



Figure 14-11 Short-range testing. Transmitter shown on the left, and receiver on the right.

device can function if properly aligned, and besides using a high quality laser module with focus adjustment, the actual weak link will not be in the distance possible, but your ability to strike the phototransistor.

Well, I hope you had fun sending your top secret information at light speed to a remote location, and if laser beam experimentation is your kind of thing, read on, because it's going to get much more interesting and devious!

## Project 88—Laser Microphone Experiment

The laser microphone has to be one of my all-time favorite high-tech laser spy devices, and it has been around for many years, popping up on just about every spy forum under names such as Laser Listener, Laser Bug, Laser Snooper, to name a few. The information presented on this device is rarely complete, and mostly incorrect, so it makes you wonder if the device actually works at all, or is it just another nerd myth such as the "over unity machine" or UFO engine? I am going to settle this question once and for all by first explaining how the laser microphone actually works, and by showing you how to create your own working model from easy-to-find parts. Once you have a basic working model, you can decide how far you want to take this technology, or make

your own modifications to create an entirely new style laser bug.

Before we dig into the electronic part of this device, let's have a look at how the device supposedly works. When I spent a night working my favorite search engine on the subject of "laser bugs," and "laser listener," I came up with the same few designs and a couple of ready-made kits and plans, each describing how the laser light is bounced off a target window, modulated by the sound waves inside the room, and then decoded by the receiver in almost the same way our laser receiver from the previous section works. After thinking about this and creating a few working prototypes, I now realize that this information is not correct.

Modulation occurs when a continuous signal or wave is altered by an input signal of varying levels. If you look back in this section to our laser transmitter and receiver projects, then you will remember that the steady beam from the laser pointer (continuous signal) was modulated by the microrecorder's audio output (varied signal) to create a laser beam that would carry the audio signal in a modulated format to the receiver. In that system, modulation does indeed occur because the impedance of the transformer that was placed in series with the laser pointer power supply was varied directly by the audio signal, creating a resulting amplitude modulated laser beam. This is the same way that almost all light based communication systems work including infrared remote controls, cordless headphones using infrared LEDs and even some distance measuring devices. The laser microphone, on the other hand, does not use modulation in this way, as it is just not possible. The popular theory is that the small vibrations in the target window caused by noise such as conversation in a room will modulate the laser beam that you have bounced off the glass, and because of this will be able to decode this modulation back into an audio signal in a way very similar to our laser receiver from the previous section. The problem with this theory is that to create modulation in the laser beam, the level or intensity of the beam would have to be varied according to the audio signal in the room, but it is not. Because the laser beam originates from our location, bounces off a target window then returns to the receiver at our same location, there would be no way for the target to modulate our source beam, and it does indeed return to its original location as a non-modulated continuous source of light. OK, if this is the case, then how can a system like this actually function, and how does it really work?

The real magic behind this device is not modulation at all—it is alignment due to vibration. If you bounce a laser beam off a window that is being vibrated slightly by the audio source behind it, this will indeed affect it, but not due to

modulation of its intensity, it will in fact be moving. Although the vibrations of the window from the weak sound within a room may equate to only a few thousandths of an inch, this can create a much larger motion of the reflected laser beam due to the distance and angles between the source and target, and this change in motion will have a great affect on a phototransistor, much as it did with the actual modulated laser beam from our laser transmission system. Knowing this, we now realize what many others did when building this type of device—the unit always works much better when the received laser beam does not directly strike the phototransistor. If we let the vibrations from the window move the laser in and out of the path of the phototransistor, then the receiver circuitry actually works as if it were decoding a modulated signal. However, in reality it is working much more like the vibrating needle on a record player. Armed with this information, it was not hard at all to build a working prototype capable of targeting a window across the street. There are indeed other issues that need to be overcome in such a sensitive and alignment critical device like the laser microphone, but we will discuss this in more detail as we build the simple prototype.

Before you even think about creating the receiver, it is highly recommended that you build the simple "window simulator" unit as shown in Figure 14-12. Without this simple device, I would not have been able to create the working laser microphone.

