Transmission Media & Optical Communication

Course Code: **COE 3201** Course Title: **Data Communication**

Dept. of Computer Engineering
Faculty of Engineering

Lecture No:	**10**	**Week No:**	**12**	**Semester:**	**Fall 23-24**
Lecturer:	*Dr Amirul Islam*				

Lecture Outline

1. The first section introduces the transmission media and defines its position in the Internet model. It shows that we can classify transmission media into two broad categories: guided and unguided media.

2. The second section discusses guided media. The first part describes twisted-pair cables and their characteristics and applications. The second part describes coaxial cables and their characteristics and applications

3. The third section discusses unguided media. The first part describes radio waves and their characteristics and applications. The second part describes microwaves and their characteristics and applications.

Transmission Medium

Transmission media are actually located below the physical layer and are directly controlled by the physical layer. We could say that transmission media belong to layer zero. Figure 7.1 shows the position of transmission media in relation to the physical layer.

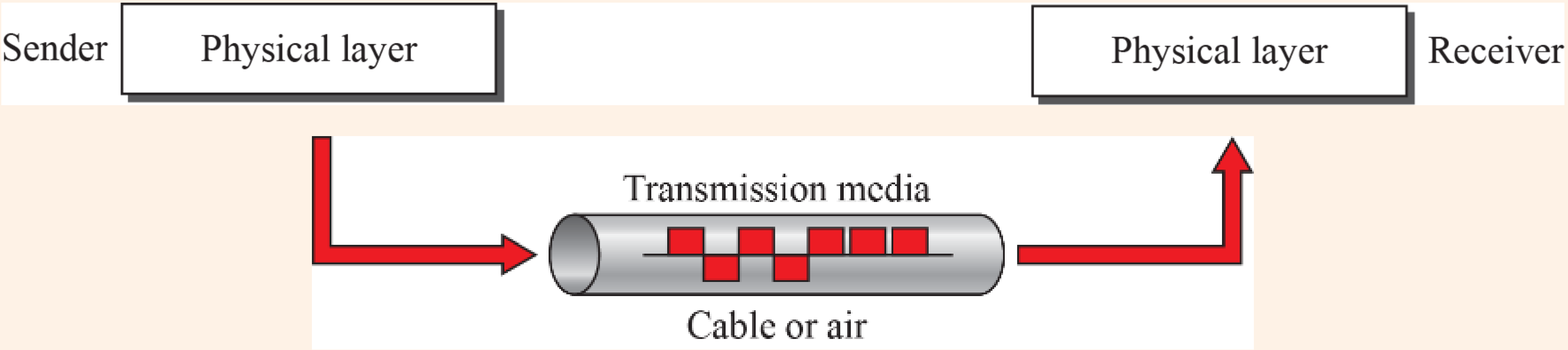


Figure 7.1: Transmission media and physical layer

Transmission media

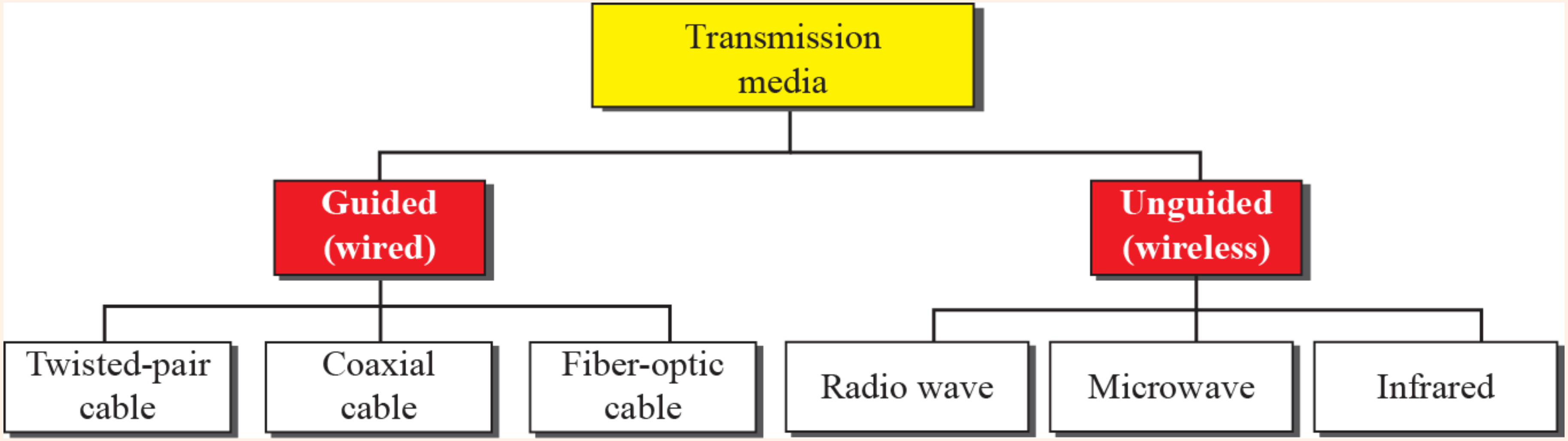


Figure 7.2: Classes of transmission media

GUIDED MEDIA

Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable. A signal traveling along any of these media is directed and contained by the physical limits of the medium.

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together, as shown in Figure 7.3.

One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two.

In addition to the signal sent by the sender on one of the wires, interference (noise) and crosstalk may affect both wires and create unwanted signals.

