REPORTE LABORATORIO:
- TITULO
- OBJETIVO GENERAL
- PROCEDIMIENTO
- DATOS
- RESULTADOS

10
CHAPTER

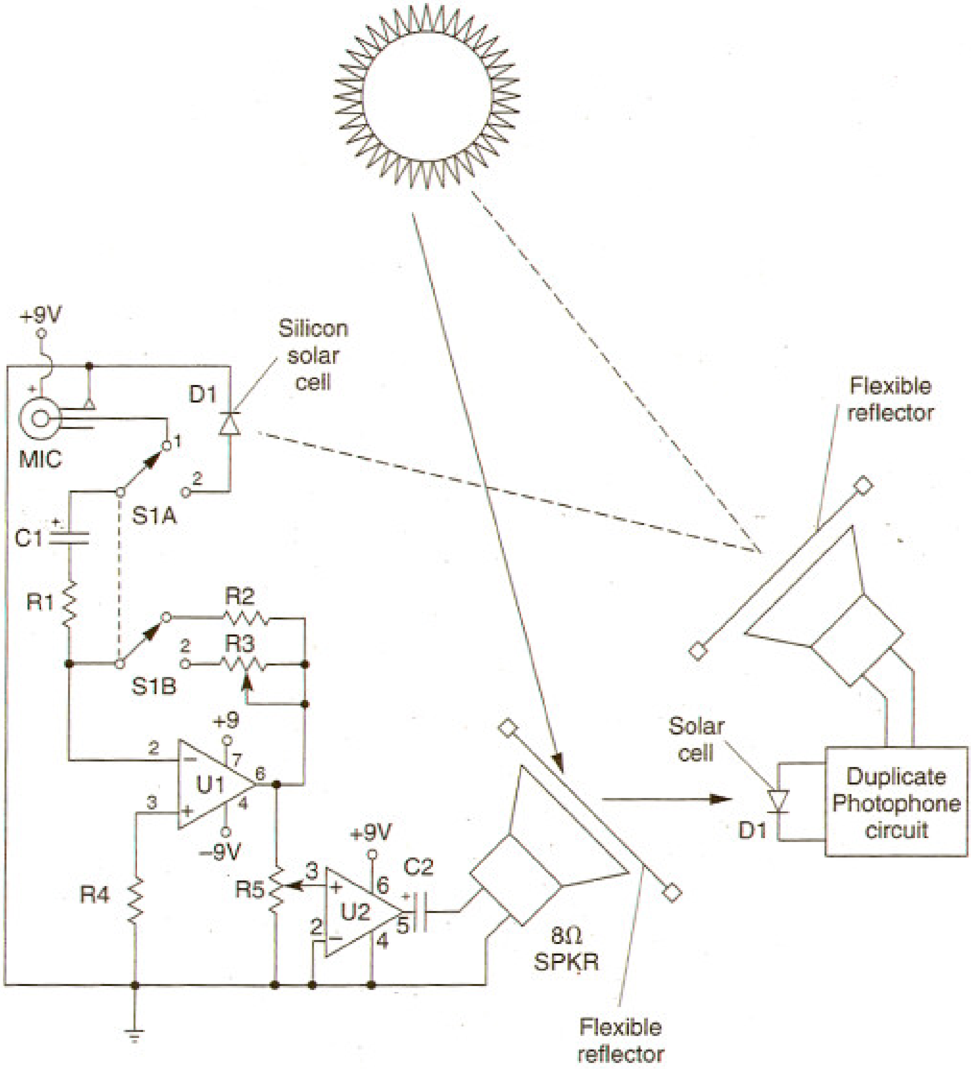
Reflective light

Alexander Graham Bell was the first person to speak over a beam of light. In February 1880, Bell and his assistant directed a beam of reflected light through a pair of comb-like grids, made by scratching parallel lines in the silver coating of two mirrors. One grid was mounted in a fixed position, and the second grid was attached to the diaphragm of a modified telephone microphone. When he spoke against the diaphragm, the grid on which it was attached moved back and forth in response to the audio signal. This caused a fluctuation in the sunlight passing through the two grids. The fluctuating light was detected by a homemade selenium light detector designed by Bell. Bell's new communicator was dubbed the Photophone and soon he and his assistant were able to talk over light beams hundreds of feet through the air. Bell believed that the Photophone was fundamentally a greater invention than the telephone. In actuality, the Photophone did not enjoy great success during Bell's lifetime, but it did lead to a number of other inventions discussed in this chapter.

