C.L. Houghton WB6IGP
San Diego Microwave Group
6345 Badger Lake Ave.
San Diego CA 92119
[clhough@pacbell.net]
[WB6IGP@ham-radio.com]

A Simple Optical Test Device for the Laser/LED Communicator

In June 2000, I published in 73 Magazine *the first of three articles about an LED communicator constructed in two sections of PVC tubing or pipe looking much like a binocular with a rifle scope for pointing the system.*

The basic concept was to make a light communication system different from other devices for optical communications due to the difficulty in modulating HeNe lasers and safety concerns. Kerry N6IZW, my partner, developed the concept and system designs.

What was envisioned was a high-output LED transmitter and photo detector, each housed in one section of the 4-inch PVC pipe. Rear splice unions (PVC) and end caps were used to house electronics for the system. Not wishing to re-invent the wheel, existing systems were used so we did not have to construct a full receiver system. What was done was to use a 4046 IC oscillator functioning at 35 kHz on one end and 45 kHz on the opposite end so as not to feed back to its own system. The modulation and RF driver for the LED is a 324 op amp and an electret mic. The mic can be removed and a computer sound card output can be used as well to provide PSK-31 for some very interesting applications.

In fact, Kerry N6IZW and I have accomplished a 15-mile-path full-duplex-operation FM narrowband communications from Mt. Palomar to Valley Center, using the upgraded Laser optical system shown here. Also tried was PSK-31 and computer-generated QSL cards sent via slow scan video. It was an exciting night demonstrating the systems that Kerry N6IZW had envisioned and developed.

Driving the transmitter, be it originally an LED or, in our up-graded version, a pocket laser, both are fed from the same modulator oscillator at 35 or 45 kHz. The 35 kHz transmitter is made to function with the opposite end receiver a 35 kHz photo detector. The opposite end transmitter is on 45 kHz, so there is minimal crosstalk between receive and transmit at either end (10 kHz separation between Rx and Tx).

Now, the sneaky part in Kerry's design is to feed the detected receiver (be it 35 or 45 kHz) energy and amplify it and drive an SRA mixer's IF port and feed the LO port with a synthesizer's 145 MHz RF signal source. This converts the 35 or 45 kHz receiver photo detector output to the RF port at 145.35 or 145.45 MHz, up-converting the received signal for insertion into a 2-meter HT for receiving narrowband FM with 5-kHz deviation. This receive system works unbelievably well, but just remember to never transmit on the HT — it is for receive operation only. Transmit is the electret mic in the power supply modulator for the LED/laser.

The system looks like two 4-inch PVC tubes spaced about an inch apart and a rifle scope and newly added Laser pen transmitter, beefing it up quite a bit over the original LED transmitter system. (When using the laser we cover up the LED transmitter and its optics with a 4-inch PVC pipe cap to shut the LED down.) Now comes the problem of dealing with 4 tube-like structures: (1) the LED transmitter, (2) The receive photo detector, (3) The pocket laser, and (4) the rifle spotting scope. Defining the problem is like wanting to hold four pencils in one hand and have them all be pointing in the same direction.

But first, to envision the problem let's take the four pencils, or actual devices we described earlier, and make them a half mile long, or even longer, and keep them all on the same axis pointing at the same spot at the remote target. It's obvious that some help in calibrating this octopus is needed.

First, it's somewhat easy to point one object at a far source and center it up to receive the far transmissions, be it an LED or a higher intensity pocket laser. Of course, the farther the distance the harder this problem gets, and micro positioning is a required function to make very fine adjustments in both vertical and horizontal directions. To add even more difficulty to this formula, you need very beefy tripods for rigidity, and even then they will still have some small wiggles and nonsolid movements in them. A lathe table would be excellent — but then where would you park the crane to haul it? A tripod, being what it is, will suffice and allow us to aim one single target to alignment. Getting them all to the same spot is the problem faced here.

One solution is to construct a simple oscillator at the system receive frequency (35 kHz, for example) and mount it into a tin can to serve as target to align the photo detector and tin can's LED together. Now add a small automobile reflector in the same tin can to serve as not only transmitting oscillator but also now reflecting the return of the laser spot. The laser spot is much more intense than the test LED in the tin can and will override it when focused on the laser. Using the positioning controls of the tripod, align the detector on the LED, and then turn on the laser and position the laser's right/left/up/down movement to align the laser spot in the reflector in the tin can while keeping the tin can LED aligned with the receiver. Verify by shutting down