Twisted-Pair Cable

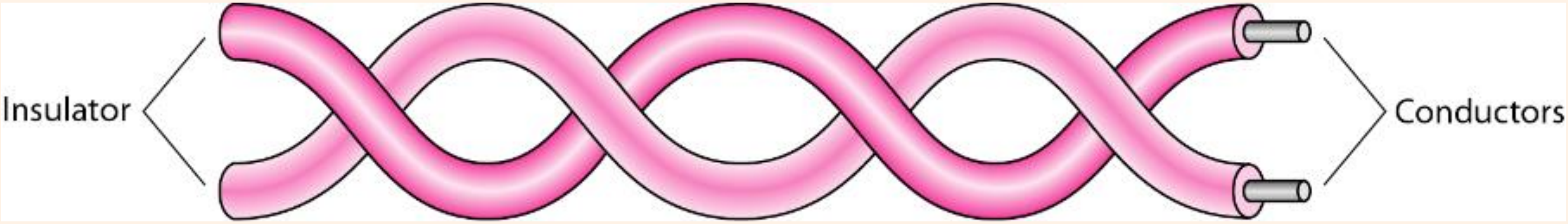


Figure 7.3: Twisted-pair cable

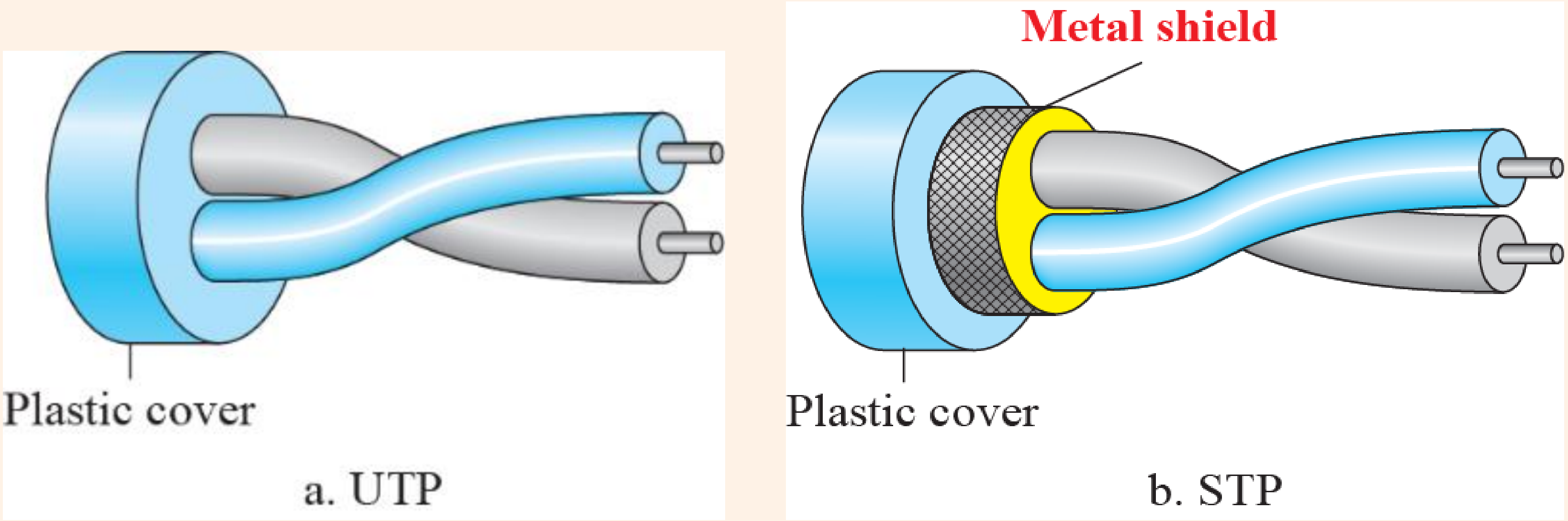
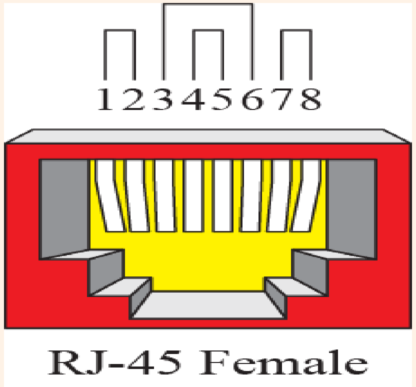


Figure 7.4: Unshielded TP (UTP) and Shielded TP (STP) cables

Twisted-Pair Cable

Table 7.1: Categories of unshielded twisted-pair cables

Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs



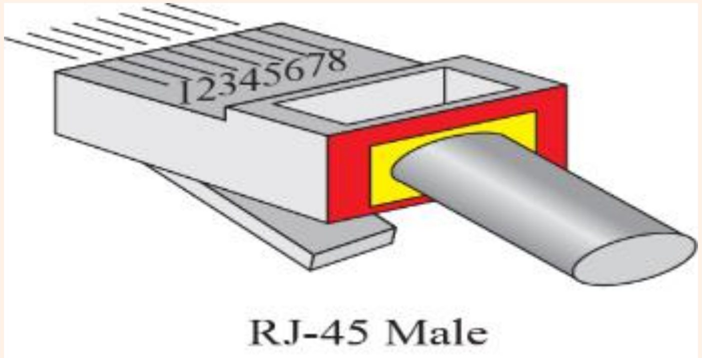
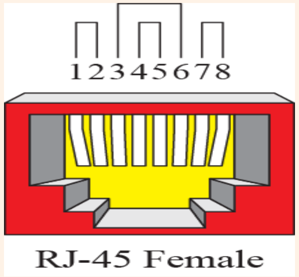


Figure 7.5: UTP Connectors

Twisted-Pair Cable

Table 7.1: Categories of unshielded twisted-pair cables

Category	*Specification*	*Data Rate (Mbps)*	*Use*
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called *SSTP (shielded screen twisted-pair)*. Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk and increases the data rate.	600	LANs



