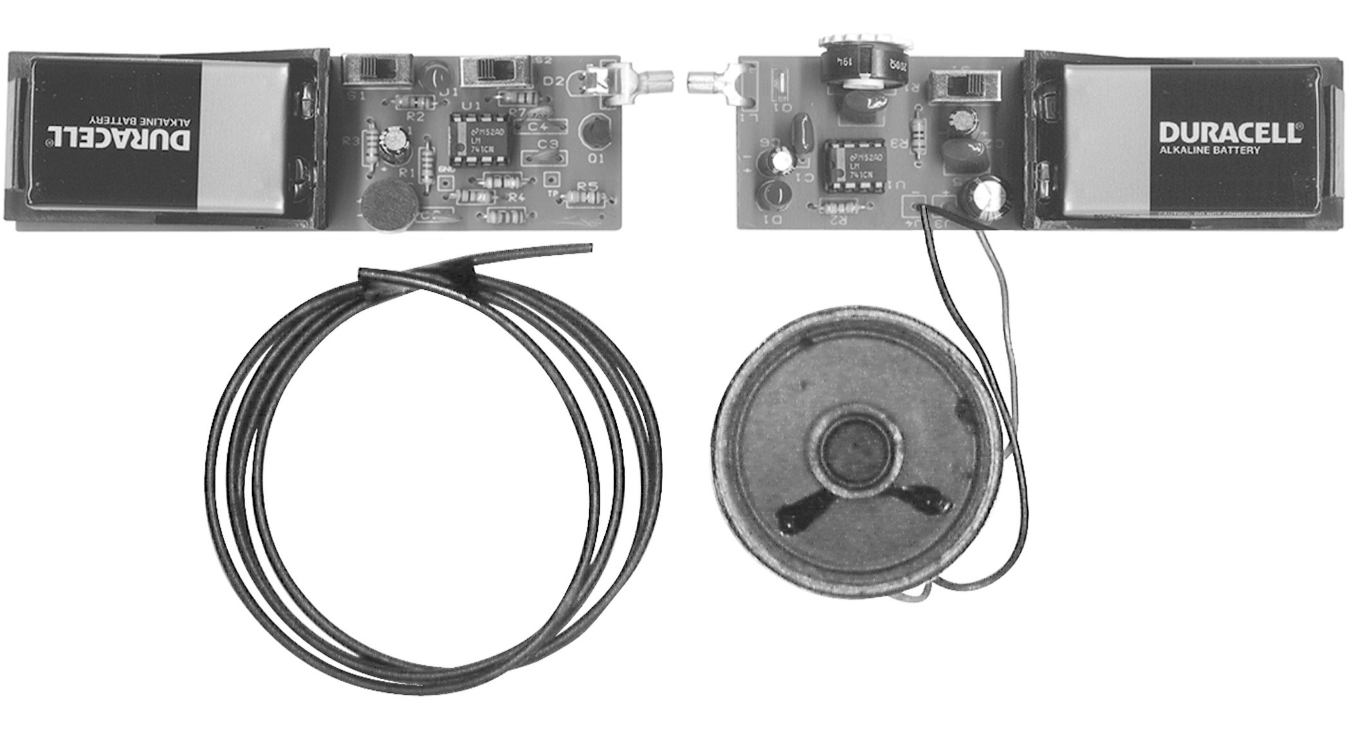
FIBER OPTICS KIT

MODEL FO-30K



Assembly and Instruction Manual

ELENCO®

INTRODUCTION

The FO-30 kit, an optical voice link, will introduce you to the wonderful world of fiber optics. By building this kit, you will learn how fiber optics works and how it could be applied to the field of communication.

GENERAL OVERVIEW

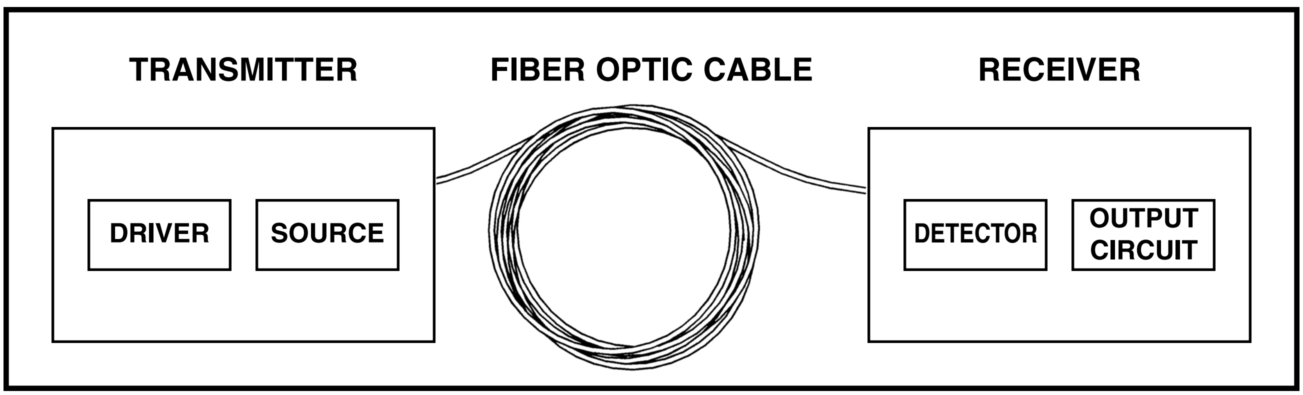
Fiber optics is a medium linking two electronic circuits. As shown in the block diagram below, this FO-30 kit consists of three basic elements; they are transmitter, fiber optic cable and receiver.

The Transmitter converts an electrical signal into a light signal. The source, either a light-emitting-diode (LED) or laser diode, does the actual conversion. The drive circuit changes the electrical signal fed to the transmitter into a form required by the source.[1]

Fiber-optic cable is the medium for carrying the light. The cable includes the fiber and its protective covering.[2]

The Receiver accepts the light and converts it back into an electrical signal. The two basic parts of the receiver are the detector, which converts it back into an electrical signal, and the output circuit, which amplifies and, if necessary, reshapes the electrical signal.[3]

The other parts which are not included in the diagram consists of connectors which are used to connect the fibers to the source and detector.



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IDENTIFYING RESISTOR VALUES

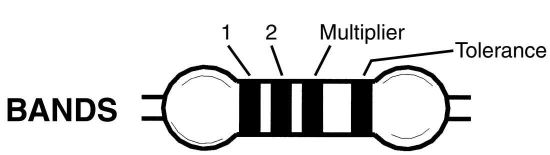
Use the following information as a guide in properly identifying the value of resistors.

BAND 1 1st Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

BAND 2 2nd Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

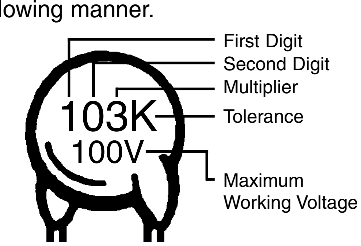
Multiplier	
Color	Multiplier
Black	1
Brown	10
Red	100
Orange	1,000
Yellow	10,000
Green	100,000
Blue	1,000,000
Silver	0.01
Gold	0.1

Resistance Tolerance	
Color	Tolerance
Silver	±10%
Gold	±5%
Brown	±1%
Red	±2%
Orange	±3%
Green	±.5%
Blue	±.25%
Violet	±.1%



IDENTIFYING CAPACITOR VALUES

Capacitors will be identified by their capacitance value in pF (picofarads), nF (nanofarads), or μF (microfarads). Most capacitors will have their actual value printed on them. Some capacitors may have their value printed in the following manner.



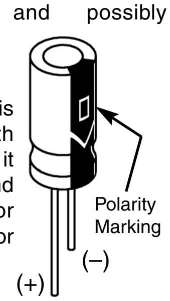
The value is 10 x 1,000 = 10,000pF or .01μF, ±10%, 100V

The letter M indicates a tolerance of ±20%
The letter K indicates a tolerance of ±10%
The letter J indicates a tolerance of ±5%

Note: *The letter "R" may be used at times to signify a decimal point; as in 3R3 = 3.3*

Electrolytic capacitors have a positive and a negative electrode. The negative lead is indicated on the packaging by a stripe with minus signs and possibly arrowheads.

Warning:
If the capacitor is connected with incorrect polarity, it may heat up and either leak, or cause the capacitor to explode.



Multiplier	For the No.	0	1	2	3	4	5	8	9
	Multiply By	1	10	100	1k	10k	100k	.01	0.1

TRANSMITTER SECTION

PARTS LIST

If you are a student, and any parts are missing or damaged, please see instructor or bookstore. If you purchased this fiber optics kit from a distributor, catalog, etc., please contact ELENCO® (address/phone/e-mail is at the back of this manual) for additional assistance, if needed. **DO NOT** contact your place of purchase as they will not be able to help you.