Two-way Photophone transceiver

A modern day Photophone transceiver is shown in Figure 10-1. You can use it to communicate over long distances using sunlight or light from a small laser pointer. The key to the Photophone transceiver is a speaker with aluminized Mylar supported in front of it. The mylar is stretched between two supports directly in front of a speaker, as shown.

A silicon solar cell is mounted at the end of a six-inch cardboard tube to eliminate stray light from reaching the detector. In the transmit mode, the electret microphone is fed to the op-amp at U1 via switch S1. The output of U1 is passed to U2 through potentiometer R5. The audio amplifier at U2 amplifies the microphone output and causes the speaker and Mylar to vibrate, which in turn modulates the sunlight or laser carrier beam. The sunlight or laser beam is then directed toward a duplicate Photophone transceiver located some distance away.



10-1 2-way Photophone communicator. From *Engineer's Mini-Notebook: Communications Circuits* (Radio Shack, 1986). Copyright by Forrest Mimms III. Used with permission.

In the receive mode, modulated light from the second Photophone is directed to the solar cell, D1. The signal from D1 is switched by S1 into the amplifying system at U1, which passes along its signal to be amplified by the audio amplifier at U2. The output from U2 is then amplified to allow you to listen to the remote Photophone.

You can substitute a laser for sunlight, but be extra careful when aligning the two Photophones to prevent eye damage. Both Photophone operators should wear sunglasses and avoid staring at reflected light. Also, be extremely careful when aligning the lasers. Both Photophone transceivers should be mounted on camera tripods for best results.

Two-way Photophone transceiver parts list

D1	Silicon solar cell
R1,R4	1-kilohm, ¼-watt resistor
R2	10-kilohm, ¼-watt resistor
R3	1-megohm potentiometer
R5	10-kilohm, ¼-watt resistor
C1	.1-µF, 25-volt disc capacitor
C2	100-mF, 25-volt electrolytic capacitor
U1	LM741 op-amp
U2	LM386 audio amplifier
SPKR	8-ohm speaker
MIC	Electret microphone
S1	Two-position rotary switch
B1,B2	9-volt batteries
Misc	Chassis, aluminized Mylar, and rubber band

As an aside, a concept similar to the Photophone was used by the Russians in the 1960s. Since very high frequency radio waves behave similarly to optical or light waves, the Russians devised a microwave listener to spy on the American Embassy. The Russians presented the American Embassy with a wall plaque, which was graciously accepted and unknowingly hung inside the Embassy conference room. The Russians had cleverly concealed their microwave listener inside plaque. An unmodulated microwave signal from a van outside the Embassy was directed toward the plaque. Voices from the conference room modulated a diaphragm placed over a microwave cavity inside the plaque. The modulated microwave cavity returned the modulated radio signal to a second van parked outside the Embassy. The Russians could then listen in to all the meetings that took place in the conference room, and the Russians enjoyed this setup until it was later discovered.

Surveillance experts and private investigators have one-upped Alexander Graham Bell, devising a laser listening device for eavesdropping on distant conversations inside a building using reflected laser light. Rather than breaking and entering the premises, conversations can be remotely monitored. I will discuss this device in more detail later in the chapter.

There are many applications for reflected light, from entertainment to measurement, and I will describe a number of reflected-light projects.

