BUILD LITE-COM!

Photo-transistor receiver and LED transmitter work on visible or invisible light, with or without fiber optics.

by C. R. Lewart

AT THE SAME TIME that food and drink prices keep going up, and UP, the cost of electronic components keeps going lower and lower. You can now communicate over a beam of light for less than ten dollars using two electro-optical semiconductors which weren't even available except in development labs a few years ago. These transducers* convert electrical signals into light, and then convert light back into electrical signals. Thus you can use the Lite-Com to send messages and music over a beam of light without most of the previously-required circuitry.

Less-sophisticated light detecting devices have been available to the experimenter for some time. There are photocells made of selenium and of cadmium sulfide which have been off-the-shelf items for years. They are used in light meters and in cameras to measure light. However, their response time is much too slow for accurate transmission of sound. Photo-transistors, on the other hand, have excellent audio frequency-response characteristics, and are ideal for the project which we describe here.

The Lite-Com uses two electro-optical transducers: the *photo-transistor,* which converts light variations into electricity, and the LED (Light-emitting diode), which converts electrical signals into changes in light intensity. Lite-Com is an easy-to-construct project using those transducers which will give you the basic circuitry for many other projects you will think of after you've put it together and seen how well it works. Combining these two circuits with other equipment should make some interesting Science Fair and other experimental (and practical) systems.

Light Detector. The basic detector used in the Lite-Com is the photo-transistor. Every transistor is sensitive to light when its cover is removed. Light falling on the base region of a transistor has the same effect as electric current being "pumped" between its base and emitter. This effect was recognized early in the development of transistors. Because transistors were not intended to be light-sensitive in their original applications (how would you like your radio to quit when exposed to light?) they are mounted in hermetically-sealed, non-transparent metal or plastic enclosures.

You could of course cut through the transistor enclosure to make a regular transistor into a photo-transistor but in the process more likely than not you would destroy the transistor. But for little more than a dollar you can buy a photo-transistor specially designed to do the job. It is hermetically sealed but has a small glass window on top to permit light to fall directly on its base region. Most commercially-available photo-transistors use the NPN config-

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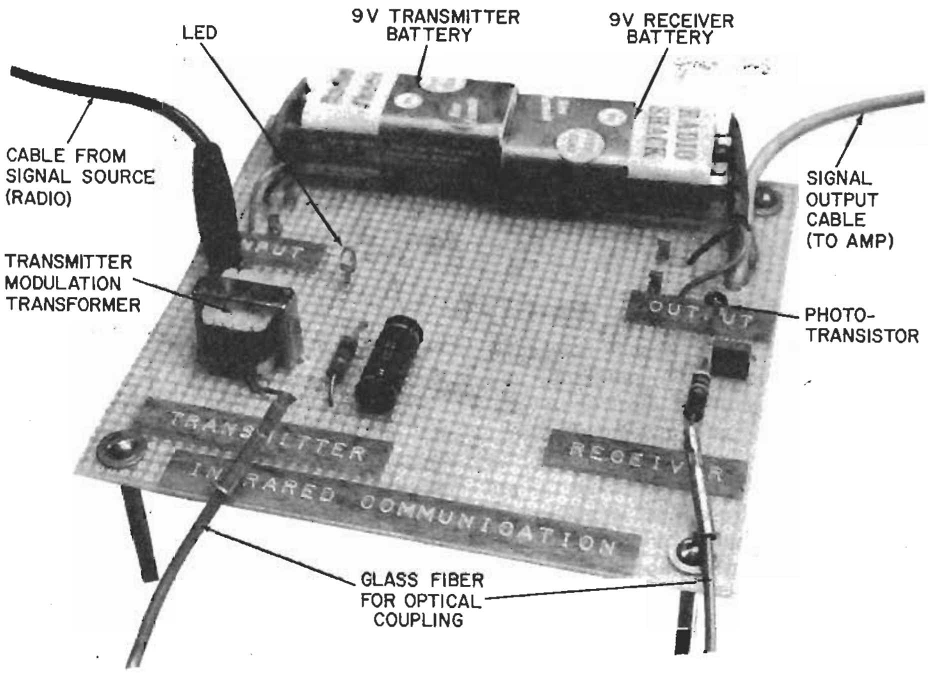
* A *transducer* is any device which accepts energy in one form, such as heat, light, or electricity, and converts it into some other form of energy, such as mechanical motion. Telephone receivers (and transmitters) as well as loudspeakers, are widely-used transducers.

uration. Some photo-transistors have three terminals, emitter, base and collector, while others have only two terminals, the emitter and collector. In either case light falling on the transistor generates the base-emitter current.