RESISTORS

Qty.	Symbol	Value	Color Code	Part #
❒ 1	R8	220Ω 5% 1/4W	red-red-brown-gold	132200
❒ 1	R7	1kΩ 5% 1/4W	brown-black-red-gold	141000
❒ 2	R1, R3	2.2kΩ 5% 1/4W	red-red-red-gold	142200
❒ 3	R2, R4, R5	10kΩ 5% 1/4W	brown-black-orange-gold	151000
❒ 1	R6	100kΩ 5% 1/4W	brown-black-yellow-gold	161000

CAPACITORS

Qty.	Symbol	Value	Description	Part #
❒ 1	C3	100pF (101)	Discap	221017
❒ 1	C2	.01μF (103)	Discap	241031
❒ 1	C4	.022μF (223)	Mylar	242217
❒ 1	C1	1μF	Electrolytic	261047

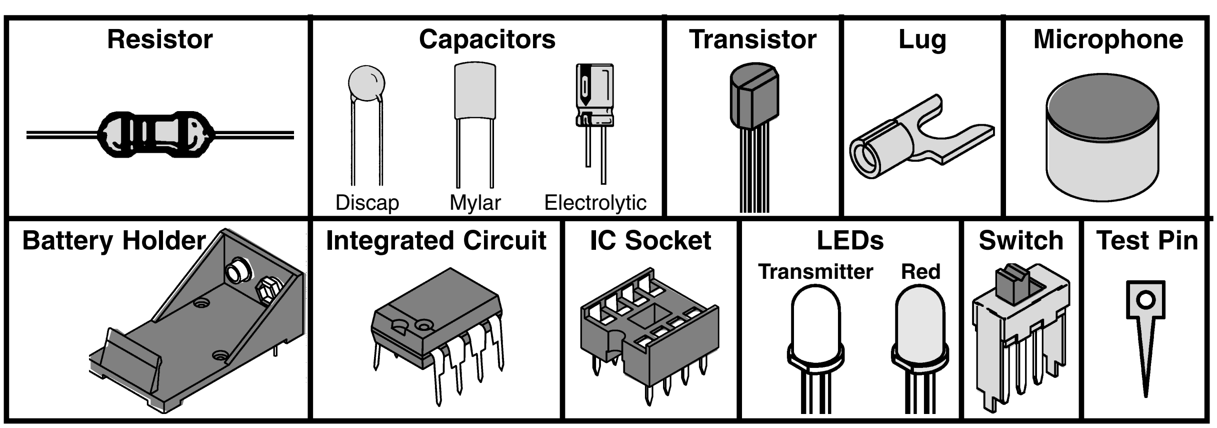
SEMICONDUCTORS

Qty.	Symbol	Value	Description	Part #
❒ 1	Q1	2N3904	Transistor NPN	323904
❒ 1	U1	LM741	Integrated Circuit	331741
❒ 1	D1		LED Red	350002
❒ 1	D2		LED Transmitter Clear	350005

MISCELLANEOUS

Qty.	Description	Part #	Qty.	Description	Part #
❒ 1	PC Board	519015A	❒ 1	Lug	661106
❒ 2	Switch	541103	❒ 1	IC Socket 8-Pin	664008
❒ 1	Microphone	568000	❒ 2	Test Pins	665008
❒ 1	Battery Holder	590096	❒ 1	Polishing Paper #400	735005
❒ 2	Screw 2-56 x 1/4”	641230	❒ 3’	Fiber Optic Cable	810020
❒ 2	Nut 2-56	644201	❒ 1	Lead-free Solder Tube	9LF99

PARTS IDENTIFICATION



TRANSMITTER

There are 5 main components in the transmitter (see Figure 1A). They are:

a) Power supply (9V battery)
b) Microphone (MIC)
c) Op-amp LM741, (the driver)
d) NPN transistor 2N3904, and
e) Transmitter LED

The microphone picks up your voice signal and converts it into a voltage signal. The strength of this voltage signal depends upon the pitch and loudness of your voice. This signal is then ac-coupled through C1 and R2 to the input pin 2 of the LM741 op-amp for amplification.

The gain of the op-amp LM741 depends on the ratio of R6 to R2, which is equal to 100k/10k = 10. Hence, the voice signal coming from the microphone will be amplified 10 times by this op-amp, and the amplified signal will appear at the output of the op-amp.

At 0 Hz (DC) the impedance of C1 is infinite. The amplifier then acts as a voltage follower. A voltage follower is an op-amp in which the output voltage is equal to the input voltage. In our case, the output voltage at pin 6 is equal to the input voltage at pin 3 and pin 2 which is about 4.5V. This 4.5V at the input pins is due to the effect of resistors R4 and R5 which act as a voltage divider. This constant DC voltage helps keep the NPN transistor (2N3904) on all the time.

The function of the NPN transistor (2N3904) is similar to that of a valve, it controls the flow of the current through the LED. The flow of this current will depend on the base voltage of the transistor. This base voltage in turn depends on the loudness and pitch of your voice. Thus, the light intensity of this LED will vary as you speak into the microphone. This encoded light signal will then be transmitted to the receiver through a fiber optic cable.

The LED (D1) acts as an ON/OFF indicator. It will also indicate the state of the battery. If the LED becomes dim, the battery is weak and should be replaced. C2 filters out any noise that comes through the voltage divider. C3 helps in stabilizing the op-amp. It will also reduce any high frequency noise generated in the transmitter. When S2 is closed (toward the LED D2), C4 is placed into the circuit and the op-amp will oscillate at about 1kHz. As a result, you will hear a shrill noise from the speaker in the receiver.

SCHEMATIC DIAGRAM

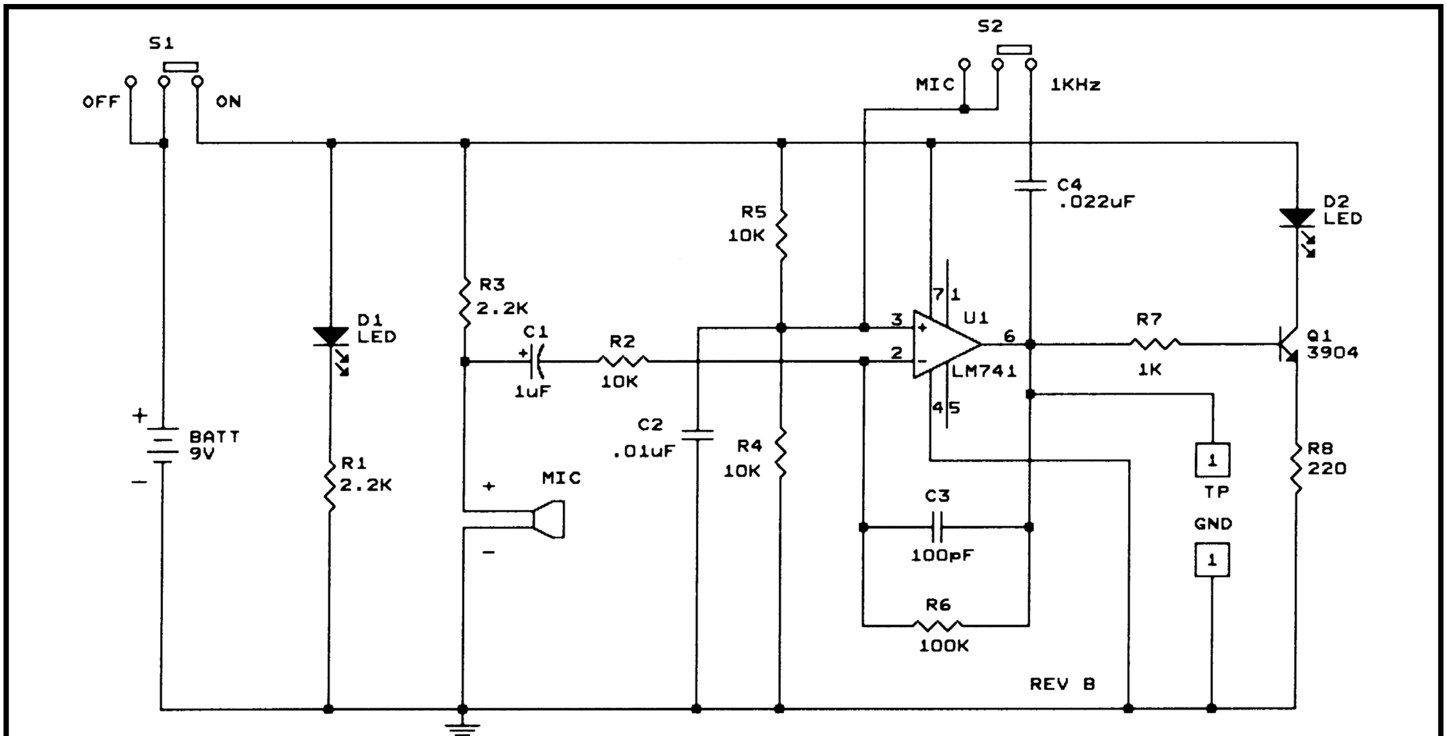


Figure 1A

CONSTRUCTION

Introduction

The most important factor in assembling your FO-30K Fiber Optics Kit is good soldering techniques. Using the proper soldering iron is of prime importance. A small pencil type soldering iron of 25 watts is recommended. **The tip of the iron must be kept clean at all times and well tinned.**

Solder

For many years leaded solder was the most common type of solder used by the electronics industry, but it is now being replaced by lead-free solder for health reasons. This kit contains lead-free solder, which contains 99.3% tin, 0.7% copper, and has a rosin-flux core.

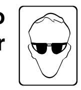
Lead-free solder is different from lead solder: It has a higher melting point than lead solder, so you need higher temperature for the solder to flow properly. Recommended tip temperature is approximately 700°F; higher temperatures improve solder flow but accelerate tip decay. An increase in soldering time may be required to achieve good results. Soldering iron tips wear out faster since lead-free solders are more corrosive and the higher soldering temperatures accelerate corrosion, so proper tip care is important. The solder joint finish will look slightly duller with lead-free solders.

Use these procedures to increase the life of your soldering iron tip when using lead-free solder:

- Keep the iron tinned at all times.
- Use the correct tip size for best heat transfer. The conical tip is the most commonly used.
- Turn off iron when not in use or reduce temperature setting when using a soldering station.
- Tips should be cleaned frequently to remove oxidation before it becomes impossible to remove. Use Dry Tip Cleaner (Elenco® #SH-1025) or Tip Cleaner (Elenco® #TTC1). If you use a sponge to clean your tip, then use distilled water (tap water has impurities that accelerate corrosion).

Safety Procedures

- **Always wear safety glasses or safety goggles to protect your eyes when working with tools or soldering iron, and during all phases of testing.**



- Be sure there is **adequate ventilation** when soldering.
- Locate soldering iron in an area where you do not have to go around it or reach over it. Keep it in a safe area away from the reach of children.
- **Do not hold solder in your mouth.** Solder is a toxic substance. Wash hands thoroughly after handling solder.