The diagram in Figure 10-2 illustrates a fun and educational project using reflected laser light. A helium-neon or semiconductor laser is aimed at a medium-sized loudspeaker. A small front-surface mirror is glued to the speaker midway between the outer edge and the center cone area. A radio or audio amplifier with a microphone attached is connected to the speaker. A projector screen, sheet, or light-colored wall can display the reflected light from the laser, which when modulated is reflected and displayed on the viewing screen. Rather than modulating the reflected laser beam, you can feed an audio amplifier with the output from an audio signal generator for some interesting results. This demonstration project is sure to please.

LABORATORIO DE COMUNICACIONES ÓPTICAS

PRACTICA # 2

TITULO: POLARIZACIÓN DE UN DIODO LÁSER

OBJETIVO: Utilizando un apuntador láser, hacer una apertura para soldar dos cables y polarizar al láser a la corriente que normalmente entregan las baterías. La presente práctica incluye la realización de la fuente de corriente.

El reporte del laboratorio debe incluir:

TITULO DE LA PRÁCTICA
OBJETIVO
PROCEDIMIENTO
DATOS Y RESULTADOS
RESUMEN Y CONCLUSIONES

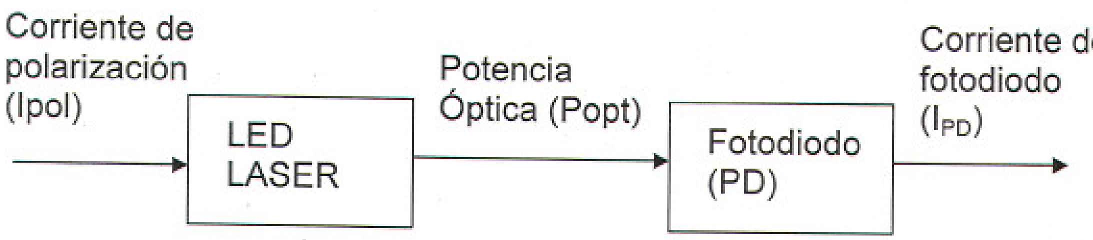
FECHA DE ENTREGA: 24 FEBRERO 2010

LABORATORIO DE COMUNICACIONES ÓPTICAS

PRACTICA # 3

TITULO: CURVAS DE RESPUESTA POTENCIA-CORRIENTE DE POLARIZACIÓN DE FUENTES LUMINOSAS (DIODO LÁSER Y LED).

OBJETIVO: Obtener las curvas de la potencia óptica emitida por fuentes luminosas en función de la corriente de polarización.
El reporte debe mostrar la respuesta de la potencia óptica de fuentes luminosas (LED y Laser) en función de la corriente de inyección.
Esto deberá ser presentado mediante las graficas de la corriente del fotodiodo (I_{PD}) en el eje Y en función de la corriente de polarización (Ipol) en el eje X.
Se grafica la corriente del fotodiodo (I_{PD}) porque esta es proporcional a la potencia óptica de las fuentes luminosas (Potp).
Se debe obtener una grafica para el LED y otra para el Láser.



El reporte del laboratorio debe incluir:

TITULO DE LA PRÁCTICA
OBJETIVO
PROCEDIMIENTO
DATOS Y RESULTADOS
RESUMEN Y CONCLUSIONES

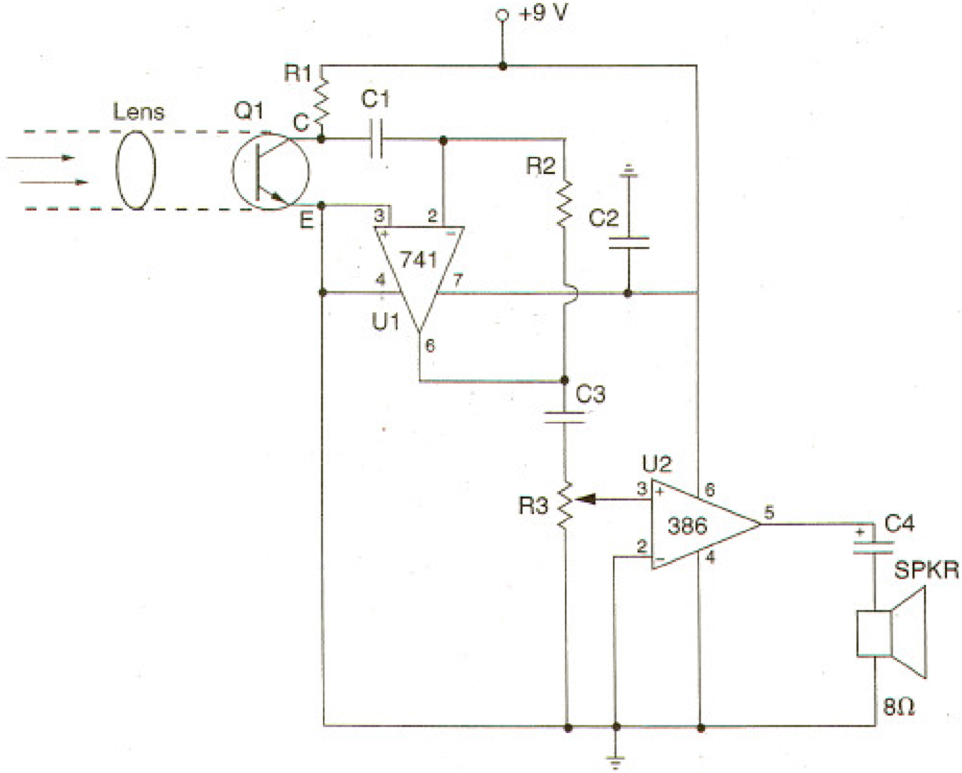
FECHA DE ENTREGA: 10 MARZO 2010

The best long-range free-space communication links consist of infrared (IR) lasers at the sending unit and an IR phototransistor at the receiver link, with an IR filter and lens ahead of the detector with a collimator, modulated by an FM or PFM modulator.

Focusing and aligning an IR free-space communications link can be a bit tricky. Both transmitter and receiver need to be mounted on a flat table top or tripod with an unobstructed view between the sending and receiving units. A quick method of aligning an IR communications link is to obtain a Radio Shack IR detector card and use it to test the IR TV remote controls. This detector will greatly aid you in aligning your IR light-wave link.

Sensitive light-wave receiver

A very sensitive light-wave listener or light-wave receiver is shown in Figure 8-4. This light-wave receiver consists of two high-gain stages of amplification. The light-wave listener can transform pulsating or modulated light that the eye cannot discern into sounds that your ear can readily hear. The light-wave listener can be used indoors as well as outdoors to "listen in" to both natural and man-made sounds.



8-4 Sensitive light-wave listener.

The light-wave listener can detect lightning flashes and produce pops and clicks in response; it can even detect some lightning missed by the human eye. Try the following experiment. Light a candle in front of your light listener and you will hear various interesting sounds. When the surrounding air is still, a soft rushing sound will be produced. When the flame is disturbed from moving air, you will hear crackles and pops from the speaker.