In a three-terminal photo-transistor there are other ways to control the base-emitter current. You can bias it by connecting a resistor between the base and collector, or you can vary the light sensitivity of the photo-transistor by connecting a potentiometer between the base and emitter. However, for Lite-Com either a two- *or* a three-terminal photo-transistor will do the job. Another option the photo-transistor designer has lies in the light region for which the photo-transistor is most sensitive. The two usual choices are in the visible light spectrum or in the infrared region as shown in the Spectral Response Graph To be able to operate with "invisible" infrared light we selected an infrared sensitive transistor with its peak sensitivity at 0.9 microns.* The visible light region extends from about 0.4 microns to 0.7 microns (violet to purple). If you want to experiment with visible light our infrared transistor will still work, as its sensitivity stretches into the visible region. However, a different photo-transistor (see the Parts List) will give you better results with visible light.

Light Sources. To generate a signal proportional to the sound energy Lite-Com uses an infrared LED. The LED generates light when it is forward-biased. That is, when its anode (+) is connected to the positive battery terminal (and its cathode, of course to the negative). Be careful, however, not to connect an LED (or any other diode) *directly* to a source of positive voltage. Doing so will burn the diode out at once, because it will draw too much current. This is because the LED (just as other diodes) has a very steep voltage/current curve. Unless you put a



Closeup of transmitter and receiver built on one chassis for demonstration. Units may be separated by any distance provided light path is provided from transmitter's LED to receiver's phototransistor.

current-limiting resistor in series with the diode any battery voltage larger than about 1.5 volts will cause the current drawn to exceed the maximum allowable value, and the diode will burn out. When in doubt always figure the size of the resistor required, using Ohm's law:

$$R = \frac{E(\text{volts})}{I(\text{amps})}$$

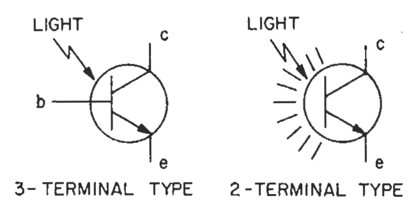
For example, for a battery voltage of 9 V, with the maximum allowable current through the diode 30 mA, assume a voltage drop across the diode of 1.5V. The limiting resistor value in this case would be found by using these figures in the formula:

$$R = \frac{(9\text{-}1.5)}{0.030} = 250 \text{ ohms}$$

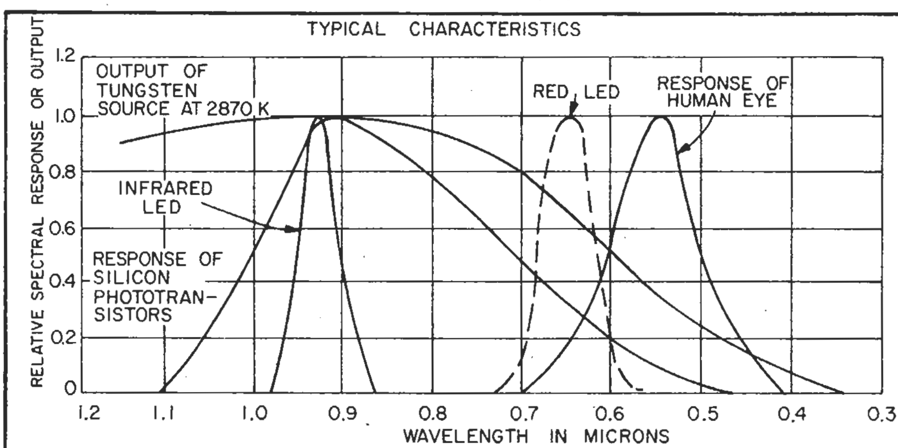
Just as photo-transistors can work in various light regions, LEDs can also be designed for various light frequencies or colors. Currently you can buy red, orange, green, and infrared LEDs. Light-emitting diodes generating invisible infrared light are particularly useful for building burglar alarms, or in areas where ambient light would be disturbing. Under such conditions an infrared filter can be used to attenuate the visible ambient light and pass only the infrared radiation. Common features of LEDs, as compared to incandescent light sources, are fast response up into *megahertz* region, and low power consumption. Thus they are ideally suited to transmission of voice frequencies.

