HOW FIBER OPTICS WORK

A fiber-optic wire

You hear about fiber-optic cables whenever people talk about the telephone system, the cable TV system or the Internet. Fiber-optic lines are strands of optically pure **glass** as thin as a human hair that carry digital information over long distances. They are also used in medical imaging and mechanical engineering inspection.

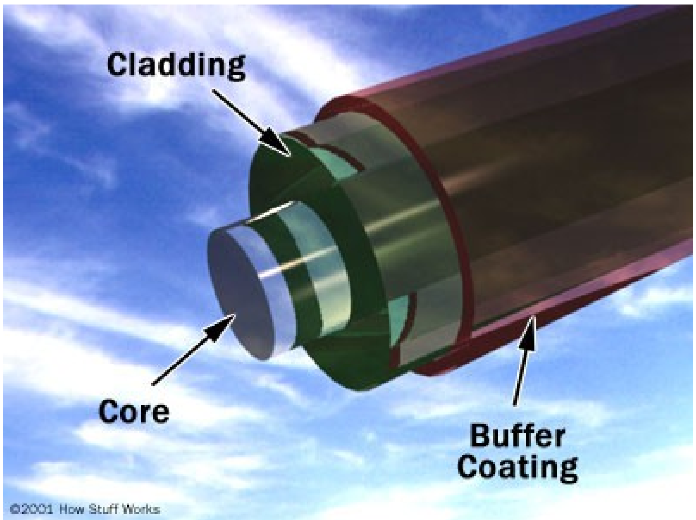
What are Fiber Optics?
Fiber optics (optical fibers) are long, thin strands of very pure glass about the diameter of a human hair. They are arranged in bundles called **optical cables** and used to transmit light signals over long distances.

Parts of a single optical fiber

If you look closely at a single optical fiber, you will see that it has the following parts:

- **Core** - Thin glass center of the fiber where the light travels
- **Cladding** - Outer optical material surrounding the core that reflects the light back into the core
- **Buffer coating** - Plastic coating that protects the fiber from damage and moisture

Hundreds or thousands of these optical fibers are arranged in bundles in optical cables. The bundles are protected by the cable's outer covering, called a **jacket**.
Optical fibers come in two types:



- **Single-mode fibers**
- **Multi-mode fibers**

Single-mode fibers have small cores (about 3.5 x 10^{-4} inches or 9 microns in diameter) and transmit infrared laser light (wavelength = 1,300 to 1,550 nanometers). **Multi-mode fibers** have larger cores (about 2.5 x 10^{-3} inches or 62.5 microns in diameter) and transmit infrared light (wavelength = 850 to 1,300 nm) from light-emitting diodes (LEDs).

LEDs

Some optical fibers can be made from **plastic**. These fibers have a large core (0.04 inches or 1 mm diameter) and transmit visible red light (wavelength = 650 nm) from LEDs.

Multimode fibers

How Does an Optical Fiber Transmit Light?

Suppose you want to shine a flashlight beam down a long, straight hallway. Just point the beam straight down the hallway -- light travels in straight lines, so it is no problem. What if the hallway has a bend in it? You could place a mirror at the bend to reflect the light beam around the corner. What if the hallway is very winding with multiple bends? You might line the walls with mirrors and angle the beam so that it bounces from side-to-side all along the hallway. This is exactly what happens in an optical fiber.