As you can see from Figure 14-12, the window simulator is nothing more than a small speaker with a little bit of reflective material glued to the center cone. I snapped the corner of a broken glass mirror using pliers then secured it in place with a hot glue gun. When there is any slight vibration of the speaker from a source such as the small microrecorder I have attached, then there will be movement of the mirror, much like what would occur to a window from sound from inside a room. To simulate a vibrating window as much as possible, the audio level of the micro recorder is

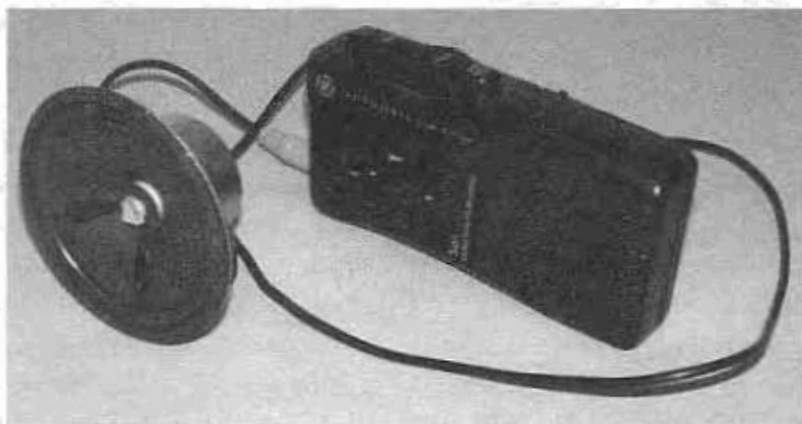


Figure 14-12 The window simulator will make prototyping a lot easier.

set to a level so low that you have to press the speaker up to your ear to ascertain that it is even working. The reflective surface does not have to be a mirror, just find something that will reflect the laser beam for testing purposes.

Now that we know the resulting laser beam will be moving rather than modulated, it should be very easy to make this rig functional, especially when you can use your window simulation device rather than your neighbor's window for testing purposes. A real laser microphone will use an invisible infrared laser rather than the visible red we will be using, but for now, this makes things much easier to align and test. A visible laser will not only kill all hopes of using the laser microphone covertly, but could get your target very nervous; after all, a red laser bouncing into your personal space usually means some evil device is targeting you. Have a look at the schematic for the laser microphone shown in Figure 14-13, and you might recognize certain parts from the laser receiver presented earlier.

The operation of the laser microphone receiver is much like the laser receiver, with the addition of a high-gain amplifier. The signal from the phototransistor was fed directly into an LM386 audio amplifier in the previous laser receiver, but this time goes to the high-gain amplifier based on the LM358 operational amplifier first. Because we are not dealing with a modulated laser beam, but

rather a beam with a very slight movement, we are going to need some serious amplification in order to change the slight voltage variances detected by the phototransistor back into an audible audio signal. The LM358 is set up as a non-inverting amplifier with a very large amount of gain, adjustable by a variable resistor. This amplified signal is then fed to the LM386 audio amplifier, which will directly power a set of headphones or recording device. Although this receiver circuit is very basic, and could be greatly improved, it did actually seem to function better than the other two I built based on the much more complicated versions floating around on the Internet. You should build the circuit on a proto board first, and verify its operation before hard-wiring the components or making a circuit board, an easy task to accomplish using the window simulator. Although the simple circuit presented here is indeed a working unit, you may want to look into additional filter circuits to deal with 60 Hz hum, or hum from street lights at night. I decided to build the working unit as simple as possible, and then test it in the real world first to come up with ways to improve the unit and make it easier to set up and give it the ability to work at greater distances.

My working unit shown in Figure 14-14 is based on the simple circuit and hand wired to a bit of perf board for easy modification. I found hand wiring to be fine, as all the noise intruded into the