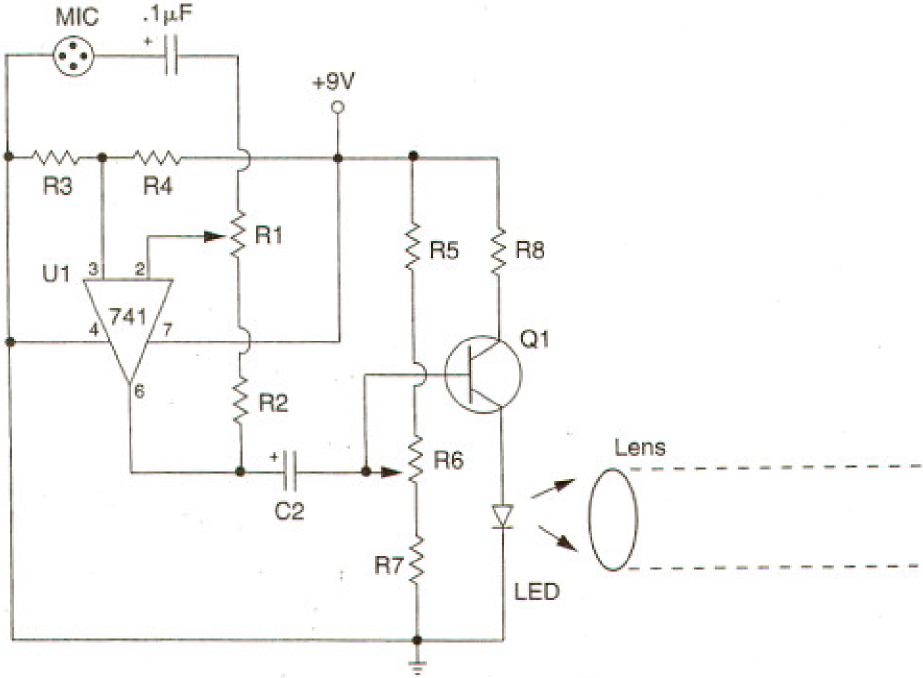
For an interesting and novel experiment, use your light listener (with a small collimator and lens) to listen to flying insects or a bird's wing beats. If you place your light listener beneath an insect or hummingbird, in line with sunlight or a light source, you will easily hear when the insect or bird's wing is reflecting sunlight into the detector because the speaker will produce a distinct buzz or hum. Take your light listener outside at dusk and nearby fireflies will produce soft clicks for each flash of light.

You can also use the light listener to detect man-made modulated light sources. Sweep a flashlight beam in front of your light listener and a soft swishing sound will be produced. Then, with a flashlight aimed at your listener, tap the flashlight with a pencil; you will hear ringing sound as the lamp filament vibrates. The headlights of cars will produce a distinct ringing when the vehicle is driven down a bumpy road. Electric displays or clocks will produce a hum or buzz when brought near the light listener. TV or computer screens will produce a buzz, while a camera flash will produce a loud pop. The light listener could also be placed in the path of a rotating fan blade or propeller, allowing you to detect the speed change with your ears. The light-wave listener could make an interesting science-fair project.

The heart of this sensitive light-wave receiver is the phototransistor Q1. Resistor R1 is used to bias the phototransistor. The output of the phototransistor is coupled to the input of U1 via capacitor C1. The 100-kilohm resistor R2 is used to set up the overall gain of the op-amp at U1. The capacitor at C3 couples the op-amp to the audio amplifier at U2, an LM386. Potentiometer R3 controls the level of signal reaching U2. Capacitor C2 is a bypass capacitor that prevents oscillation in the circuit. The output of U2 is fed to an 8-ohm speaker or headphone via C4. The light-wave listener is powered by a 9-volt transistor radio battery. The light-wave receiver in Figure 8-4 can be used with the AM light-wave transmitter in Figure 8-5 or in a number of other interesting projects.

Sensitive light-wave receiver parts list

R1,R2,R3	100-kilohm, ¼-watt resistor
C1,C2,C3	.1-µF, 25-volt disc capacitor
C4	100-µF, 25-volt electrolytic capacitor
U1	LM741CN op-amp
U2	LM386 audio amplifier
Q1	Phototransistor (Motorola MRD-300)
SPKR	8-ohm speaker or headphone
B	9-volt battery
Misc	Enclosure, battery clip, and collimator



8-5 Light-wave voice transmitter.

AM light-wave voice transmitter

The light-wave receiver shown in Figure 8-4 can be readily combined with the light-wave transmitter in Figure 8-5 to form a medium-range light-wave communications link. The light-wave transmitter consists of an electret microphone coupled to an LM741C op-amp, which modulates the LED via transistor Q1. The overall gain is controlled by resistors R1 and R2, while R6 is adjusted for best sound quality in the receiver unit. The op-amp is coupled to the LED driver via C2. The LED shown can be a conventional, super-bright, or IR LED. Using a very bright IR LED with lenses at both ends of the link will allow communications up to hundreds of feet. You will obtain the best results by placing a lens and collimator at the receiver input and using tripods to stabilize both the transmitter and receiver.