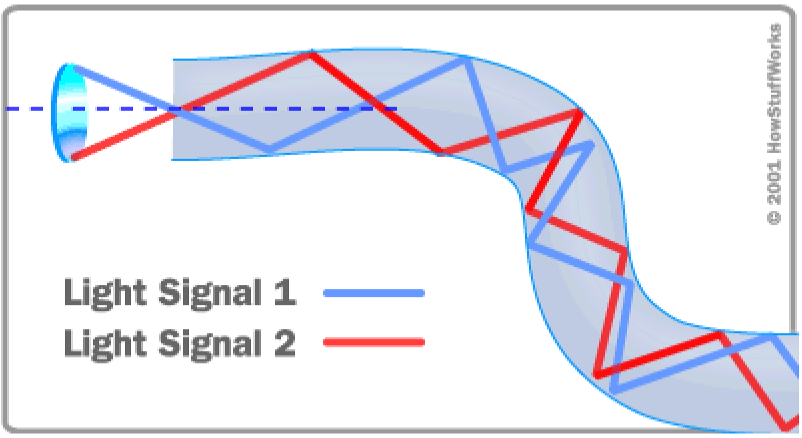


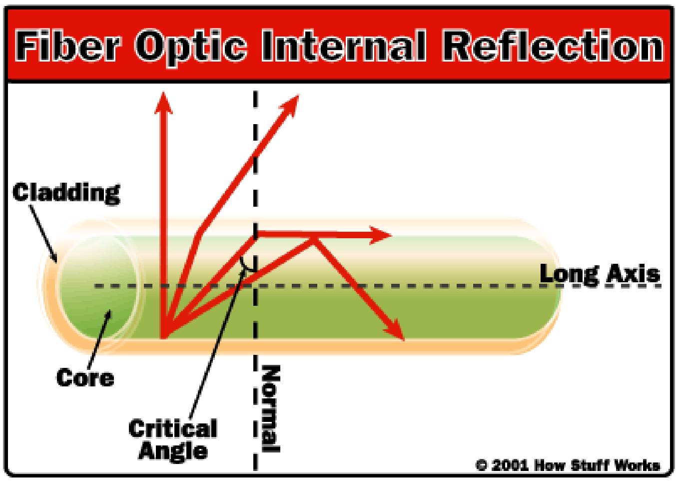
Diagram of total internal reflection in an optical fiber

The light in a fiber-optic cable travels through the core (hallway) by constantly bouncing from the cladding (mirror-lined walls), a principle called **total internal reflection**. Because the cladding does not absorb any light from the core, the light wave can travel great distances. However, some of the light signal **degrades** within the fiber, mostly due to impurities in the glass. The extent that the signal degrades depends on the purity of the glass and the wavelength of the transmitted light (for example, 850 nm = 60 to 75 percent/km; 1,300 nm = 50 to 60 percent/km; 1,550 nm is greater than 50 percent/km). Some premium optical fibers show much less signal degradation -- less than 10 percent/km at 1,550 nm.

A fiber-optic relay system

To understand how optical fibers are used in communications systems, let's look at an example from a World War II movie or documentary where two naval ships in a fleet need to communicate with each other while maintaining radio silence or on stormy seas. One ship pulls up alongside the other. The captain of one ship sends a message to a sailor on deck. The sailor translates the message into **Morse code** (dots and dashes) and uses a **signal light** (floodlight with a venetian blind type shutter on it) to send the message to the other ship. A sailor on the deck of the other ship sees the Morse code message, decodes it into English and sends the message up to the captain.
Imagine doing this when the ships are on either side of the ocean separated by thousands of miles and you have a fiber-optic communication system in place between the two ships. Fiber-optic relay systems consist of the following:

- **Transmitter** - Produces and encodes the light signals
- **Optical fiber** - Conducts the light signals over a distance
- **Optical regenerator** - May be necessary to boost the light signal (for long distances)
- **Optical receiver** - Receives and decodes the light signals



Transmitter

The **transmitter** is like the sailor on the deck of the sending ship. It receives and directs the optical device to turn the light "on" and "off" in the correct sequence, thereby generating a light signal.
The transmitter is physically close to the optical fiber and may even have a lens to focus the light into the fiber. Lasers have more power than LEDs, but vary more with changes in temperature and are more expensive. The most common wavelengths of light signals are 850 nm, 1,300 nm, and 1,550 nm (infrared, non-visible portions of the spectrum).

Optical Regenerator

As mentioned above, some **signal loss** occurs when the light is transmitted through the fiber, especially over long distances (more than a half mile, or about 1 km) such as with undersea cables. Therefore, one or more **optical regenerators** is spliced along the cable to boost the degraded light signals.
An optical regenerator consists of optical fibers with a special coating (**doping**). The doped portion is "pumped" with a laser. When the degraded signal comes into the doped coating, the energy from the laser allows the doped molecules to become lasers themselves. The doped molecules then emit a new, stronger light signal with the same characteristics as the incoming weak light signal. Basically, the regenerator is a laser amplifier for the incoming signal.

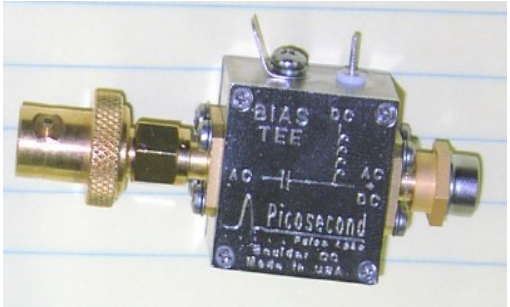
Optical Receiver

The **optical receiver** is like the sailor on the deck of the receiving ship. It takes the incoming digital light signals, decodes them and sends the electrical signal to the other user's computer, TV or telephone (receiving ship's captain). The receiver uses a **photocell** or **photodiode** to detect the light.

