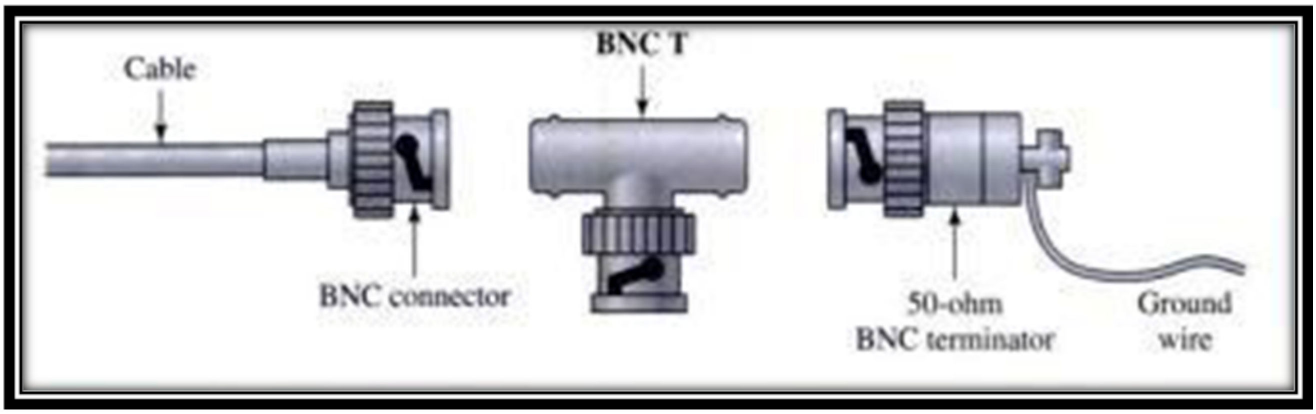


Figure (7) BNC connectors

Applications

Coaxial cable was widely used in analog telephone networks where a single coaxial network could carry 10,000 voice signals. Later it was used in digital telephone networks where a single coaxial cable could carry digital data up to 600 Mbps. However, coaxial cable in telephone networks has largely been replaced today with fiber-optic cable. Cable TV networks also use coaxial cables. In the traditional cable TV network, the entire network used coaxial cable. Later, however, cable TV providers replaced most of the media with fiber-optic cable; hybrid networks use coaxial cable only at the network boundaries, near the consumer premises. Cable TV uses RG-59 coaxial cable. Another common application of coaxial cable is in traditional Ethernet LANs . Because of its high bandwidth, and consequently high data rate, coaxial cable was chosen for digital transmission in early Ethernet LANs. The 10Base-2, or Thin Ethernet, uses RG-58 coaxial cable with BNe connectors to transmit data at 10 Mbps with a range of 185 m. The lOBase5, or Thick Ethernet, uses RG-11 (thick coaxial cable) to transmit 10 Mbps with a range of 5000 m. Thick Ethernet has specialized connectors.

Fiber-Optic Cable

A fiber-optic cable is made of glass or plastic and transmits signals in the form of light. To understand optical fiber, we first need to explore several aspects of the nature of light. Light travels in a straight line as long as it is moving through a single uniform substance. If a ray of light traveling through one substance suddenly enters another substance (of a different density), the ray changes direction. Figure (8) shows how a ray of light changes direction when going from a more dense to a less dense substance.

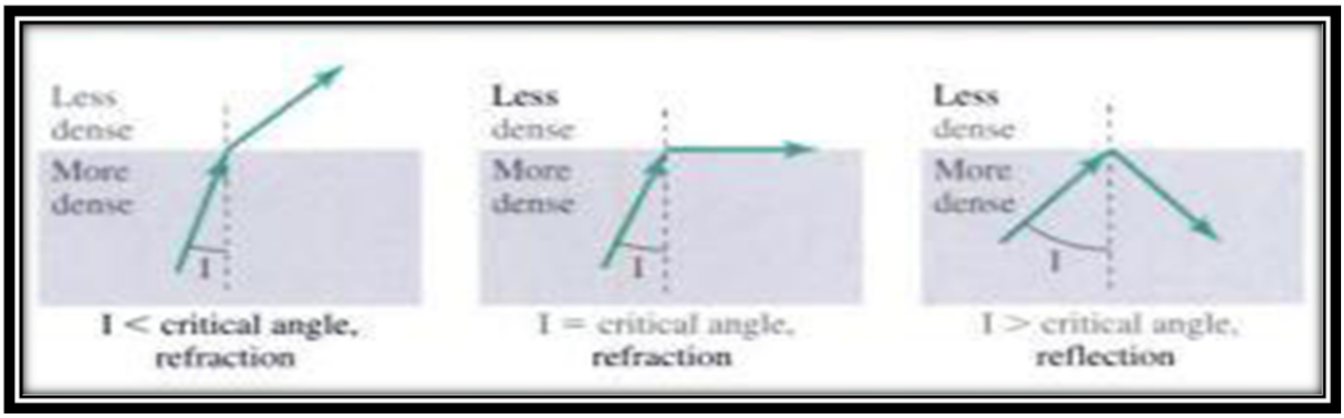


Figure (8) Bending of light ray

As the figure shows, if the angle of incidence *I* (the angle the ray makes with the line perpendicular to the interface between the two substances) is less than the critical angle, the ray refracts and moves closer to the surface. If the angle of incidence is equal to the critical angle, the light bends along the interface. If the angle is greater than the critical angle, the ray reflects (makes a turn) and travels again in the denser substance. Note that the critical angle is a property of the substance, and its value differs from one substance to another. Optical fibers use reflection to guide light through a channel. A glass or plastic core is surrounded by a cladding of less dense glass or plastic. The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it. See Figure (9).

Propagation Modes

Current technology supports two modes (multimode and single mode) for propagating light along optical channels, each requiring fiber with different physical characteristics. Multimode can be implemented in two forms: step-index or graded-index (see Figure 10).