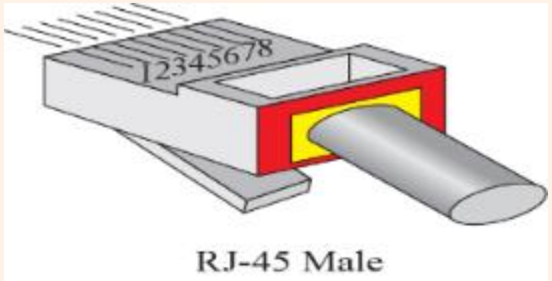


Figure 7.5: UTP Connectors

Twisted-Pair Cable

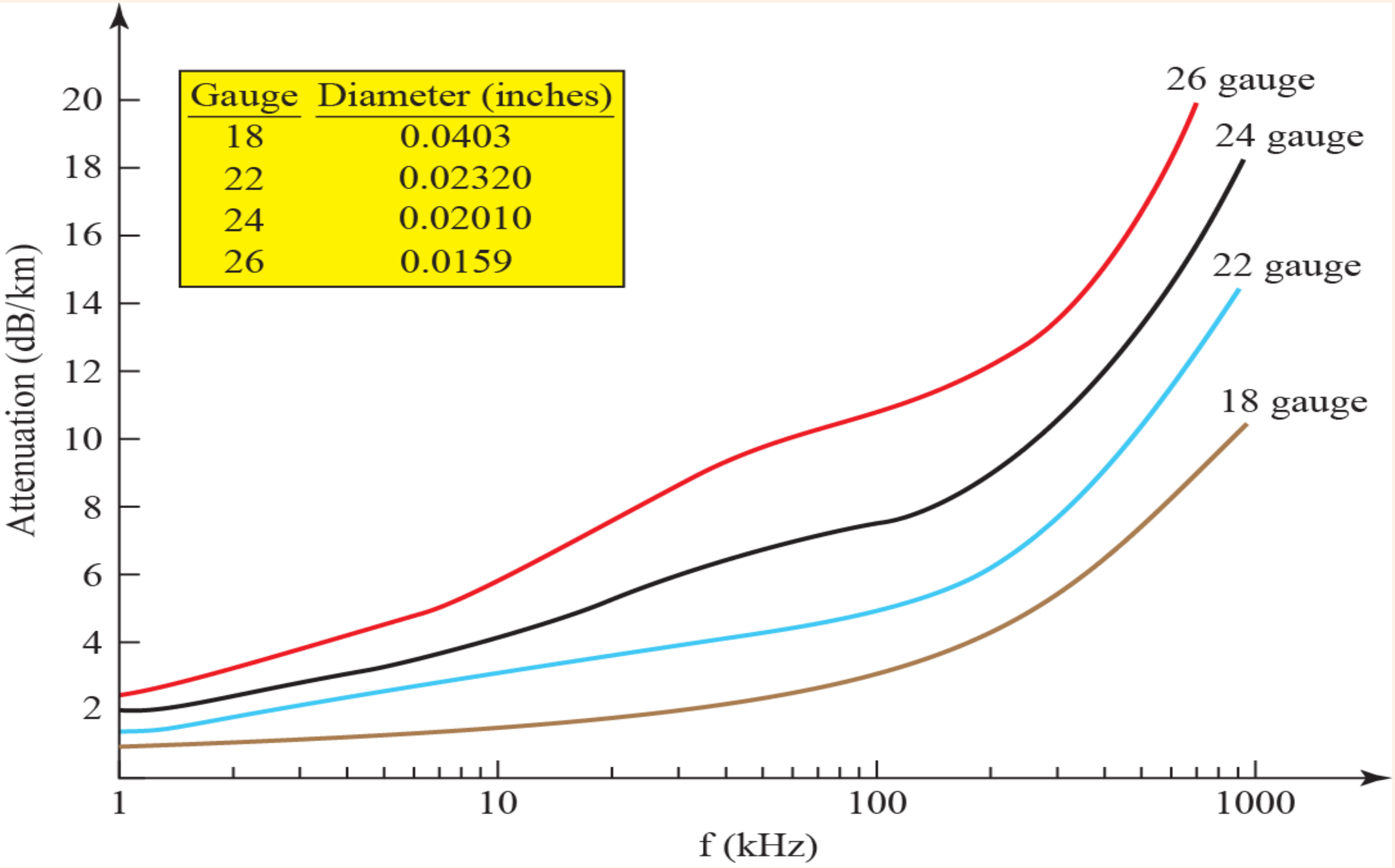


Figure 7.6: UTP Performance

Coaxial Cable

Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted pair cable, in part because the two media are constructed quite differently. Instead of having two wires, coax has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two. The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit.