Advantages of Fiber Optics

Why are fiber-optic systems revolutionizing telecommunications? Compared to conventional metal wire (copper wire), optical fibers are:

- Less expensive
- Thinner
- Higher carrying capacity
- Non-flammable
- Lightweight
- Flexible
- Medical imaging
- Mechanical imaging
- Plumbing



Photodiode

How Are Optical Fibers Made?

Optical fibers are made of extremely pure **optical glass**. We think of a glass window as transparent, but the thicker the glass gets, the less transparent it becomes due to impurities in the glass. However, the glass in an optical fiber has far fewer impurities than window-pane glass. One company's description of the quality of glass is as follows: If you were on top of an ocean that is miles of solid core optical fiber glass, you could see the bottom clearly.

Testing the Finished Optical Fiber

Finished spool of optical fiber

The finished optical fiber is tested for the following:

- Tensile strength - Must withstand 100,000 lb/in^2 or more
- Refractive index profile - Determine numerical aperture as well as screen for optical defects
- Fiber geometry - Core diameter, cladding dimensions and coating diameter are uniform
- Attenuation - Determine the extent that light signals of various wavelengths degrade over distance
- Information carrying capacity (bandwidth) - Number of signals that can be carried at one time (multi-mode fibers)

- Chromatic dispersion - Spread of various wavelengths of light through the core (important for bandwidth)
- Operating temperature/humidity range
- Temperature dependence of attenuation
- Ability to conduct light underwater - Important for undersea cables

Once the fibers have passed the quality control, they are sold to telephone companies, cable companies and network providers. Many companies are currently replacing their old copper-wire-based systems with new fiber-optic-based systems to improve speed, capacity and clarity.

Task one. ANSWER THE QUESTIONS.

1. What are fiber optics?
2. How can they be used?
3.What the their constituent parts?
4.What types of fibre otpics do you know?
5.How does the light in an optics travel?
6.What happens to the light signal?
7. What is Morse code?
8. What are the components of a relay system?
9. Where are optics used due to their flexibility?
10. What steps are used to produce an optics?

Task two. MATCH THE WORDS WITH THE DEFINITION.

1. core	to be crooked, curved	
2. cladding	to relay or reflect (a signal or message) by a communications satellite	
3. strand	deterioration	
4. spool	the conducting wire and its insulation in a subterranean or submarine cable	
5. bend	a small cylinder of wood or metal on which thread, wire, cord or tape is wound, a reel	
6. bounce	the process of overlaying one metal with another, to give it a corrosion-resisting surface or for other purposes	
7. degradation	the reduction in power, measured by the difference between the power input and power output.	
8. hallway	the metal which resists rust and is easily shaped into thin sheets or fine wire, an excellent conductor of heat and electricity	
9. regeneration	passage, passageway, corridor	
10. loss	one of the threads, strings, or wires that are twisted together to form a rope, cord, line, cable, or electric conductor	
11. photocell	the amplification of the strength of a radio signal by transferring a portion of the power from the output circuit to the input circuit	
12. tensile strength	any cell or vacuum tube, used for the detection and	

	measurement of light, that varies the flow of electric current according to the amount of light falling upon its sensitive element; electric eye; photocell.	
13. copper	the maximum stress that a material can withstand before it breaks, expressed in pounds per square inch	
14. non-flammable	the water pipes and fixtures in a building.	
15. plumbing	that will not catch fire	

Task three. PUT THE WORDS BELOW IN THE APPROPRIATE MORE COMMON SPEECH SENTENCES BELOW.

dispersion, bounce, dots, flammable core, impurities, jacket, image, degrade, reflection

1. The desertion of his dog had touched him to the __________________ .
2. Filtering the water removed its _________________ .
3. I caught the ball on the first ________________ .
4. She was wearing a blue necklace with white ________________ .
5. _________________ is the only real answer to atomic attack .(New York Times)
6. There was still the threat to dust the author's ________________ for the gratification of private malice.
7. You _______________ yourself when you steal.
8. An echo is a __________________ of sound.
9. I can shut my eyes and see ________________ of things and persons.
10. Hair and beards are extremely _________________ in the oxygen-rich atmosphere of a spacecraft (Science News).