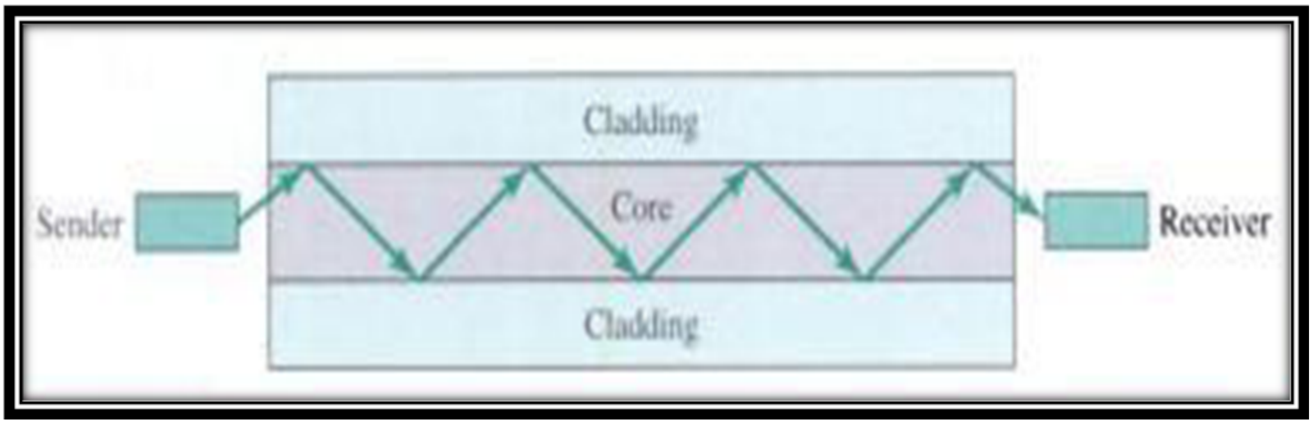


Figure (9) Optical fiber

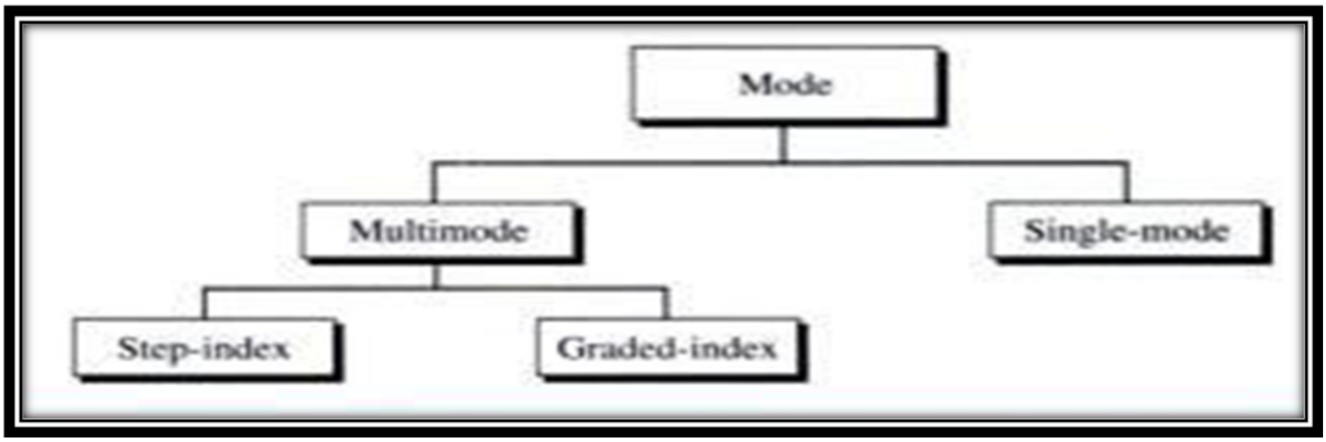


Figure (10)Propagation modes

Multimode is so named because multiple beams from a light source move through the core in different paths. How these beams move within the cable depends on the structure of the core, as shown in Figure (11).

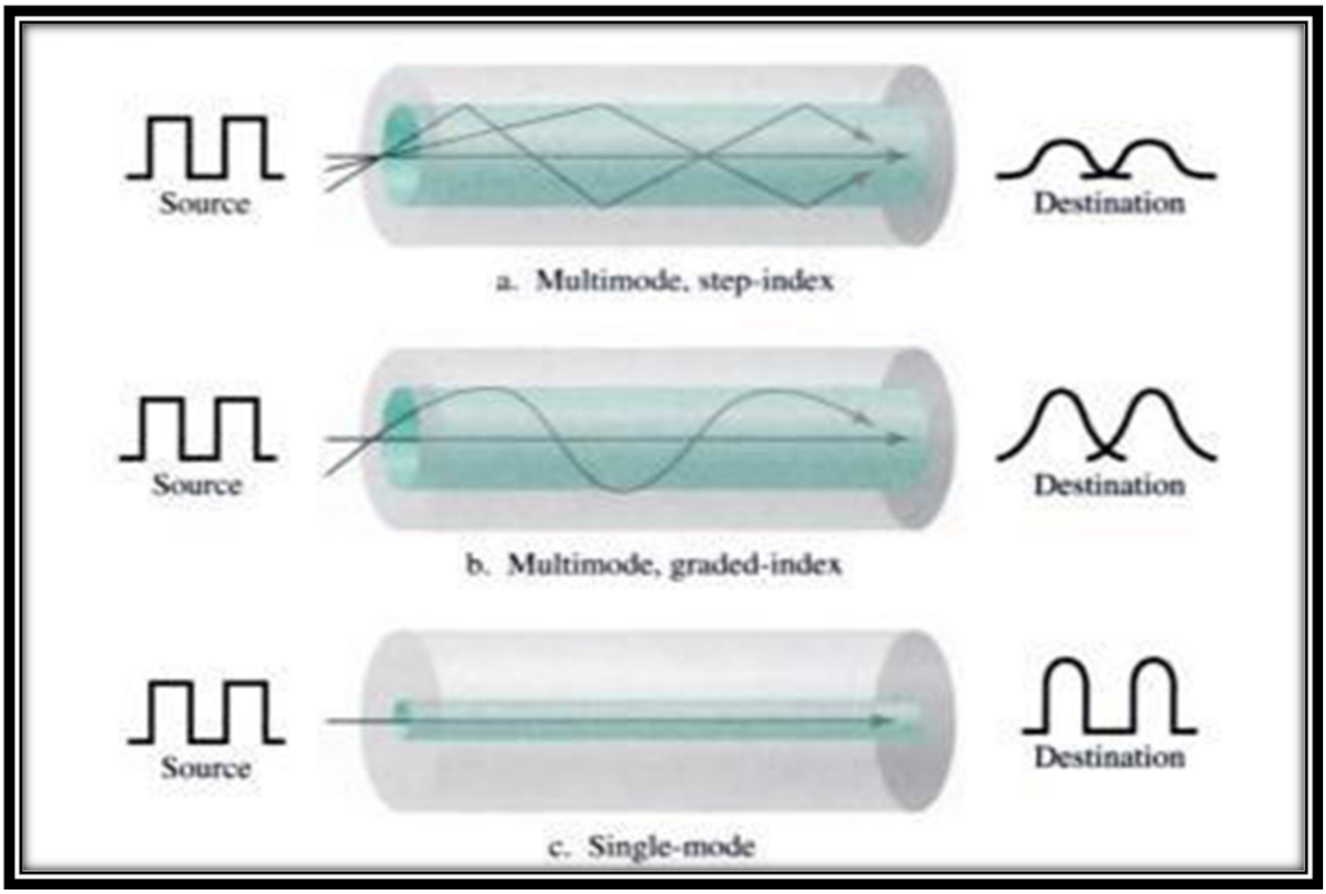


Figure (11) Modes

In multimode step-index fiber, the density of the core remains constant from the center to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding. At the interface, there is an abrupt change due to a lower density; this alters the angle of the beam's motion. The term *step index* refers to the suddenness of this change, which contributes to the distortion of the signal as it passes through the fiber. A second type of fiber, called multimode graded-index fiber, decreases this distortion of the signal through the cable. The word *index* here refers to the index of refraction. As we saw above, the index of refraction is related to density. A graded-index fiber, therefore, is one with varying densities. Density is highest at the center of the core and decreases gradually to its lowest at the edge. Figure (11) shows the impact of this variable density on the propagation of light beams. Single-Mode Single-mode uses step-index fiber and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal. The single mode fiber itself is manufactured with a much smaller diameter than that of multimode fiber, and with substantially lower density (index of refraction). The decrease in density results in a critical angle that is close enough to 90° to make the propagation of beams almost horizontal. In this case, propagation of different beams is almost identical, and delays are negligible. All the beams arrive at the destination "together" and can be recombined with little distortion to the signal (see Figure 11).

<u>Fiber Sizes</u>

Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding, both expressed in micrometers. The common sizes are shown in Table (3). Note that the last size listed is for single-mode only.

Table (3) ***Fiber types***

Type	Core (µm)	Cladding (µm)	Mode
50/125	50	125	Multimode, graded-index
62.5/125	62.5	125	Multimode, graded-index
100/125	100	125	Multimode, graded-index
7/125	7	125	Single-mode

Cable Composition

Figure (12) shows the composition of a typical fiber-optic cable. The outer jacket is made of either PVC or Teflon. Inside the jacket are Kevlar strands to strengthen the cable. Kevlar is a strong material used in the fabrication of bulletproof vests. Below the Kevlar is another plastic coating to cushion the fiber. The fiber is at the center of the cable, and it consists of cladding and core.