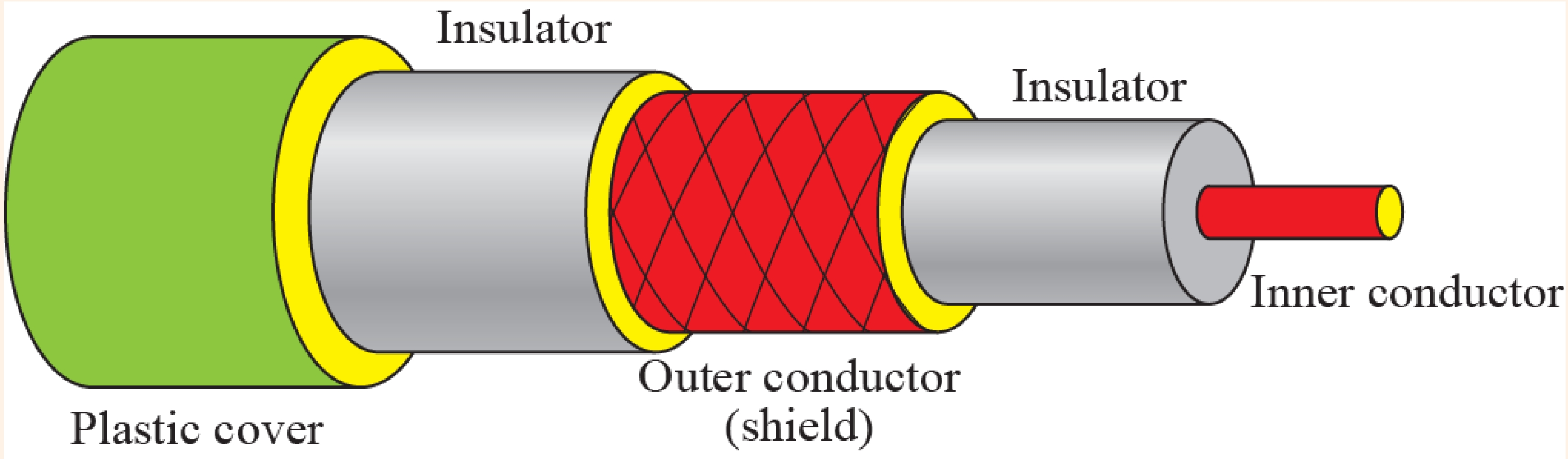


Figure 7.7: Coaxial cable

Coaxial Cable

Table 7.2: Categories of coaxial cables

Category	*Impedance*	*Use*
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

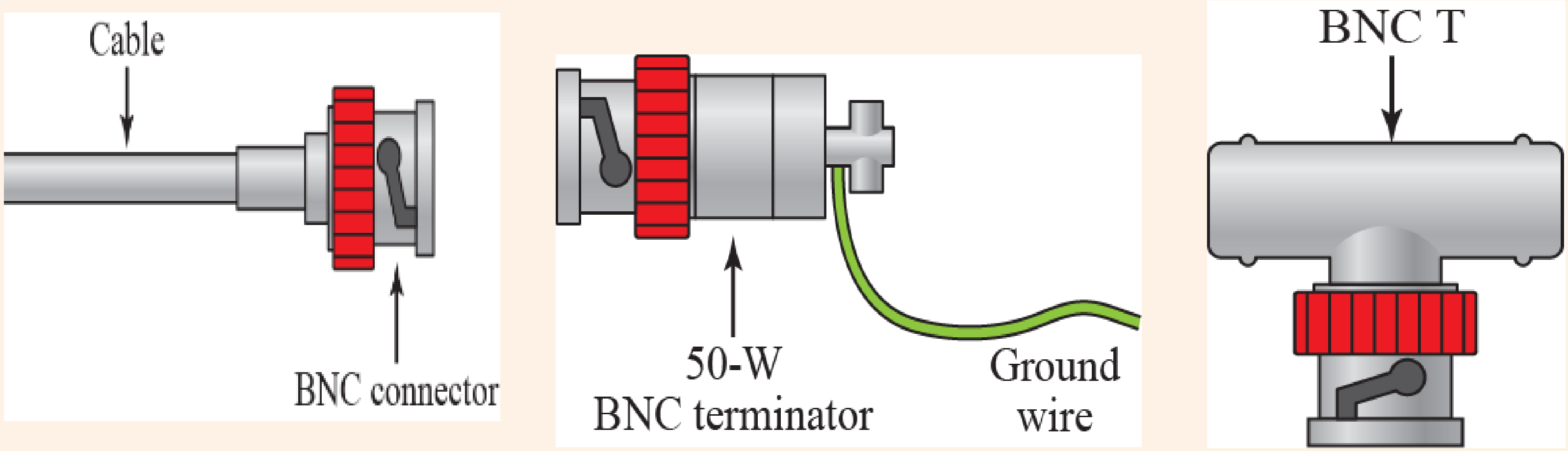


Figure 7.8: Bayonet Neill-Concelman (BNC) connectors

Coaxial Cable

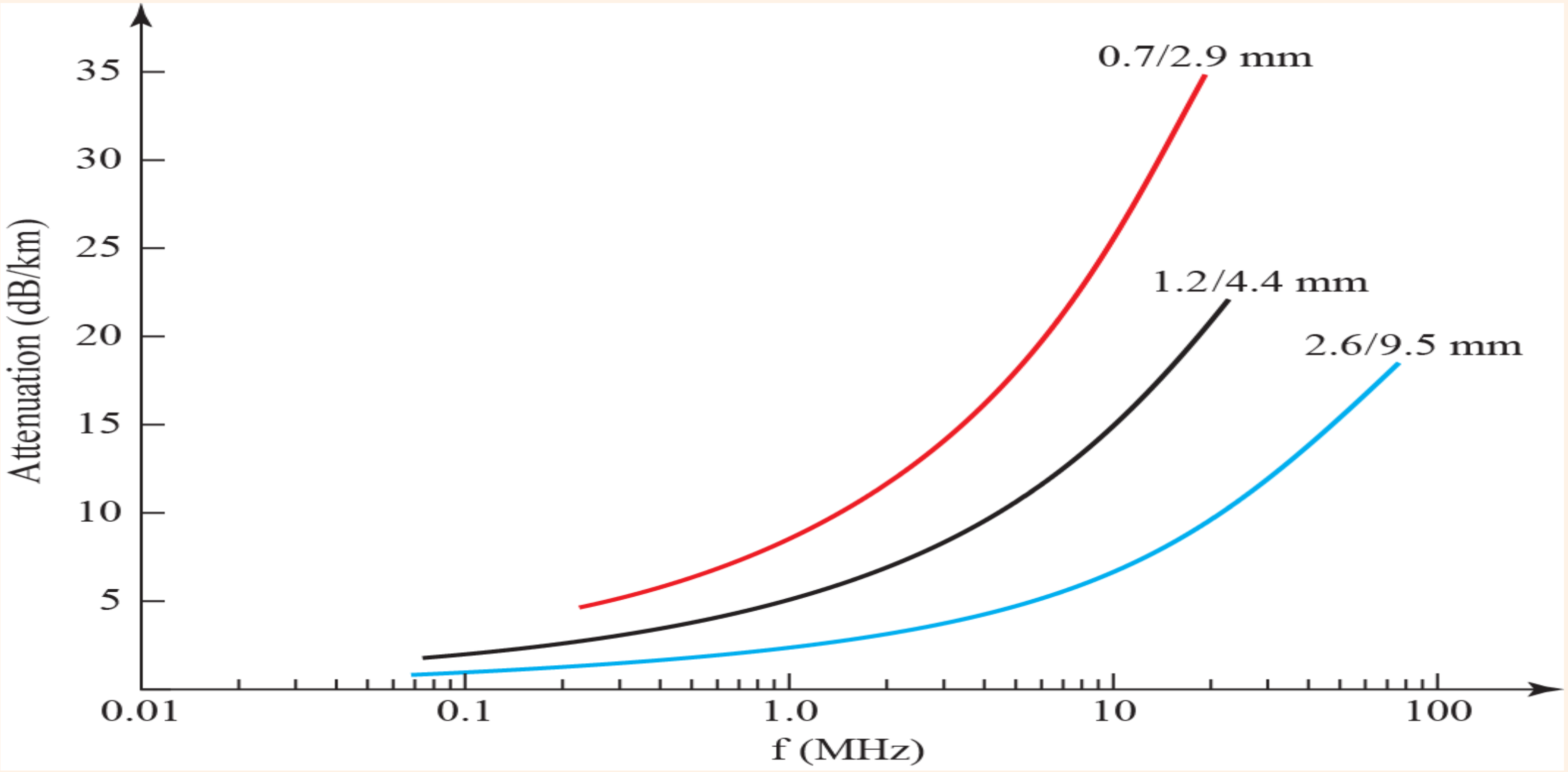


Figure 7.9: Coaxial cable performance

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.

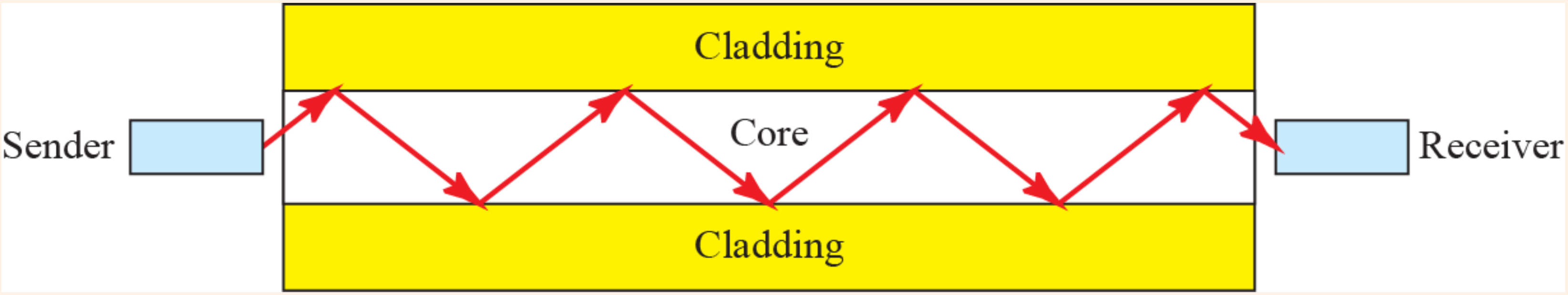


Figure 7.11: Optical fiber

Type	*Core (µm)*	*Cladding (µm)*	*Mode*
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	Multimode, graded index
100/125	100.0	125	Multimode, graded index
7/125	7.0	125	Single mode