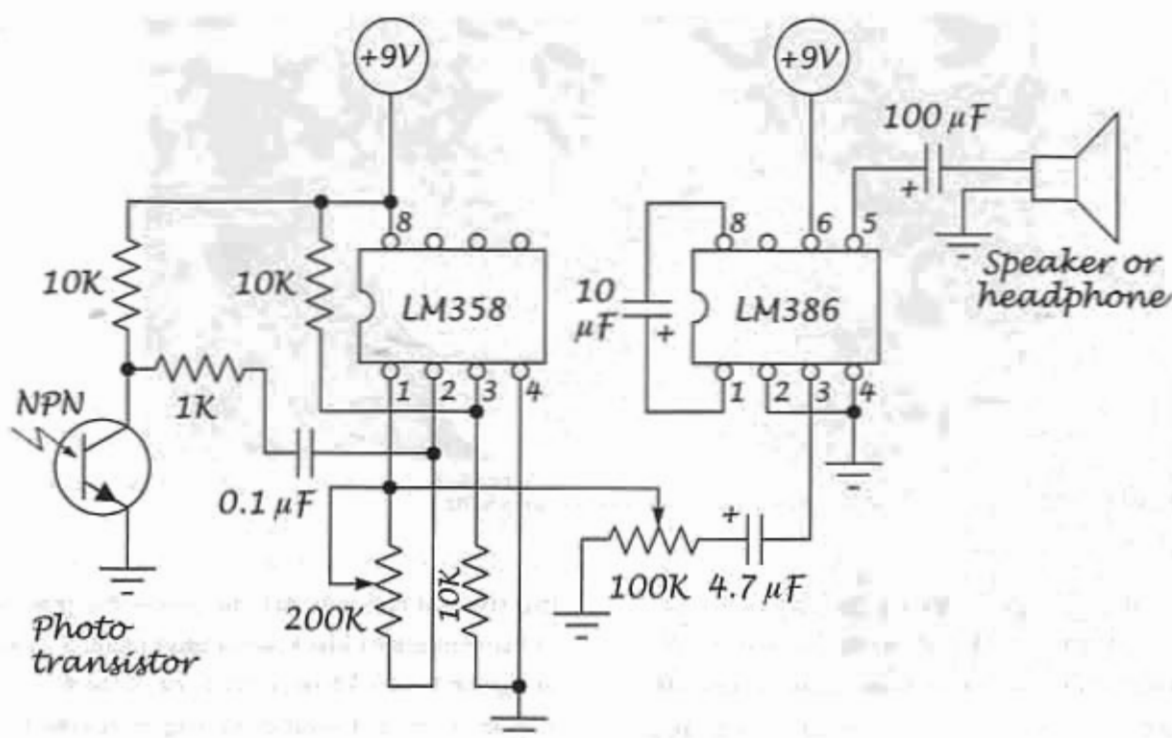


Figure 14-13 Schematic for the laser microphone receiver.

unit was from external sources such as AC hum and ambient light sources, not the circuitry itself.

The phototransistor is not critical, and any shape will work just fine since the laser spot will be very directional and focused directly into the input window of the device. I mounted my phototransistor on a length of wire so that I could experiment with different mounting systems and light attenuators to help block out unwanted AC lighting causing hum. The best system for mounting the phototransistor was a simple black tube that would stop some of the ambient light from saturating the base. A bit of drinking straw painted black fits nicely over many of the standard phototransistor cases. Originally, I thought that the phototransistor would be the most critical part of the device; after all, it has to detect the extremely small changes in the laser position to recreate the analog voltage for the audio amplifier.

I tried several phototransistors, a PIN diode, and even a new light sensor IC with incredible

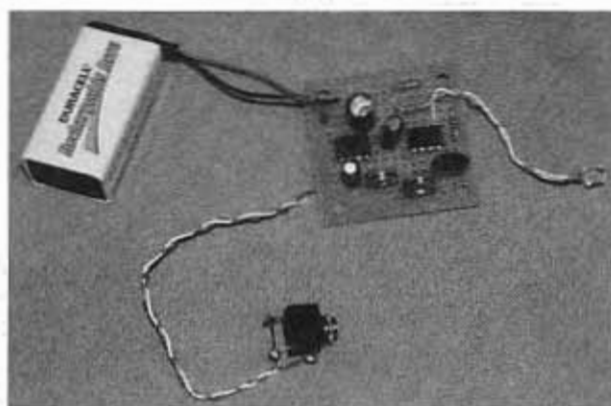


Figure 14-14 The original laser microphone circuit hand wired on a bit of perf board.

sensitivity, but in the end, the old phototransistor salvaged from a 1980's television remote control receiver worked best. After a bit of thinking, it made sense as to why the worst light sensor achieved the best results. The laser beam is always going to be way too much light for the phototransistor, which is why the beam must be offset from the phototransistor's input window.



