Introduction to Communication Systems
Chapter 1

Dr. Saeed Mahmud Ullah
Professor
EEE, DU

Text Book

- Principles of Electronic Communication Systems
  - L. E. Frenzel
  - 4^{th} edition

Figure 1-1 Milestones in the history of electronic communication.

When?	Where or Who?	What?
1837	Samuel Morse	Invention of the telegraph (patented in 1844).
1843	Alexander Bain	Invention of facsimile.
1866	United States and England	The first transatlantic telegraph cable laid.
1876	Alexander Bell	Invention of the telephone.
1877	Thomas Edison	Invention of the phonograph.
1879	George Eastman	Invention of photography.
1887	Heinrich Hertz (German)	Discovery of radio waves.
1887	Guglielmo Marconi (Italian)	Demonstration of "wireless" communications by radio waves.
1901	Marconi (Italian)	First transatlantic radio contact made.
1903	John Fleming	Invention of the two-electrode vacuum tube rectifier.
1906	Reginald Fessenden	Invention of amplitude modulation; first electronic voice communication demonstrated.
1906	Lee de Forest	Invention of the triode vacuum tube.
1914	Hiram P. Maxim	Founding of American Radio Relay League, the first amateur radio organization.
1920	KDKA Pittsburgh	First radio broadcast.
1923	Vladimir Zworykin	Invention and demonstration of television.
1933–1939	Edwin Armstrong	Invention of the superheterodyne receiver and frequency modulation.

1939	United States	First use of two-way radio (walkie-talkies).
1940–1945	Britain, United States	Invention and perfection of radar (World War II).
1948	John von Neumann and others	Creation of the first stored program electronic digital computer.
1948	Bell Laboratories	Invention of transistor.
1953	RCA/NBC	First color TV broadcast.
1958–1959	Jack Kilby (Texas Instruments) and Robert Noyce (Fairchild)	Invention of integrated circuits.
1958–1962	United States	First communication satellite tested.
1961	United States	Citizens band radio first used.
1973–1976	Metcalfe	Ethernet and first LANs.
1975	United States	First personal computers.
1977	United States	First use of fiber-optic cable.
1982	United States	TCP/IP protocol adopted.
1982–1990	United States	Internet development and first use.
1983	United States	Cellular telephone networks.
1993	United States	First browser Mosaic.
1995	United States	Global Positioning System deployed.
1996–2001	Worldwide	First smartphones by BlackBerry, Nokia, Palm.
1997	United States	First wireless LANs.
2000	Worldwide	Third-generation digital cell phones.
2009	Worldwide	First fourth-generation LTE cellular networks.
2009	Worldwide	First 100 Gb/s fiber optical networks.

Human Communication

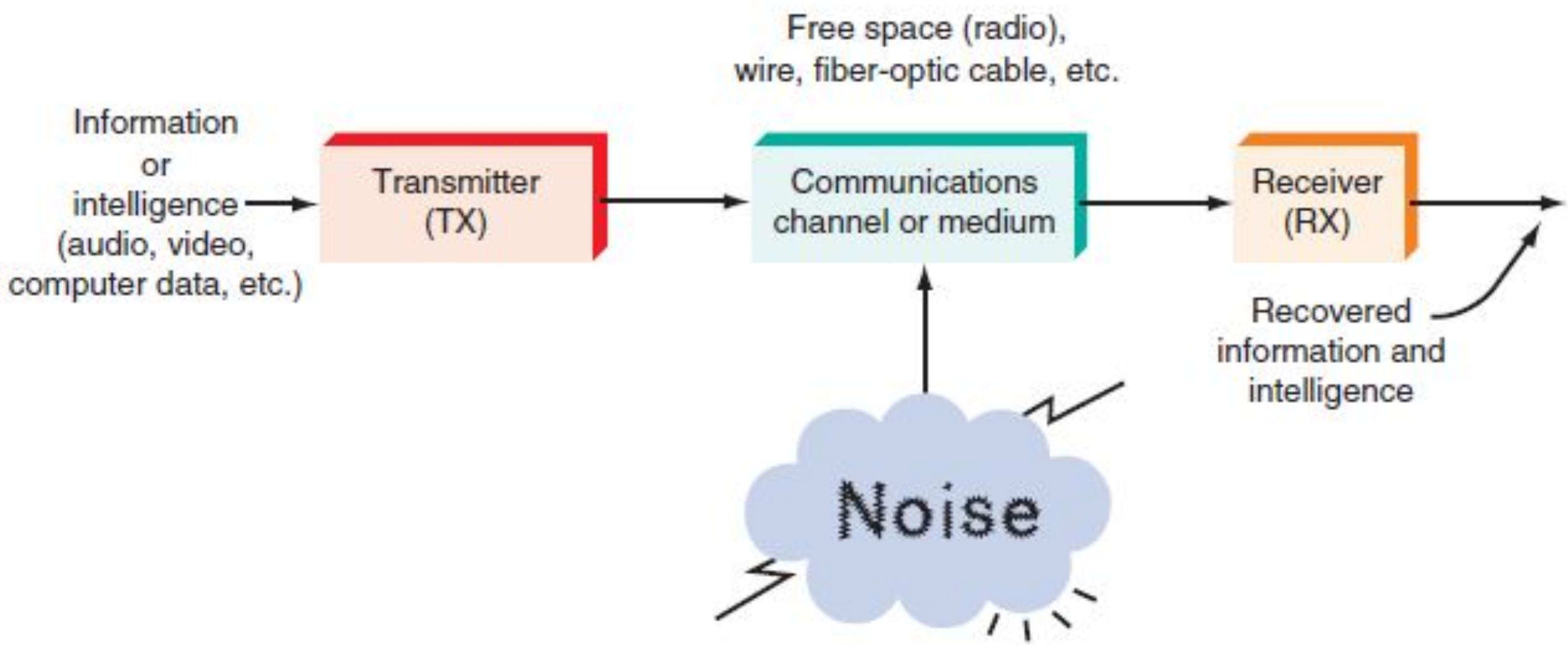
Methods of communication:

1. Face to face
2. Signals
3. Written word (letters)
4. Electrical innovations:

- Telegraph
- Telephone
- Radio
- Television
- Internet (computer)

Communication System

Figure 1-2 A general model of all communication systems.



