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ABSTRACT

This laboratory training manual on laser communications and fiber optics may be used in a general technology-communications course for ninth graders. Upon completion of this exercise, students achieve the following goals: match concepts with laser communication system parts; explain advantages of fiber optic cable over conventional copper wire; and explain the process of how laser communications and fiber optics work. The module contains objectives, methodology, activities, resources, and evaluation. The laboratory manual contains the following sections: introduction; activity length; evaluation; equipment; steps of procedure; the microphone (encoding); the laser and laser beam (transmitting); laser beam transmission (signal propagating); telephone wire versus fiber optic cable; the receiver box (receiving); and the speaker (decoding). Evaluation consists of the laser communications and fiber optics worksheet, a 15-question attachment reflecting laboratory manual information. (NLA)

High-Technology Training Module

Module Title: LASER COMMUNICATIONS AND FIBER OPTICS LAB MANUAL

Unit:

Course: GENERAL TECHNOLOGY - COMMUNICATIONS

Grade Level (s): 9TH GRADE

Developed by: ROBERT BIDDICK

Date: JULY 6, 1990

School: RICE LAKE HIGH SCHOOL

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OBJECTIVES

Upon completion of this exercise, the student will be able to:

1) match concepts with laser communication system parts.
2) explain advantages of fiber optic cable over conventional copper wire.
3) explain the process of how laser communications and fiber optics work.

METHODOLOGY

1) Activity Length: 1 class period.
2) Hand out student lab manual.
3) Explain process and worksheet evaluation.

ACTIVITIES

The student will complete the lab manual and worksheet.

RESOURCES

Equipment:
- 1 - microphone
- 1 - laser receiver
- 1 - laser
- 1 - fiber optic cable

EVALUATION

Fiber Optics Worksheet

Laser Communications and Fiber Optics

LAB MANUAL

Introduction:

Since it's invention in 1958 the later has been an important tool of man. New applications (uses) for lasers applications are being developed every day. The potential of lasers applications that can be developed to serve man are truely infinite. Amongst it's already wide variety of uses is for the transmission of information and data. Through a laser beam an office in Manhattan will be able to deliver to an office in Los Angeles the information equivalent of an entire 30-volume encyclopedia in less than 1/10th of a second. Not since the development of the computer has there been a device that has the potential to change the way man lives, learns, and communicates.

To learn more about this exciting and revolutionary tool of mankind, follow the steps of procedure below to set up and perform the following laser activity.

Activity Length: 1 class period

Evaluation: -Laser Communication Worksheet 10 points

Equipment: 1-microphone
1-laser receiver
1-laser
1-fiber optic cable

Steps of Procedure:

1. Set up a laser, microphone, and laser receiver so that it looks like figure 1 below:

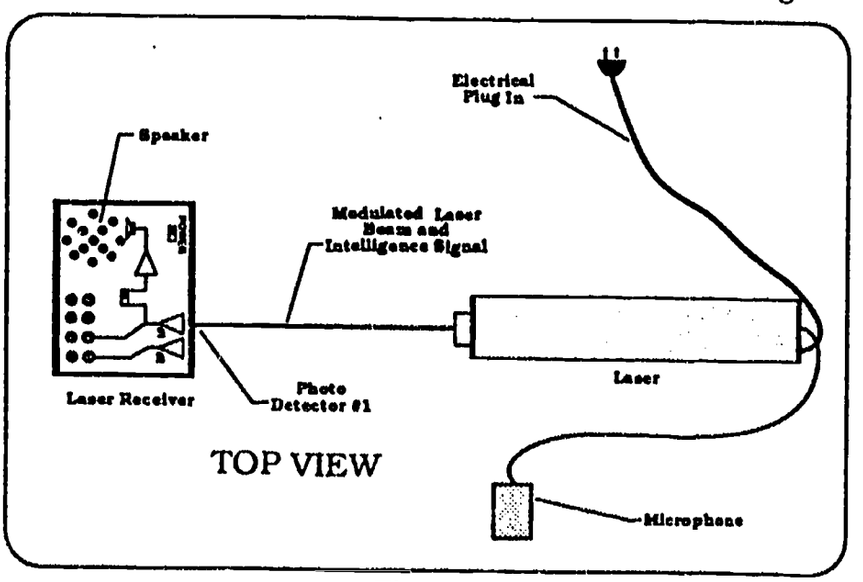


Figure 1

2. Plug the microphone into the back of the laser.

3. Place the laser receiver approximately 5 feet away from the laser.

4. Plug in the laser and receiver box and then point the beam into the photo detector #1 located on the side of the receiver box. ***Caution-do not point the laser beam directly into your eyes, stare at the laser beam, or stare directly at an intensly reflected laser beam, or possible eye damage could occur. The laser beam is an intense beam of light that could damage the retina of your eye.**

5. With one person at the laser and one at the receiver, try to communicate across the laser beam by talking into the microphone.