Assemble Components

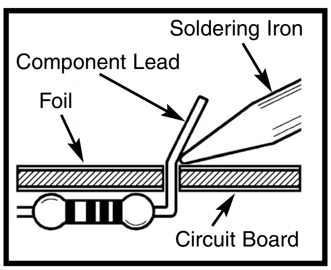
In all of the following assembly steps, the components must be installed on the top side of the PC board unless otherwise indicated. The top legend shows where each component goes. The leads pass through the corresponding holes in the board and are soldered on the foil side.
Use only rosin core solder.

DO NOT USE ACID CORE SOLDER!

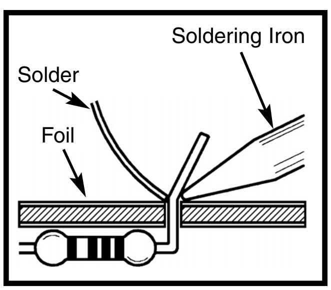
What Good Soldering Looks Like

A good solder connection should be bright, shiny, smooth, and uniformly flowed over all surfaces.

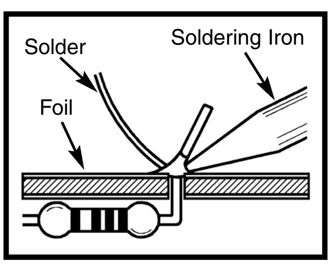
1. Solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil.



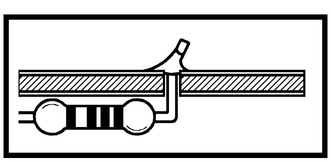
2. Apply a small amount of solder to the iron tip. This allows the heat to leave the iron and onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron. Allow the heated component and the circuit foil to melt the solder.



3. Allow the solder to flow around the connection. Then, remove the solder and the iron and let the connection cool. The solder should have flowed smoothly and not lump around the wire lead.

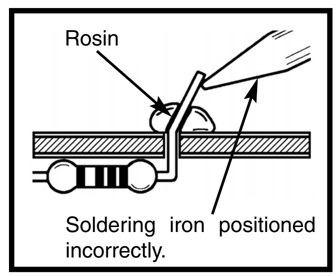


4. Here is what a good solder connection looks like.

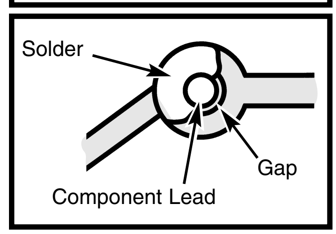


Types of Poor Soldering Connections

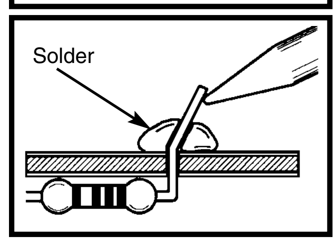
1. **Insufficient heat** - the solder will not flow onto the lead as shown.



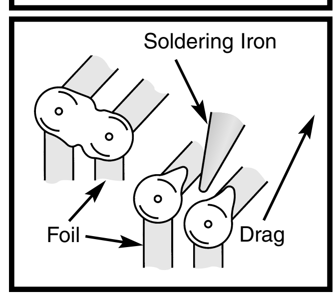
2. **Insufficient solder** - let the solder flow over the connection until it is covered.
   Use just enough solder to cover the connection.



3. **Excessive solder** - could make connections that you did not intend to between adjacent foil areas or terminals.

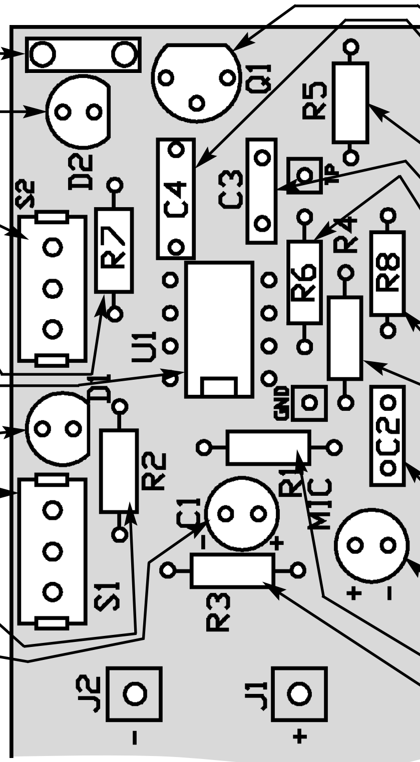


4. **Solder bridges** - occur when solder runs between circuit paths and creates a short circuit. This is usually caused by using too much solder.
   To correct this, simply drag your soldering iron across the solder bridge as shown.



ASSEMBLY INSTRUCTIONS FOR TRANSMITTER

- ☐ Lug (see Figure A)
- ☐ D2 - LED Transmitter Clear (see Figure B)
- ☐ S2 - Switch
- ☐ R7 - 1kΩ 5% 1/4W Resistor (brown-black-red-gold)
- ☐ 8-Pin IC Socket
- ☐ U1 - 741CN (see Figure G)
- ☐ D1 - LED Red (see Figure C)
- ☐ S1 - Switch
- ☐ R2 - 10kΩ 5% 1/4W Resistor (brown-black-orange-gold)
- ☐ C1 - 1µF Electrolytic Capacitor (see Figure D)



- ☐ Q1 - 2N3904 NPN Transistor (see Figure F)
- ☐ C4 - .022µF (223) Capacitor
- ☐ R5 - 10kΩ 5% 1/4W Resistor (brown-black-orange-gold)
- ☐ C3 - 100pF (101) Capacitor
- ☐ R6 - 100kΩ 5% 1/4W Resistor (brown-black-yellow-gold)
- ☐ R8 - 220Ω 5% 1/4W Resistor (red-red-brown-gold)
- ☐ R4 - 10kΩ 5% 1/4W Resistor (brown-black-orange-gold)
- ☐ C2 - .01µF (103) Capacitor
- ☐ MIC - Microphone (see Figure E)
- ☐ R1 - 2.2kΩ 5% 1/4W Resistor
- ☐ R3 - 2.2kΩ 5% 1/4W Resistor (red-red-red-gold)

Figure A

Mount the lug as shown.

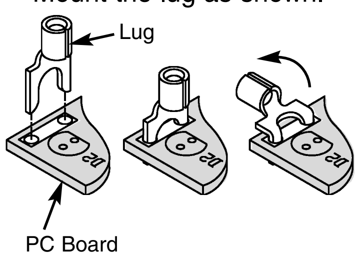


Figure B

Bend the leads as shown. Mount the LED transmitter with the flat side in the direction shown below.

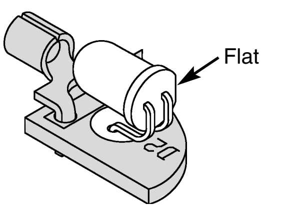


Figure C

Mount the LED with the flat side in the same direction as marked on the top legend.

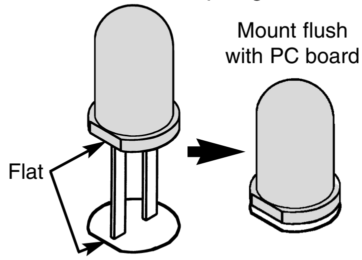


Figure D

Electrolytics have a polarity marking indicating the (–) lead. The PC board is marked to show the lead position.

Warning: If the capacitor is connected with incorrect polarity, it may heat up and either leak or cause the capacitor to explode.

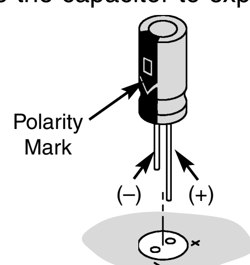


Figure E

You have received one of four different types of microphones. If you have type A or B, mount it with the leads in the correct holes on the PC board. If you have type C or D, then bend the leads as shown.

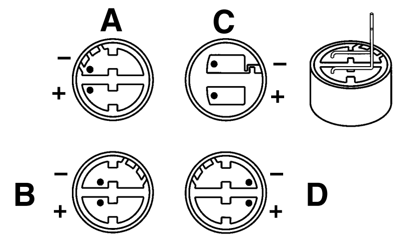


Figure F

Mount the transistor in the correct direction as marked on the top legend.

