

I've written many articles and several books on lightwave communications. Much of the material in these articles and books can be applied to infrared remote-control applications. *A Practical Introduction to Lightwave Communications* (Howard W. Sams & Co., 1982) is currently not in print, but you might be able to find it in a library that has a good technical reference section.

For additional information about pulse-frequency-modulated lightwave communications, see *The Forrest Mims Scrapbook* (McGraw-Hill, 1983, pp. 40 through 42). Also see *Forrest Mims' Circuit Scrapbook II* (Howard W. Sams & Co., 1987, pp. 118 through 121). **ME**