Task four. READING. Which line is described?

twisted pair, parallel wires, waveguide, coaxial cable

1. ____________________
This is the simplest type of transmission line consisting of a pair of insulated copper wires running side-by-side and covered by a plastic sheath. It is prone to interference and is used only to carry information over small distances such as telephone connection within a building.
2. ____________________
Two insulated copper wires are twisted together to reduce interference effects and are enclosed in an insulating polyethylene sheath. Because the wires are twisted, unwanted stray signals picked up by one tend to be cancelled by similar signals picked up ny the other. They are used for communications over long distances, for example to connect telephones to their local exchange.
3. ___________________
It has a copper wire core surrounded by copper braid. The core and the braid are insulated from each other by a dielectric material such as polyethilene and covered by a PVC sheath. The braid helps to screen the signals from interference. It can carry a large number of signals over long distances at frequencies up to 1000 MHz. It is used to connect telephone exchanges and for cable TV.
4. ___________________
Microwaves can be guided along rectangular copper ducts by a series of reflections from the inner walls. The exact dimensions of the ducts are determined by the frequency to be

transmitted. Suitable frequencies are between 1 GHz and 300 GHz. They are used to carry microwave signals between dish aerials and receivers.

TERMINATIONS

Para 1

UTP (**unshielded** twisted pair) cables are terminated with standard connectors (plugs and jacks) or punchdowns. The plug/jack is often referred to as a "RJ-45", but that is really a telco designation for the "modular 8 pin connector" **terminated** with a USOC pinout used for telephones. The male connector on the end of a patchcord is called a "plug" and the receptacle on the wall outlet is a "jack."

These terminations are called "IDC" for "insulation-displacement connections," by the way, since the wires are held in knife-edge terminations that slice through the insulation and dig into the copper wire, forming a tight seal.

In LANs, as specified by 568, there are two possible pinouts, called T568A and T568B that differ only in which color coded pairs are connected - pair 2 and 3 are **reversed**. Either work equally well, as long as you don't mix them! If you always use only one version, you're OK, but if you mix A and B in a cable run, you will get crossed pairs!

Each pair consists of a colored wire and a white wire with a matching color stripe. The stripe wire is "tip" and the solid color wire is "ring," referring to the tip of the old 1/4" telephone plug and the ring around the shaft that makes the connections.

Note: **Plugs**/jacks and punchdowns have different color codes! You cannot mix them up as they will result in wire map errors - esp. split pairs which cause big problems with high speed **transmission.**

Para 2

Jacks: The jacks are then terminated with these layouts, looking into the jack:

Note that the only difference between T568A and T568B is the **reversal** of pairs 2 and 3 - it's only a color code change.

The cable color code is the 568B standard on each end of a straight-through 10/100BaseT cable. If a crossover cable is needed, use the 568A standard on one end and 568B on the other end.

However, Cat 5, 5e and 6 jacks have internal connections that continue the twists as close to the **pins** in the jacks as possible. Thus the pin out on the back of the jacks will not usually follow the standard color code layouts- see the pin sequence in the photo above and the twists in the internal connections of the jack here!

Remember: Always follow the color codes on the back of the jacks to insure proper connections!

Plugs: The plugs are terminated by straightening our the wires in proper order and crimping on a **connector.** Like we said before, you MUST keep the twists as close to the plug as possible to minimize cross talk.

Patch cords: They generally use **stranded** wire for flexibility but can be made with solid wire for higher performance. Note that plugs may be different for each type of wire, so make sure you have the right type.

Crossover Cables: Normal cables that connect a PC/NIC card to a Hub are wired straight through. That is pin 1 is connected to pin 1, pin 2 to pin 2, etc.

However, if you are simply connecting two PCs together without a hub, you need to use a **crossover** cable_made by reversing pair 2 and 3 in the cable, the two pairs used for transmission by Ethernet. The easy way to make a crossover cable is to make one end to T568A color coding and the other end to T568B. Then the pairs will be reversed.

Para 3
Punchdowns
Sometimes there are cross connects using punchdowns in the telecom closet, more common on telephone wires than data. These are called punchdowns because the cable is punched down into the IDC contacts with a special tool, called (surprise!) a punchdown tool. Of course, you MUST keep the twists as close to the punchdown as possible to minimize **crosstalk**.
Punchdowns come in 4 varieties: 110, 66, Bix and Krone. Most popular for LANs is the 110 , for telcos it's the 66, and the Bix and Krone are rare (price, proprietary designs, etc.)