Table 7.3: Fiber types

Fiber-Optic Cable

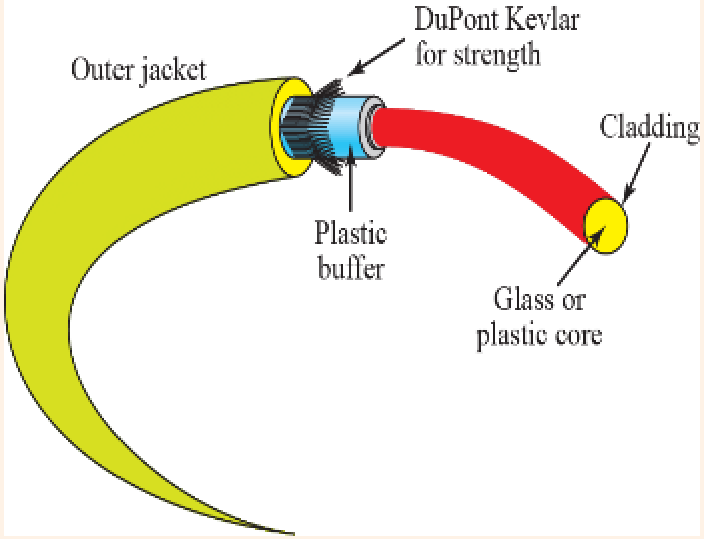
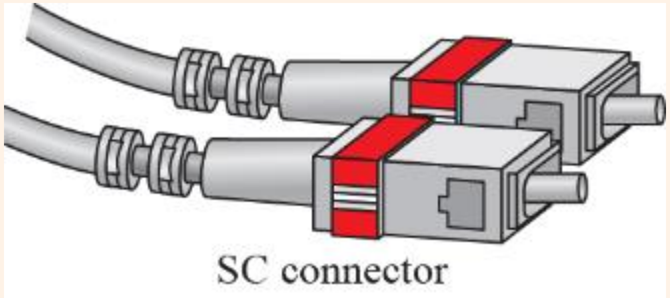
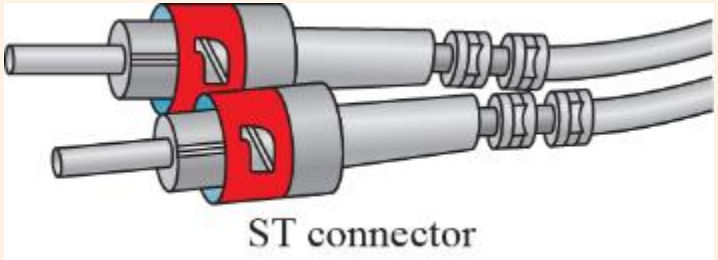