AM light-wave transmitter parts list

R1,R6	50-kilohm potentiometer
R2	1-megohm, ¼-watt resistor
R3,R4	5.6-kilohm, ¼-watt resistor
R5,R7	1-kilohm, ¼-watt resistor
R8	220-ohm, ¼-watt resistor
C1	.1-µF, 25- volt disc capacitor
C2	10-mF, 25-volt electrolytic capacitor
U1	LM741CN op-amp

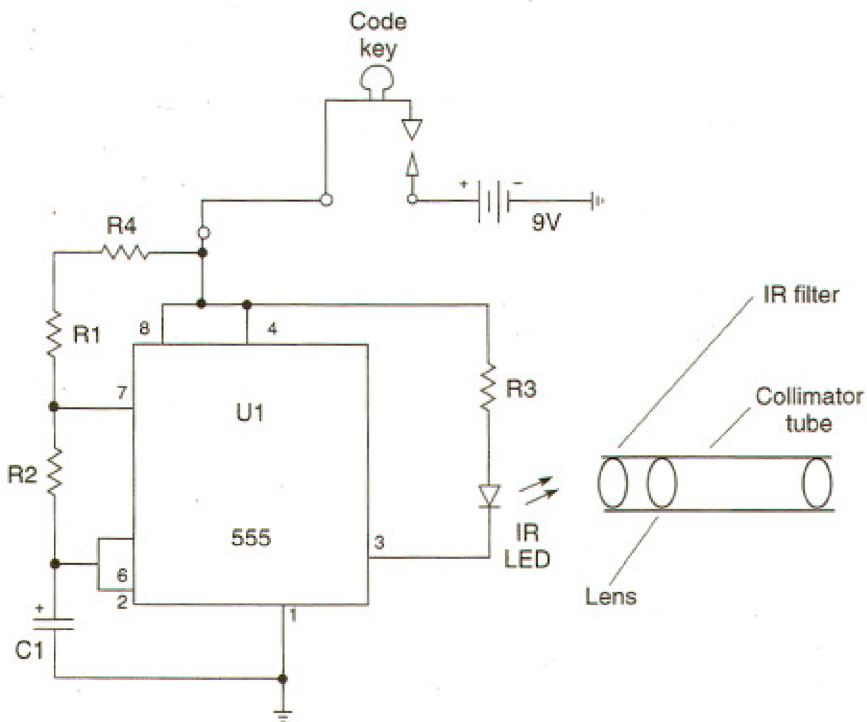
AM light-wave transmitter parts list continued

Q1	2N2222 transistor
LED	Bright LED
MIC	Electret microphone
B	9-volt battery
Misc	Enclosure, battery clip, and lens