Questions:

1. Does this set-up work? Explain what happens when you talk into the microphone.

2. In the space provided below identify what concepts apply for each of the listed parts of the laser communication system (encoding, transmitting, receiving, storing, retrieving, or decoding).

Speaker _____ Laser beam _____

Microphone _____ Photo detector #1 _____

3. What two concepts are missing in this communication system?

1.
2.

4. What devices could include in this communication system to provide the two missing concepts?

The Microphone (Encoding):

This laser communication system is fast replacing the traditional method of transmitting telephone calls with electricity and wire. The laser communication system you set up begins with a microphone, very similar to the ones found on a telephone. The microphone converts acoustical (sound waves) into electrical waves, therefore it is an encoding device. A microphone consists of an outer piece of thin metal known as the diaphragm (see microphone illustration below).

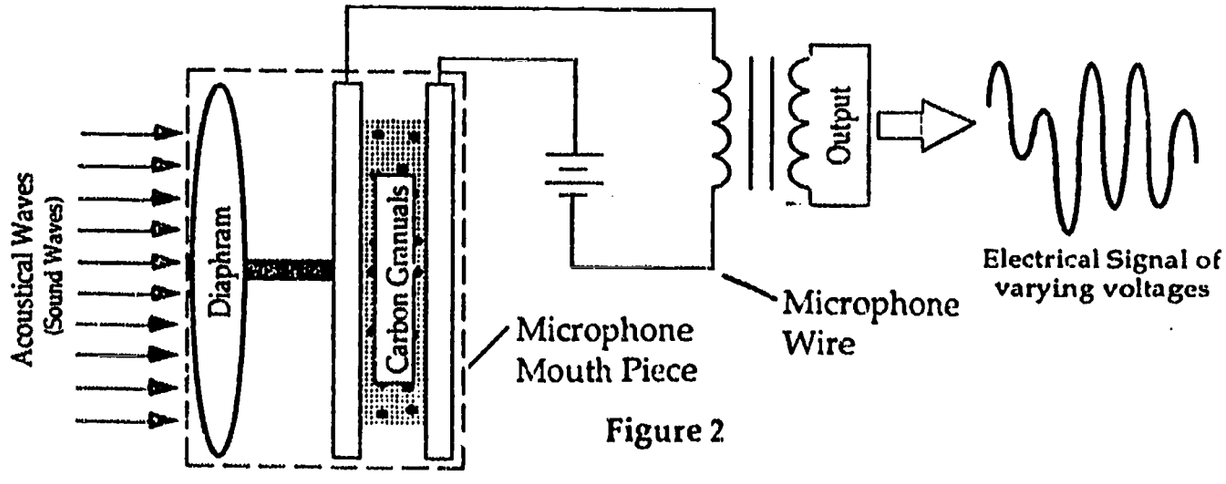


Figure 2

This diaphram can fluctuate, or move in and out. You place pressure on, and thus move the diaphram by speaking into it. Your voice strikes the diaphram and causes it to fluctuate. Directly behind this diaphram is a collection of carbon granules. When the diaphragm is forced to move inward, it changes the ability of the carbon granules to conduct electricity. Pressure on the carbon lowers its resistance and thus increases electron flow. When you quit speaking, the pressure on the microphone is released and the current flow returns to normal. The varying current flow is directly proportional to the amplitude and frequency of your voice. The result of the carbon microphone's work is to produce an electrical signal which varies in direct accordance to an acoustical signal and thus carries intelligenc