Figure 7.14: Fiber connection





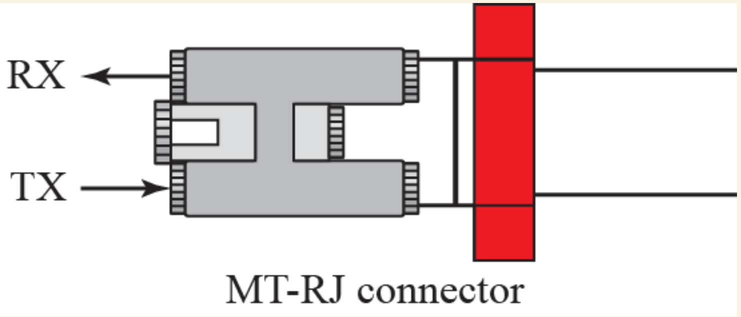


Figure 7.15: Fiber-optic cable connector

Fiber-Optic Cable

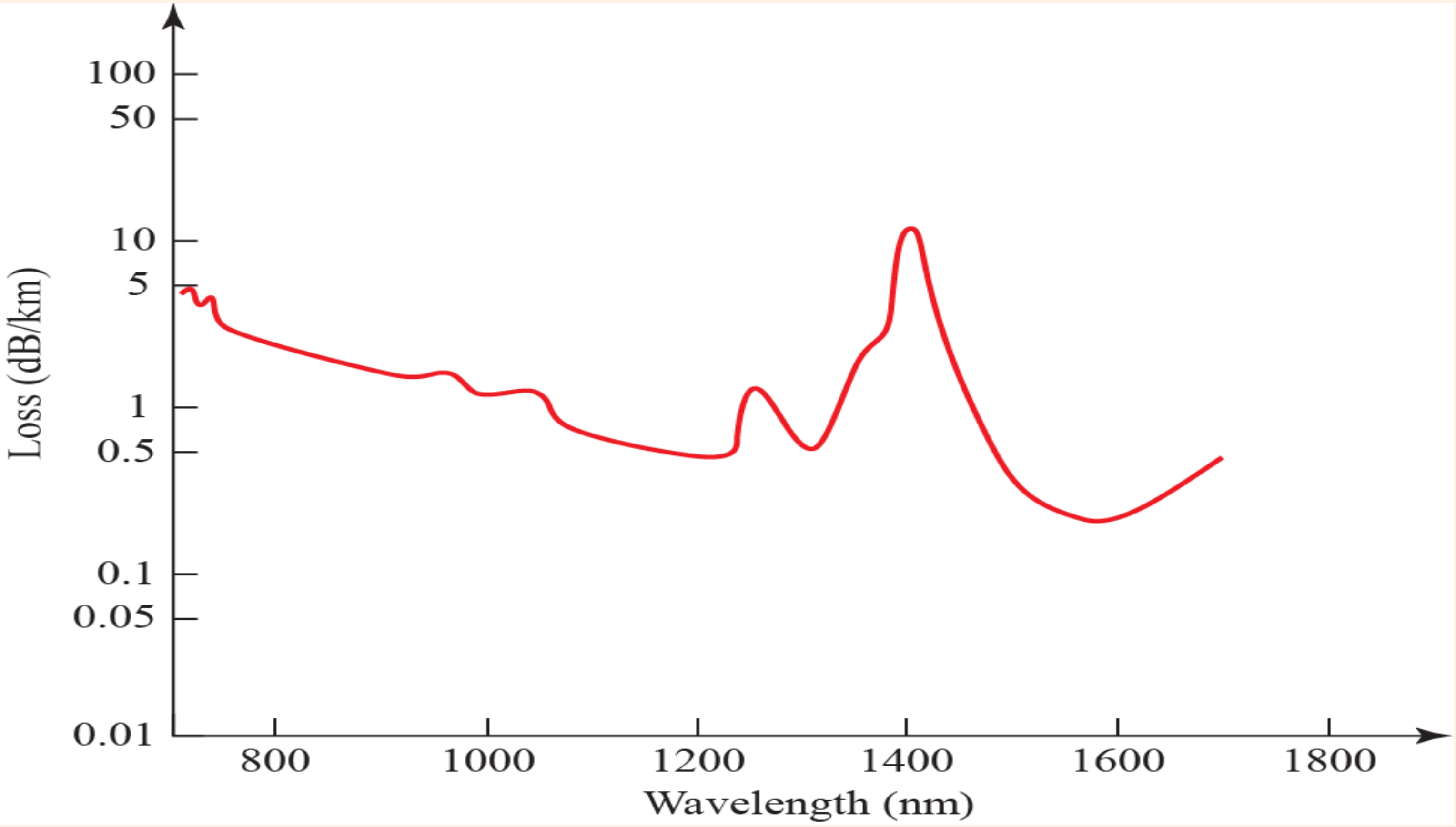


Figure 7.16: Optical fiber performance

Optical Communication

The components of a typical fiber-optic communications system are illustrated in following Fig. 13-1. The information signal to be transmitted may be voice, video, or computer data. The first step is to convert the information into a form compatible with the communications medium. This is usually done by converting continuous analog signals such as voice and video (TV) signals into a series of digital pulses. An A/D converter is used for this purpose. Computer data is already in digital form. These digital pulses are then used to flash a powerful light source off and on very rapidly.

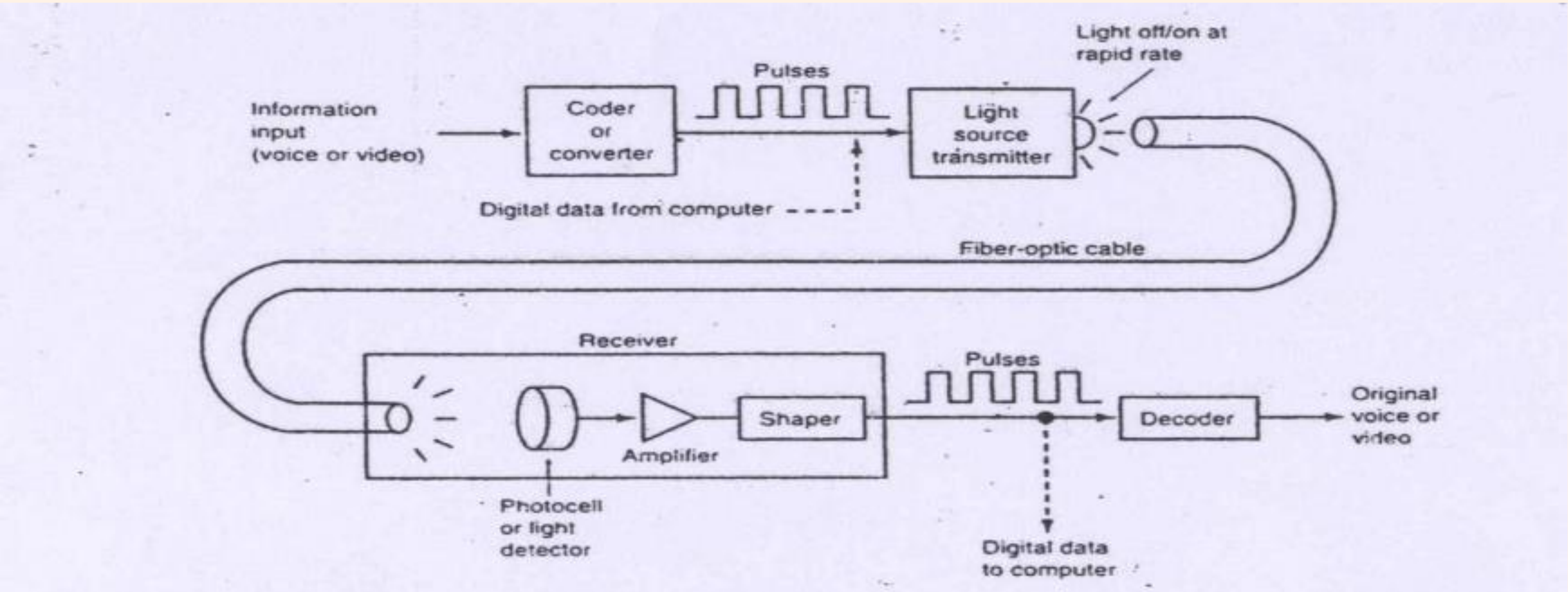


Fig. 13-1 Basic elements of a fiber-optic communications system.

Fiber Optic Communication System

Light source: LED or ILD (Injection Laser Diode): amount of light emitted is proportional to the drive current

Source-to-fiber-coupler (similar to a lens):A mechanical interface to couple the light emitted by the source into the optical fiber

Light detector:PIN (p-type-intrinsic-n-type) or APD (avalanche photo diode) both convert light energy into current