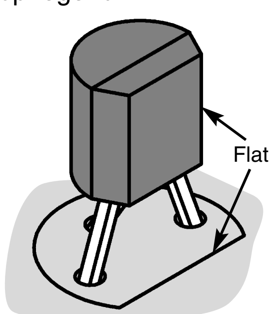
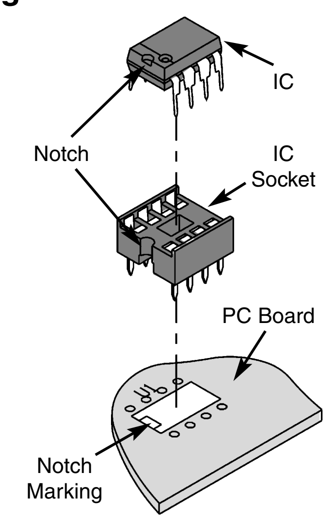


Figure G

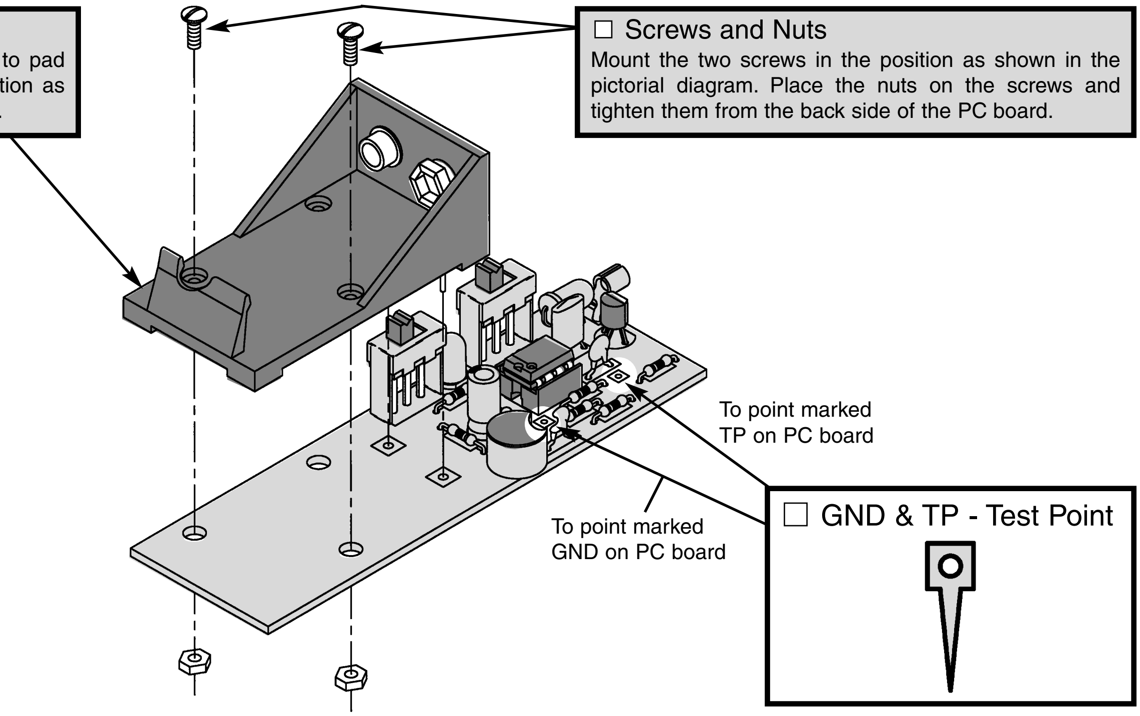
Insert the IC socket into the PC board with the notch in the direction shown on the top legend. Solder the IC socket into place. Insert the IC into the socket with the notch in the same direction as the notch on the socket.



☐ 9V Battery Holder
Solder the 9V battery holder to pad J1 and J2 in the correct position as shown in the pictorial diagram.

☐ Screws and Nuts
Mount the two screws in the position as shown in the pictorial diagram. Place the nuts on the screws and tighten them from the back side of the PC board.

☐ GND & TP - Test Point



TESTING PROCEDURE

1. Connect a 9 volt battery to the battery holder.
2. Switch S2 to the 1kHz position (toward LED D2) and S1 on (toward LED D1). Observe that LED D1 and D2 are on.
3. If you have a voltmeter, measure the DC voltage on pins 2, 3, and 6 of the IC. All of these voltages should be 1/2 the battery voltage.
4. If you have an oscilloscope, connect it to test point TP. Switch S2 in the 1kHz position (toward LED D2) to place C4 in the circuit. You should see a 6V peak-to-peak square wave of about 1kHz on the scope.
5. Switch S2 to the mic position (toward the battery), speak into the microphone and observe your voice waveform on the scope.

If you experience any problems, see the Troubleshooting Guide on page 20.

QUIZ 1

1. The FO-30 Kit consists of three basic elements that are found in every fiber optic link. They are _____________, _____________, and _____________.
2. The function of the transmitter is to convert an _____________ signal into a _____________ signal.
3. The function of the fiber optic cable is to transmit a _____________ signal from the transmitter to the receiver.
4. The receiver accepts a _____________ signal and converts it back to an _____________ signal.
5. The microphone picks up a _____________ signal and converts it to an _____________ signal.
6. The gain of the LM-741 is equal to _____________.
7. The DC output to the op-amp is _____________ volts.
8. The NPN transistor (3904) controls the _____________ through the LED.
9. The LED (D1) indicated the state of the _____________.
10. C2 filters out any _____________ that comes through the voltage divider.

Answers: 1. transmitter, fiber optic cable, receiver; 2. electrical, light; 3. light; 4. light, electrical; 5. voice, electrical; 6. 10; 7. 4.5; 8. current; 9. battery; 10. noise

FIBER OPTICS

SECTION A

FIBER OPTICS AND ITS ADVANTAGES

The obvious questions concerning fiber optics are these: Why go through all the trouble of converting the signal to light and back? Why not just use wire? The answers lie in the following advantages of fiber optics.

a) Wide bandwidth
b) Low loss
c) Electromagnetic immunity
d) Light weight
e) Small size
f) Safety
g) Security

Of all the above mentioned advantages, wide bandwidth, low loss and electromagnetic immunity are probably the most important features.

Bandwidth is an effective indication of the rate at which information can be sent. Potential information-carrying capacity increases with the bandwidth of the transmission medium. From the earliest days of radio, useful transmission frequencies have pushed upward five orders of magnitude, from about 100kHz (100×10^3 Hz) to about 10GHz (10×10^9 Hz). Optical fibers have a potential useful range to about 1THz (1×10^{12} Hz). The information-carrying possibilities of fiber optics have only begun to be exploited, whereas the same potentials of copper cable are pushing their limits. To give perspective to the incredible capacity that fibers are moving toward, a 10GHz (10×10^9) signal has ability to transmit any of the following per second.

a) 1,000 books
b) 130,000 voice channels

Loss indicates how far the information can be sent. As a signal travels along a transmission path, be it copper or fiber, the signal loses strength. The loss of strength is called attenuation. In a copper cable, attenuation increases with frequency. The higher the frequency of the information signal, the greater the loss. In an optical fiber, attenuation is flat. Loss is the same at any signaling frequency up until a very high frequency. The combination of high bandwidth and low loss has made the telephone industry probably the heaviest user of fiber optics.

Unlike copper cables, optical fibers do not radiate or pick-up electromagnetic radiation. Any copper conductor acts like an antenna, either transmitting or receiving energy. One piece of electronic equipment can emit electromagnetic interference (EMI) that disrupts other equipment. Among reported problems resulting from EMI are the following:

- An electronic cash register interfered with aeronautical transmissions at 113MHz.
- Coin-operated video games interfered with police radio transmissions in the 42MHz band.
- Some personal computers tested by the Federal Communications Commission (FCC) in 1979 emitted enough radiation to disrupt television reception several hundred feet away.

Since fibers do not radiate or receive electromagnetic energy, they make an ideal transmission medium when EMI is a concern. Furthermore, signals do not become distorted by EMI in fiber. As a result, fiber offers very high standards in error-free transmission.[4]

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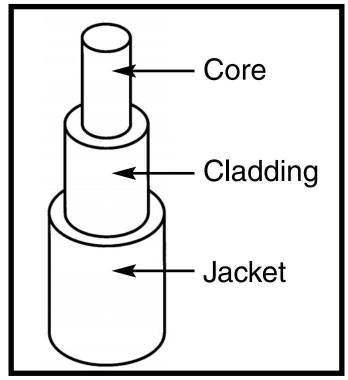
FIBER MATERIAL

There are many materials that can be used to transmit light. The two most popular optical fibers are glass, which has the best optical characteristics, and plastic. Plastic is less expensive and does not break easily. This kit uses a plastic optical cable similar to the one shown.



Plastic Optical Cable

SECTION B

PRINCIPLES OF LIGHT

WAVELENGTH

Light occupies only a small portion of the electromagnetic spectrum shown in Figure 2A. The equation $\lambda = c/f$ is used to convert frequency to wavelength, where λ = wavelength, c = speed of light, and F = Frequency of the light wave.

Note that in Figure 2A, the visible range of light is approximately 380 x 10^{-9} meters (violet) to 750 x 10^{-9} meters (red). When using plastic as the fiber optic cable medium, the best results occur around 660 x 10^{-9} (orange-red).

Light also can be thought of as little bundles of energy being rapidly transmitted. These discrete groups of energy are called photons, and the amount of energy present in each photon is dependent on the frequency at which they are transmitted. Higher frequencies produce more energy than lower frequencies of light. The equation for the amount of energy in each photon is $E = hf$. Where E = energy in joules, h is Planck's constant (6.63 x 10^{-34} joules-seconds), and f is the frequency in hertz.

It is important to remember that light can be explained on a wave or a photon energy packet when investigating the properties of fiber optics.

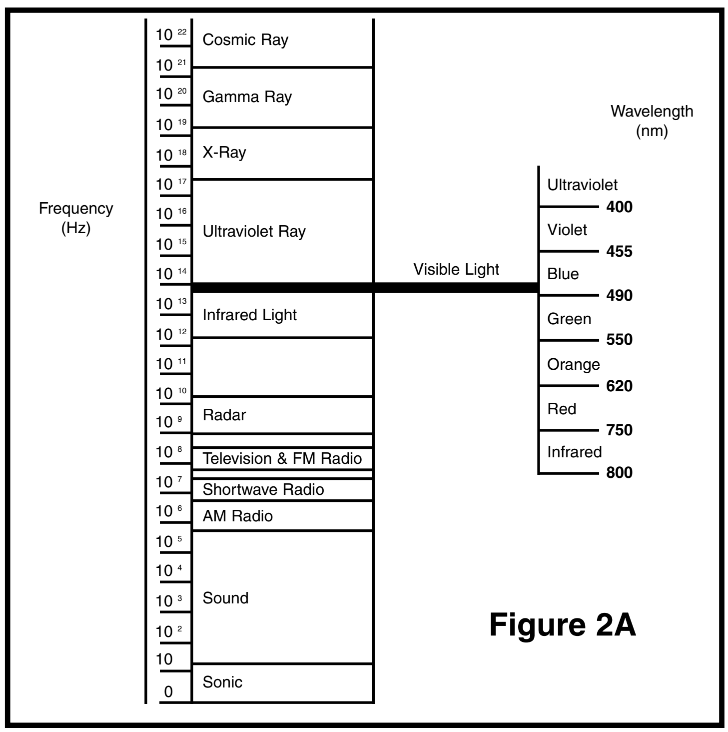


Figure 2A

REFRACTION

The speed of light can be defined as the velocity of electromagnetic energy in a vacuum such as space. The speed of light will vary as it travels from one material to another, which, because of wave motion, results in light changing its direction. This change of direction of light is called refraction. In addition, different wavelengths of light travel at different speeds in the same material.