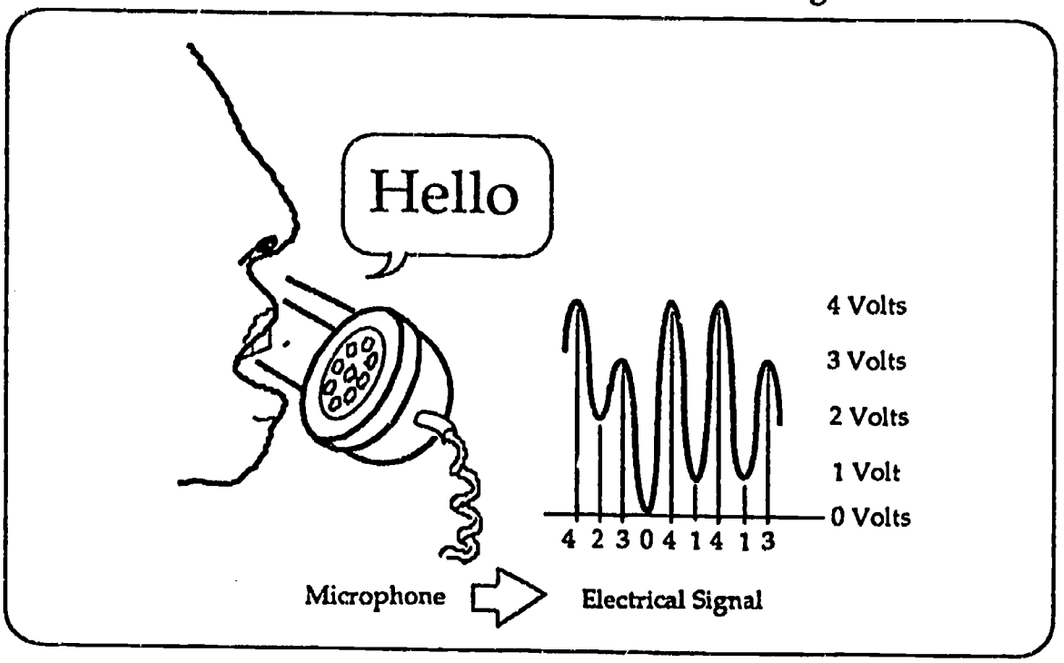


Figure 3

Question:

5. In your own words, how does a microphone convert acoustical energy into electrical energy?

The laser and laser beam (Transmitting)

The next link in the laser communication system that we will look at is the laser and laser beam. Once the microphone has converted acoustical energy (sounds) into a continuous flow of electrical energy, this electricity is then sent into the laser by way of the microphone cord. The lasers job is to determine the strength of the electrical wave at certain intervals (see figure 3). These strengths (measurements) are then turned into a code of flashing laser light, called pulse code modulation, which is then transmitted. The code is transmitted as a series of flashes in the form of on and off pulses. A flash of light stands for a "one" and an absence of a flash stands for a "zero". If the strength of one interval of the original electrical signal is 4 volts, the laser's beam would be triggered as a FLASH, NO FLASH, NO FLASH. If the strength of the original electrical signal was 1 volt, the laser's beam would be triggered as a NO FLASH, NO FLASH, FLASH. Figure 4 represents what a laser transmission code might be like.

Signal Voltage	Binary Code	Laser Transmission Signal
0 volts →	0, 0, 0 →	No Flash, No Flash, No Flash
1 volt →	0, 0, 1 →	No Flash, No Flash, One Flash
2 volts →	0, 1, 0 →	No Flash, One Flash, No Flash
3 volts →	0, 1, 1 →	No Flash, One Flash, One Flash
4 volts →	1, 0, 0 →	One Flash, No Flash, No Flash

Figure 4

For the message in figure 3 (hello) the entire laser transmission signal may appear as follows:

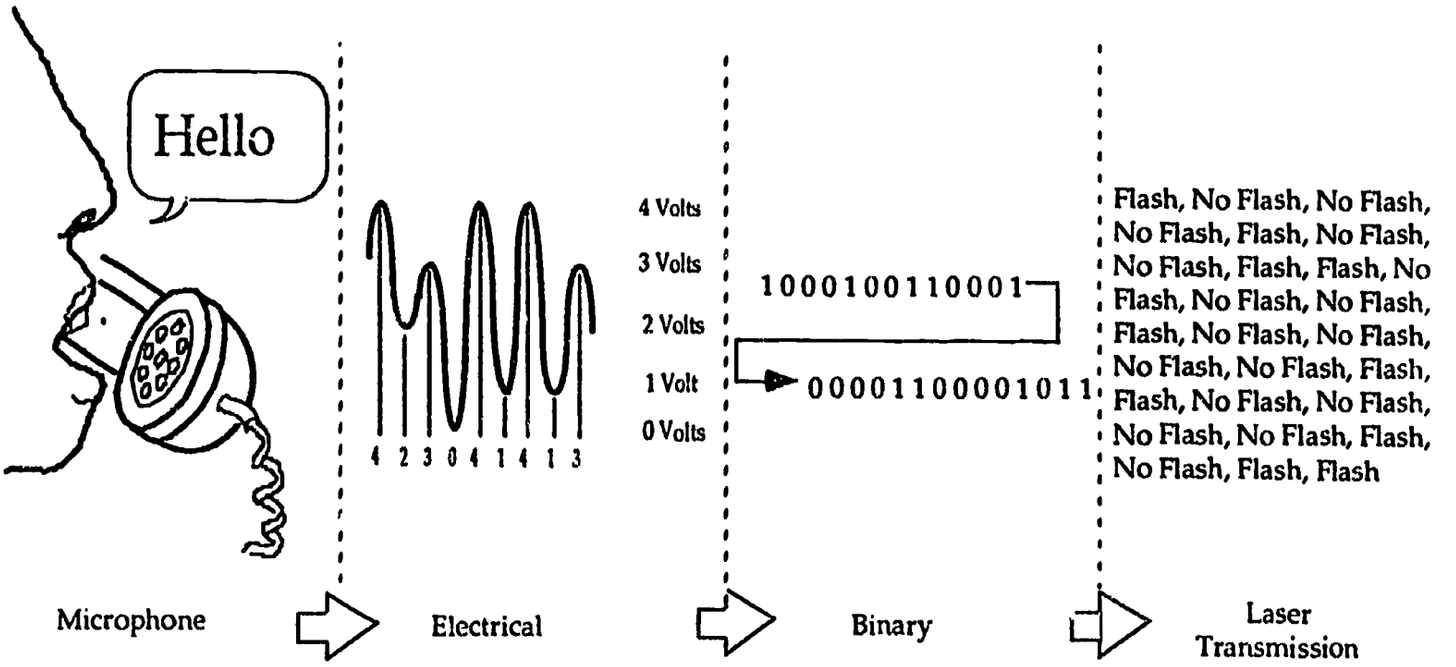


Figure 5

Question:

6. Explain in your own words how the laser converts the electrical signal (from the microphone) into a laser beam code?

7. What would the laser transmission be if it received an electrical signal of 3 volts, 2 volts, 0 volts, and 1 volt?

The laser and laser beam are responsible for the transmission of the information from the source to it's destination. The laser beam can travel through the atmosphere or through a physical channel, such as fiber optics. Fiber optics is a glass material that aides in the guiding of the laser beam. The process of sending a signal through some channel, such as the atmosphere is called "signal propagation". Follow the step of procedure below to learn about laser beam transmission.

Steps of Procedure:

1. With the previous setup, place your hand in front of the laser beam as you speak into the microphone.

2. Obtain a section of fiber optic cable from the laser station cabinet. The cable will look like a piece of black wire, approximately 1/8" in diameter. ***Caution***-handle the fiber optic cable very carefully. Do not twist the cable or bend it into a tight loop or the glass will break and cause possible injury.

3. Place one end of the fiber optic cable into the hole at the front of the laser.

4. Look at the opposite end of the fiber optic cable. ***Caution-look at the end of the fiber optic cable but do not stare at it directly.

5. Begin answering the question below.

Questions:

8. Explain what happens when you placed your hand in front of the laser beam?

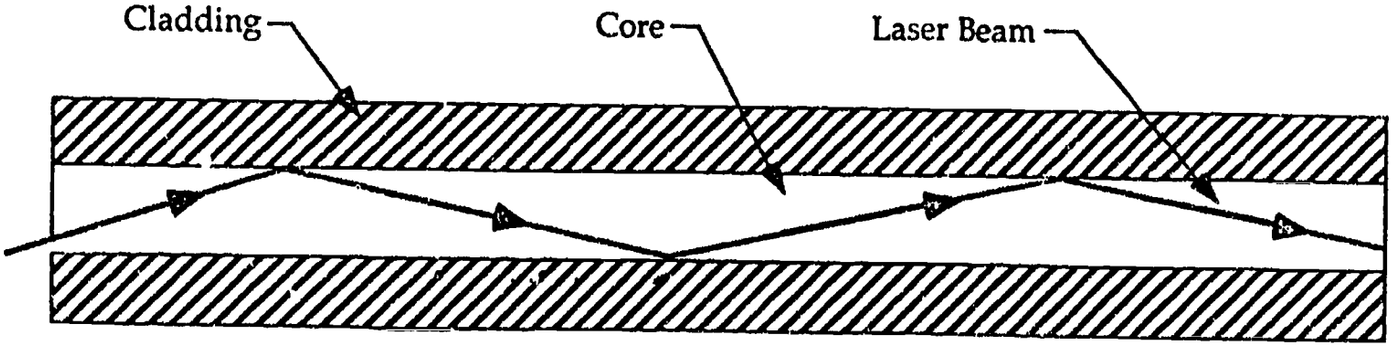
9. What happens to the laser beam when it is projected into the laser beam?

10. Define "signal propagation".

Laser Beam Transmission (Signal Propagating):

From the above activity you can see that lasers can indeed transmit an intelligent signals by using beam pulses (on/off pulses of laser beam), called pulse code modulation.
But, one of the problems associated with sending a laser beam through the atmosphere is beam blockage. If we were to transmit phone messages through the atmosphere there would be many unhappy telephone customers. Everytime a bird, plane, or other object got in the way of the laser beam our message would be temporarily lost. To eliminate this problem, a material called fiber optics was developed. Fiber optics offer several other advantages over transmitting the laser beam through the atmosphere. A laser beam inside a fiber optic material can be bent to go around corners. Fiber optic cable continuously reflects the laser beam back to the center of the cable allowing the beam to travel great distances before it needs to be amplified. A fiber optic cable can be placed underground to eliminate unsightly telephone lines, and helps to protect the cable from damage.

Dr. Walter P. Sigmund of the American Optical Corporation best describes the laser beam in the fiber optic cable with "a light beam travels through an optical fiber much like a bullet ricocheting down a steel pipe. The beam caroms through the fiber's core, trapped there by cladding. The cladding does more than simply confine the light, it provides a mirror effect, turning the light back into the core (center of the cable). This creates what is known as 'total internal reflection'. It is so perfect that you can still have a light beam emerge largely undimmed." In order to transmit a signal many miles through fiber optic cable it must be made of very pure glass. Any impurities in the glass results in internal reflections and losses of the signal.



Typical Fiber Optic Cable

Figure 6

Question:

11. What does the cladding in a fiber optic cable do to the laser beam?

Telephone Wire versus Fiber Optic Cable:

Conventional telephone calls for years were made over copper wire. The telephone converted the acoustical signal to an electrical signal and then transmitted this signal through copper wire. Since light waves can not be transmitted through copper wire fiber optic cable was developed. Today your phone call may be transmitted to it's destination by way of copper cable, fiber optics, satellite, or microwave signals. A computer in the telephone companies central office is responsible for the routing of all long distance phone calls based on what lines are open at that particular moment, and/or which method would be the most economical. Fiber optic cable offers many advantages over copper wire cabling.

Advantages of fiber optic cable over copper cable

- lower transmission losses
- wider bandwith (moving video images can be sent)
- insensitive to interferences
- higher security (harder to tap the line)
- smaller diameter cable, lighter weight, stronger
- no short circuits
- no cross talk (multiple conversations on one line)
- copper supply limited and expensive, fiber optic material abundant and cheap (silicon-commonly know as sand)
- safe to use fiber optics in a highly exposive environment since no electricity is present in cable

Figure 7

Copper wire cabling is typically jammed with 1800 copper wires that can carry 900 simultaneous telephone conversations for distances of 3,000 to 6,000 feet before the signal needs to be amplified and sent again. The light pulses of a semi-conductor laser (the size of a grain of salt) can carry up to 500,000 simultaneous telephone conversations through a fiber optic cable 10 miles before amplification is required.

1/2" of fiber optic material will transmit an equal amount of phone conversations as 4-1/2" of copper cable.