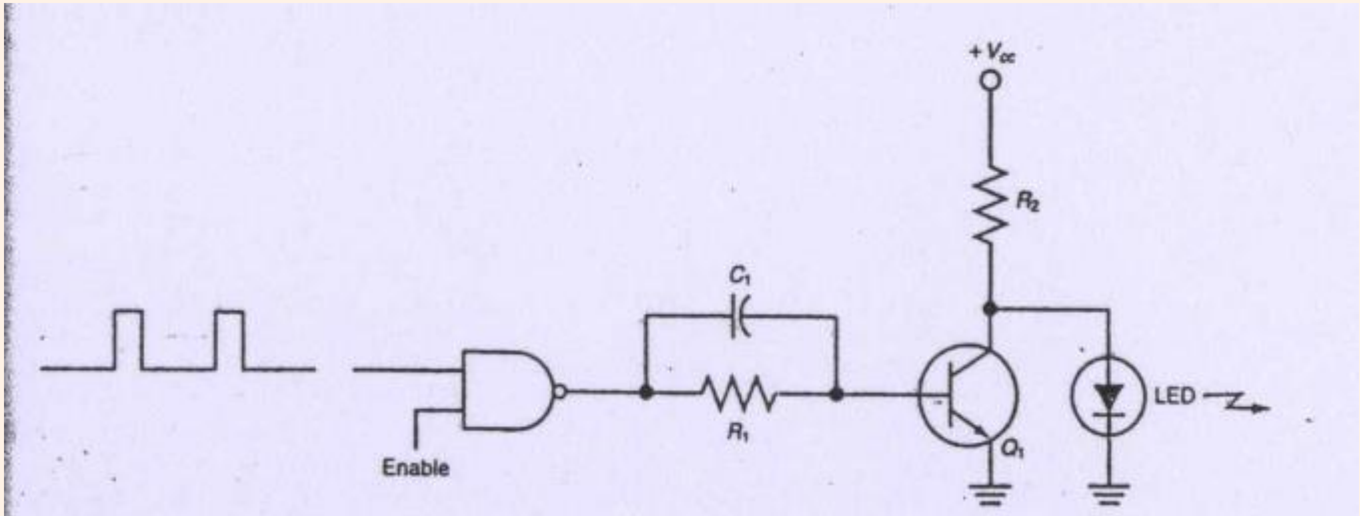


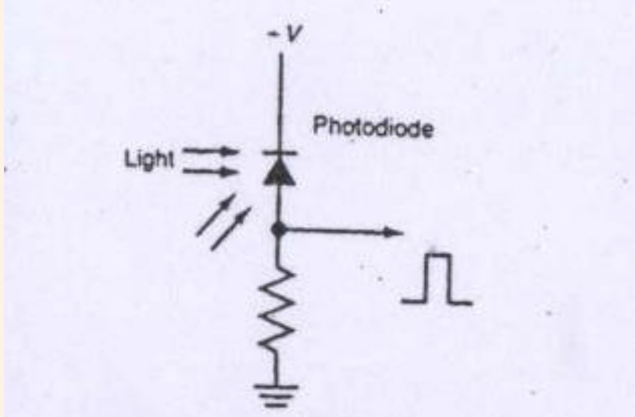
Fig. 13-23 Optical transmitter circuit using an LED.

Fiber Optic Communication System

- The Digital data to be transmitted is converted into a serial pulse train and then into the desired RZ or NRZ format. These pulses are then applied to light transmitter.
- The light transmitter consists of the LED and its associated driving circuitry.
- A typical circuit is shown in Fig. 13-23. The binary pulses are applied to a logic gate which, in turn, operates a transistor switch Q_1 that turns the LED off and on.
- A positive pulse at the NAND gate input causes the NAND output to go to zero. This turns off Q_1, so the LED is forward-biased through R_2 and turns on. With zero input, the NAND output is 1, so Q_1 turns on and shunts current away from the LED.

Fiber Optic Communication System

- The receiver part of the optical communications system is relatively simple.
- It consists of a detector that will sense the light pulses and convert them into an electrical signal.
- This signal is then amplified and shaped into the original serial digital data. The most critical component, of course, is the light sensor.
- The most widely used light sensor is a photodiode.
- This is a silicon PN junction diode that is sensitive to light. This diode is normally reverse-biased as shown in Fig. 13-26



13-26 How a photodiode converts light into voltage pulses.

UNGUIDED MEDIA

Unguided medium transport 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.