The best example of refraction if the prism of Figure 2B. White light entering the prism contains all colors. The prism refracts the light and changes speed as it enters the prism. Because each color or frequency changes speed differently, each is refracted differently. Red light deviates the least and travels the fastest, while violet light deviates the most and travels the slowest. The white light then emerges from the prism divided into the colors of the rainbow.[5]

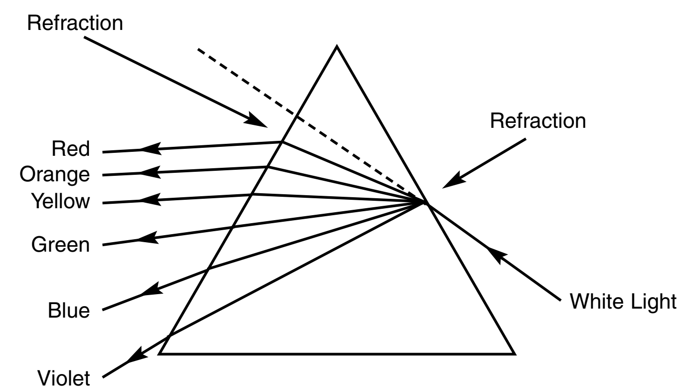


Figure 2B

REFRACTIVE INDEX

One of the important measures that you often come across in light is refractive index. The refractive index can be defined as the ratio of the speed of light in a vacuum to the speed of light in a material.

n = c(vacuum) / c(material)

where: **n** is the refractive index
c is the speed of light

Since the speed of light in a vacuum is always faster that the speed of light in any material, the refractive index is always greater than one. The amount that a ray of light is refracted depends on the refractive index of the two materials.

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REFLECTION

Before trying to explain reflection, we must first define some important terms shown in Figure 2C.

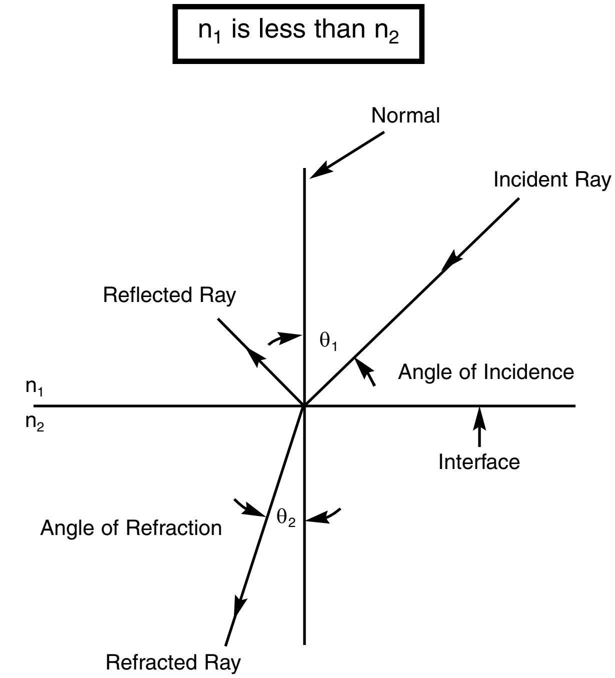

Figure 2C

- The normal is an imaginary line perpendicular to the interface of the two materials.
- The angle of incidence (θ_1) is the angle between the incident ray and the normal.
- The angle of refraction (θ_2) is the angle between the refracted ray and the normal.

Light passing from a lower refractive index to a higher one is bent toward the normal, as shown in Figure 2C. Light going from a higher index to a lower will refract away from the normal, as shown in Figure 2D-1. As the angle of incidence increases, the angle of refraction approaches 90^{o} to the normal. The angle of incidence that yields an angle of refraction of 90^{o} to the normal is the critical angle as shown in Figure 2D-2. If the angle of incidence increases past the critical angle, the light is totally reflected back to the first material so that it does not enter the second material as shown in Figure 2D-3. The angles of incidence and reflection are equal.[6]

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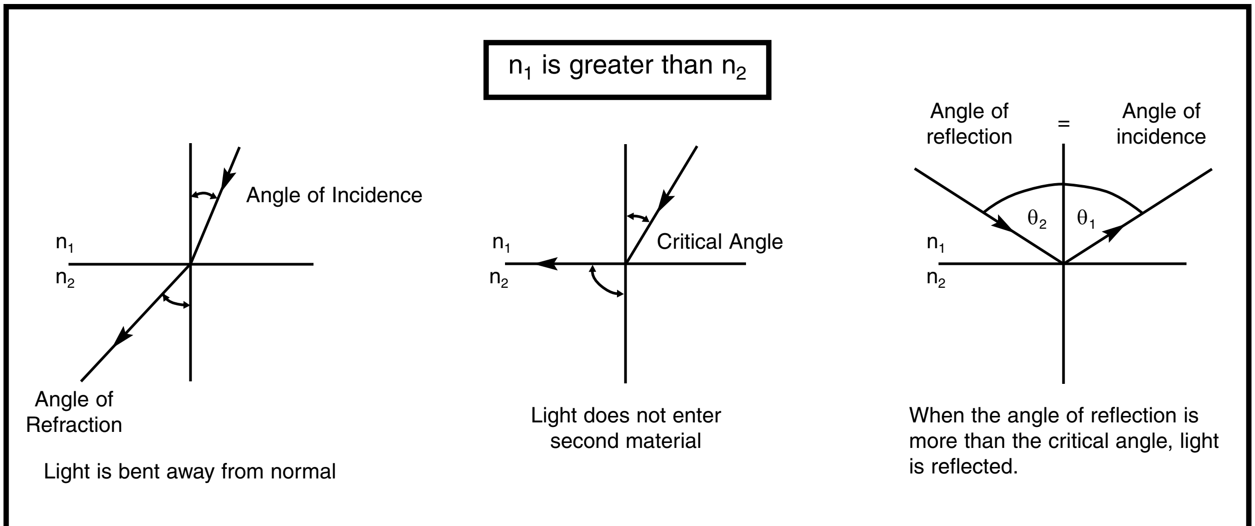

Figure 2D-1 **Figure 2D-2** **Figure 2D-3**

Figure 2D

SNELL'S LAW

Snell's Law states the relationship between the incident and refracted rays.

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

where: n_1 and n_2 are refractive indexes
θ_1 and θ_2 are angle of incidence and angle of refraction respectively.

The law shows that the angles depend on the refracted indices on the two materials. Knowing any three of the values, of course, allows us to calculate the fourth through simple rearrangement of the equation.

The critical angle of incidence θc, where $\theta_2 = 90^\circ$, is

$\theta c = \arcsin (n_2/n_1)$

At an angle greater than θc, the light is reflected. Because reflected light means that n_1 and n_2 are equal (since they are in the same material), θ_1 and θ_2 are also equal. The angle of incidence and reflection are equal. These simple principles of refraction and reflection form the basis of light propagation through an optical fiber.[7]

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OPTICAL FIBER CONSTRUCTION

The optical fiber has two concentric layers called the core and the cladding. The inner core is the light-carrying part. The surrounding cladding provides the difference in the refractive index that allows total internal reflection of light through the core. The fiber usually has an additional coating around the cladding. The coating, which is usually one or more layers of polymer, protects the core and cladding from shock that might affect their optical or physical properties. Figure 2E shows the cross-section of an optical cable.[8]

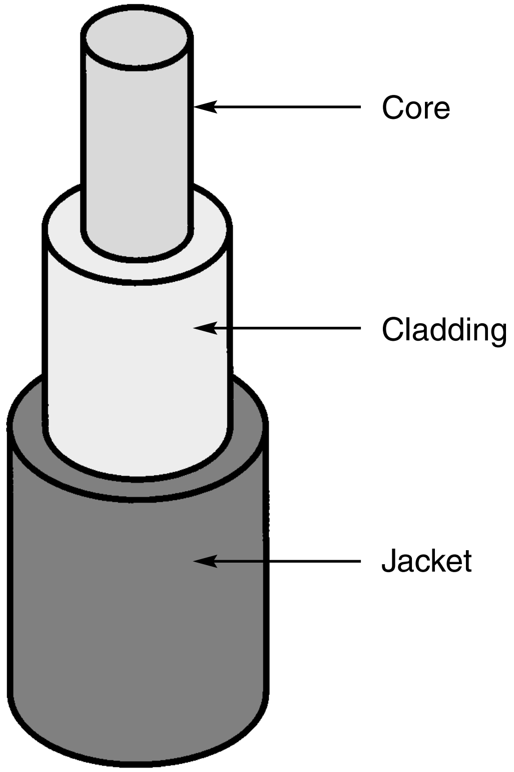

Figure 2E

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HOW LIGHT TRAVELS THROUGH AN OPTICAL CABLE

To best understand how light propagates through an optical fiber, let us look at an example. Assume that the core has a refractive index (n_1) of 1.48 and the cladding has a refractive index (n_2) of 1.46 (these values are typical for optical fibers). By applying Snell's Law, we can calculate the critical angle:

$\theta c = \arcsin (n_2/n_1)$

$\theta c = \arcsin (1.46/1.48) = 80.6^\circ$ or approximately 81°

Figure 2F shows that as light rays are injected into the fiber, they strike the core-to-cladding interface at an angle greater than that of the critical angle (80.6°). As a result, the light will reflect back to the core. Since the angles of incidence and reflection are equal, the reflected light will again be reflected. The light will continue zig-zagging down the length of the fiber. Any light that strikes the interface at less than the critical angle will be absorbed by the cladding. This total internal reflection forms the basis of light propagation through a simple optical fiber.[9]

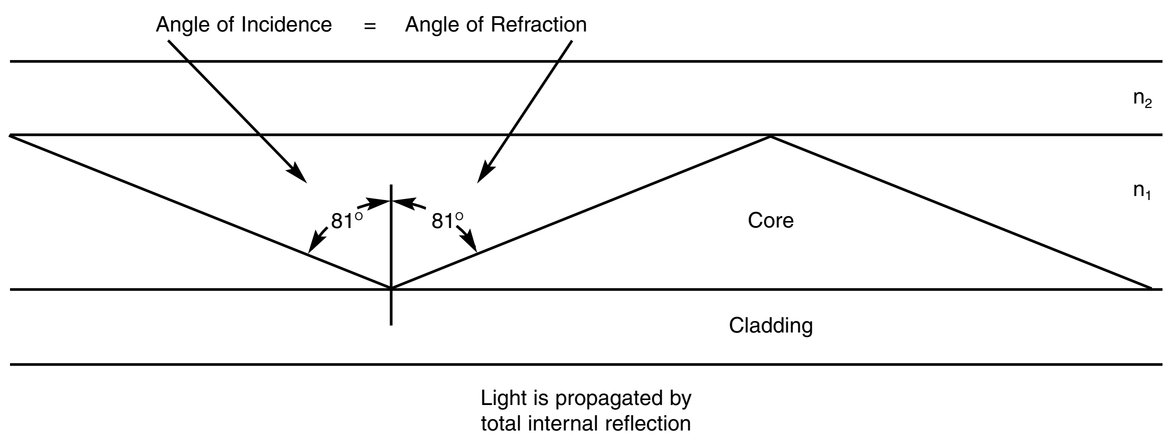

Figure 2F

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AN IMPORTANT UNIT IN FIBER OPTICS (THE DECIBEL)

The decibel is an important unit that you will use continually in fiber optics as well as in electronics. It is used to express gain or loss in a system or component. A transistor, for example, can amplify a signal, making it stronger by increasing its voltage, current or power. This is called gain. Similarly, loss is a decrease in voltage, current, or power. The basic equations for the decibel are:

$$dB = 20 \log_{10} (V_1/V_2)$$
$$dB = 20 \log_{10} (I_1/I_2)$$
$$dB = 10 \log_{10} (P_1/P_2)$$

Where V is voltage, I is current, and P is power. The decibel then is the ratio of two voltages, currents, or powers. Notice that voltage and current are 20 times the logarithmic ratio, and power is 10 times the ratio.

The basic use of the decibel is to compare the power entering the system, circuit, or component to the power leaving it. In fiber optics, we deal mostly with loss and optical power. The source emits optical power. As light travels through the fiber to the receiver, it loses power. This power loss is expressed in decibels. For example, if the source emits 1,000 microwatts (μW) of power and the detector receives 20μW, the loss through the system is about 17dB.

$$\text{Loss} = 10 \log_{10} (P_r/P_{tr})$$
$$= 10 \log_{10} (20/1,000)$$
$$= -16.989 \text{ dB}$$

Where P_{tr} is the power transmitted from the source and P_r is power received by the receiver. A 10dB loss represents a loss of 90% of the power; only 10% remains. A useful figure to remember is 3dB, which represents a loss of one half of the power.

Fiber optic links easily tolerate losses of 30dB, meaning that 99.9% of the power from the source is lost before it reaches the detector. If the source emits 1,000μW of power, only 1μW reaches the detector. In fiber optics, it is common to omit the negative sign.[10]

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HOW TO TERMINATE AN OPTICAL FIBER

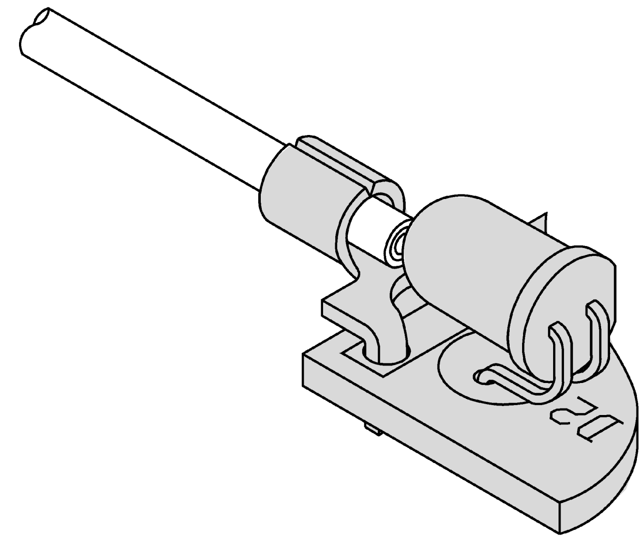
Both ends of the optical cable are terminated in the same way. Please follow the steps below.

1) Use a razor blade (a very sharp knife will do) to cut the cable at a right angle to the length of the cable. Make the cut as close to 90^{o} as possible.

2) Place the polishing paper on a work bench or other flat surface, and apply a few drops of water or oil to it. Hold the cable at a right angle to the polishing paper and polish the end that was just cut. The cable should not flex while polishing. To avoid flexing, clamp the cable between the two PC boards with only a small length of the cable extending beyond the edge of the PC board.

3) Repeat steps 1 and 2 for the other end.

4) Mount the two ends of the cable to the two connectors on the transmitter and receiver PC board as shown in the figure.



QUIZ 2

1. The three most important features of fiber optics are _________, _________ and __________.

2. Bandwidth is an indication of the _________ at which information can be sent.

3. The loss of signal strength is called ________.

4. The two most popular optical fibers are ________ and _________.

5. Unlike copper cables, optical fibers do not radiate or pick up _________.

6. The Decibel is a unit used to express _________ or _________ in a system or component.

7. Refractive index is the ratio of the speed of _________ in vacuum to the speed of _________ in any material.

8. If the angle of incidence is greater than the critical angle, light will completely _______ back.

9. The optical fiber has two concentric layers called the _________ and __________.

10. The total internal _________ forms the basis of light propagation through a simple optical fiber.

Answers: (1) wide bandwidth, low loss, electromagnetic immunity (2) rate (3) attenuation (4) glass, plastic (5) radiation (6) loss, gain (7) light, light (8) reflect (9) cladding, core (10) reflection

RECEIVER SECTION

PARTS LIST

If you are a student, and any parts are missing or damaged, please see instructor or bookstore. If you purchased this fiber optics kit from a distributor, catalog, etc., please contact ELENCO® (address/phone/e-mail is at the back of this manual) for additional assistance, if needed. **DO NOT** contact your place of purchase as they will not be able to help you.

RESISTORS

Qty.	Symbol	Value	Color Code	Part #
❒ 1	R3	10Ω 5% 1/4W	brown-black-black-gold	121000
❒ 1	R2	2.2kΩ 5% 1/4W	red-red-red-gold	142200
❒ 1	R1	200Ω Pot		191322

CAPACITORS

Qty.	Symbol	Value	Description	Part #
❒ 3	C1, C3, C5	.047μF (473)	Mylar	244717
❒ 1	C6	10μF	Electrolytic	271045
❒ 1	C2	47μF	Electrolytic	274744
❒ 1	C4	220μF	Electrolytic	282244

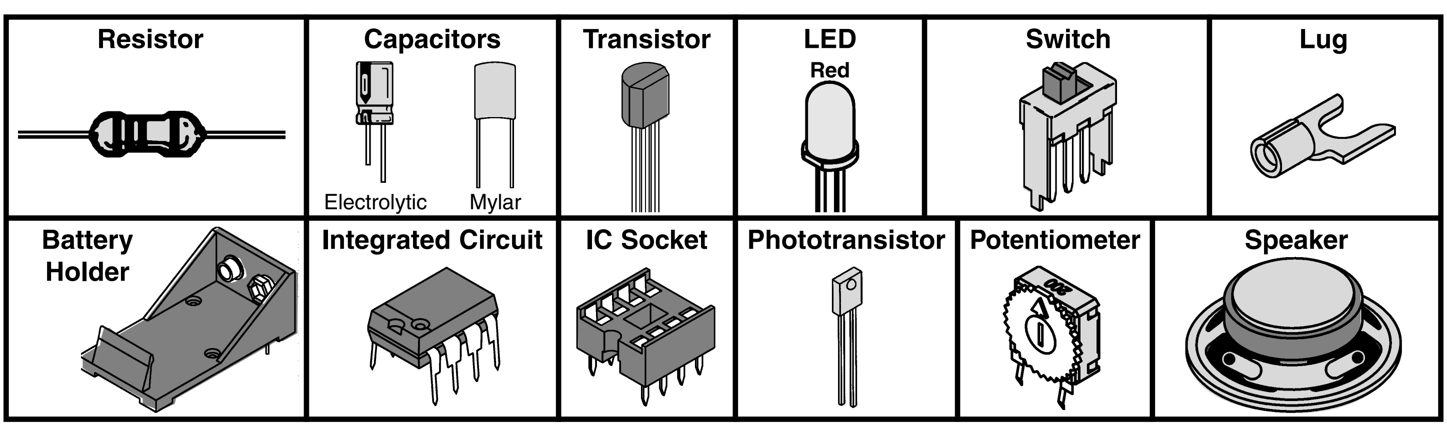
SEMICONDUCTORS

Qty.	Symbol	Value	Description	Part #
❒ 1	Q1	LPT80A	Phototransistor	32T80A
❒ 1	U1	LM-386	Audio Op-amp Integrated Circuit	330386
❒ 1	D1		LED Red	350002

MISCELLANEOUS

Qty.	Description	Part #	Qty.	Description	Part #
❒ 1	PC Board	519015B	❒ 2	Nuts 2-56	644201
❒ 1	Switch	541103	❒ 1	Lug	661106
❒ 1	Battery Holder	590096	❒ 1	IC Socket 8-pin	664008
❒ 1	Speaker	590102	❒ 6”	Wire 22ga. Black	814120
❒ 2	Screws 2-56 x 1/4”	641230	❒ 6”	Wire 22ga. Red	814220

PARTS IDENTIFICATION



RECEIVER

There are 4 main components in the receiver (refer to Figure 3). They are:

a) Power Supply (9V battery)
b) Phototransistor LPT80A (the detector)
c) Audio op-amp LM-386
d) Speaker

The phototransistor Q1 (LPT80A) used in a common-collector configuration has high current gain. This transistor acts as a valve which controls the flow of current to the potentiometer R1. The flow of current is directly proportional to the intensity of light striking the base. The more intense the light, the more current will flow through transistor Q1. The current will then be coupled to the audio amplifier (LM386) through capacitor C1 for amplification.