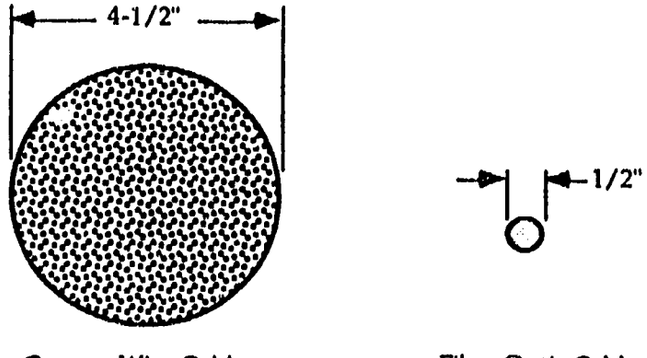


Figure 8

Questions:

12. List at least 3 advantages of fiber optic cable over conventional copper wire for the transmission of telephone messages.

The Receiver Box (Receiving):

The laser receiver box you used to transmit your voice through the laser communication system provides two functions: receives the laser beam signal and decodes the message. The photodetector on the side of the receiver box is an electronic device that converts the light waves into electricity. The laser's beam pulses hit the photodetector and are converted into a electrical pulse (binary code). The receiver box then converts this electrical pulse back into a continuous electrical signal. This process is called demodulation (see figure 9). Basically we are reversing the process done by the laser before transmission.

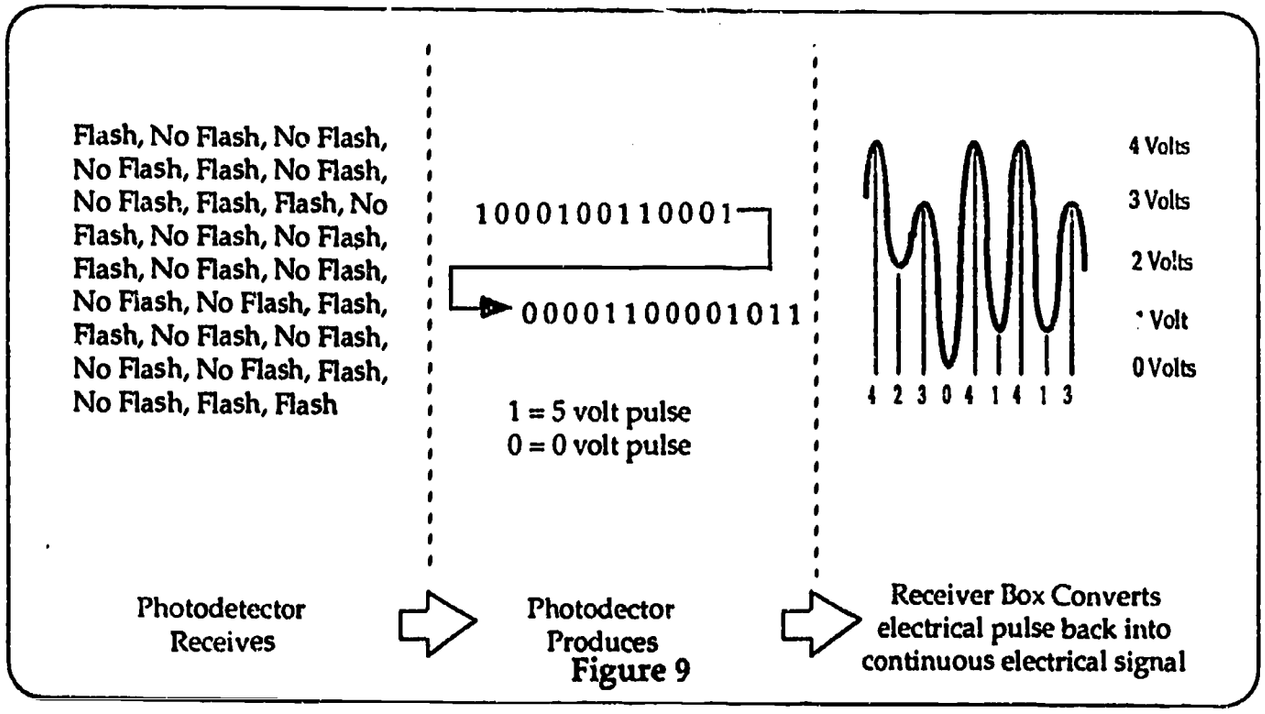


Figure 9

The Speaker (Decoding):

The last thing that needs to be explained about the laser communication system you set up and used is decoding the signal. The speaker in the receiver box performs the decoding process. It takes in the recreated continuous electrical signal and converts this into acoustical energy (sound). In the back of the speaker there is a large magnet. A wire is wrapped around this permanent magnet. Mounted next to this magnet is a diaphram and cone. As the electrical signal passes through the magnet it creates a varying magnetic field. This varying magnetic field causes the surrounding air to vibrate. This vibration, in turn causes the diaphram to vibrate, thus causing sounds to be created. The cone which is attached to the diaphram aids in moving the sound waves out from the diaphram into the space around the speaker.