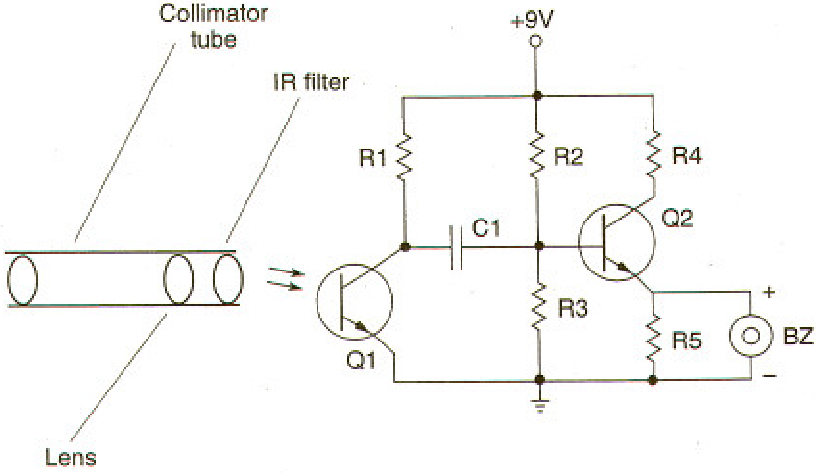
Short- to medium-range signaling system

Figures 8-6 and 8-7 illustrate a short- to medium-range tone-signaling or Morse-code light-wave link. The tone transmitter consists of an LM555 timer IC, which forms an oscillator that modulates the transmitter's LED sender. The LM555's pulse rate is controlled by the 100-kilohm potentiometer at R1. The tone oscillator is set up for a 50-percent duty cycle. Use the code key, push-button switch, or relay contacts to activate the tone transmitter unit. The tone transmitter is powered by a 9-volt transistor radio battery.

The companion light-wave receiver consists of a phototransistor that receives the incoming modulated light-wave signals and an electronic receiver that contains two transistors, used to drive a sounder. Resistor R1 biases transistor Q1. The modulated light-wave signal from the phototransistor is coupled to the second transistor



8-6 Short/medium-range signaling transmitter.



8-7 Short/medium-range signaling receiver.

Q2 via capacitor C1. Transistor Q2 drives the piezo buzzer to reproduce the code sent from the transmitter unit. Both the tone transmitter and receiver units are powered by the ubiquitous 9-volt transistor radio battery. The simple tone transmitter and companion receiver would also make a good demonstration project for a science fair.

Signaling system transmitter parts list

R1	100-kilohm potentiometer
R2	10-kilohm, ¼-watt resistor
R3	220-ohm, ¼-watt resistor
R4	5-kilohm, ¼-watt resistor
C1	.01-mF, 25-volt disc capacitor
D1	LED
U1	LM555 timer IC
B	9-volt battery
CK	Code key
Misc	Enclosure and battery clip

Signaling system receiver parts list

R1	47-kilohm, ¼-watt resistor
R2,R3,R5	4.7-kilohm, ¼-watt resistor
R4	22-kilohm, ¼-watt resistor
Q1	Phototransistor
Q2	2N2222 transistor
BZ	Piezo buzzer
B	9-volt battery
Misc	Enclosure, battery clip, collimator, and lens

Experimental Procedures

Answers

1. Construct the circuit shown in Figure 2-5, using an LED and photodetector (MFOD300). The LED and photodetector should be mounted through a piece of stiff paper or cardboard on which 10° lines have been drawn. (See Fig. 2-6.) Reduce ambient room light to a minimum. The photodetector can be mounted on its own separate piece of cardboard so that it will be free to move.
2. The LED should be placed at the apex of the junction aligned with the 0° line.
3. After radiant room light has been reduced to a minimum level, engage the detector circuit and record the voltage reading on the voltmeter.
4. Place the detector on the 0° line, pointing toward the LED, and record the voltage.
5. Move the detector to the +40° line and, subsequently, to each line, ending with the −40° line. Record the voltmeter reading at each position. Use Table 2-1.
6. Compute the current flow *I* through the LED at the 0° point.