Transmitter

- **Transmitter** is a collection of electronic components and circuits that converts the electrical signal into a signal suitable for transmission over a given medium. Transmitters are made up of oscillators, amplifiers, tuned circuits and filters, modulators, frequency mixers, frequency synthesizers, and other circuits.
- Transmitters are made up of oscillators, amplifiers, tuned circuits and filters, modulators, frequency mixers, frequency synthesizers, and other circuits.

Communication Channel

- The **Communication Channel** is the medium by which the electronic signal is sent from one place to another.

Electrical Conductors. In its simplest form, the medium may simply be a pair of wires that carry a voice signal from a microphone to a headset. It may be a coaxial cable such as that used to carry cable TV signals. Or it may be a twisted-pair cable used in a local-area network (LAN).

Optical Media. The communication medium may also be a fiber-optic cable or "light pipe" that carries the message on a light wave. These are widely used today to carry long-distance calls and all Internet communications. The information is converted to digital form that can be used to turn a laser diode off and on at high speeds. Alternatively, audio or video analog signals can be used to vary the amplitude of the light.

Free Space. When free space is the medium, the resulting system is known as radio. Also known *as wireless, radio* is the broad general term applied to any form of wireless communication from one point to another. Radio makes use of the electromagnetic spectrum. Intelligence signals are converted to electric and magnetic fields that propagate nearly instantaneously through space over long distances. Communication by visible or infrared light also occurs in free space.

Receiver

- **RECEIVER** is a collection of electronic components and circuits that accepts the transmitted message from the channel and converts it back into a form understandable by humans.
- Receivers contain amplifiers, oscillators, mixers, tuned circuits and filters, and a demodulator or detector that recovers the original intelligence signal from the modulated carrier.

Transceiver

- **TRANSCEIVER** is an electronic unit that incorporates circuits that both send and receive signals.
- Examples are:
  - Telephones
  - Fax machines
  - Handheld CB radios
  - Cell phones
  - Computer modems

Attenuation

- Signal **Attenuation**, or degradation, exists in all media of wireless or wired transmission. It is proportional to the square of the distance between the transmitter and receiver.

Noise

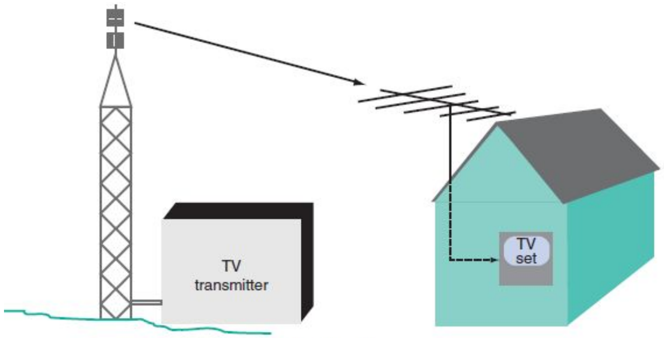
- It is random, undesirable electronic energy that enters the communication system via the communicating medium/ electronics and interferes with the transmitted message.

Types of Electronic Communication

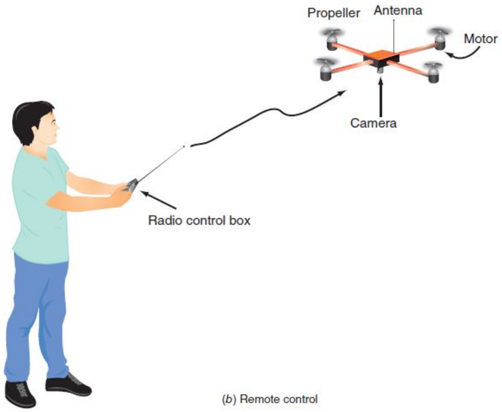
- Electronic communications are classified according to whether they are
  - (1) one-way (simplex) or two-way (full duplex or half duplex) transmissions
  - (2) analog or digital signals.

Simplex

- The simplest method of electronic communication is referred to as simplex. This type of communication is one-way.
- Examples are:
  - Radio
  - TV broadcasting
  - Beeper (personal receiver)



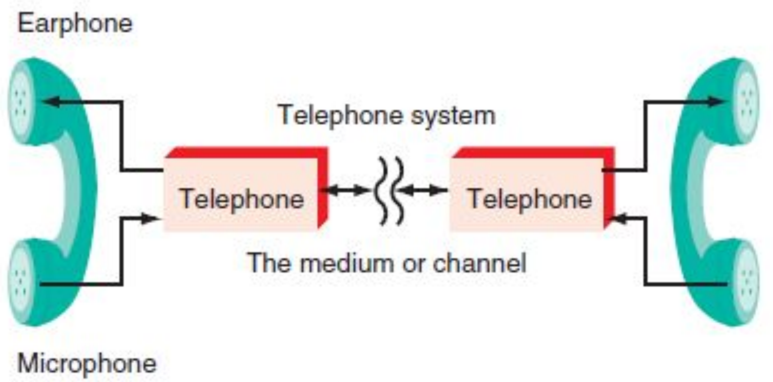
(a) TV broadcasting



(b) Remote control

Full duplex

- Most electronic communication is two-way and is referred to as duplex. When people can talk and listen simultaneously, it is called full duplex. The telephone is an example of this type of communication.