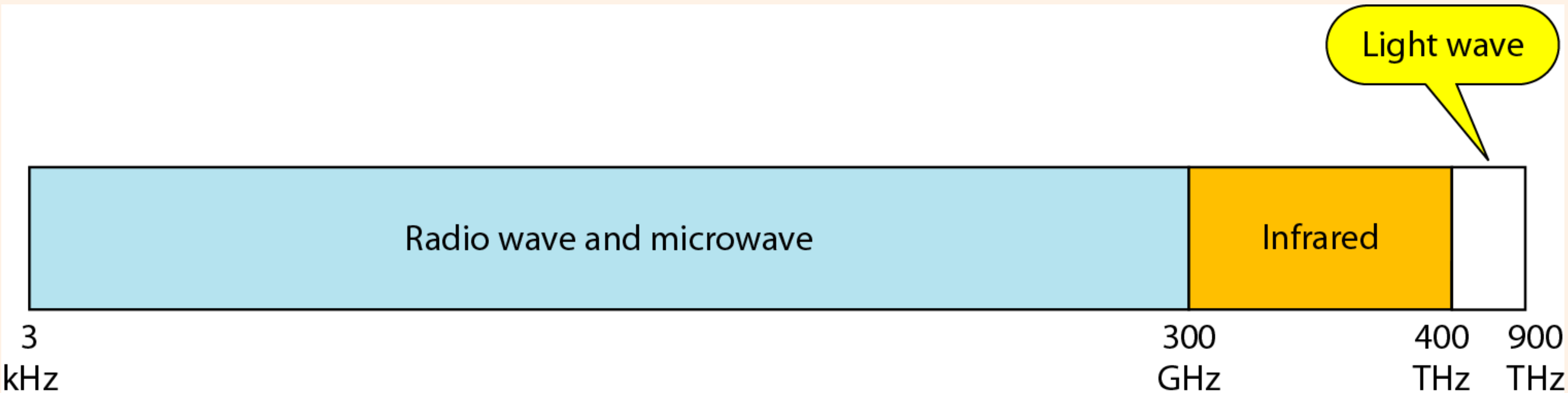


Figure 7.17: Electromagnetic spectrum for wireless communication

UNGUIDED MEDIA

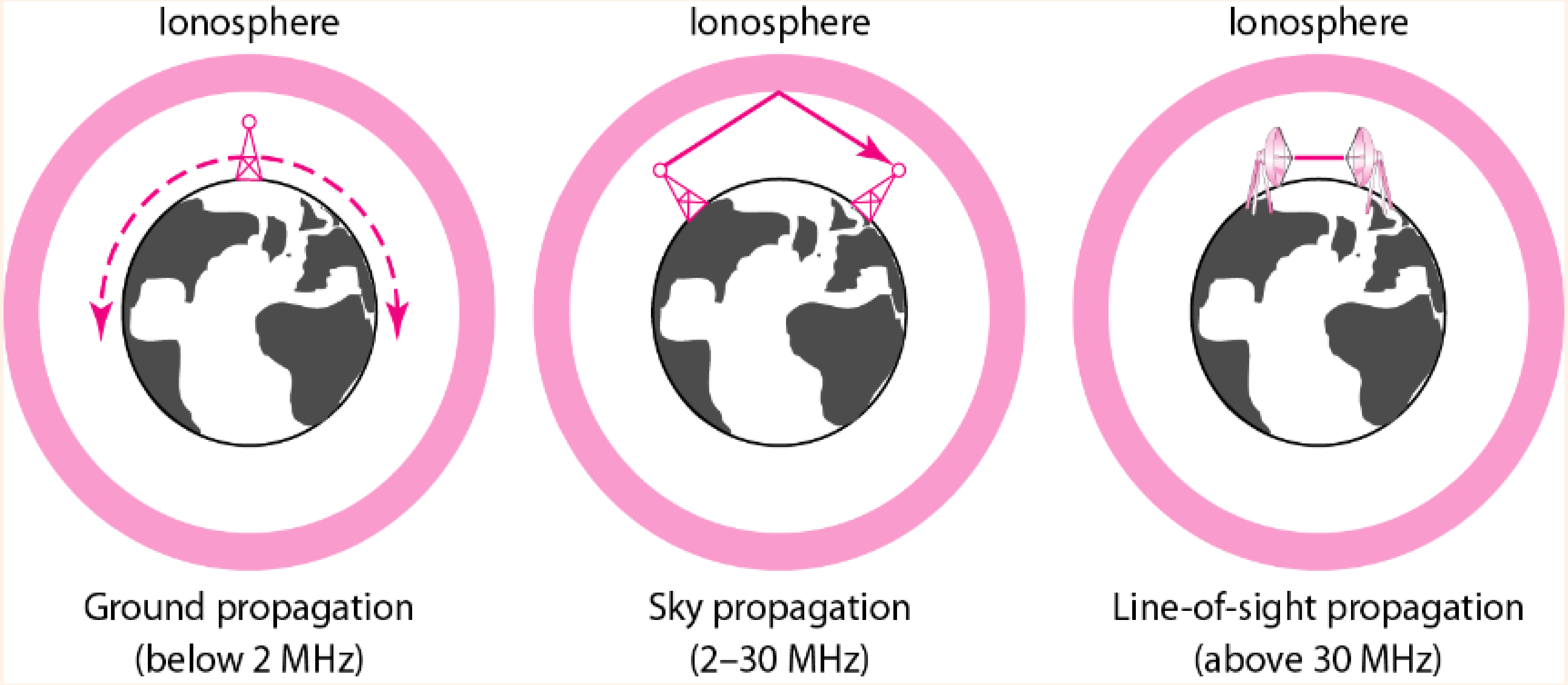


Figure 7.18: Propagation methods

UNGUIDED MEDIA

Table 7.4: Bands

Band	*Range*	*Propagation*	*Application*
very low frequency (VLF)	3–30 kHz	Ground	Long-range radio navigation
low frequency (LF)	30–300 kHz	Ground	Radio beacons and navigational locators
middle frequency (MF)	300 kHz–3 MHz	Sky	AM radio
high frequency (HF)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft
very high frequency (VHF)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
ultrahigh frequency (UHF)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
superhigh frequency (SF)	3–30 GHz	Line-of-sight	Satellite
extremely high frequency (EHF)	30–300 GHz	Line-of-sight	Radar, satellite

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.

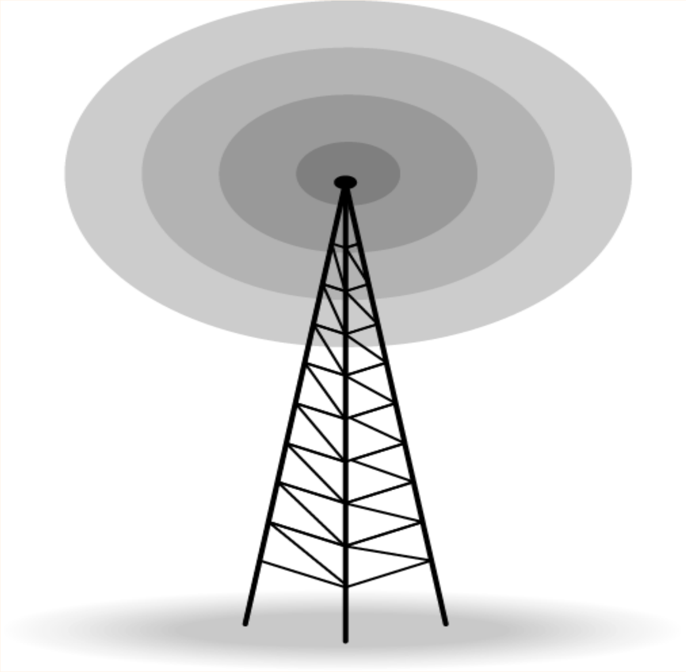


***Figure 7.19:* Omnidirectional antenna**

Microwaves

Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves. Microwaves are unidirectional. When an antenna transmits microwaves, 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.

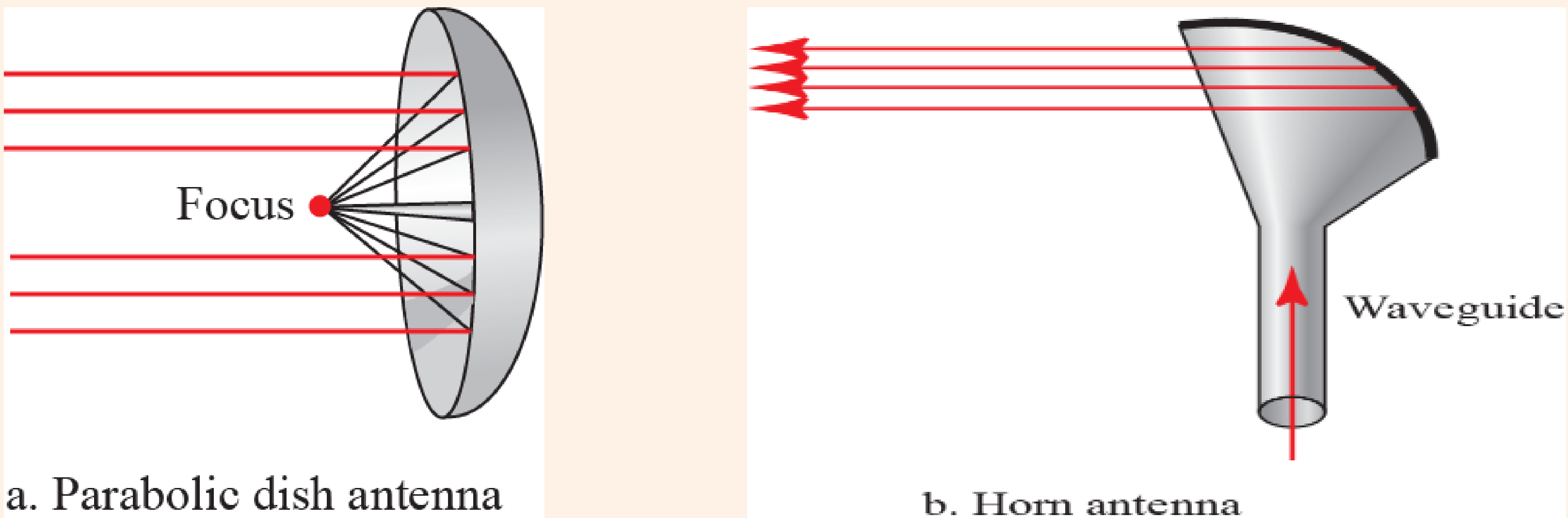


Figure 7.20: Unidirectional antenna

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.

Books

1. Forouzan, B. A. "Data Communication and Networking. Tata McGraw." (2005).

References

1. Prakash C. Gupta, “Data communications”, Prentice Hall India Pvt.
2. William Stallings, "Data and Computer Communications”, Pearson
3. Forouzan, B. A. "Data Communication and Networking. Tata McGraw." (2005).