Fiber-Optic Cable Connectors

There are three types of connectors for fiber-optic cables, as shown in Figure (13). The **subscriber channel** (SC) **connector** is used for cable TV. It uses a push/pull locking system. The **straight-tip** (ST) **connector** is used for connecting cable to networking devices. It uses a bayonet locking system and is more reliable than SC. **MT-RJ** is a connector that is the same size as RJ45.

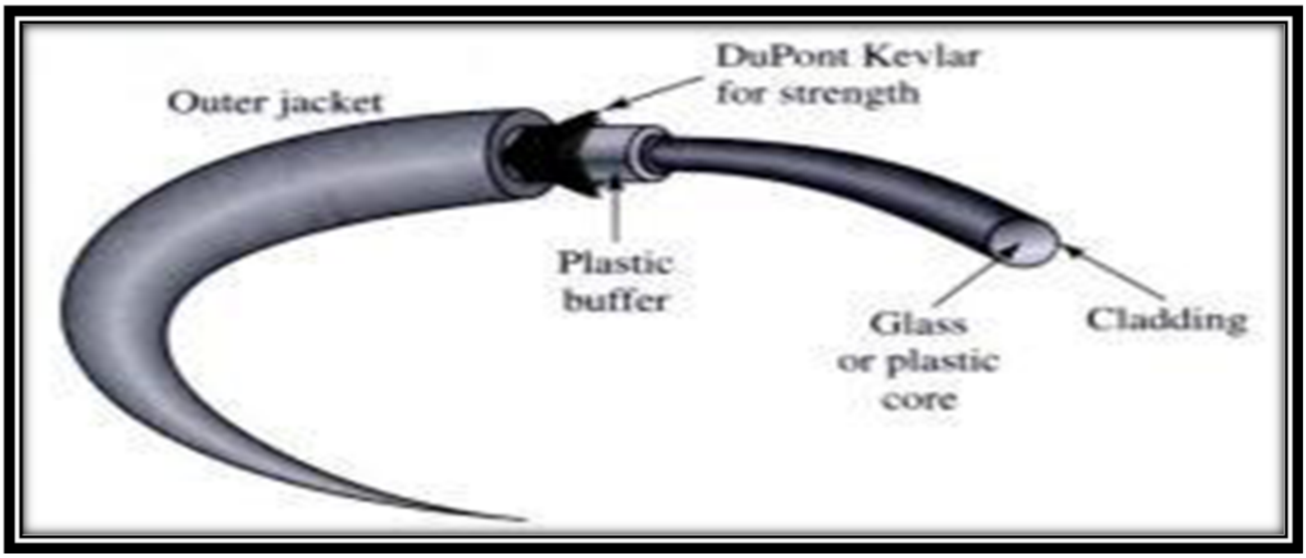


__Figure (12) Fiber construction__

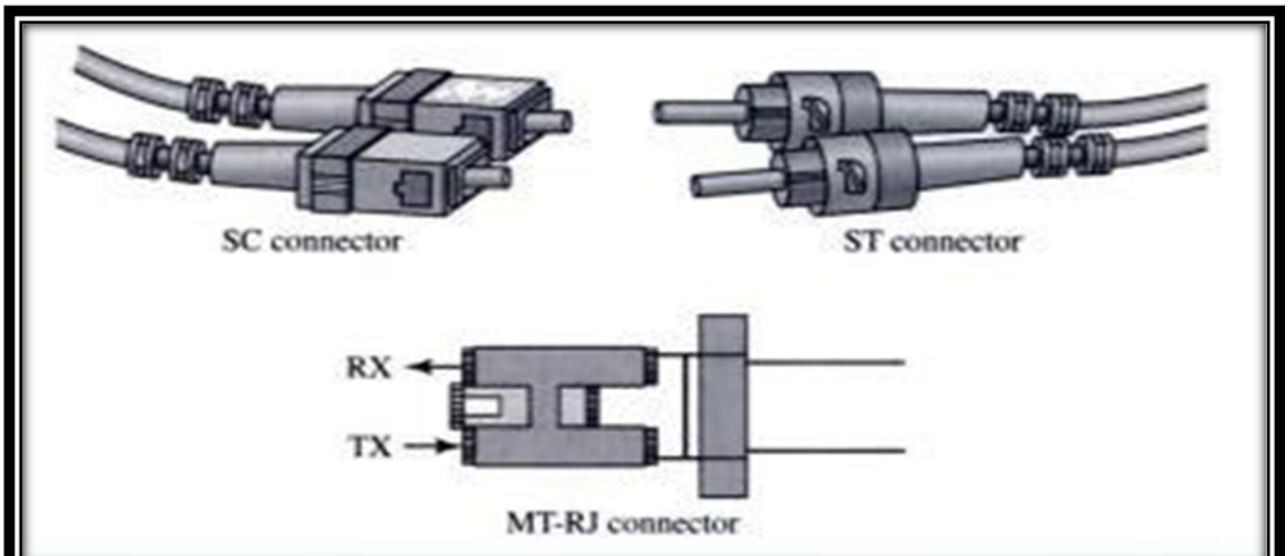


Figure (13) Fiber-optic cable connectors

Applications

Fiber-optic cable is often found in backbone networks because its wide bandwidth is cost-effective. Today, with wavelength-division multiplexing (WDM), we can transfer data at a rate of 1600 Gbps. The SONET network that provides such a backbone. Some cable TV companies use a combination of optical fiber and coaxial cable, thus creating a hybrid network. Optical fiber provides the backbone structure while coaxial cable provides the connection to the user premises. This is a cost-effective configuration since the narrow bandwidth requirement at the user end does not justify the use of optical fiber. Local-area networks such as 100Base-FX network (Fast Ethernet) and 1000Base-X also use fiber-optic cable.

Advantages and Disadvantages of Optical Fiber

Advantages Fiber-optic cable has several advantages over metallic cable (twisted pair or coaxial)

1- Higher bandwidth. Fiber-optic cable can support dramatically higher bandwidths (and hence data rates) than either twisted-pair or coaxial cable. Currently, data rates and bandwidth utilization over fiber-optic cable are limited not by the medium but by the signal generation and reception technology available.

2- Less signal attenuation. Fiber-optic transmission distance is significantly greater than that of other guided media. A signal can run for 50 km without requiring regeneration. We need repeaters every 5 km for coaxial or twisted-pair cable.

3- Immunity to electromagnetic interference. Electromagnetic noise cannot affect fiber-optic cables.

4- Resistance to corrosive materials. Glass is more resistant to corrosive materials than copper.

5- Light weight. Fiber-optic cables are much lighter than copper cables.

6- Greater immunity to tapping. Fiber-optic cables are more immune to tapping than copper cables. Copper cables create antenna effects that can easily be tapped.

Disadvantages There are some disadvantages in the use of optical fiber.

1- Installation and maintenance. Fiber-optic cable is a relatively new technology. Its installation and maintenance require expertise that is not yet available everywhere.

2-Unidirectional light propagation. Propagation of light is unidirectional. If we need bidirectional communication, two fibers are needed.

3- Cost. The cable and the interfaces are relatively more expensive than those of other guided media. If the demand for bandwidth is not high, often the use of optical fiber cannot be justified.

UNGUIDED MEDIA: WIRELESS

Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication. Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them Figure (14) shows the part of the electromagnetic spectrum, ranging from 3 kHz to 900 THz, used for wireless communication Figure (14) *Electromagnetic spectrum for wireless communication*.

Figure (14) Electromagnetic spectrum for wireless communication

Unguided signals can travel from the source to destination in several ways: ground

propagation, sky propagation, and line-of-sight propagation, as shown in Figure (15).