(*a*) Full duplex (simultaneous, two-way)

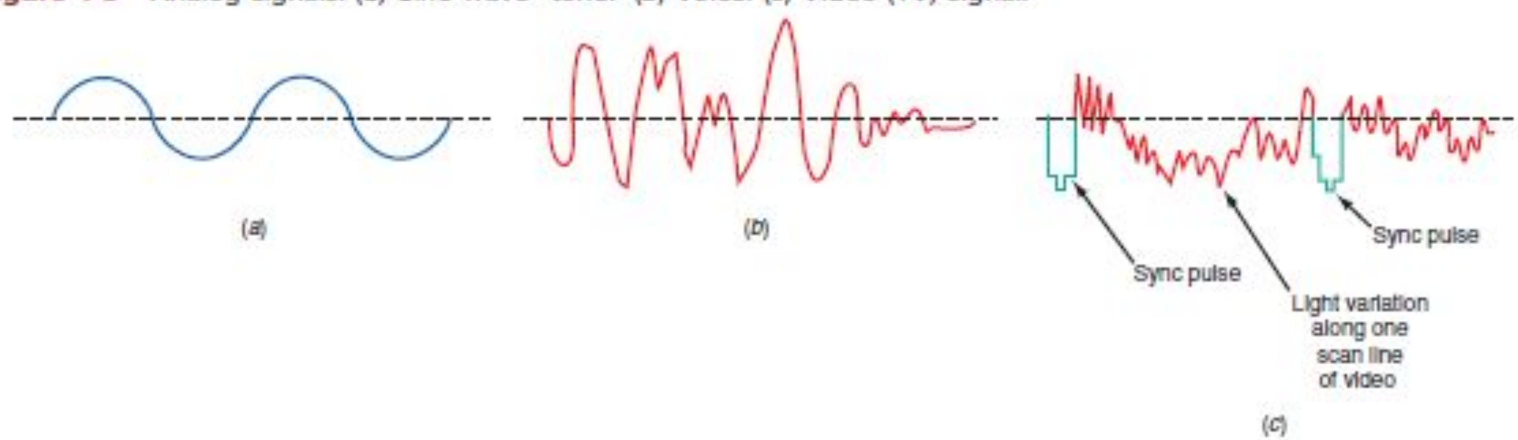
Half duplex

- The form of two-way communication in which only one party transmits at a time is known as half duplex.
- Examples are:
  - Police, military, etc. radio transmissions
  - Citizen band
  - Family radio
  - Amateur radio

Analog Signal

- An *analog signal is a smoothly and continuously varying voltage or current in terms of both amplitude and time.*
- A sine wave is a single-frequency analog signal.
- Voice and video voltages are analog signals that vary in accordance with the sound or light variations that are analogous to the information being transmitted.

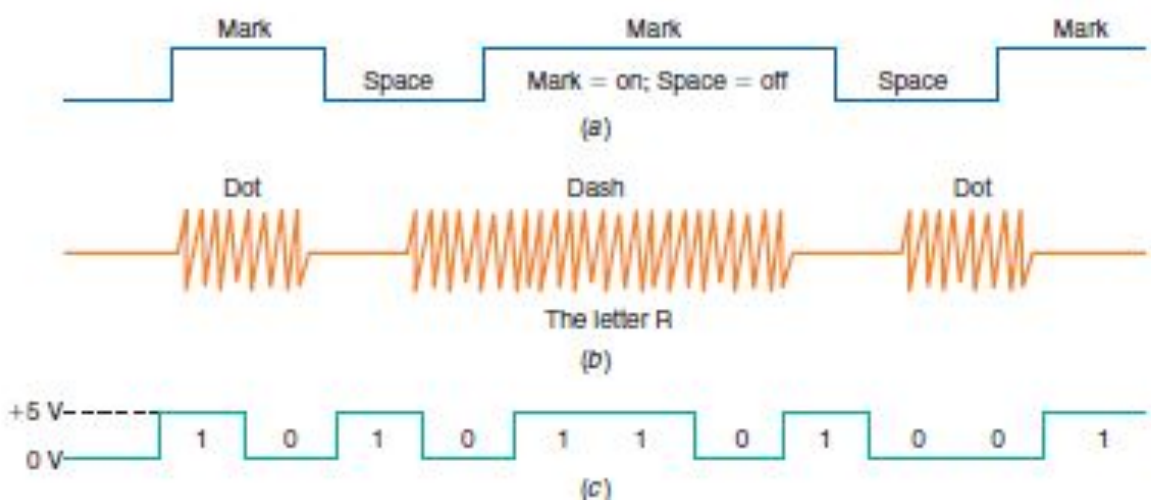
Figure 1-5 Analog signals. (*a*) Sine wave "tone." (*b*) Voice. (*c*) Video (TV) signal.



Digital signal

- *Digital signals do not vary continuously, but change in* steps or in discrete increments in terms of both amplitude and time.
- Most digital signals use binary or two-state codes. Some earliest forms of both wire and radio communication used a type of on/off digital code. The telegraph used Morse code, with its system of short and long signals (dots and dashes) to designate letters and numbers.
- The most commonly used digital code in communications is the *American Standard Code for Information Interchange (ASCII).*

Figure 1-6 Digital signals. (*a*) Telegraph (Morse code). (*b*) Continuous-wave (CW) code. (*c*) Serial binary code.