Continued on page 50

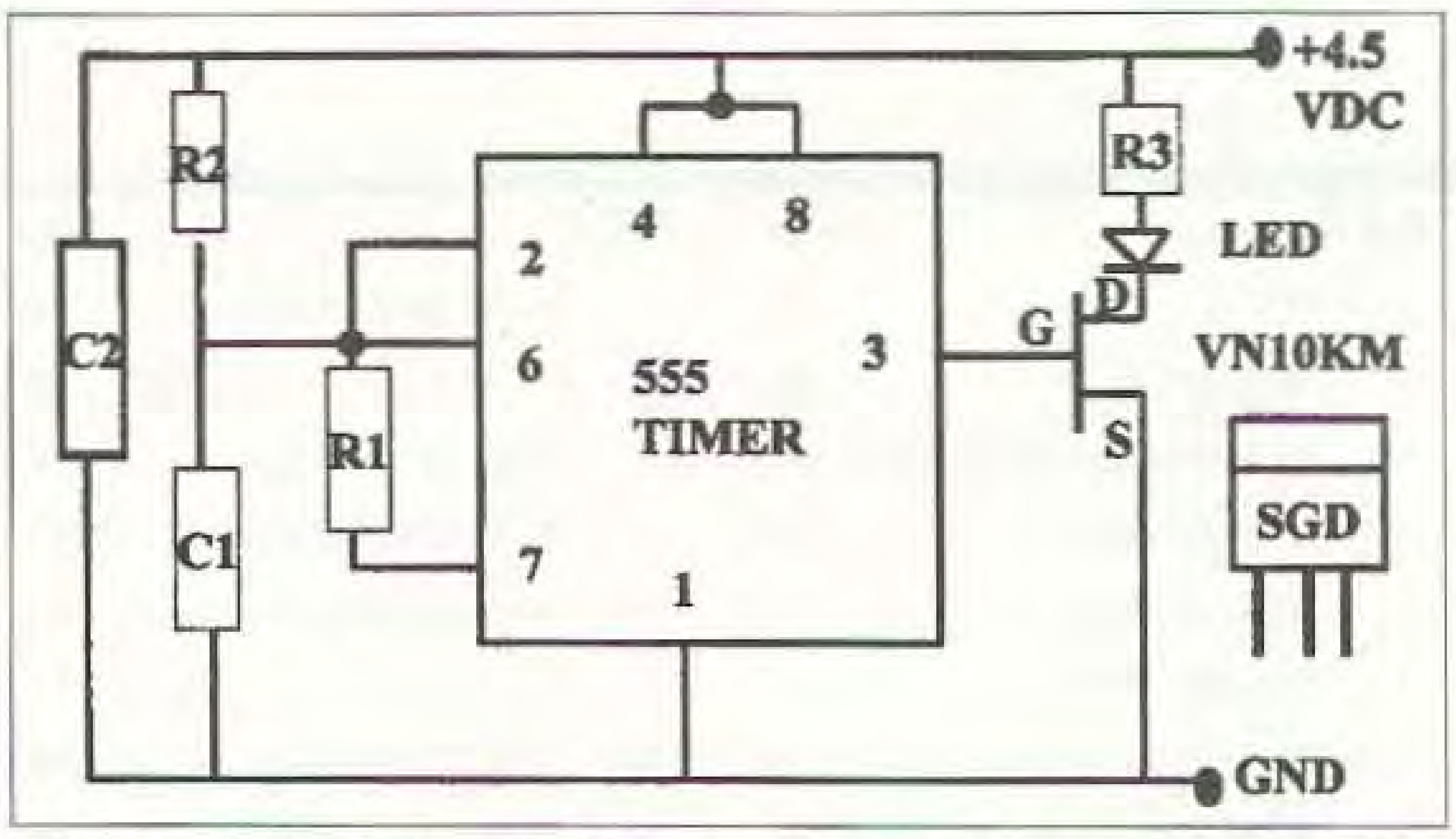

Fig. 1. Schematic of 555 oscillator circuitry, construction mounted dead-bug style on copper circuit board as common ground solder surface.