Para 4
Color Codes For Punchdowns:
Punchdowns of all types are always made with the pairs in order with the white/stripe wire (tip) first, then the solid colored wire (ring).
Pair 1(w/blue-blue)
Pair 2 (w/orange-orange)
Pair 3 (w/green-green)
Pair 4 (w/brown-brown)
(This color code is often remembered by **B**lue **O**range **G**reen and **B**rown)

Patch Panels
Patch **panels** offer the most flexibility in a telecom closet. All incoming wires are terminated to the back of the patch panel on 110-style punch downs (again watching the 1/2 inch limit of untwisting pairs). Then patch cables are used to interconnect the cables by simply plugging into the proper jacks.

Patch panels can have massive number of cables, so managing these cables can be quite a task in itself. It is important to keep all cables neatly bundled and **labeled** so they can be moved when necessary. However, it is also important to maintain the integrity of the cables, preventing kinking or bending in too small a radius which may adversely affect frequency performance.
(Note: Cat 6 cabling is physically larger in diameter than Cat 5e and usually has a separator for the pairs. The cable construction makes the cable stiffer and more prone to kinking, requiring a larger bend radius.)

TASK ONE. Which words from the text can be matched with the ones described below? There are more marked than necessary.

a short, slender piece of wire with a point at one end and a head at the other, for fastening things together	
the passing through space of radio or television waves	
unprotected	
brought to an end, put an end to, ended	
noises heard in a telephone or radio channel when currents from one channel interfere with those of another	
turned backward, opposite or contrary in position or direction	
a device to make an electrical connection.	
made of strands, having a certain number of strands	
a plug or other device that attaches to an electrical terminal	

an insulated cable with fittings, used to connect an electrical appliance	

TASK TWO. Find the right synonyms in the correct paragraphs above.

1. _______________ *to direct the attention of* (para 1)
2. _______________ *the act or process of insulating* (para 1)
3. _______________ *a socket or outlet into which a plug can be inserted to make an electrical connection (para 1)*
4. _______________ *system of words, letters, figures, or other symbols, used to keep a message short or secret* (para 2)
5. _______________ *a strong, thick rope, now usually made of wires twisted together* - (para 2)
6. _______________ *a long piece of metal drawn out into a thread used for electrical transmission, as in electric lighting, telephones, and telegraphs* (para 2)
7. _______________ *regular, usual* (para 3)
8. _______________ *a set of two, two that go together* (para 3)
9. _______________ *make something very small* (para 3)
10. _______________ *firm* (para 4)
11. _______________ *an act of being bent without breaking in all directions* (para 4)
12. _______________ *curving, inclining* (para 4)

TASK THREE. Complete the sentences.

1. UTP cable end is always fitted with standard ________________.
2. IDC stands for ____
3. T568A and T568B contain _____________ coded pairs 2 and 3.
4. All terminations have different _________ ____________.
5. 568A and 568B are used when a ______________ cable is necessary.
6. Color codes should be _____________ to insure proper connections.
7. A cable is punched down into the IDC contacts by a ____________ _____________ .
8. There are __________ types of punchdowns.
9. The pair 3 has _______/_________/_________ colors.
10. Cat 6 is ____________ in diameter than Cat 5e.

TASK FOUR. Gap fill. Insert <u>*install, primary, systems, coaxial, around, bandwidth, more, but.*</u>

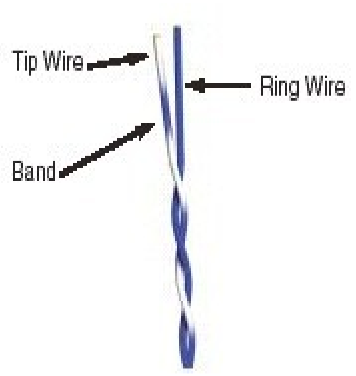
Network Cabling Types

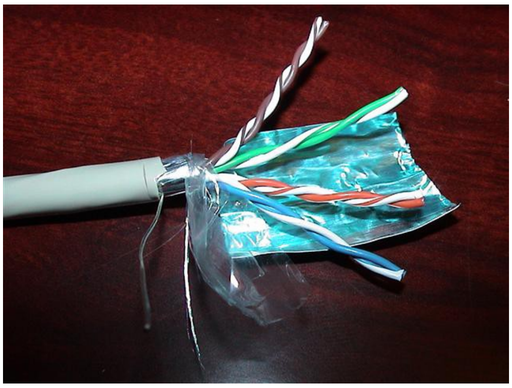
A number of cabling options are available for networking connections.