Modulation and Multiplexing

- *Modulation makes the information signal more* compatible with the medium
- *Multiplexing allows more than one signal to be transmitted* concurrently over a single medium.

Baseband transmission

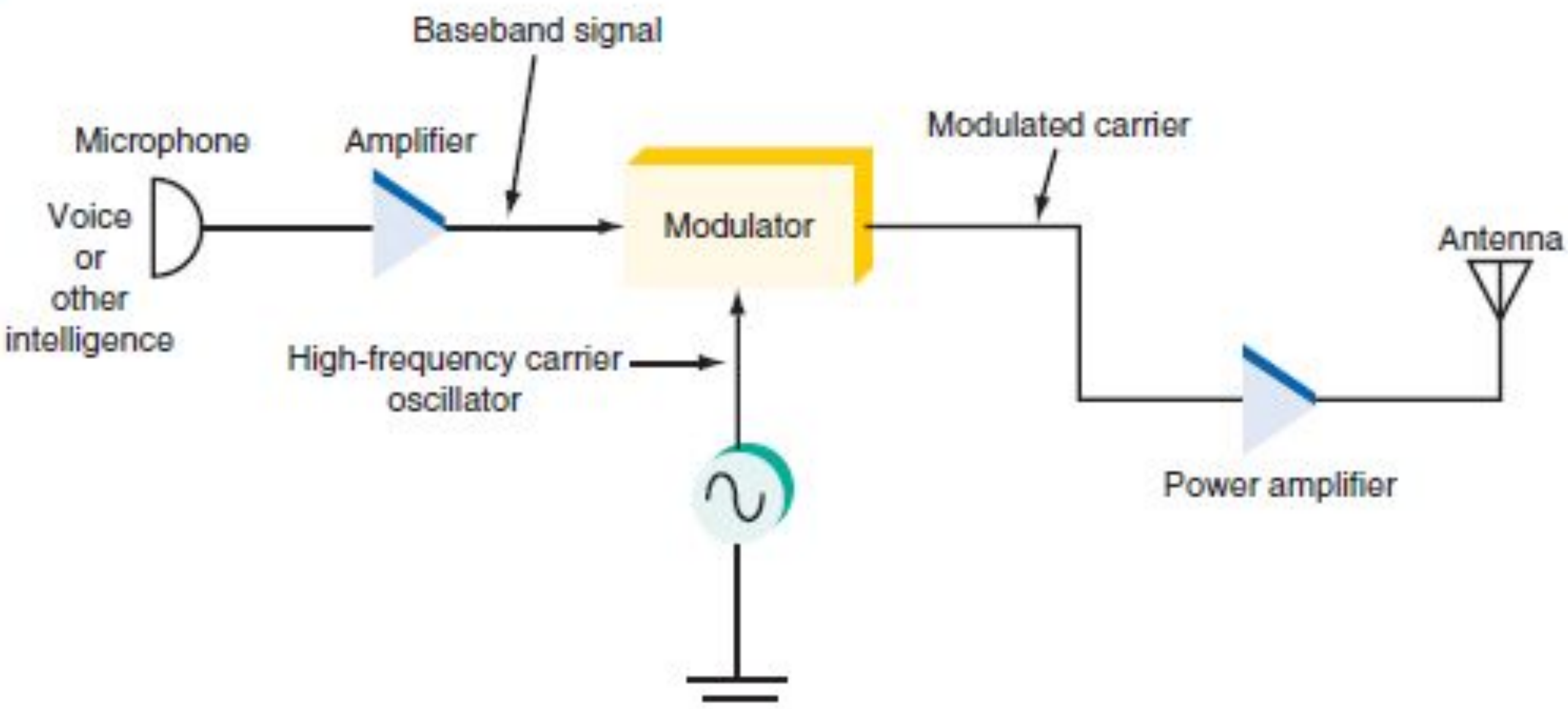
- **Baseband transmission** is **transmission** of the encoded signal using its own **baseband** frequencies; i.e. without any shift (up-converting) to higher frequency ranges
- Many telephone and intercom systems, it is the voice itself that is placed on the wires and transmitted over some distance to the receiver. In most computer networks, the digital signals are applied directly to coaxial or twisted-pair cables for transmission to another computer.

Broadband transmission

- Modulation is the process of having a baseband voice, video, or digital signal modify another, higher-frequency signal, the carrier. The information or intelligence to be sent is said to be *impressed upon the carrier. The carrier* is usually a sine wave generated by an oscillator. The carrier is fed to a circuit called a modulator along with the baseband intelligence signal. The intelligence signal changes the carrier in a unique way. The modulated carrier is amplified and sent to the antenna for transmission. This process is called ***broadband transmission***.

Broadband transmission

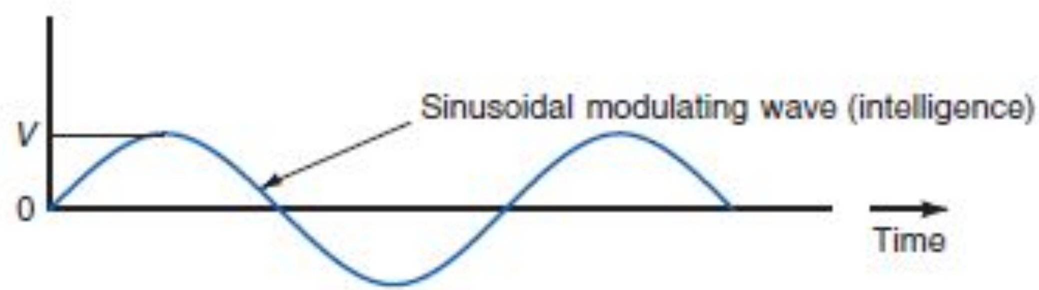
Figure 1-7 Modulation at the transmitter.



