Build a Light-Beam Communicator

Here is a circuit that allows you to communicate over short distances using an ordinary flashlight!

BY JERRY PENNER

Everyone is familiar with IR information transmission, after all there is hardly an electronics leisure-time device (TV's, VCR's, stereos, and even some boom boxes, to name a few) that does not come with an IR remote control. But did you know that IR is not the only form of light radiation the can be used to convey intelligence?

Light emitted by an ordinary flashlight lamp can be used to move voice and other audio over short distances. And that's just what our experimental *Solar Cell Communicator* (a receiver and transmitter pair) is designed to do. The circuit was not designed to fill any particular need, nor generate any useful amount of data, power, or "chicken sandwiches." It's pure fun, and was designed for its high "HTN" (Hey, That's Neat!) value.

Of course, the range of such a device will be inherently limited, but with a little imagination, the circuit can be altered to transmit over greater distances, or can be used for listening to various light and heat sources.

Theory of Operation. The whole idea behind the two circuits presented here is to send intelligent data from the transmitter to the receiver using light. Actually, the transmitter and receiver circuits are nearly identical, save for the input and output devices. The transmitter is nothing more than an amplified microphone circuit that's used to drive an incandescent lamp instead of a speaker. The receiver is similar to an amplifier circuit that has a solar cell input and a speaker or headphone output.

The transmitter circuit picks up sound, amplifies it and then uses that audio signal to vary the voltage across the lamp at a rate equal to the frequency of input. The solar cell, which feeds an op-amp in the receiver, picks up the varying light and converts it back into a voltage, which is then applied to a speaker to reproduce the audio.

The Transmitter. A schematic diagram for the transmitter section of the Solar Cell Communicator is shown in Fig. 1. The circuit is essentially a microphone-fed audio amplifier—consisting of R2, R3, R4, and U1 (which is configured for inverting operation)—whose output is fed to the base of a general-purpose transistor. (The microphone in this case is a headphone speaker, but for simplicity and clarity, we'll continue to refer to it as a microphone.) The transistor, in turn, responds to the incoming audio by increasing and decreasing the intensity of the light emitted by lamp I1.

The microphone takes sound waves presented to it and converts them into a varying (with respect to the intensity of the sound) electrical signal. That input signal is capacitively coupled via C1 to the inverting input of U1. Capacitor C1 (a 33-µF unit) and R1 (a 100-ohm unit) limit the low-end frequency to about 60 Hz. Because U1 (a 741 general-purpose op-amp) is powered from a single-ended power supply, its output will always be at half the supplied voltage with no input signal applied, therefore lamp I1 remains at half brightness. With I1 at half brightness, the receiver circuit has a zero output, thereby greatly reducing distortion in its output.

When a signal is applied to the amplifier, its output varies in amplitude, following the input signal. That signal causes Q1's level of conductance to vary and the light intensity emitted by I1 to increase and decrease accordingly. The 6-volt flashlight lamp used for I1 will last a reasonably long time, because the average voltage across the lamp is

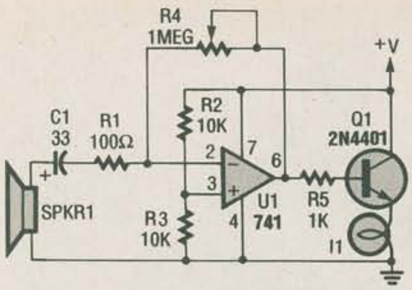

Fig. 1. The transmitter section of the Solar Cell Communicator is essentially a microphone-fed audio amplifier whose output is used to vary the intensity of the light emitted by an ordinary flashlight lamp.

PARTS LIST FOR THE TRANSMITTER

U1—741 general-purpose op-amp, integrated circuit
Q1—2N4401 general-purpose silicon NPN transistor
R1—100-ohm, ¼-watt, 5% resistor
R2, R3—10,000-ohm, ¼-watt, 5% resistor
R4—1-megohm logarithmic-taper potentiometer
R5—1000-ohm, ¼-watt, 5% resistor
C1—33-µF, 20-WVDC, electrolytic capacitor
I1—6-volt, 200-mW, incandescent lamp
SPKR1—Headphone speaker or microphone (see text)
Printed-circuit materials, enclosure, 6-volt DC source, 8-pin IC socket, switch, lamp holder, wire, etc.

3 volts; well within the voltage rating of the bulb.

The author used a 30-ohm headphone speaker as the input device in his prototype, but any speaker with an impedance of up to 100 ohms may be used.

Receiver Theory. The receiver in Fig. 2 is just as simple as the transmitter and a lot more fun to play with. The solar cell picks up any light striking it and converts it to a DC voltage. Components C1 and R1 limit the lower input frequency as well as blocking DC from the solar cell. Components U1, R2, R3, R4, and C2 make up the amplifier stage. Speaker SPKR1 can be a headphone speaker or dynamic microphone.

A single solar cell delivers up to 0.5 volt in direct bright sunlight; the output current is based on the size and efficiency of the cell. The prototype uses a 200 mA unit. The actual current output of those devices is also based on the load across it. The cell in the prototype generates 200mA under full light if short circuited.

Since the circuit will never need more than a few milliamps to produce a usable signal, it would be more beneficial to use several cells in series to increase the magnitude of the voltage variations. Increasing the voltage swings for a given light input would also increase the sensitivity and night range of the circuit.