In ground propagation, radio waves travel through the lowest portion of the atmosphere, hugging the earth. These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet. Distance depends on the amount of power in the signal: The greater the power, the greater the distance. In sky propagation, higher-frequency radio waves radiate upward into the ionosphere (the layer of atmosphere where particles exist as ions) where they are reflected back to earth. This type of transmission allows for greater distances with lower output power. In line-or-sight propagation, very high-frequency signals are transmitted in straight lines directly from antenna to antenna. Antennas must be directional, facing each other, and either tall enough or close enough together not to be affected by the curvature of the earth. Line-of-sight propagation is tricky because radio transmissions cannot be completely focused The section of the electromagnetic spectrum defined as radio waves and microwave is divided into eight ranges, called *bands,* each regulated by government authorities. These bands are rated from *very low frequency* (VLF) to *extremely high frequency* (EHF).

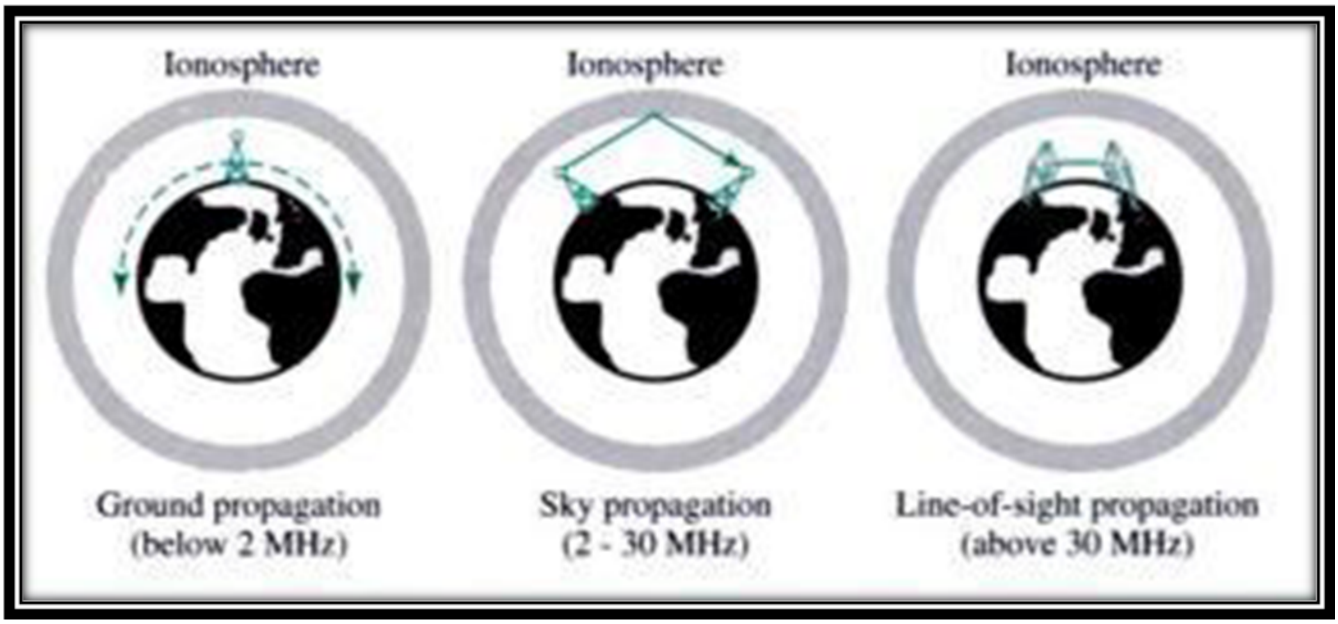


Figure (15) Propagation methods

Table (4) lists these bands, their ranges, propagation methods, and some applications.

Table (4) Bands

Band	Range	Propagation	Application
VLF (Very low frequency)	3–30 KHz	Ground	Long-range radio navigation
LF (Low frequency)	30–300 KHz	Ground	Radio beacons and navigational locators
MF (Middle frequency)	300 KHz–3 MHz	Sky	AM radio
HF (High frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (Very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (Ultra high frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (Super high frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (Extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite

We can divide wireless transmission into three broad groups: radio waves, microwaves, and infrared waves. See Figure (16).

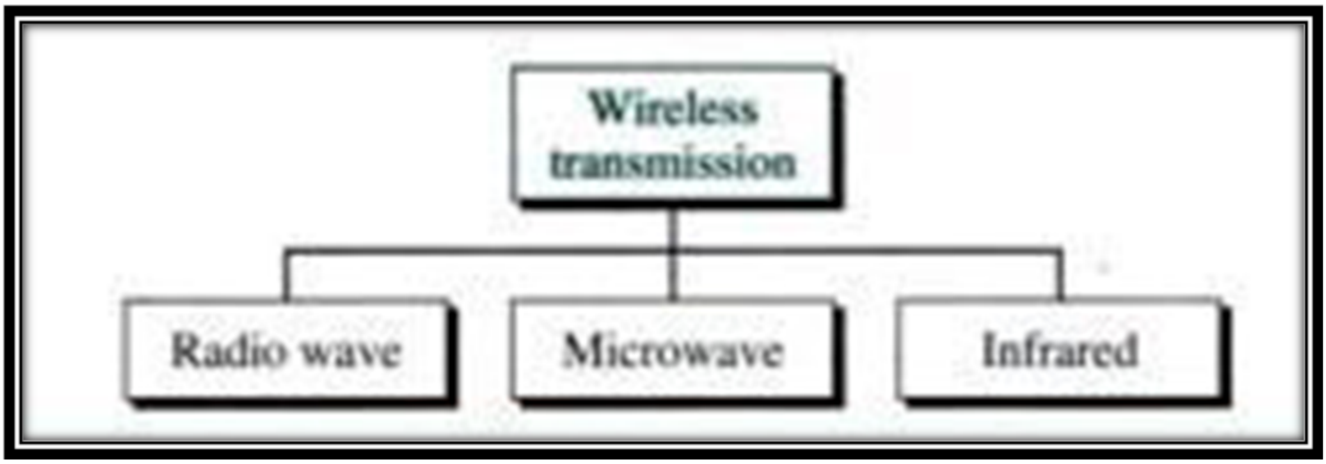


Figure (16) Wireless transmission waves

Radio Waves

Although there is no clear-cut demarcation between radio waves and microwaves, electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called radio waves; waves ranging in frequencies between 1 and 300 GHz are called microwaves.

However, the behavior of the waves, rather than the frequencies, is a better criterion for classification. Radio waves, for the most part, are omnidirectional. When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and

receiving antennas do not have to be aligned. A sending antenna sends waves that can

be received by any receiving antenna. The omnidirectional property has a disadvantage, too. The radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signals using the same frequency or band. Radio waves, particularly those waves that propagate in the sky mode, can travel long distances. This makes radio waves a good candidate for long-distance broadcasting such as AM radio. Radio waves, particularly those of low and medium frequencies, can penetrate walls. This characteristic can be both an advantage and a disadvantage. It is an advantage because, for example, an AM radio can receive signals inside a building. It is a disadvantage because we cannot isolate a communication to just inside or outside a building. The radio wave band is relatively narrow, just under 1 GHz, compared to the microwave band. When this band is divided into subbands, the subbands are also narrow, leading to a low data rate for digital communications. Almost the entire band is regulated by authorities (e.g., the FCC in the United States). Using any part of the band requires permission from the authorities.

Omnidirectional Antenna

Radio waves use omnidirectional antennas that send out signals in all directions. Based on the wavelength, strength, and the purpose of transmission, we can have several types o antennas. Figure (17) shows an omnidirectional antenna.