<u>Unshielded Twisted pair</u> (UTP) - UTP cable is the 1) ________ cable used for networks, as specified in the EIA/TIA 568 standard. This cable type has been widely used because it is inexpensive and simple to 2) ____________.

Limited 3) ____________(which translates into slower transmissions) has pushed development of new cable grades (the "categories" of 568) but has created a more expensive product and more complicated installation process.

<u>Screened Twisted pair</u> (ScTP) - Same as UTP with an overall shield 4) __________the 4 pairs. While not currently specified for any networks or covered in the EIA/TIA 568 standard, it is used in many networks in Europe where EMI is a greater concern. It tends to be more expensive, harder to terminate and requires special plugs and jacks.





Unshileded twisted pair **Shilded twisted pair**

Shielded Twisted Pair (STP) - Like UTP but with a shield around every pair. Widely used in IBM 5) ____________ (IBM Type 1 cable) and **included in 568.**
6) ___________ *Coaxial* Cables - Original Ethernet, used in CATV systems. This is familiar and easy to install, has good bandwidth and lower attenuation but 7) __________expensive, bulky. **Not included in 568**, **but in 570 for residential use.**
<u>Optical Fiber -</u> Optional for most networks, top performance, excellent bandwidth, very long life span, excellent security 8) ___________slightly higher installed cost than twisted pair cables
, more expensive electronics interface to them. Cost effective with optimal architecture.

Coaxial Cable

<u>Read the text and insert the following words</u>: ***cable, copper, adapters, interference,braided, length, networks thinnet, bus, insulation, cover, connectors***

Coaxial cabling has a single **1)** __________ conductor at its center. A plastic layer provides **2)** __________between the center conductor and a **3)** __________ metal shield (See fig. 3). The metal shield helps to block any outside interference from fluorescent lights, motors, and other computers.

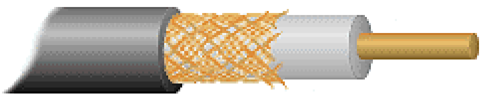


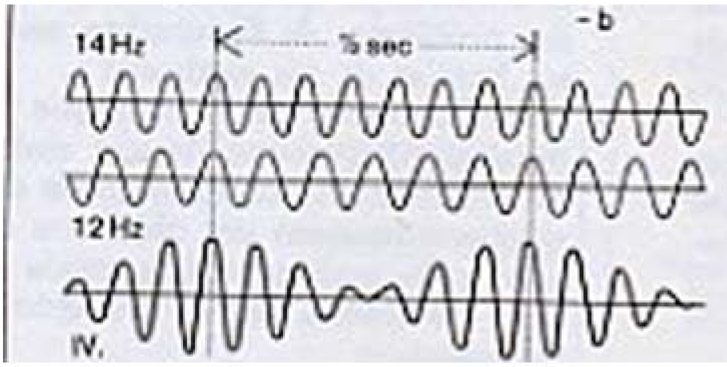
Fig. 3. Coaxial cable

Although coaxial cabling is difficult to install, it is highly resistant to signal **4)** __________. In addition, it can support greater **5)** __________ lengths between network devices than twisted pair cable. The two types of coaxial cabling are thick coaxial and thin coaxial.

Thin coaxial cable is also referred to as **6)** __________. 10Base2 refers to the specifications for thin coaxial cable carrying Ethernet signals. The 2 refers to the approximate maximum segment **7)** __________ being 200 meters. In actual fact the maximum segment length is 185 meters. Thin coaxial cable is popular in school **8)** __________, especially linear bus networks

.

Thick coaxial cable is also referred to as thicknet. 10Base5 refers to the specifications for thick coaxial cable carrying Ethernet signals. The 5 refers to the maximum segment length being 500 meters. Thick coaxial cable has an extra protective plastic **9) __________** that helps keep moisture away from the center conductor. This makes thick coaxial a great choice when running longer lengths in a linear **10) __________** network. One disadvantage of thick coaxial is that it does not bend easily and is difficult to install.