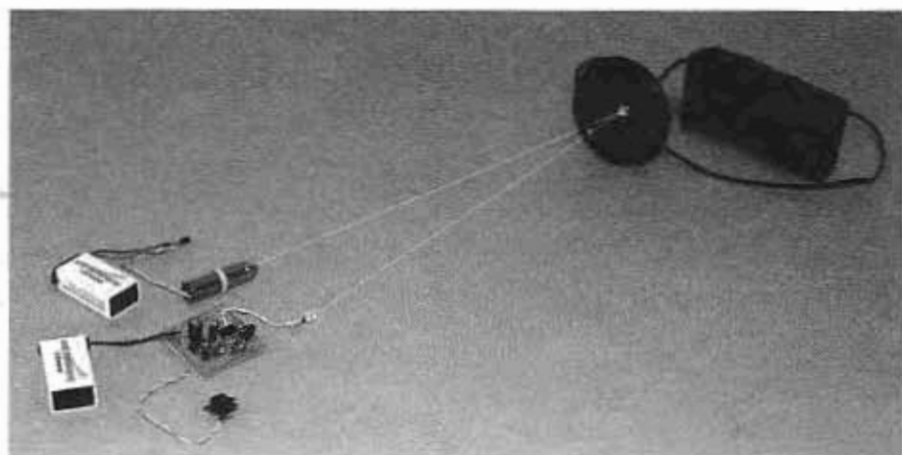


Figure 14-15 Testing the laser microphone using the window simulator.

Detecting a laser beam with a phototransistor is like listening to a rock concert by holding a stethoscope directly to the speaker on an amplifier, so we must offset the received beam so only its edge hits the input window. Varying the gain potentiometer can reduce some of this over saturation, but in reality, this just reduces the fidelity of the audio signal. You will see exactly what I am talking about when you set up your test unit using the window simulator. You are almost ready for testing the laser microphone, but first, you need a laser to be used as your source. As shown in Figure 14-15, I have connected a garden variety red laser pointer to a 9-volt battery using a 4.5-volt regulator.

The laser could be run from the original button cells as well, but due to the steady use, they would be drained in only a few minutes. With a 9-volt battery, or three AAA cells, the run duration will be several hours. I would avoid using an AC adapter to run the source laser, as this could introduce hum into the receiver if there was even the slightest ripple in the regulation circuitry, a common problem with most AC adapters. If you are worried about long duration run time, then three D size batteries powering the laser will yield more than a full day of operation.

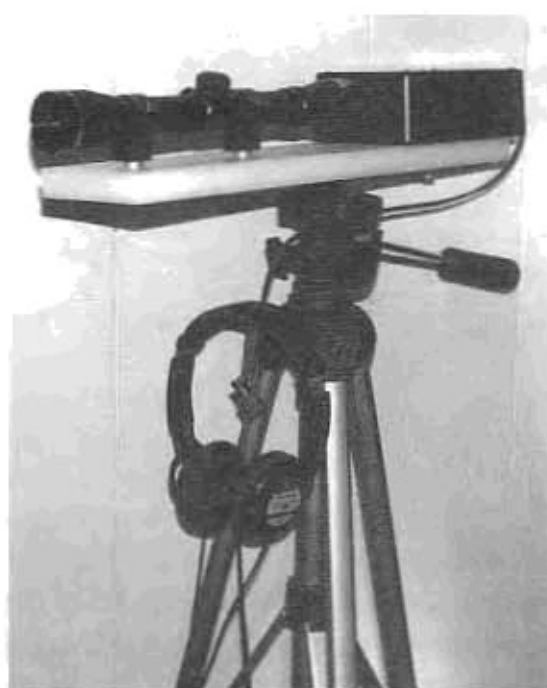
Before you get deep into the covert operations, it is a good idea to practice a few alignments using the window simulator so you can not only verify

that the unit is functional, but gain some practice in the sometimes black art of alignment. As shown in Figure 14-15, I have placed the window simulator speaker roughly 90 degrees to the bench so that the reflected beam would be easily captured by the receiver's phototransistor. The small microrecorder is playing a bit of recorded music at a volume level so slight that I can just barely hear it on the speaker if my ear was pressed against it. Although the laser beam is only simulated in the photo, it is indeed working, and at this distance of only a few inches, alignment was a very simple task. Working with the unit across the room is quite a bit more challenging, and takes a fair amount of trial and error to get things aligned properly. I would first shine the laser directly at the little mirror on the speaker, and then look to see where on the wall behind me the reflected beam was ending up, and depending on the angle of the mirror to the source, this could be several inches to many feet from the origin. As you will have found out really quickly, there will be almost zero chance of the receiver and source laser being in the same spot during operation, as you have very little control over the orientation of the reflective surface at the target. If you ever see a so-called "laser spy" device for sale that combines the source laser with the receiver, then most certainly it will be nothing more than a short range toy, functional only in the most controlled test bench environment. Bouncing

a laser beam off of a window across the street is entirely possible as long as the alignment between your position and the target window is not so far off that the returning beam misses your location, a problem that is multiplied as the distance between the source and target increases.