Expression of Sine wave

$$v = V_p \sin(2\pi ft + \theta) \quad \text{or} \quad v = V_p \sin(\omega t + \theta)$$

where $v =$ instantaneous value of sine wave voltage
$V_p =$ peak value of sine wave
$f =$ frequency, Hz
$\omega =$ angular velocity $= 2\pi f$
$t =$ time, s
$\omega t = 2\pi ft =$ angle, rad ($360° = 2\pi$ rad)
$\theta =$ phase angle

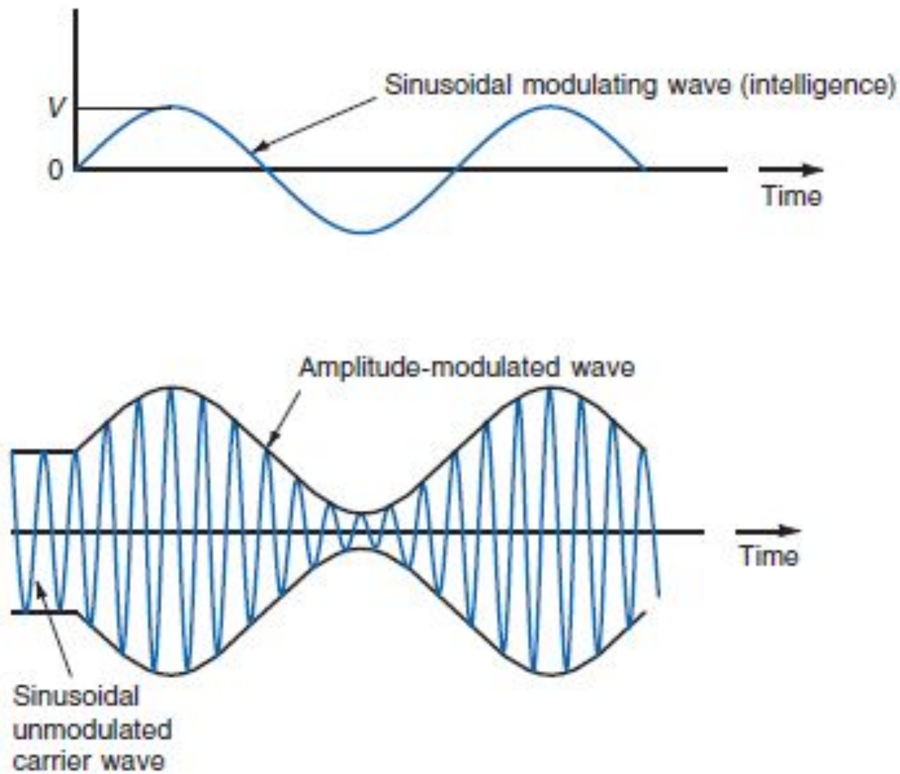


Analog modulation techniques

- Amplitude modulation (AM)
- Frequency modulation (FM)
- Phase modulation (PM)

Amplitude modulation

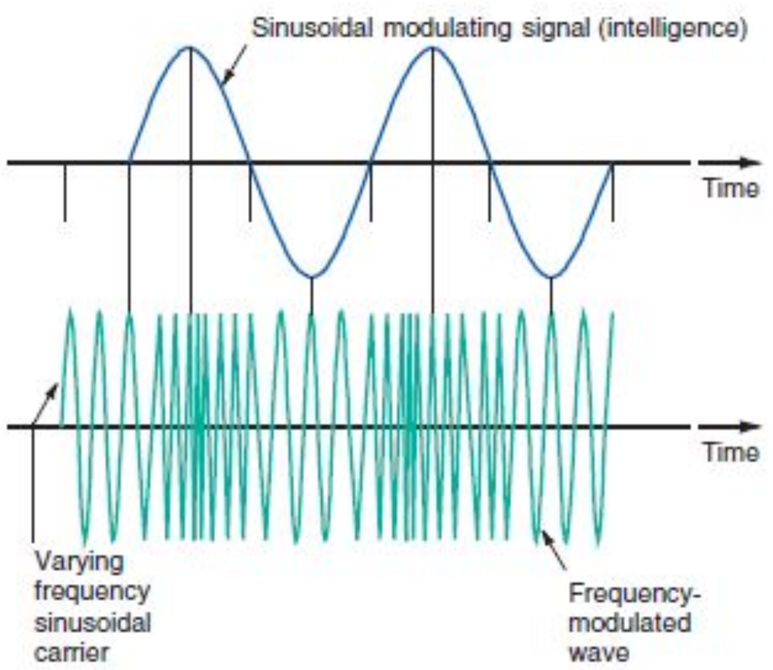
- In AM, the baseband information signal called the modulating signal varies the amplitude of the higher-frequency carrier signal. *It changes the Vp part of* the equation.