Interference

Coaxial Cable Connectors

The most common type of connector used with coaxial cables is the Bayone-Neill-Concelman (BNC) connector (See fig. 4). Different types of **11) __________** are available for BNC connectors, including a T-connector, barrel connector, and terminator. **12) __________** on the cable are the weakest points in any network. To help avoid problems with your network, always use the BNC connectors that crimp, rather than screw, onto the cable.

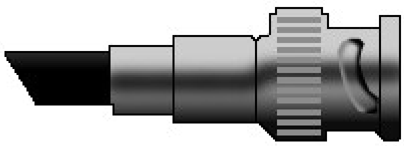


Fig. 4. BNC connector

True or false.

1. Coax has only one central conductor.
2. The shield blocks interference.
3. Coax installation is demanding.
4. Thinnet stands for thick coax.
5. The thinnet application is mostly with non-linear bus networks.
6. Thicknet stands for large cables.
7. Additional cover provides dry center conductor.
8. Connectors are the strongest part of the networks.

Read the text.

The basic elements of a telecommunication system are:

1. a transmitter that takes information and converts it to a signal for tranmission
2. a transmission medium over which the signal is transmitted
3. a receiver that receives and converts the signal back into usable information

For example, consider a radio broadcast. In this case, the broadcast tower is the transmitter, the radio is the receiver and the transmission medium is free space. Often telecommunication systems are two-way and devices act as both a tranmitter and receiver or *transceiver*. For example, a mobile phone is a transceiver. Telecommunication over a phone line is called point-to-point communication because it is between one transmitter and one receiver, telecommunication through radio broadcasts is called broadcast communication because it is between one powerful transmitter and numerous receivers.[2]

Signals can either be analogue or digital. In an analogue signal, the signal is varied continuously with respect to the information. In a digital signal, the information is encoded as a set of discrete values (e.g. 1's and 0's).[3]

A collection of transmitters, receivers or transceivers that communicate with each other is known as a network. Digital networks may consist of one or more routers that route data to the correct user. An analogue network may consist of one or more switches that establish a connection between two or more users. For both types of network, a repeater may be necessary to amplify or recreate the signal when it is being transmitted over long distances. This is to combat noise which can corrupt the information carried by a signal.

A channel is a division in a tranmission medium so that it can be used to send multiple independent streams of data. For example, a radio station may broadcast at 96 MHz while another radio station may broadcast at 94.5 MHz. In this case the medium has been divided by frequency and each channel received a separate frequency to broadcast on. Alternatively one could allocate each channel a segment of time over which to broadcast.

The shaping of a signal to convey information is known as modulation. Modulation is a key concept in telecommunications and is frequently used to impose the information of one signal on another. Modulation is used to represent a digital message as an analogue waveform. This is known as keying and several keying techniques exist — these include phase-shift keying, amplitude-shift keying and minimum-shift keying. Bluetooth, for example, uses phase-shift keying for exchanges between devices (see note).

However, more relevant to earlier discussion, modulation is also used to boost the frequency of analogue signals. This is because a raw signal is often not suitable for transmission over free space due to its low frequencies. Hence its information must be superimposed on a higher frequency signal (known as a carrier wave) before transmission. There are several different modulation schemes available to achieve this — some of the most basic being amplitude modulation and frequency modulation. An example of this process is a DJ's voice being superimposed on a 96 MHz carrier wave using frequency modulation (the voice would then be received on a radio as the channel “96 FM”).

ANSWER THE FOLLOWING QUESTIONS.

1. How many basic elements of telecom systems are there? 3.

2. What is a transciever? A combination of a transmitter and receiver.

3. What is broadcast communication? Communication between one powerful transmitter and numerous receivers.

4. What makes a digital signal different? It's encoded as a set of 1's and 0's.

5. What do both networks consists of? Repeaters.

6. What is the function of repeaters? To reduce noise.

7. What does modulation mean? Shaping of a signal.

8. What does modulation combine? Digital message and analogue waveform.

9. What is a carrier wave? A higher frequency signal before transmission.

10. What basic types of modulation are available? Frequency and amplitude modulation.

10 points

SUTDENT'S.

ANSWER THE FOLLOWING QUESTIONS.

1. How many basic elements of telecom systems are there?
2. What is a transciever?
3. What is broadcast communication?
4. What makes a digital signal different?
5. What do both networks consists of?
6. What is the function of repeaters?
7. What does modulation mean?
8. What does modulation combine?
9. What is a carrier wave?
10. What basic types of modulation are available?

10 points