You should be able to make the unit function no matter where you place the window simulator in your house, but as you might have already found out, your receiver may be on the opposite side of the room from the source beam, or even worse, many feet higher or lower depending on both the vertical and horizontal misalignment between the angle of the beam and target reflector. If you look out your window and see nothing except buildings full of windows aligned in the same manner as your window, then it's going to be easy hunting. But if this is not the case, you may have to choose your setup location in order to catch the received beam. Once you have the knack of aligning the laser microphone in your test area using the window simulator, go ahead and try a real test using your own window. If you cannot spot a window from your test bench, then some type of proper mounting of the source laser and receiver will be necessary as I have done in Figures 14-16 and 14-17. Figure 14-16 shows the receiver built into a small project box to contain all of the electronics and batteries. The box is then mounted to a bit of plastic that can be attached to any standard tripod used for video or still photography.

You will also notice that there is a gun sight placed directly in front of the receiver's phototransistor in Figure 14-16, and although this does little to increase the range of the unit, it does allow the use of a video camera during alignment at large distances. Since you would never want to look through a gun sight when attempting to spot the reflected laser beam, a small black and white video camera can be swapped for the receiver and viewed safely on a monitor while you attempt to position the source beam and receiver's tripod. Because of the sensitivity of the low lux black and



**Figure 14-16** The receiver unit is mounted to a tripod for easy alignment.

white camera, it is easy to see the general direction of the reflecting beam even if it is not yet hitting the receiver. Once the reflected beam is within visible range (shown as a spot on your wall), you can then remove the camera and replace it with the receiver box for final alignment. Although this method did work well for me, even when experimenting with an infrared laser, it is definitely not the only answer to alignment, and with a little creativity, you will most likely be able to invent a much faster and more reliable method. Figure 14-17 shows the source laser contained in a small plastic box with its external battery source and a power switch. Using batteries as a power source eliminates any induce hum from AC noise, a problem that can easily drown out the usable audio signal. This experiment does indeed prove that the laser microphone is a working device, but not like many of the spy stores claim with their "point and shoot" ready to operate units. Distance targeting requires a lot of patience in finding the proper location of your source beam and receiver, and there are many factors that can easily render the signal unusable.



Figure 14-17 The source laser is powered by battery and mounted to a tripod.

There should be no reason at all that the laser microphone would fail when experimenting with the window simulator, even at great distances, although alignment may have been a bit of a chore. When bouncing the beam off real world objects, a lot can hamper the ability of the unit to collect a usable source. Some of these factors include: the inability to bounce the source back to your location due to extreme angles; dirty surfaces reflecting a very reduced beam; multiple panes of glass causing a dampening of sound; extreme hum from a nearby street light; sound levels much too weak in the target area; ambient noise levels in the target room too high; and, countermeasures such as white noise or infrared modulation in use.

So, there you have it—the good, the bad, and the ugly on the mythical laser microphone device. I hope I didn't turn you off from building an experimental unit, as the device does indeed work if the conditions are in your favor. I was able to record a conversation of moderate levels from a location across the street from my source laser and receiver, and although this was a controlled experiment with optimal position of the two buildings, often these conditions will arise right outside your own window. If you plan on building the device into a portable hand-held unit that you can aim at any window, instantly eavesdropping on any sound in the room, then you will be greatly disappointed, and no, those cheap devices that claim to do this rarely work well at all. The laser microphone is a device for the truly dedicated spy who does not mind hiding in the darkness tweaking electronics and pushing the envelope of possibilities to the maximum. I do intend to study this technology much further to improve on not only the usable range of the device, but also the filtering and enhancing of the received audio signal. With enough patience and understanding, it may even be possible to create a device that can shoot a laser at a distant window and instead of attempting to catch the reflected beam, directly decode the slight variations of the exact spot where the laser point is hitting the target. Yes, this would take an extremely sensitive receiving system with state of the art long-range optics, but you just never know what the Evil Genius could accomplish with the proper motivation. Are you up to the task?

## Project 89—Laser Perimeter Alarm

In most high-tech crime or spy movies there is a scene in which the hero or villain will find him/herself traversing a secure room jam packed with laser beams bouncing all over the place, and

if even one beam is crossed, the alarm will sound, foiling his/her evil plans. Well, how would you like to have that exact system installed in your home or office, built from nothing more than a cheap laser



**Figure 14-18** A typical laser pointer and some dental mirrors are a few of the required parts.

pointer, a few dental mirrors and a handful of easy to find electronic components? Yes, you can have a state-of-the-art laser security system which with proper installation can be just as foolproof as the ones you see in the movies. This laser perimeter alarm system can be installed just about anywhere, and depending on how many mirrors you want to use, could protect an extremely large area from unwanted guests.