Transmission Medium. Both infra-

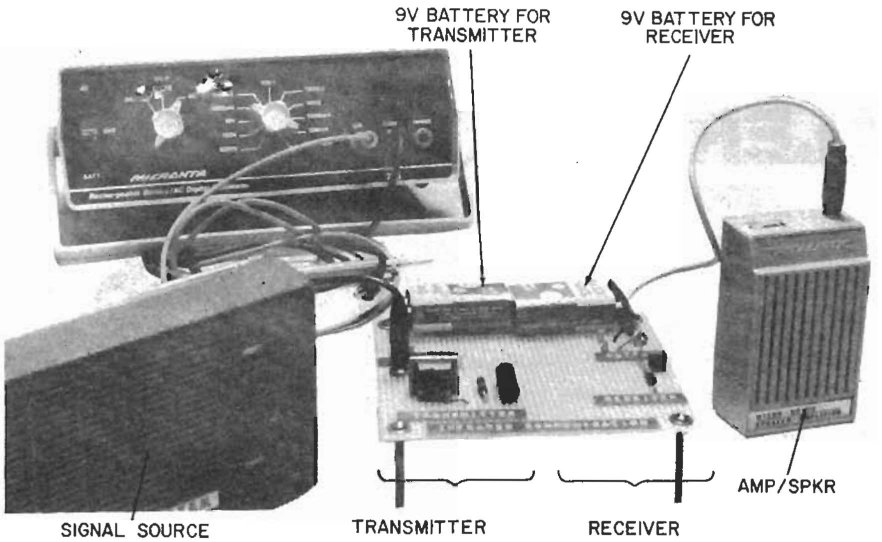
*one micron = 10^{-6} meters (one millionth of a meter)



Ordinary transistor—light-sensitive, if open. Phototransistor has clear window, omits base connection.



Wavelength of infrared LED, visible-light LED, and tungsten filament emissions, compared with wavelengths of silicon phototransistor and human retina.



Lite-Com uses electrical signals from radio (or other source) to modulate infra-red LED transmitter. Receiver phototransistor senses infra-red light variations, feed external amplifier/speaker. LED and photo-transistor may be coupled directly, with lenses, or with glass fiber optics.

red and visible light propagate along straight lines through the air. This path can be bent by prisms, mirrors, lenses or bundles of glass fibers. In fact you will have the most fun by using one or more glass fibers between the transmitting LED and the receiving photo-transistor. You can tie the glass fibers in knots and they will still pass the visible or infrared light energy. Our Parts List gives suppliers of glass fibers for experimenters. You can even use just one glass fiber about 1/16-inch in diameter, and any convenient length.

Setting It Up. To use the Lite-Com we modulate the output of the LED with sound signals such as the output of a radio, a tape machine (connect from the earphone output jack), a ceramic phono pickup, or a microphone and mike amplifier. The light can be transmitted directly (by placing the LED face-to-face with the photo-transistor), or more conveniently by transmitting the light signals through a glass