(a)

Frequency modulation

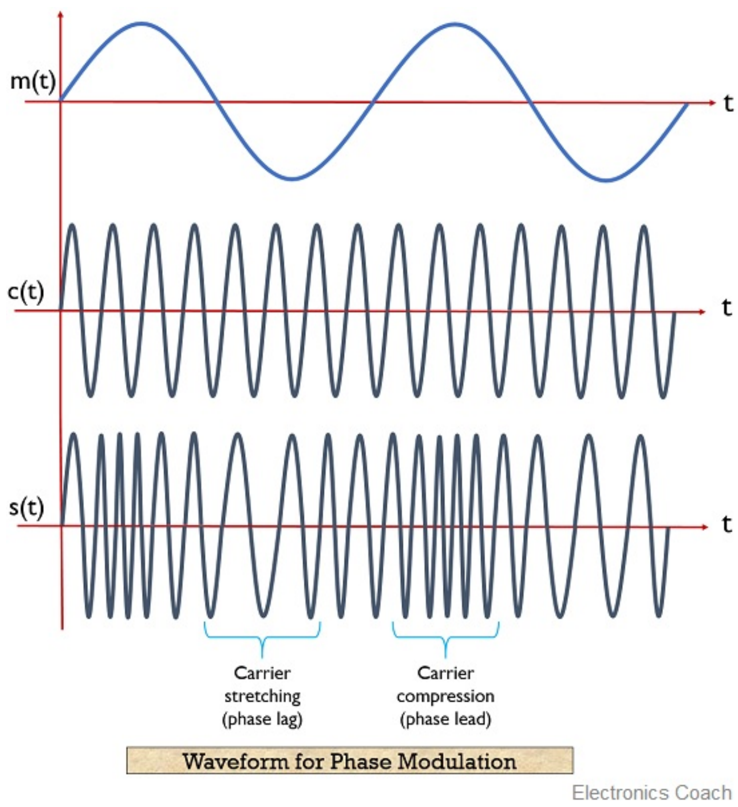
- In FM, the information signal varies the frequency of the carrier. *The carrier amplitude remains constant. FM varies the value of f in the* first angle term inside the parentheses.



(b)

Phase modulation

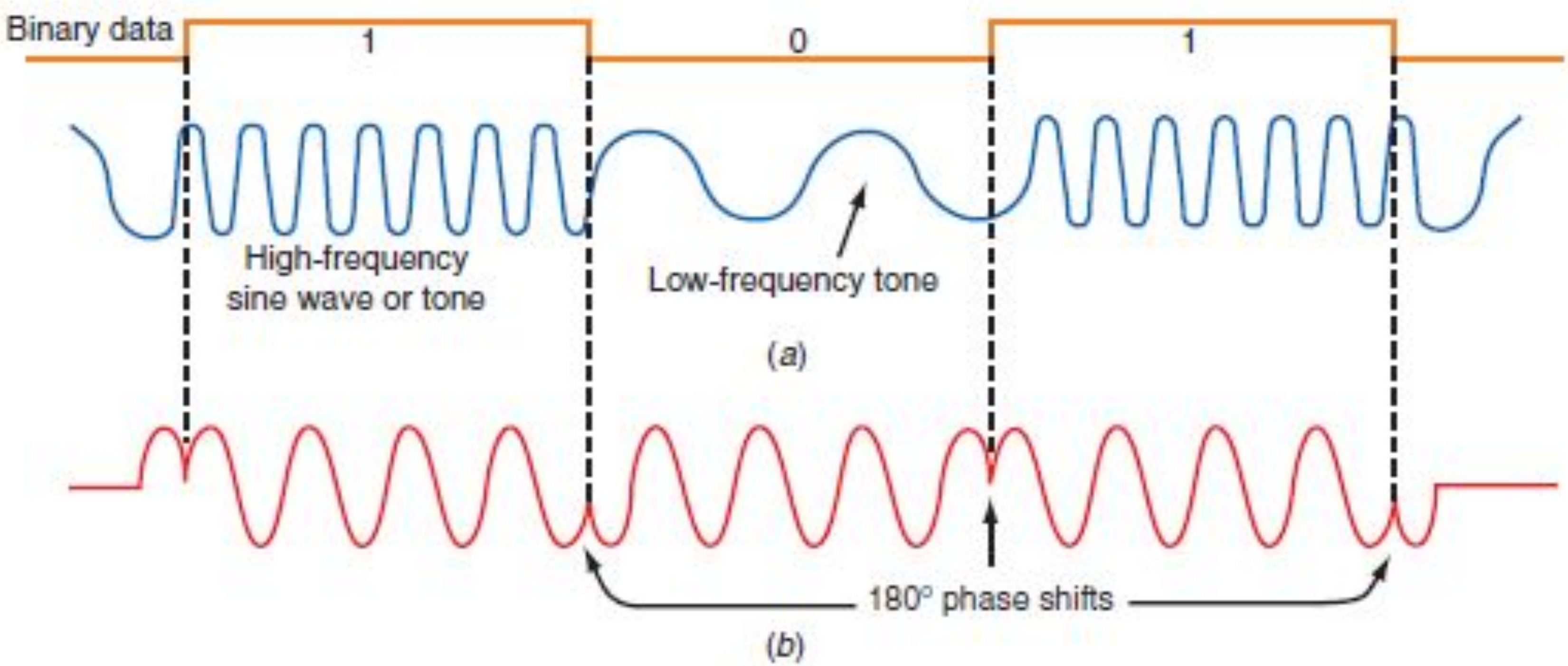
- Varying the phase angle produces *phase modulation (PM). Here, the second term inside the parentheses (ϑ) is made to vary by the* intelligence signal.