The laser beam source for the alarm is just a typical visible red laser pointer, and the reflective points that will steer the beam around the perimeter of your secured area are made from commonly available dental mirrors as shown in Figure 14-18. You could use as little as one mirror to make a working device, or as many as you have patience to align, but three or four mirrors is usually the optimum choice to protect a room or yard.

The laser source will need some type of external power source other than those wimpy button cells that came with it since it will be running at all times. Like many of the previous projects in this section, connecting the laser to an external power supply such as three 1.5-volt batteries in series or a higher voltage battery through a 4.5-volt regulator will do the trick. Because the laser beam does not have to be absolutely fluctuation free, an AC adapter feeding the proper voltage through a regulator would also be just fine; just make sure you never exceed the pointer's 4.5-volt rating.

Although a laser pointer will run continuously for many hundreds of hours, you may actually want to work with a higher quality laser module, as these units can be directly powered by a standard 5-volt regulator, have a higher tolerance to voltage fluctuations, and are specifically designed for long-term use where a highly collimated or focusable beam is needed. Laser modules, however, do cost 10 times the price of cheap laser pointers, so even if you have to replace the pointer every year, it still is very economical. I mounted my laser pointer in a small plastic box with a switch and a 4.5-volt regulator that can accept a DC power source from 9 to 12 volts, so any common wall wart could be used. The laser pointer shell is held securely through the hole cut in the box lid and the plastic tie wrap which also keeps the small pushbutton switch on the laser body engaged. This unit is not weatherproof, but could easily be made so by mounting it inside some type of lighting enclosure or jar. I did not need this as my system placed the source laser inside the house with the beam heading out the window. The laser pointer is shown in Figure 14-19, mounted in the small plastic box with the regulator and switch.

The heart of this system is a small light-sensitive device called a cadmium sulphide photocell, a small semiconductor that changes its resistance depending on how much light strikes the surface. Think of it as a solar cell that generates a change in impedance rather than a voltage. Because the resistance changes from about 10 k $\Omega$  in full daylight to as much as 1 M $\Omega$  in darkness, this large resistance swing can easily be adapted to switch a transistor on or off for light or dark detection—dark detection in our case. In the schematic shown in Figure 14-20, the photocell will not be able to saturate the base of the transistor as long as sufficient light such as that from our laser is striking the surface. The variable resistor is used to set the sensitivity of the unit so that it will function properly in daylight, which to the photocell is not nearly as bright as the highly focused laser spot. Once the laser beam is interrupted, the base of the



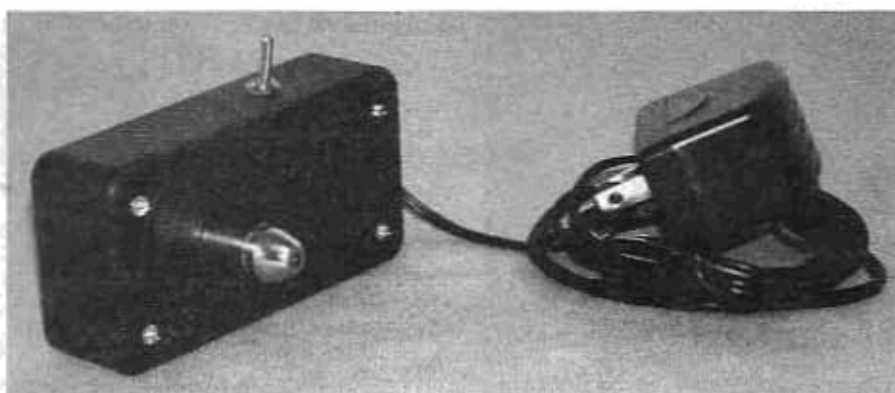


Figure 14-19 The laser pointer will run continuously from an AC adapter.

transistor will see enough voltage to close the emitter collector circuit and set the 12-volt buzzer screaming for your attention. To make sure you hear the buzzer, a large capacitor with a value of at least  $1000\ \mu\text{F}$  is placed in parallel with the buzzer so that it runs for at least a few seconds even if the laser beam is only interrupted for a fraction of a second. To make the buzzer wait a little longer, just add a larger capacitor, or more of them in parallel. The buzzer is a stand-alone unit that only requires a power source to emit sound. These sources can be found in doorbells, door-opening alarms, or off the shelf at your electronics hobby store. Any buzzer between 5 and 12-volts will be run just fine from a 9-volt battery using a standard 2N222 or 3904 NPN transistor as the switch.