The gain of the audio amplifier (LM386) is internally set to 20. Hence, the voltage signal that is coupled through C1 to input pin 2 will be amplified 20 times, and will appear on the output of the op-amp (pin 5).

The above amplified voltage will then be coupled through C4 to the speaker. The speaker then converts this voltage into sound.

The LED (D1) acts as an ON/OFF indicator. It will also indicate the state of the battery. If this LED becomes dim, the battery is weak and should be replaced. C2 filters out any noise at the power supply (9V battery).

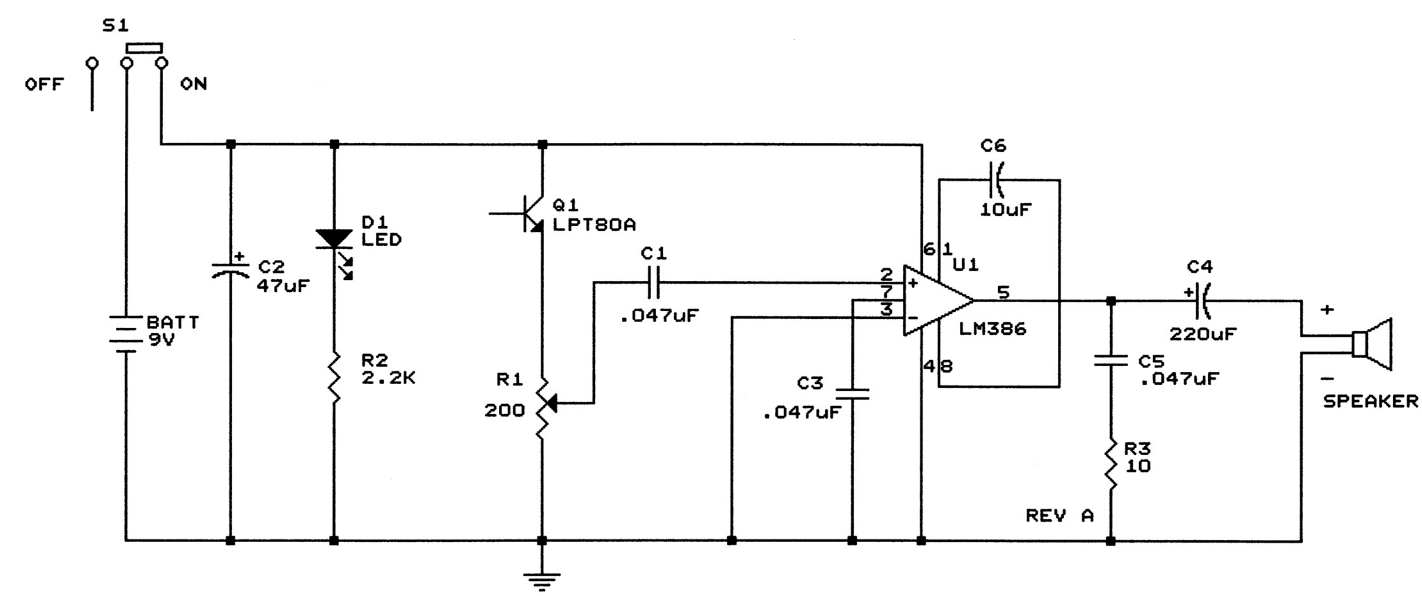
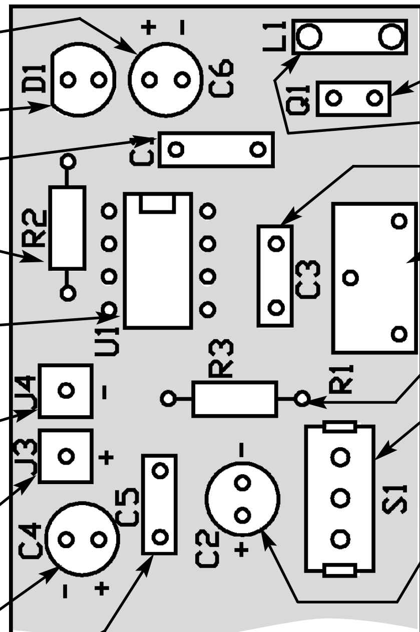


Figure 3A

ASSEMBLY INSTRUCTIONS FOR RECEIVER

- ☐ C6 - 10μF Electrolytic Capacitor (see Figure B)
- ☐ D1 - LED (see Figure A)
- ☐ C1 - .047μF Mylar Cap. (473)
- ☐ R2 - 2.2kΩ 5% 1/4W Resistor (red-red-red-gold)
- ☐ 8-Pin IC Socket
- ☐ U1 - LM386N Integrated Circuit (see Figure C)
- ☐ 6” Black Wire - Strip 1/8” of insulation off of both ends of the wire.
- ☐ 6” Red Wire - Strip 1/8” of insulation off of both ends of the wire.
- ☐ C4 - 220μF Electrolytic Capacitor (see Figure B)
- ☐ C5 - .047μF Mylar Cap. (473)



- ☐ Q1 - Phototransistor (see Figure D)
- ☐ L1 - Lug (see Figure E)
- ☐ C3 - .047μF Mylar Cap. (473)
- ☐ R1 - 200Ω Pot (see Figure F)
- ☐ R3 - 10Ω 5% 1/4W Resistor (brown-black-black-gold)
- ☐ S1 - Switch
- ☐ C2 - 47μF Electrolytic Capacitor (see Figure B)

Figure A

Mount the LED with the flat side in the same direction as marked on the top legend.

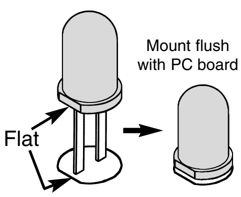


Figure B

Electrolytics have a polarity marking indicating the (–) lead. The PC board is marked to show the lead position.

Warning: If the capacitor is connected with incorrect polarity, it may heat up and either leak or cause the capacitor to explode.

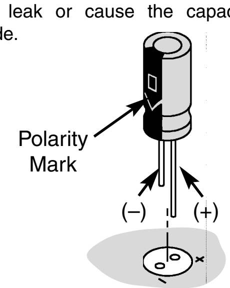


Figure C

Insert the IC socket into the PC board with the notch in the direction shown on the top legend. Solder the IC socket into place. Insert the IC into the socket with the notch in the direction as the notch on the socket.

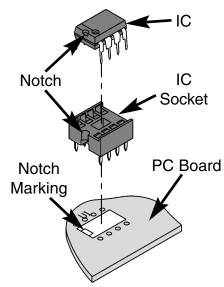


Figure D

Insert the phototransistor into the PC board in the direction shown.

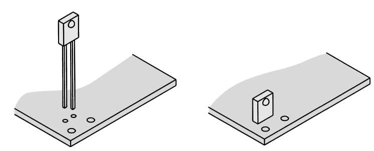


Figure E

Mount the lug as shown. Make sure that the phototransistor lens lines up with the lug hole.

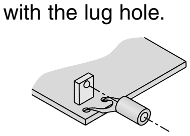
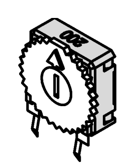


Figure F



☐ Screws and Nuts

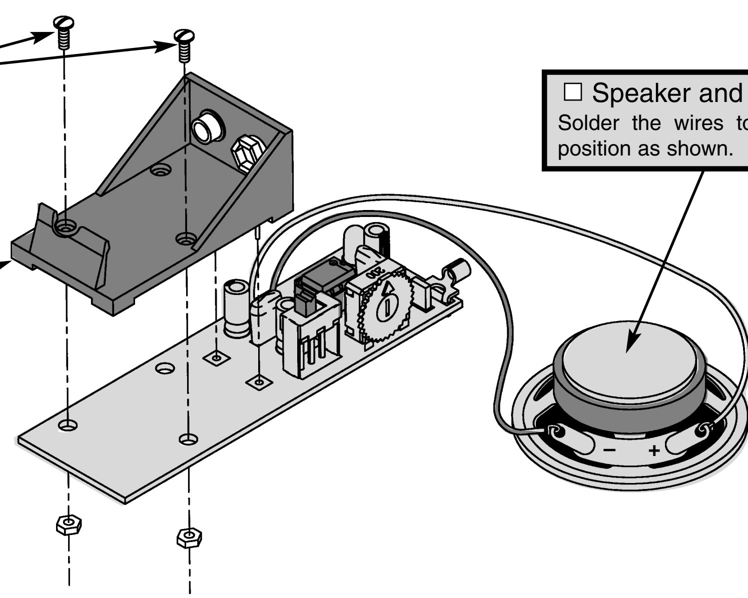
Mount the two screws in the position as shown. Place the nuts on the screws and tighten them from the back side of the PC board.