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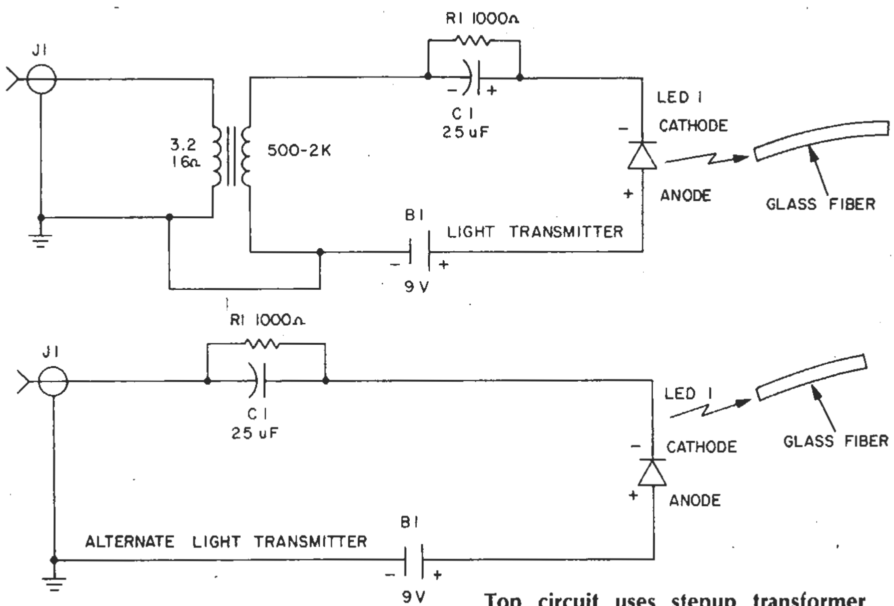
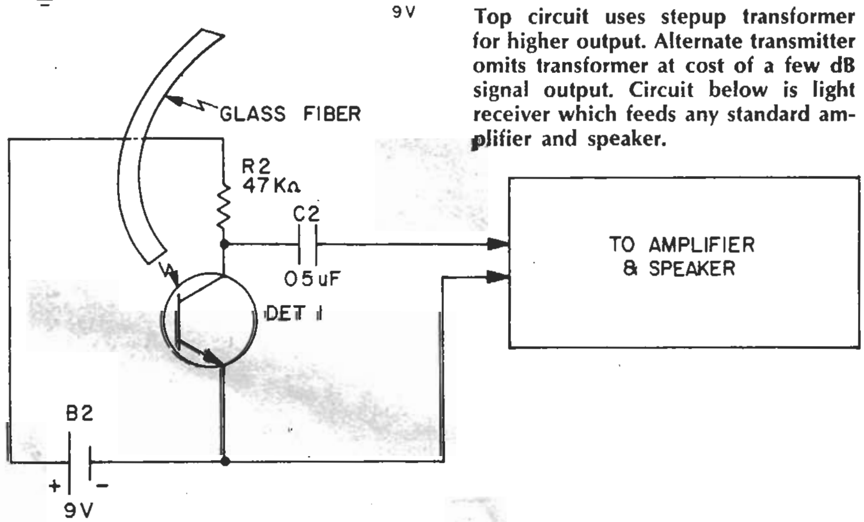


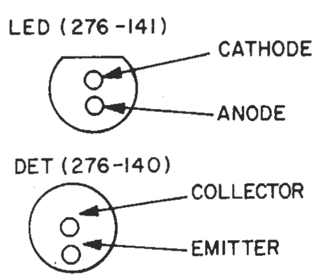


Top circuit uses stepup transformer for higher output. Alternate transmitter omits transformer at cost of a few dB signal output. Circuit below is light receiver which feeds any standard amplifier and speaker.

PARTS LIST FOR LITE COM

AMP—transistor amplifier with speaker (Radio Shack 277-1008 or equiv.)
B1, B2—9 V transistor radio batteries
C1—25-uF, 35-V capacitor (Radio Shack 272-1026 or equiv.)
C2—0.5-uF, 35 V or more capacitor (Radio Shack 272-1071 or equiv.)
DET 1—Infrared photo-transistor (Radio Shack 276-140 or equiv.) or photo-transistor for visible light (Radio Shack 276-130 or equiv.)
J1—phono jack (Radio Shack 274-336 or equiv.)
LED 1—infrared light-emitting diode (Radio Shack 276-141 or equiv.), or visible light LED (Radio Shack 276-026 or equiv.)
R1—1000-ohm, ½-watt resistor (Radio Shack 271-000 or equiv.)
R2—47K-ohm, ½-watt resistor (Radio Shack 271-1000 or equiv.)
T1—audio output transformer. Primary may be anywhere from 500 to 2000 ohms, secondary between 3.2 and 16 ohms (Radio Shack 273-1380 or equiv.)
Misc.—Perf board, battery connectors. A selection of glass fibers (also called **fiber optics**) can be obtained from Radio Shack (page 72 in the 1976 catalog) or from Edmund Scientific, Barrington, N.J. 08007. Edmund also carries many optical components for the hobbyist.

PIN CONNECTORS



Lite-Com

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fiber. The signal output of the phototransistor is then amplified by an external amplifier to drive a loudspeaker.

Although we used a handy pocket-size amplifier with built-in speaker (see the Parts List), there's no reason you can't design and build your own small amplifier. You can also use the *Tape* or *Aux* input on your hi-fi receiver or amplifier. Try bending the light fibers, and you can show how light goes around corners.

Simple Circuits. Lite-Com's two circuits are quite simple and straightforward. Resistor R1 and the DC resistance of T1's secondary winding determine the quiescent current through the LED (5-10 mA). C1 bypasses R1