Digital modulation

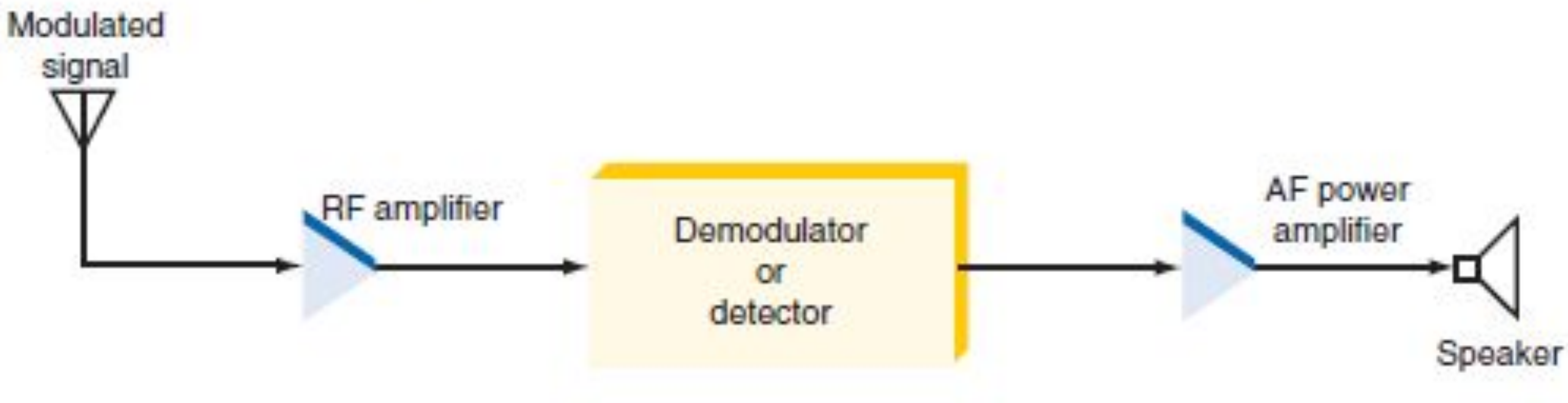
- FSK and PSK

Figure 1-9 Transmitting binary data in analog form. (*a*) FSK. (*b*) PSK.



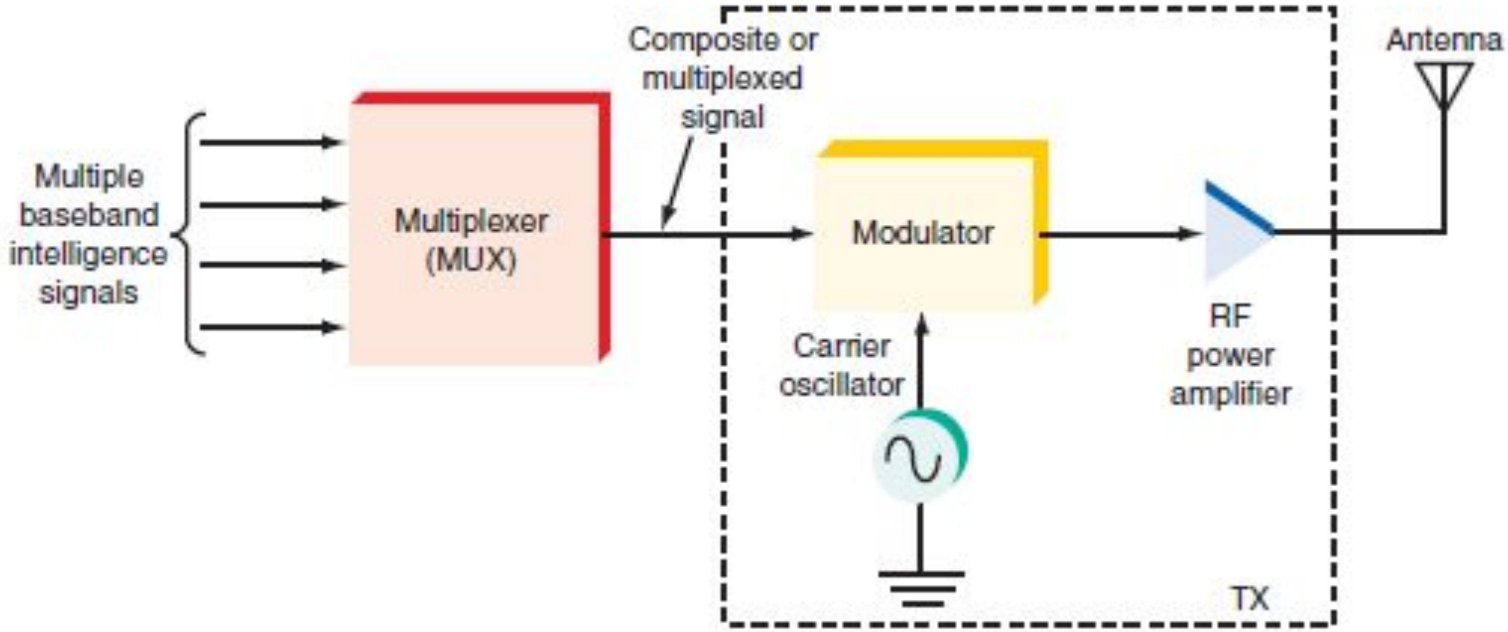
Signal detection

Figure 1-10 Recovering the intelligence signal at the receiver.