6. ____________________

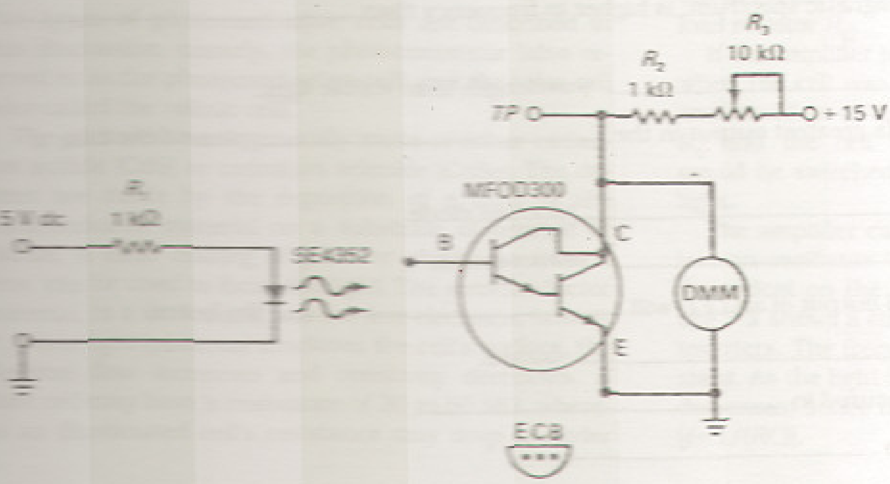


FIG. 2-5 Circuit arrangement, LED, and photodetector.

7. After all measurements are complete with the LED, replace it with the IRED. Repeat Steps 3 through 6 for the IRED.
8. Construct a graph of the voltage readings obtained versus degree angle for the LED and IRED.
9. From your graph, which emitter had the most concentrated and directed flux pattern?
10. From the technical data provided, what is the emitted wavelength for the IRED?
11. How does your plotted radiation pattern compare with that provided in the IRED Technical Data Sheet?

9. ____________________

10. ____________________

11. ____________________

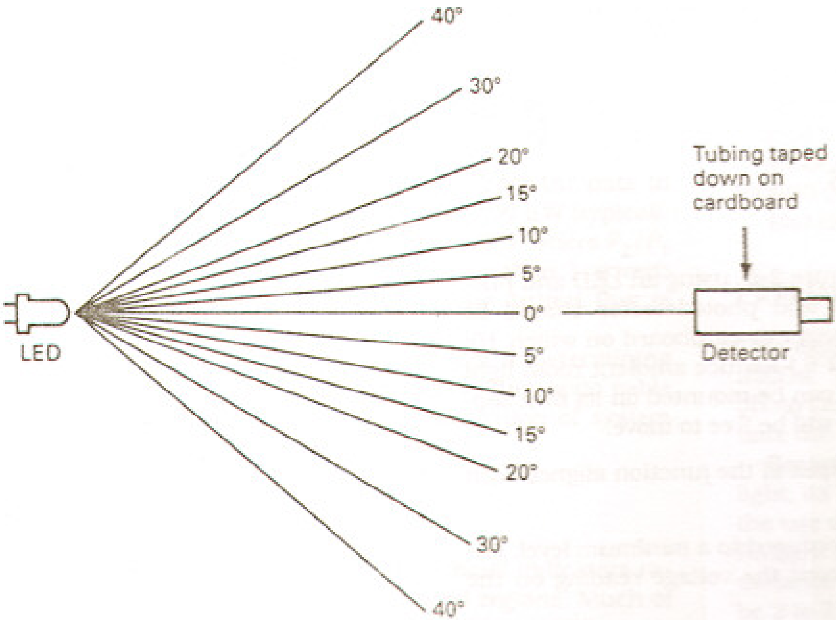


FIG. 2-6 Layout for angles in measuring LED radiation.

TABLE 2-1

	LED	IRED
+40		
+30		
+20		
+15		
+10		
+5		
0		
−5		
−10		
−15		
−20		
−30		
−40		

REVIEW QUESTIONS

Complete the following statements with an appropriate word or words.

1. Visible light, in the electromagnetic spectrum, is higher in frequency than ____________ light.
2. Ultraviolet light has a ____________ wavelength than visible light.
3. An incandescent lamp has its greatest output in the ____________ plane if the base is pointing down.
4. An LED is basically a(n) ____________ junction diode.
5. The lumen is a unit of ____________ measurement.
6. Adding a lens to the radiated output of an LED will ____________ the beam.
7. To light, an LED must be ____________-biased.
8. The output of an LED is measured in ____________.
9. The term angstrom relates to ____________.
10. The device that picks up the radiated light from an LED or IRED is called a ____________.