The ultra simple circuit is very effective, and depending on where you allow the laser beam to go before it enters the photocell, detection of people, small animals or even large bugs would be no problem at all since any object larger than the 1 mm laser spot will break the beam temporarily. As long as the source laser unit, reflecting mirrors and receiver are mounted in a sturdy fashion, the range of the device could easily exceed several hundred feet, allowing you to protect an area as small as your bedroom or as large as a football field. There is really no limit to the number of mirror bounces you can implement to this unit, but do remember, every single mirror adds another

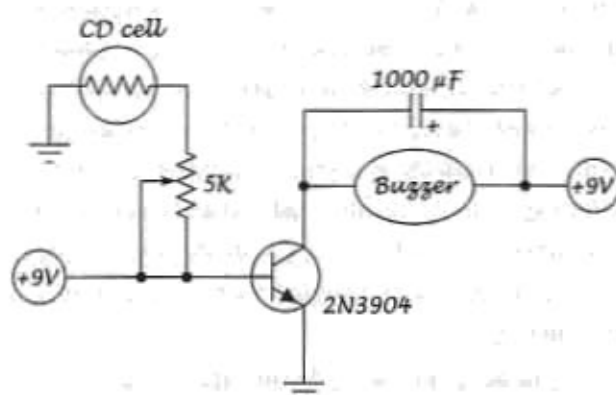


Figure 14-20 The laser perimeter alarm schematic uses a photocell for detection.

level of complexity to alignment, a task that takes a bit of patience to get correct.

Before you start stringing mirrors all over the yard, mount the alarm circuit in a type of sturdy enclosure, and test its operation by aiming the laser directly at the surface of the photocell while you turn the potentiometer until the alarm stops. Once the alarm is silent, an interruption of the beam will set it off instantaneously when the unit is working properly. Battery operation is fine for this device, as it will draw very little current when it is not sounding the alarm. As shown in Figure 14-21, the circuit is so simple that it fits on a bit of perf board that takes up less space than the 9-volt battery powering the unit. The larger black disc is the high pitch alarm, and it has a very capable ear-piercing screech that can be heard a long way away. The variable resistor is mounted directly to the board,

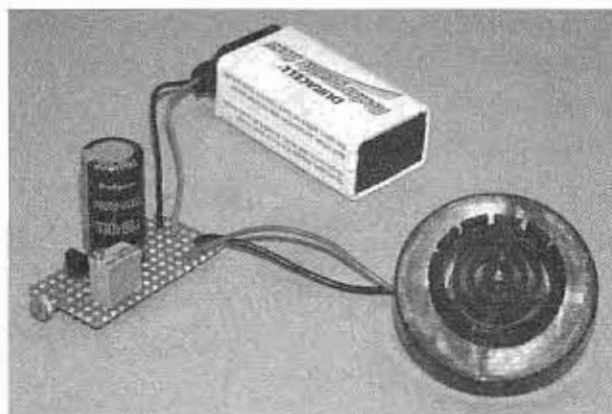


Figure 14-21 The laser perimeter alarm device uses a photocell for detection.

and normally it would not need any more than the initial adjustment to get the alarm sensitivity set up correctly.

The receiver can be mounted in the same manner as the source laser, in a type of plastic container that will contain the circuit board, battery and a switch if you decide to add one. I found a small plastic box just large enough to contain the unit, as well as the front lens from one of those door peephole gadgets. The lens does not really do much for sensitivity or alignment, but it does protect the surface of the photocell, and adds a nice professional look to the completed unit.

Your job now is to place the source laser, reflectors and alarm in such a way that the beam traces out the perimeter of the area you want to secure at a level that will allow desirable targets to interrupt the beam. If you do not want to hear that siren screeching in the middle of the night every time a mouse or other critter walks through your beam, then shoot for a beam height of at least three feet. Although it is true that a person could just jump over the beam or crawl underneath, unlike the movies that show a brilliant red laser path, the light will be completely invisible at every point in the system with the exception of the pointer's exit tube and the dot on the photocell. To see a red laser beam would require a laser with enough power to cut the target in half—not the goal of this project! In the movies, the effects folks will either