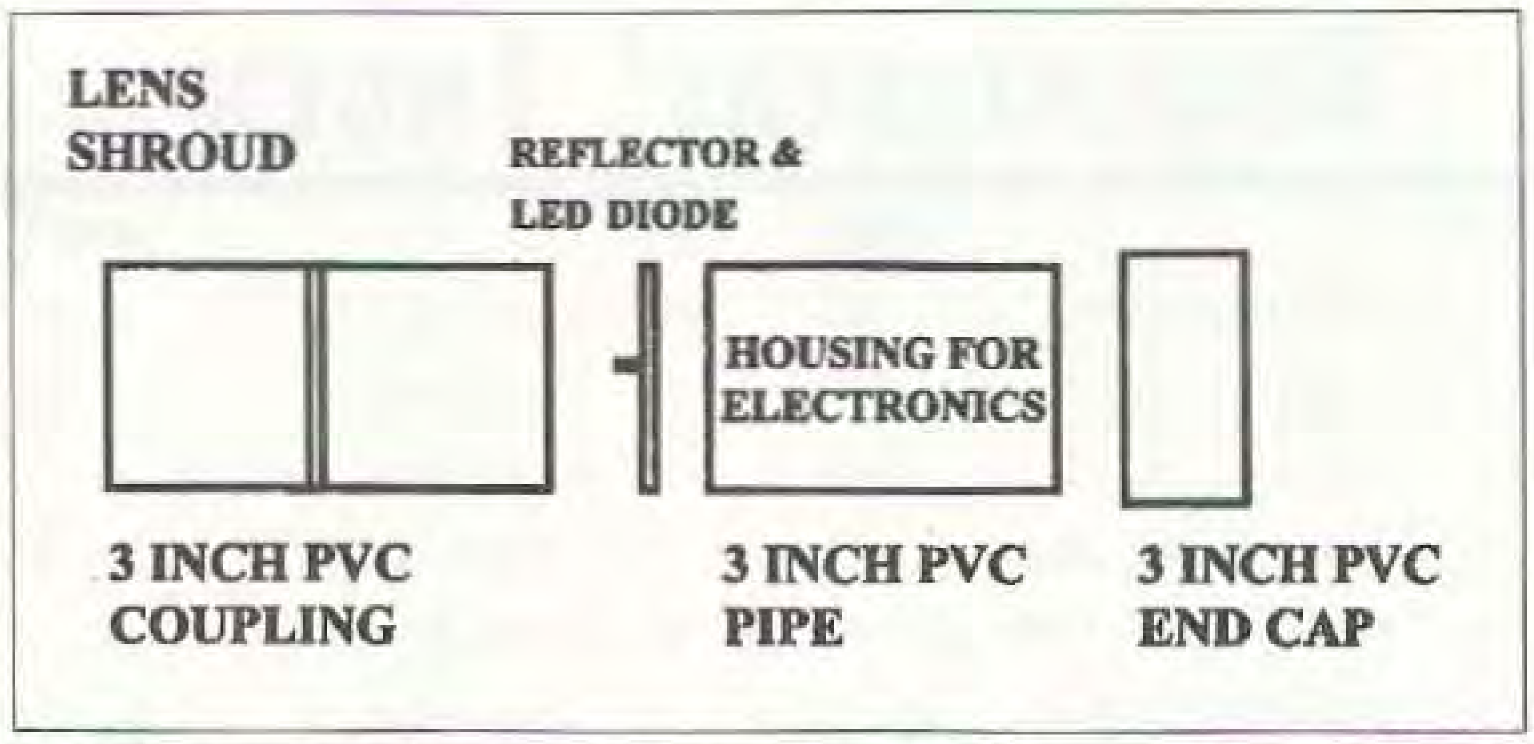

Fig. 2. Layout of construction of 3-inch PVC pipe, couplings and end caps for housing reflector and electronics for test circuitry. Reflector is pushed into coupling to touch against center ridge held in place by 6-inch or so length of PVC pipe. Front section of coupling forms lens reflector shroud.

Above & Beyond

continued from page 48

the laser. Align the receiver and turn on the laser and verify collimation between both systems. Then align the telescopic rifle spotting scope with both the receiver and the laser spot to the rifle scope.

How far away the target is positioned is a factor in how accurate you will be and at what distance you will be in alignment. It's best to make additional long distance tests on some targets (like a power pole transformer), as the gray surface gives a fair return and shows up on distant targets reasonably well. The "tin can" can be positioned out quite some distance and be hit with a well-calibrated system. For example, an optical-quality retro reflector positioned some 4 to 5 miles away can be regularly hit and return a strong signal to the source for system performance tests. For closer-in tests, the simple tin can and auto reflector is just fine for making system evaluations in a near range of a hundred to several hundreds of feet.

If your system uses a 1 kHz tone detection system, or something like our synthesized up-converted receiver system oscillator of higher frequency, the principle is the same. If you transmit a laser or LED frequency to a remote target and reflect it back to the source, you can detect it when you are in alignment between your receiver and transmitter. How, then, do you construct a simple, inexpensive oscillator LED transmitter reflector?

I located a three-and-one-eighth-inch-wide round reflector at our local Kragen auto parts store. This reflector fit like a glove into a 3-inch PVC splice union meant for joining two sections of 3-inch PVC pipe. A short section of 3-inch PVC pipe (about 6 to 7 inches long) is inserted behind the reflector to position the reflector tight up to the center ridge inside the splice union, holding the reflector firmly. A rear 3-inch pipe cap closes off the rear of the PVC pipe and allows insertion of controlling electronics inside the PVC pipe.