Applications

The omnidirectional characteristics of radio waves make them useful for multicasting,

in which there is one sender but many receivers. AM and FM radio, television, maritime

radio, cordless phones, and paging are examples of multicasting. Radio waves are used for multicast communications, such as radio and television, and paging systems.

Figure (17) Omnidirectional antenna

Microwaves

Electromagnetic waves having frequencies between I and 300 GHz are called microwaves. Microwaves are unidirectional. When an antenna transmits microwave waves, they can be narrowly focused. This means that the sending and receiving antennas need to

be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas. The following describes some characteristics of microwave propagation:

o Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct sight of each other, towers that are far apart need to be very tall. The curvature of the earth as well as other blocking obstacles do not allow two short towers to communicate by using microwaves. Repeaters are often needed for long distance communication.

o Very high-frequency microwaves cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside buildings.

o The microwave band is relatively wide, almost 299 GHz. Therefore wider subbands can be assigned, and a high data rate is possible

o Use of certain portions of the band requires permission from authorities.

Unidirectional Antenna

Microwaves need unidirectional antennas that send out signals in one direction. Two

types of antennas are used for microwave communications: the parabolic dish and the

horn (see Figure 18). A parabolic dish antenna is based on the geometry of a parabola: Every line parallel to the line of symmetry (line of sight) reflects off the curve at angles such that all the lines intersect in a common point called the focus. The parabolic dish works as a

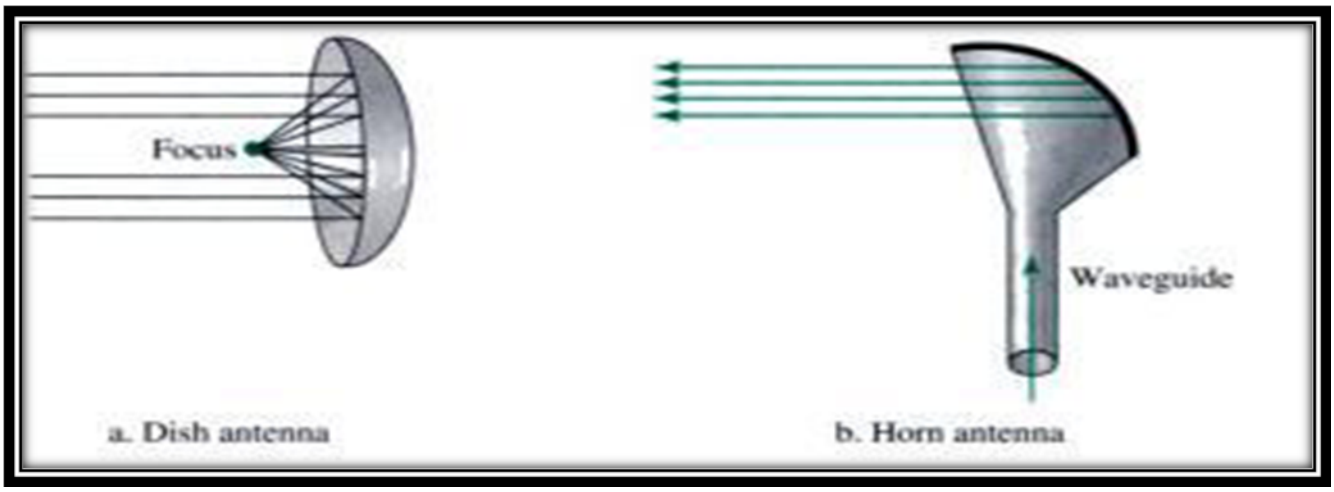


Figure (18) Unidirectional antennas

funnel, catching a wide range of waves and directing them to a common point. In this way, more of the signal is recovered than would be possible with a single-point receiver. Outgoing transmissions are broadcast through a horn aimed at the dish. The microwaves hit the dish and are deflected outward in a reversal of the receipt path. A horn antenna looks like a gigantic scoop. Outgoing transmissions are broadcast up a stem (resembling a handle) and deflected outward in a series of narrow parallel beams by the curved head. Receive transmissions are collected by the scooped shape of the horn, in a manner similar to the parabolic dish, and are deflected down into the stem.

Applications

Microwaves, due to their unidirectional properties, are very useful when unicast (one-to-one) communication is needed between the sender and the receiver. They are used in cellular phones , satellite networks , and wireless LANs. Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.

Infrared

Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication. Infrared waves, having high

frequencies, cannot penetrate walls. This advantageous characteristic prevents interference

between one system and another; a short-range communication system in one room cannot be affected by another system in the next room. When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors. However, this same characteristic makes infrared signals useless for long-range communication. In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

Applications

The infrared band, almost 400 THz, has an excellent potential for data transmission.

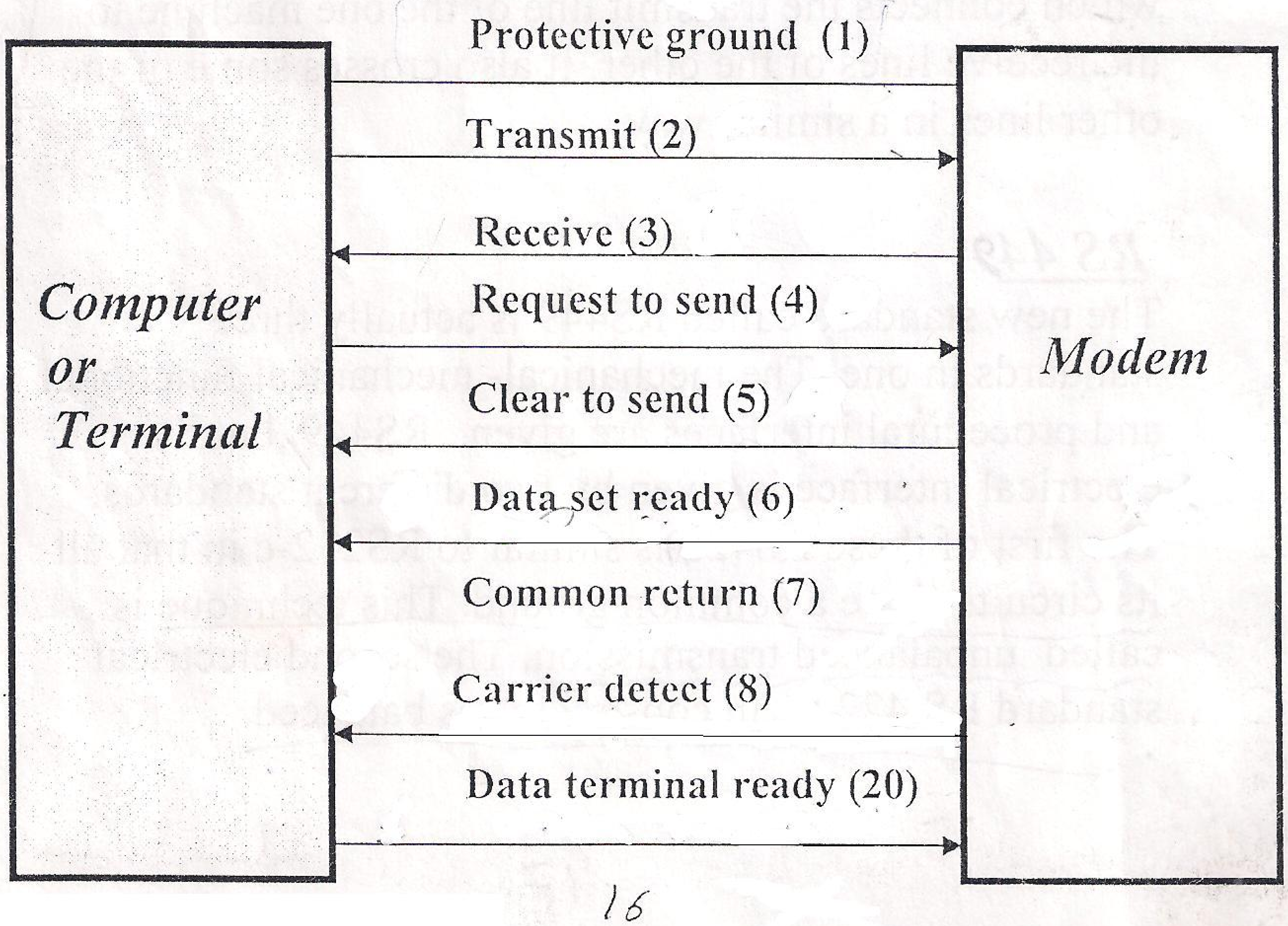
Such a wide bandwidth can be used to transmit digital data with a very high data rate.