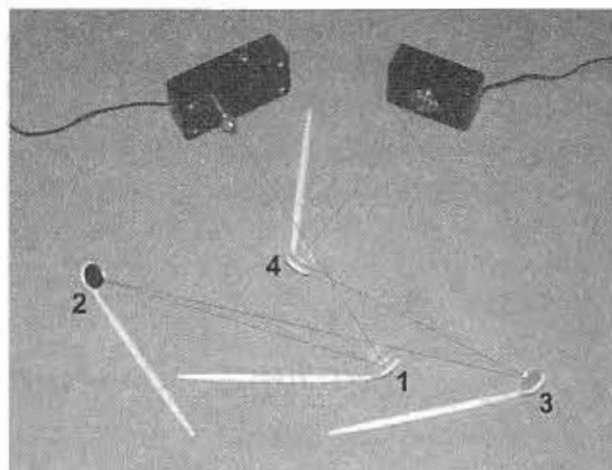


Figure 14-22 A tangled web of laser light is directed by mirrors to the alarm.

fill the room with a bit of smoke to show the beam, or simulate the beam with computer graphics. Aligning the mirrors is not very difficult unless you have more than four of them around your perimeter, then it takes a bit of effort. Every mirror adds twice the margin of error, and even the slightest movement at the source would end up becoming a large diversion of the final beam. To begin, set the source laser so that it is held securely in place on either a window sill or tripod and point it towards the first corner of your perimeter at as parallel to the ground as you can. A helper holding a bit of white paper at the target area can make this job a lot simpler. Once the beam is hitting the first corner of the perimeter, place a mirror at 45 degrees to the spot so you can reflect it into the next corner where your helper will again be waiting with the white paper: 45 degrees is not a required angle, it is just the correct angle that you would need to make a 90-degree corner in a square yard. Again, you will want the beam to remain as close to parallel to the ground as possible until the last mirror, where it may be required to bounce the beam upwards towards the photocell. Adjustment should always be done mirror by mirror rather than attempting to move the actual source laser or any mirror previous to the last one you installed—this will make the job a lot easier. As shown in Figure 14-22 (simulated beam), the laser beam is

deflected by the mirrors as though it were a tennis ball thrown against a brick wall—45 degrees makes a 90-degree corner.

It is also no problem at all to cross the beams, as long as the photocell becomes the final destination

of the source laser beam. Now you will have an early detection and warning system the next time an intruder—human or animal—invades your space.

## Project 90—Remote Control Sniper

Here is a project that will give you power over almost any infrared remote controlled device that you can see with your naked eyes or through a pair of binoculars. Why on earth would you want to take control of a television, VCR, or stereo system from 10 blocks away you ask? Let's not forget the title of this book, people! Of course, there may be a time when the loud parties next door at 3:00 a.m. disturb your peaceful slumber, so rather than repeatedly trying to reason with the partygoers or wait hours for the police to show up to shut the party down, you decide to take matters in your own hands and shut off their music with the remote control sniper, so that you can get some shut eye.

This project uses some of the techniques discussed in the laser beam transmitter earlier in this section, although this time the information is in the form of remote control protocol carried by an invisible laser beam. This project can be thought of as the world's longest range infrared remote control, as this is actually what it is.

A typical remote control will have a range of about 50 feet, depending on how much current is pulsed into the one or more 940 nm infrared LEDs used to modulate the 40 kHz remote control signal. Although the LEDs can be made to emit a fair amount of light for their size, the expected range will never be anywhere near what even the smallest laser can achieve. Even an array of 1000 LEDs will barely be able to transmit the remote control signal across the street, whereas a 5 mW

laser module will easily reach 1000 feet or more. The laser does have its drawback though, and what it does is trade distance for field of view. The typical remote control seems to work no matter what direction you point it in, even though the LEDs are always at the top end of the unit. You can even point the remote control at a distant wall opposite of the television, or hide it under you shirt and it will still work, but the laser has no such similarities, and must be pointed directly at the target in order to deliver its light.

Because of the ultra directional properties of a laser beam, we must target the appliance's infrared receiver directly with the beam, a factor that actually makes this device better for sniping. Since you will want to take control over a very distant target, the ability to spot the exact point where the beam will be most effective is a bonus.

Since we are going to be merging a laser module into a universal remote control, you will need to start with these two items. As shown in Figure 14-23, a garden-variety universal remote control with standard TV, VCR, DVD, and home entertainment functionality is chosen as our front end. The more devices the controller can imitate, the better, as you might have to "hack" the target system by trying many different codes if it cannot be identified from the distance you might be required to operate from it. Also shown in Figure 14-23 is the infrared laser module, a small 808 nm laser with an output power of no more than 5 mW for class III operation.