General Technology-Communications
Rice Lake High School

Laser Communications and Fiber Optics Worksheet

Answer the following questions as you complete the Laser Communications and Fiber Optic lab manual.

1. Does this set-up work? Explain what happens when you talk into the microphone.

2. In the space provided below identify what concepts apply for each of the listed parts of the laser communication system.

   Speaker _____ Laser beam _____

   Microphone _____ Photodetector #1 _____

3. What two communication concepts, of the six, are missing in this system?

   a. _____

   b. _____

4. What devices could we add to this communication system to include the two missing concepts?

5. In your own words, how does a microphone convert acoustical energy into electrical energy?

6. Explain in your own words how the laser converts the electrical signal (from the microphone) into a laser beam code.

Turn this worksheet over and complete back side.

7. What would the laser transmission be if it received an electrical signal of 3 volts, 2 volts, 0 volts, and 1 volt?

8. Explain what happens when you placed your hand in front of the laser beam.

9. What happens to the laser beam when it is projected into the fiberoptic cable?

10. Define "signal propagation".

11. What does the cladding in a fiber optic cable do to the laser beam?

12. List at least 3 advantages of fiber optic cable over conventional copper wire for the transmission of telephone messages.

13. What important thing does the receiver box do in this laser communication system you used in this lab?

14. Explain in your own words how a speaker converts electrical energy back into acoustical energy?

15. What 3 steps take place in the demodulation process?

Questions:

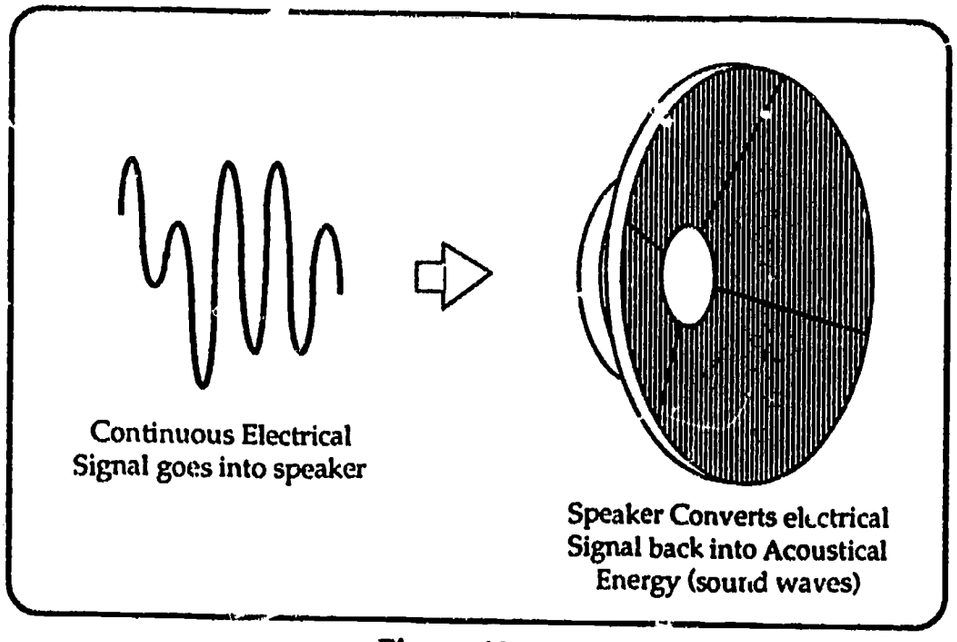


Figure 10

13. What important things does the receiver box do in the laser communication system you used in this lab?

14. Explain in your own words how a speaker converts electrical energy back into acoustical energy?

15. What 3 steps take place in the demodulation process?