A high-intensity LED is selected for the transmitter LED. By using four and a half volts (3 AA cells) for a power supply, I drew about 17 mA current through the LED I selected. Pretest your LED portion of the circuit first; mine has a 150 ohm resistor to the anode of the diode to limit current. The LED Kerry and I use is from Hosfelt Electronics, 1-800-524-6464, part # 25-339, and about $5 each. Any other high-output LED will be suitable. You might have to experiment with your LED to set the desired brightness and current through the LED for the one you select. The driver circuit is nothing simpler than a good old 555 timer that uses three resistors and two capacitors besides the 555 timer chip itself. The circuitry is shown in **Fig. 1.** Place a 10 µF cap from the positive battery line to ground. For simple construction, wire the circuit dead-bug style on a small piece of scrap copper PC board. Position the chip upside down, solder pin 1 to ground on the copper surface middle, and position the other parts accordingly.

Parts values for **Fig. 1** go as follows (1-kHz frequency/35-kHz): R1 — 22k/820Ω; R2 — 51k/33.3k; R3 — 50Ω–150Ω (standard 50Ω LED used)/150Ω (high-output LED); C1 — 0.015 µF/0.0082 µF; C2 — 10 µF/10 µF.

I drilled a hole to position the large LED in the center of the reflector. Carefully drill a small hole first, and enlarge as required, so as not to shatter the reflector. I used automotive RTV to hold the LED in the center of the reflector. When dried, attach two wire leads and then heat shrink over the leads. Verify diode polarity and attach in series to the anode end a current-limiting resistor from the earlier test for your selected LED. Allow 24 hours for the RTV to set solid before going further.

This is a good time to construct your 555 oscillator on a scrap piece of copper board. The parts are not critical and can be trimmed by extra capacitance or varying resistor values. The output of the oscillator on pin 3 can be measured on an o-scope or frequency counter. If you can't find an "N"-channel enhancement-mode MOSFET like the VN10KM or VN5001A MOSFET, send me $3 and I will send you a couple devices from my junk box (new devices). (Cost will cover postage and cost of jiffy envelope.) If you need any other parts and I have them, I will be glad to comply if I can. All other parts in this project are garden variety ones.

I selected 3-inch PVC pipe because it fit the reflector I found in the auto parts store. Use your resources, as nothing is critical in construction or parts, be it optics (reflector) or LED. A tin can or a Pringles chip container might work well for you. Just match up your reflector with a container diameter and construct away. One note of caution is that if you use a filter over your photo detector, make sure the LED you select works in the range of your filter. Our laser and LED transmitter works at 650 Nm, a very RED beam of light, and our filter is ±5 Nm wide. Some lasers are 623 Nm, and they never make it through the optical filter. Just check out what you have.

The 3-inch PVC pipe solved many problems, like centering the reflector in the housing, and the rear section on PVC pipe gave room to put a small plastic box for the PC board. I rubber-banded the three "AA" cells to the plastic box for rigidity. Then I cut some packing foam to protect the rear of the reflector and LED wiring coming out of the center of the reflector from the battery and oscillator box banging into it. Some extra foam over the far end to keep things from moving around finishes out the circuitry, save for an on/off switch on the rear cover. Use a locking toggle switch, if you can find one — it will save you on batteries. See **Fig. 2** or **Photo B** for construction of my oscillator system using the 3-inch PVC plumbing pipe and fittings.

Be it a 1-kHz laser system or a system like ours, the addition of a real retro reflector surplus can cost $95. One retro reflector (63.5 mm diam.) source is the Surplus Shed, part #L1792, [http://www.surplusshed.com], or 1-877-778-7758 for surplus optics. The retro reflector is actually a trihedral prism that reflects any beam entering it back to its source regardless of the prism's orientation. Kerry and I use a slightly different trihedral prism for our 5-mile test range described earlier. The reflector at the auto parts store cost $1.99 for two of them — quite a bargain. While it's not a retro reflector, the automobile-grade reflector suffices for closer work and confirms basic alignment of your optics and lasers all in one test box. The reflector is simple to construct and will serve well until you can upgrade your system to greater distance and possibly a retro reflector in your test kit.

NOTE: The original article covering the LED transceiver was published in *73 Magazine*, Parts 1, 2, and 3 were in June, July, and August 2000. If you have any questions about this optical, or any other subject, send an E-mail to my address at [clhough@ pacbell.net], and I will try to answer them as best I can. Best 73, Chuck WB6IGP.

***Photo A.** Picture of new laser LED transceiver system at WB6IGP. Electronics and 4-inch Fresnel lens inside white 4-inch PVC tubing. PVC coupling sleeves and short sections of pipe and end caps used to create compartments for electronics. Bottom right: photo detector; left: LED transmitter. Top center: spotting scope; just below: laser inside beam expander, laser transmitter.*

***Photo B.** Optical reflector in housing with high-output LED in center of reflector. Electronics in rear of housing pipe containing 555 timer chip running at 35 kHz rate to drive LED transmitter. LED used from Hosfelt Electronics, part #25-339; cost, about $5 each (1-800-524-6464). Other LED diodes suitable.*