Circuit Construction. Since the transmitter and receiver circuits are so simple and parts placement is not critical, the circuits may be assembled using the technique that you are most comfortable with. But to reduce the likelihood of errors and make construction as simple as possible, printed-circuit patterns for the transmitter and receiver circuits are provided in Figs. 3 and 4, respectively.

The transmitter's and receiver's parts-placement diagrams are shown in Figs. 5 and 6, respectively. Once the two circuit boards have been completely assembled, and your work checked, it's time to start thinking about housings for the two circuits. The transmitter can be built into an old flashlight (as the author did), which would also provide a means by which to focus the beam and extend the range.

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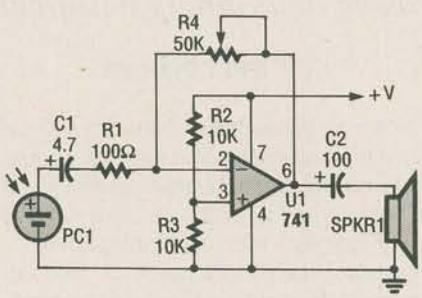

Fig. 2. The receiver portion of the communicator is just as simple as the transmitter: A solar cell picks up light emitted by the transmitter and converts it into a varying DC voltage.

PARTS LIST FOR THE RECEIVER

U1—741 general-purpose op-amp, integrated circuit
R1—100-ohm, ¼-watt, 5% resistor
R2, R3—10,000-ohm, ¼-watt, 5% resistor
R4—50,000-ohm logarithmic-taper potentiometer
C1—4.7-µF, 20-WVDC, electrolytic capacitor
C2—100-µF, 20-WVDC, electrolytic capacitor
PC1—0.5-volt, 200-mA photocell
SPKR1—Headphone speaker (see text)
Perfboard materials, enclosure, 6-volt DC source, 8-pin IC socket, switch, lamp holder, wire hardware, etc.

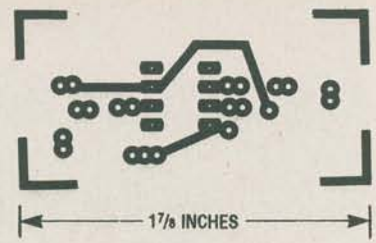

Fig. 3. Here's the printed-circuit pattern for the transmitter section of the communicator.

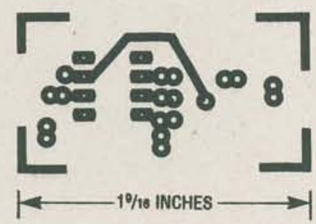

Fig. 4. There is very little difference between the printed-circuit patterns for transmitter (see Fig. 3) and receiver (shown here).

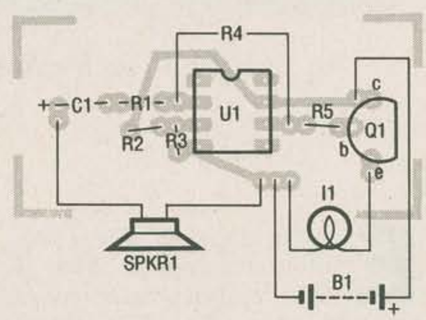

Fig. 5. Assemble the transmitter's printed-circuit board using this parts placement diagram as a guide.

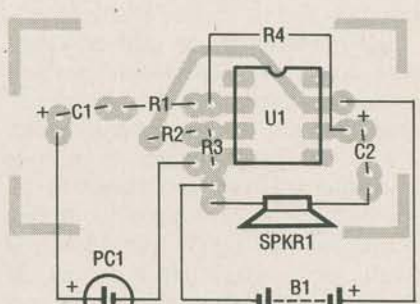

Fig. 6. Be careful when assembling the receiver circuit; some solar cells are extremely fragile, and are easily damaged by heat and other stress.

LIGHT BEAM

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The receiver needs no special consideration except for the solar cell; if an unmounted cell is being used, be very careful with it. Some are more fragile than eggshells and are easily damaged. Soldering to the backplane and front collector on an unmounted cell may also prove to be more difficult than imaginable, since excess heat can damage the cell.

Limitations. The transmitter and receiver have a frequency response of from 500 Hz to over 10 kHz. The high end can be cut off by using a higher current lamp. Such a lamp is slower to brighten and dim, and so will not reproduce all that is fed into it.

Since the receiver is designed to turn light variations into sound, simply pointing the receiver at a household lamp should produce a 120-Hz hum in the receiver's speaker. Although the frequency response cuts off at about 500 Hz, incandescent and fluorescent bulbs produce massive amounts of flicker, of which the tiniest bit will be picked up by the receiver. That also limits communications to nighttime or dark rooms, because the 120 Hz hum of room lights may override the transmitter signal.

Also, since sunlight is a DC source, it will raise the solar-cell bias to a point that gives a clipped output, or none at all. Solar cells are more sensitive to ultraviolet light than infrared, so television remotes won't activate the receiver, but suntanning lamps will.

Conclusion. Now that you have your Solar Cell Communicator, start pointing the receiver at whatever generates light. Clock-radio displays, neon signs, incandescent and fluorescent lamps, the television, the fireplace, jet engines, automobile headlights, and whatever else you desire. No two sounds you hear will be the same.

The prototype has an effective range of about four inches without the benefit of lenses, focusing mirrors, or multiple cells. But the range can be easily increased by running the transmitter on 12 volts, swapping the 2N4401 transistor for a high-power Darlington, and using an automobile headlamp.

The circuit may not do anything important, but to the untrained (and sometimes trained) observer, you'll look like you're doing some very important work instead of having fun. ■