☐ Speaker and 2 Wires

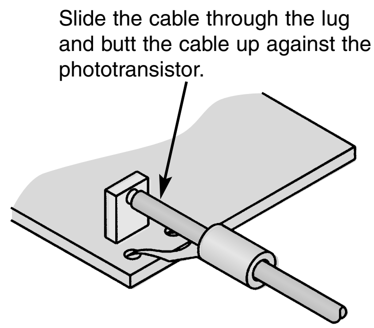
Solder the wires to the correct position as shown.

☐ 9V Battery Holder

Solder the 9V battery holder to pad J1 and J2 in the correct position as shown.



INSERT THE CABLE



TESTING PROCEDURE

1. Plug a fresh 9 volt battery into the battery holder.
2. Turn S1 on (toward the pot), observe that LED D1 is on.
3. If you have a voltmeter, measure the DC voltage at pin 5, it should be about 4V.
4. Connect one end of the fiber to the source connector to the transmitter, and the other end to the detector connector of the receiver. Make sure switch S2 of the transmitter is in the off position (toward the battery). Now, speak into the microphone. You should hear your voice from the speaker of the receiver. Now, place C4 into the circuit by sliding switch S2 toward the infrared LED. You should hear a shrill noise from the speaker.

QUIZ 3

1. The receiver consists of 4 main components. They are _________, _________, _________ and ________.
2. The phototransistor Q1 converts a __________ signal into an __________ signal.
3. The flow of the current through Q1 is directly proportional to the ________ of light that strikes its base.
4. The gain of the audio amplifier (LM386) is internally set to _________.
5. The amplifier signal is coupled to the speaker through __________.
6. The speaker converts an _________ signal into a _________ signal.
7. The LED D1 acts as an _________ indicator.
8. C2 filters out any __________ at the power supply.
9. The pot R1 is a __________ control device.
10. The LM386 chip is an __________ amplifier.

Answers: (1) power supply, phototransistor, audio op-amp, speaker (2) light, electrical (3) intensity (4) 20 (5) C4 (6) electrical, sound (7) On-Off (8) noise (9) volume (10) audio

TROUBLESHOOTING GUIDE

TRANSMITTER

PROBLEM	POSSIBLE CAUSE
IF LED D1 DOES NOT LIGHT	Check battery connection. Check orientation of D1. Check soldering around S1.
THERE IS NO DIM RED GLOW FROM THE TRANSMITTER LED D2	Check the value of R1, R4, R5 and orientation of transistor Q1 and U1. Check soldering around Q1 and U1.
THERE IS NO WAVEFORM ON THE OSCILLOSCOPE WHEN S2 IS ON	Check soldering around S2. Check the value of C4. Check soldering around U1.
THERE IS NO VOICE SIGNAL ON TEST POINT TP	Check resistors R2, R4, R5, and R6. Check microphone orientation. Check capacitors C1 and C3. Check U1.

RECEIVER

PROBLEM	POSSIBLE CAUSE
IF LED D1 DOES NOT LIGHT	Check battery connection. Check orientation of D1 or battery life. Check soldering around S1.
NO SOUND FROM THE SPEAKER	Check speaker and C4 orientation. Check U1 orientation and soldering. Check fiber optic cable connection.
THE OUTPUT VOLTAGE IS NOT EQUAL TO 4V	Check orientation of U1. Check soldering around S1, R1, U1, C5 and C4.

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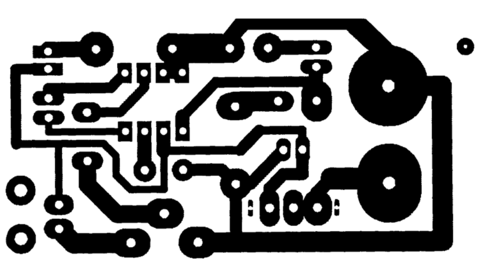
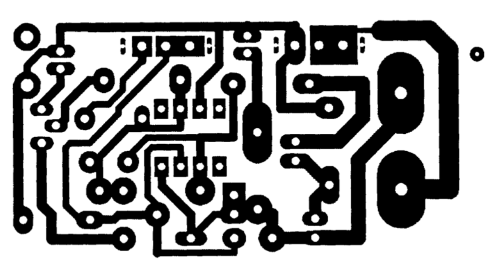
Foil Side of Receiver PC Board



Foil Side of Transmitter PC Board



GLOSSARY[11]

ABSORPTION	Loss of power in an optical fiber, resulting from conversion of optical power into heat and caused principally by impurities, such as transition metals and hydroxyl ions, and also exposure to nuclear radiation.
ANGLE OF INCIDENCE	Angle between the incident ray and the normal.
ANGLE OF REFRACTION	Angle between the refracted ray and the normal.
ATTENUATION	A general term indicating a decrease in power from one point to another. In optical fibers, it is measured in decibels per kilometer at a specified wavelength.
BANDWIDTH	A range of frequencies.
CABLE	A fiber covered by a protective jacket.
CAPACITOR	A capacitor stores electrical energy when charged by a DC source. It can pass alternating current (AC) but blocks direct current (DC) except for a very short charging current, called transient current.
CLADDING	The outer concentric layer that surrounds the core and has a lower index of refraction.
CONNECTOR	A connector is a device which is used to connect both ends of the fiber to the source and detector.
CORE	The central, light-carrying part of an optical fiber; it has an index of refraction higher than the surrounding cladding.
dB	Decibel.
DECIBEL	A standard logarithmic unit for the ratio of two powers, voltages or currents. In fiber optics, the ratio is power. $dB = 10 \log_{10} (P_1/P_2)$
ELECTROMAGNETIC INTERFERENCE	Any electrical or electromagnetic energy that causes undesirable response, degradation, or failure in electronic equipment. Optical fibers neither emit nor receive EMI.
EMI	Electromagnetic interference.
FIBER	A light-carrying conductor made up of glass or plastic.
INDEX OF REFRACTION	The ratio of the velocity of light in free space to the velocity of light in a given material. Symbolized by n.
INTERFACE	Surface that separates two materials.
LED	Light-emitting diode.
LIGHT	Electromagnetic radiation which is visible to the human eye.
LIGHT EMITTING DIODE	A semiconductor diode that spontaneously emits light from the PN junction when forward current is applied.
NORMAL	An imaginary line perpendicular to the interface of two materials.
OP AMP	A semiconductor device which is used to amplify current, voltage, or power.
PHOTON	A photon of electromagnetic energy. A “particle” of light.
PHOTO-TRANSISTOR	A transistor that detects light.
PLASTIC FIBER	An optical fiber having a plastic core and plastic coating.
PC BOARD	Its full name is printed circuit board. It is a conductive pattern glued to one or both sides of an insulating material. Holes are punched or drilled through the conductor and board to allow the interconnection of electronic parts.
PRISM	A device which splits white light into a rainbow of colors.
SOURCE	The light emitter, either an LED or a laser diode in a fiber optic link.
WAVELENGTH	The distance between the same two points on adjacent waves.

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Fiber Optic Tool Kit

Model TK-5000

Includes:

- **C-200** Case
- **ST-92** Viewing microscope
- **C-10** Parts case
- **ST-90** Fiber continuity tester
- **ST-88** Fiber optical stripper
- **ST-91** Carbide fiber scribe
- **ST-340** Kevlar scissors
- **ST-950** Hex-type crimping tool
- **ST-86** Polishing pad SC (37.8mm)
- **ST-87** Polishing pad ST (32.8mm)
- **ST-89** Foam swab cleaning kit

Fiber Continuity Tester

Model ST-90

Powerful Krypton light source provides long range over multimode fiber.

Requires two “AA” batteries. Included with kit.

Fiber Optic Viewing Scope Kit

Model ST-92

This fiber optic viewing scope kit makes it simple to view ST/SC/FC - supplied with dual face plates.

Zoom lens: 160X, 180X, and 200X.

Requires two “AA” batteries. Included with kit.

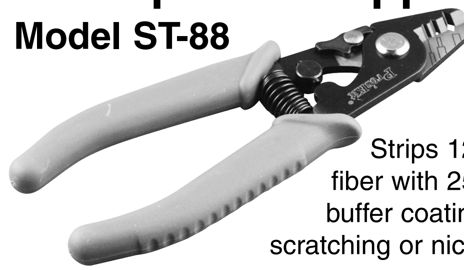
Carbide Fiber Scribe

Model ST-91

Wide inclined carbide tip for easy cleaving. Lightweight, pen-size body clips to shirt pocket.

Fiber Optical Stripper

Model ST-88



Strips 125 micron fiber with 250 micron buffer coating without scratching or nicking fiber.

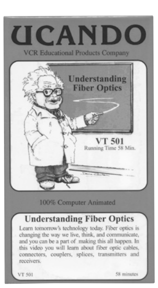
Fiber Optic Lab Kit

with training course Model FO-40K

The course includes a 61 page manual and all of the material necessary to conduct nine stimulating experiments related to fiber optic communications. The experiments will give you a better understanding of fiber optics techniques and real fiber optics hardware.

Understanding Fiber Optics

Model VT-501

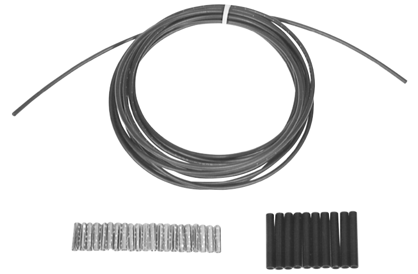


Learn tomorrow’s technology today! Fiber optics is changing the way we live, think and communicate. You will learn about fiber optic cables, connectors, couplers, splicers, transmitters and receivers.
58 minutes viewing time.

Fiber Optic Splice Kit

Model TK-25

For mending or extending 1,000µm plastic fiber. It contains fiber sleeves and retention clips to complete ten splices. No special tools, polishing or adhesive required. Instructions included.



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