The *Infrared Data Association* (IrDA), an association for sponsoring the use of infrared

waves, has established standards for using these signals for communication between devices such as keyboards, mice, PCs, and printers. For example, some manufacturers provide a special port called the IrDA port that allows a wireless keyboard to communicate with a PC. The standard originally defined a data rate of 75 kbps for a distance up to 8 m. The recent standard defines a data rate of 4 Mbps. Infrared signals defined by IrDA transmit through line of sight; the IrDA port on the keyboard needs to point to the PC for transmission to occur. Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

RS 232 –C

The interface between the computer or terminal and the modem is an example of a physical layer protocol .RS232-C is a third revision of the original RS 232-C standard .in the standard the terminal or computer is officially called a DTE (data terminal equipment) and the modem is officially called a DCE (data circuit terminating equipment) the mechanical specification is for a 25 pin connector .The electrical specification is that avoltage more negative than -3 is a binary 1and a voltage more positive than 4 volts is a binary 0, Data rates up 20 kbps are permitted, as are cables up to 15m. The functional specification tells which circuits are connected to each of the 25 pins and what they mean. Fig( ). shows 9 pins that are nearly always implemented. The remaining ones are frequently omitted.- When the terminal or computer is powered up ,it a asserts (i.e sets to a logical 1) data terminal ready (pin 20 When the modem is powered up it asserts data set ready (pin 6).



When the modem detects a carrier on the telephone line asserts carrier detect (pin 8). Request to send (pin4) indicates that the terminal wants to sends data. Clear to send (pin 5) mean that the modem is prepared to accept data. Data is transmitted on the transmit circuit (pin2) and received on the receiver circuit (pin 3) Other circuits are provided for selecting the data rate, testing the modem, clocking the data, detecting ringing signals and sending data in the reverse direction on a secondary channel. They are hardly ever used in practice. The procedural speciation is the protocol that legal sequence of events. The protocol is based on action- reaction pairs. When the terminal asserts request to send , for example, the modem replies with clear to send, if it is able to accept data. Similar action - reaction pairs exist for other circuits as well .

It commonly occurs that two computers must be connected using RS 232-C.Since neither one is a modem, there is an interface problem. The problem is solved by connecting them with a device called a *null modem* which connects the transmit line of the one machine to the receive lines of the other. It also crosses some of the other lines in a similar way.

RS 449

The new standard called RS449 is actually three standards in one, The mechanical- mechanical functional and procedural interfaces are given RS449, but the electrical interface is given by two different standards. The first of these RS423A is similar to RS232-c in that all its circuits share a common ground. This technique is called unbalanced transmission. The second electrical standard RS 422 A in constract uses balanced transmission, in which each of the main circuits requires two wires with no common ground. As a result RS-422 A can be used at speeds up to 2 Mbps over 60 meter cables , and at even higher speeds over shorter cables. The circuits used in RS449 are show in figure (1) several new circuits not present in RS 232-C have been added. In particular circuits for testing the modem both locally and remotely were included . Due to the inclusion of a number of 2 wire circuits (when RS 422 A is used) more pins are needed in the new standard so the familiar 25 pin connector was dropped in it is place is a 37 pin connector and a 9 pin connector. The 9 pin connector is only required . If the second (reverse) channel is being leased if it is not being used the 37 pin connector is sufficient.

TRENSMISSION AND SWITCHING

1) CIRCUIT SWITCHING

Communication via circuit switching implies that there is a dedicated communication path between two stations. That path is a connected sequence of links between nodes. The most common example of circuit switching is the telephone network. Communication via circuit switching involves the phases:

a) Circuit establishment
b) Data transfer
c) Circuit disconnect

The connection path is established before data transmission beings. Circuit switching can be rather in efficient . Channel capacity is dedicated for the duration of a connection , even if no data are being transferred. For a voice connection, utilizations may be rather high, but it still does not approach 100%. For terminal to computer or computer to computer connection the capacity may be idle during most of the time of the connection. In terms of performance , there is a delay prior to data transfer for call establishment .Data are transmitted at a fixed data rate with no delay other than the propagation delay

2) MESSAGE SWITCHING

Communication via message switching does necessitate the establishment of a dedicated path between two stations rather, if a station wished to send a message it appends a destination address to the messsage. The message is then passed through the network from node to node.At each node , the entire message is received, stored briefly and then transmitted to next node (This class of network is also called *"store and forward"* networks).

In a circuit - switched network, each node is an electronic or perhaps electro-mechanical switching device which transmits data as soon as it receives them. and for this reason , circuit switching is an appropriate and easily used technique in the case of data exchange that involves
a relatively continuous flow , such as voice (telephone).

While a message switching node is typically a general purpose ..Mini computer, with sufficient storage to buffer message as they come in.A message is delayed at each node for the time required to receive all bits of the message, plus a queuing delay. Waiting for an opportunity to retransmit to the next node.

The primary disadvantage of a message switching is that it is not suited to real time or interactive traffic. The delay through the networks is relatively long. Thus it can not be used for voice communication. Nor suited to interactive terminal- host connection. Message – switched network is best suited for telegrams, electronic mail, and computer files

PACKET SWITCHING

-
Packet switching differs from other types of switched networks. In that long message are first segmented into smaller segments called " ***packet*** " these packets then independently traverse the network until they reach the desired node, where they are reassembled again into the

corresponding message . For the networks to handle the stream of packets, there exist, two approaches:

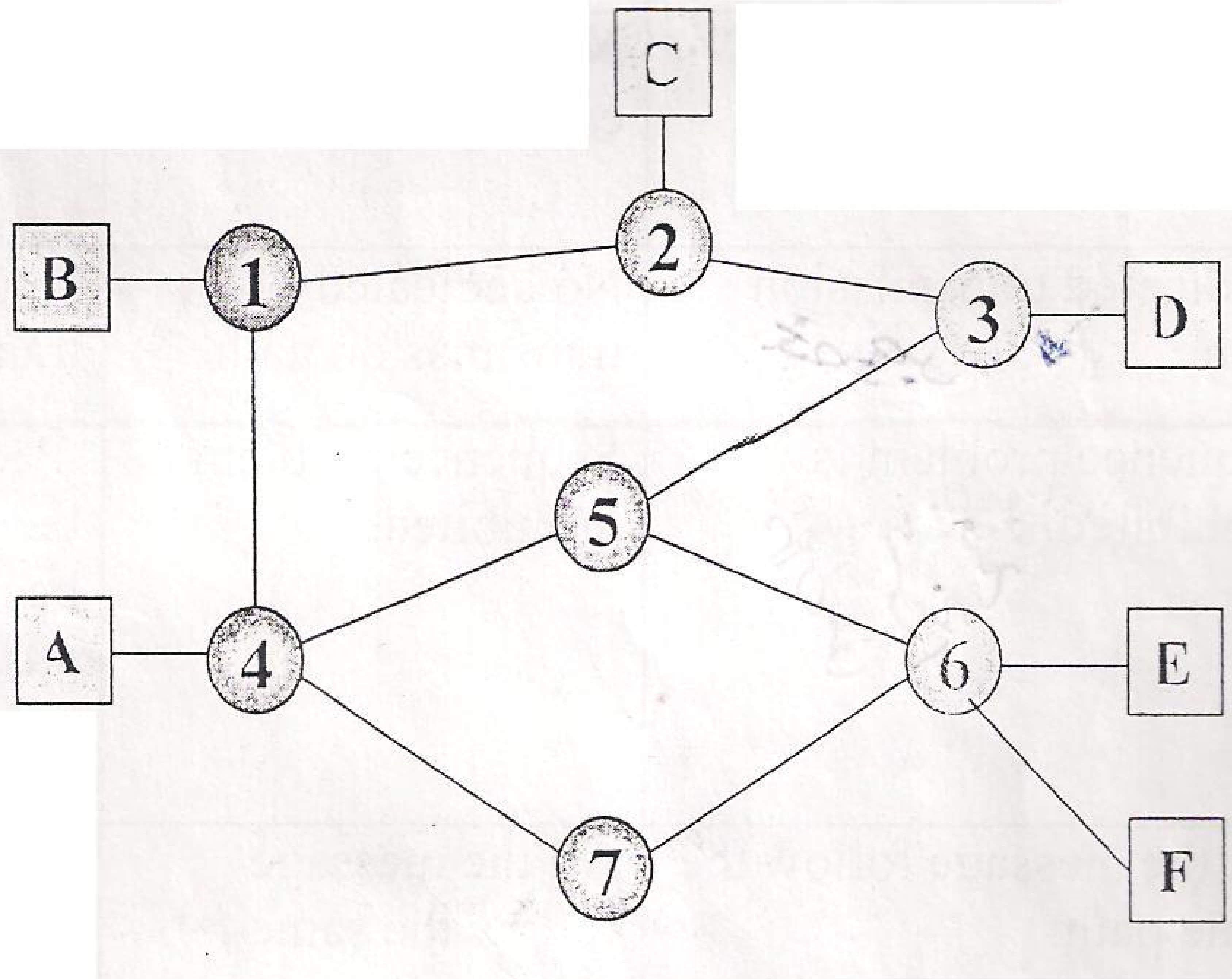
DATA GRAM:

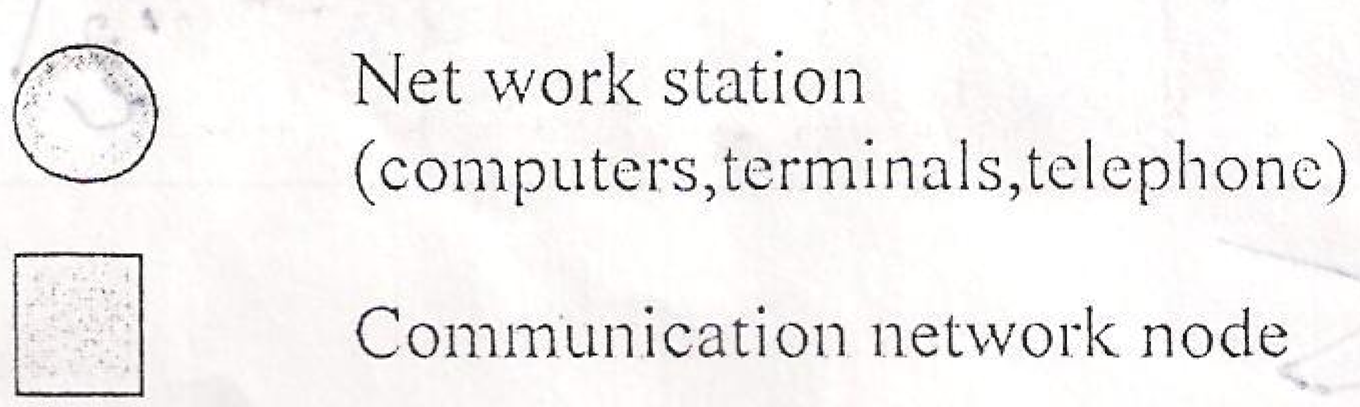
In the data gram, each packet is treated independently, just as each message is treated independently in a message switched networks .i.e if one station **A** wishes to send to another station **B** then station **A** first segments the data into packets, the first packet is routed to the proper node in the network, then this node will route it to the other proper one, and soon till the packet reaches the destination.For the second packet, it is not necessary for it to follow the same route followed by the first packet. If this route is ongested, then this route is congested, then this packet will follow any other route on its way to the destination, so the nodes in datagram networks, must have the ability to decide which path to be taken by each packet a according to the situation of the networks ppath .thus it is possible,that the packet will be delivered to station **B** in a different sequence form the one in which they were sent. It is up to station **B** to figure out how to reorder them

VIRTUAL CIRCUIT

In this approach a logical connection is established before any packets are sent. For example, suppose that station **A** has data to be sent for station **B**. **A** first sends a call request packet to the first node in the networks requesting a connection to **B.** This node will route the request to the proper node, in order to make a logical connection between **A & B**.If **B** is prepared to accept the connection , it sends out a call accept packet to the same nodes used in requesting the call but in reverse manner. Stations **A & B** may now exchange data over the logical connection or virtual circuit that has been established . Each packet now contains a virtual circuit identifier as well as data. Each node on the pre established route knows where to direct such packets, no routing decisions are required, one of the stations terminate the connection with a clear request packet.

At any time, each station can have more than one virtual circuit to any other station and can have virtual circuits to more than one station. So the main characteristic of the virtual circuit technique is that a route between stations is set up prior to data transfer. Note that this does not mean that there is a dedicated path as in circuit as in circuit switching.





	CRICUIT SWITECHING	MESSAGE SWITECHING	DATA GRAM PACKET SWITECHING	VIRTUAL CIRCUIT PACKET SWITECHING
1	continuous transmission of data	Transmission of messages.	Transmission of packets.	Transmission of packets
2	Fast enough for interactive.	Two slow for interactive.	Fast enough for interactive	Fast enough for interactive
3	The path is establishing for entire conversation.	Route establish for. each message	Route establish for each packet.	Route establish for entire conversation.
4	Call set up delay.	No Call set up delay.	No Call set up delay.	Call set up delay.
5	Over load may block call set up.	Over load increases message delay...	Over load increases packets delay.	Over load may block call set up increases packet delay
6	Fixed transmission band width	Dynamic use of BW	Dynamic use of BW	Dynamic use of BW
7	No over head bits after call set up.	No over head bits in each message.	No over head bits in each packet...	No over head bits in each packet
8	Dedicated transmission path.	No dedicated transmission path	No dedicated transmission path	No dedicated transmission path
9	Sequence problem is prohibited.	Sequence problem is prohibited.	Packets should be re ordered because they may arrive in a disturbed sequence.	since all the packets follow the same route ,hence no sequencing problem appear.
10	All the message follow the same path.	All the message follow the same path.	Data packets may not use the same route and can avoid congested paths.	All the packets should follow the same path even if congestion arises.

Terminal handling:-

For many applications the cost of communication lines exceeds the cost of the equipment connected by those lines. In an attempt to reduce communication costs, many networks providę away for multiple terminals to share a single communication line .The conceptual model is that of fig.1 in which a terminal controller accepts input from a cluster of terminals and outputs them on to one line.
In fig (A) all the terminals are wired on to the same multidrop line ,where as in fig (B) each terminal has its own point to point line to the controller.

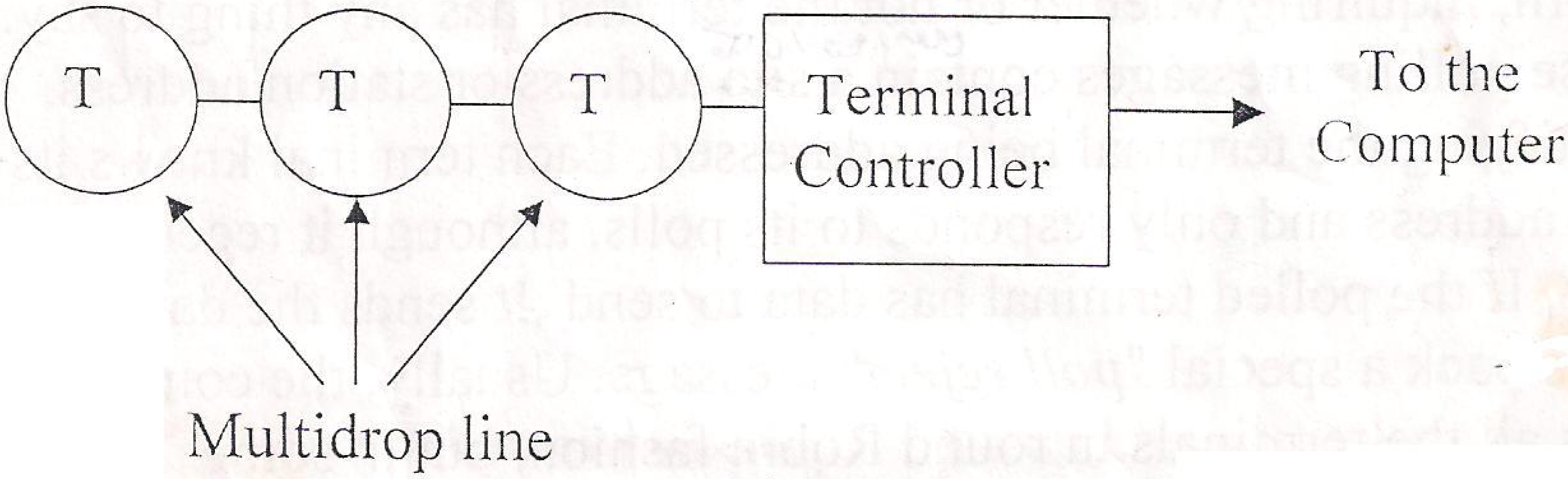


Fig. (A)

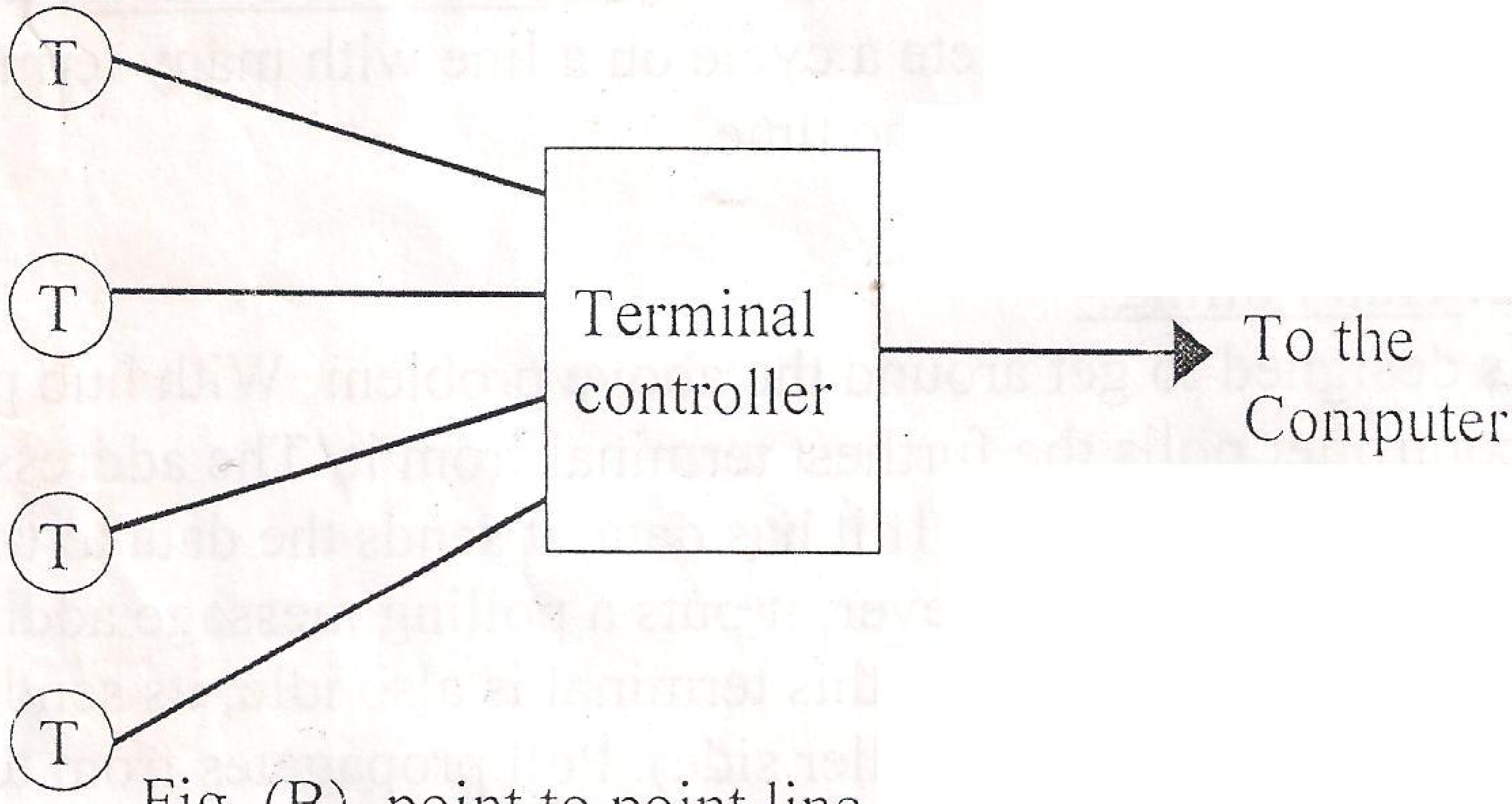


Fig. (B) point to point line

Polling:-

Having only one output line to the computer gives rise to a problem what happens if all the terminals try sending at once ? Clearly some method of enforcing discipline is needed. The traditional method is to require each terminal to keep quite until the controller says "***Go a head***". The general name for this technique is polling.

Multidrop case:-

Two polling methods are common:-

1. ROLL – CALL POLLING:-

Consists of the controller simply sending a message to each terminal in turn, inquiring whether or not the terminal has any thing to say. These polling messages contain a site address or station address. identifying the terminal being addressed. Each terminal knows its own address and only responds to its polls, although it receives all polls, If the polled terminal has data to send ,It sends the data. If not, it sends back a special "***poll reject***" message. Usually, the controller just polls all the terminals in round Robin fashion, but in some circumstances important terminals may get several polls per cycle. On half duplex lines each poll requires two lines turn a rounds, one to allow the controller to send ,and one to allow the terminal to send. Since line turn around time is often hundreds of msec; it may take along time to complete a cycle on a line with many terminals, even if most are idle most of the time.

2. Hub Polling:-

Is designed to get around the above problem. With hub polling, the controller polls the furthest terminal from it/The addressed terminal turns the line around. If it has data, it sends the data to the controller If it has no data, however, it puts a polling message addressed to its neighbor on the line. If this terminal is also idle, its sends a poll to its neighbor (on the controller side). Poll propagates from terminal to terminal until one can be found that some thing to say or until the poll gets back to the controller .