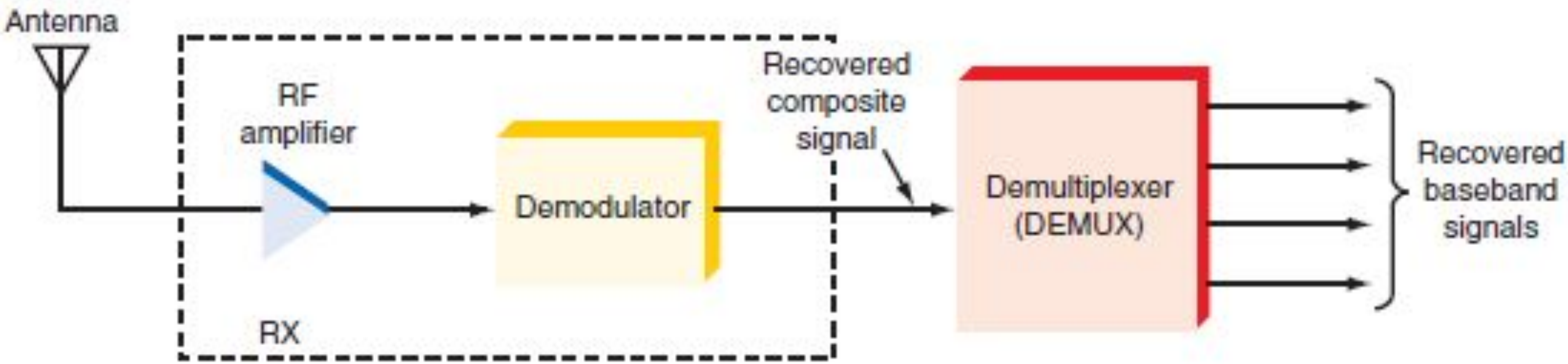
Multiplexing

Figure 1-11 Multiplexing at the transmitter.



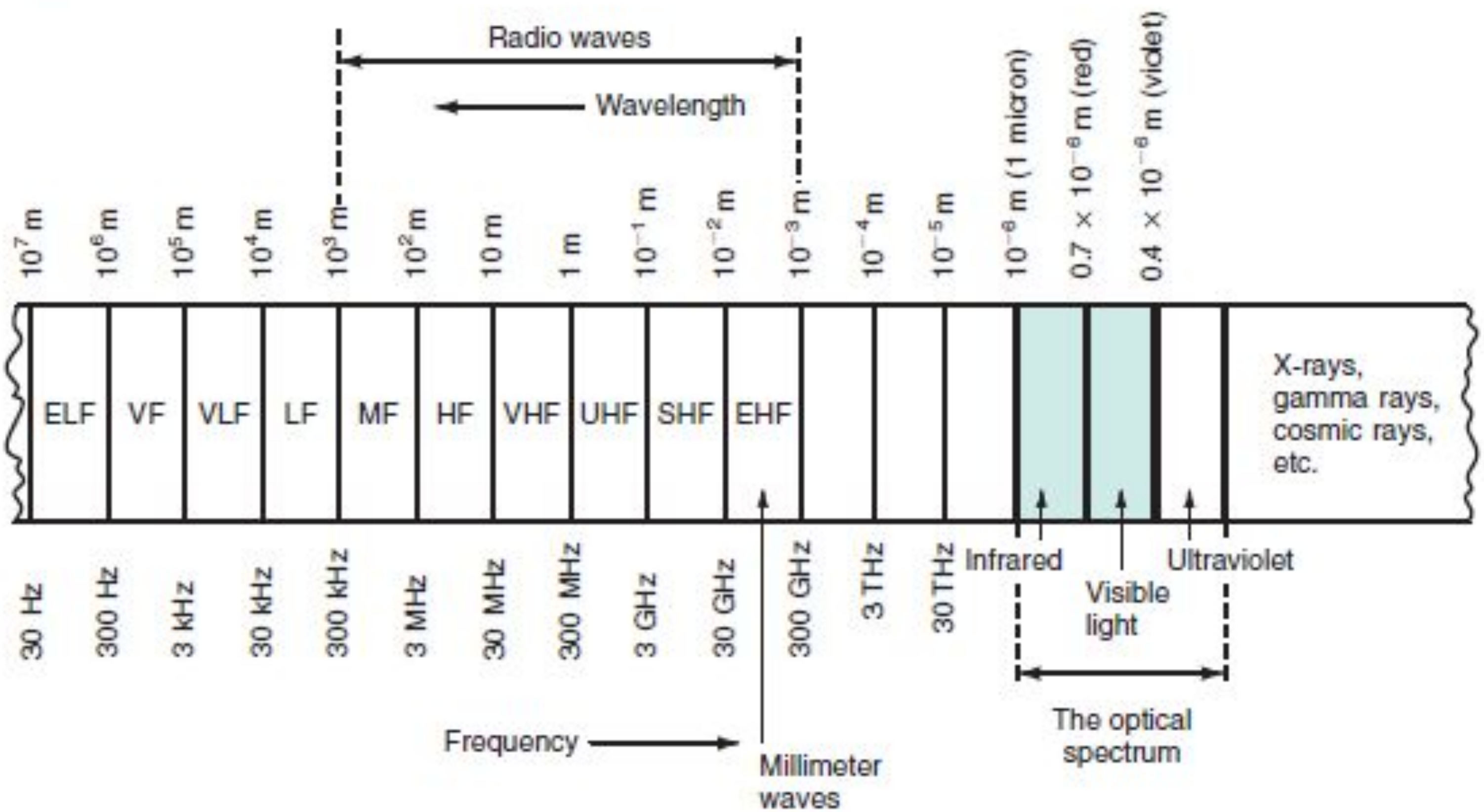
Demultiplexing

Figure 1-12 Demultiplexing at the receiver.



Electromagnetic spectrum

Figure 1-13 The electromagnetic spectrum.



Example 1-1

Find the wavelengths of (*a*) a 150-MHz, (*b*) a 430-MHz, (*c*) an 8-MHz, and (*d*) a 750-kHz signal.

a. $\lambda = \dfrac{300{,}000{,}000}{150{,}000{,}000} = \dfrac{300}{150} = 2 \text{ m}$

b. $\lambda = \dfrac{300}{430} = 0.697 \text{ m}$

c. $\lambda = \dfrac{300}{8} = 37.5 \text{ m}$

d. For Hz (750 kHz = 750,000 Hz):

$$\lambda = \frac{300{,}000{,}000}{750{,}000} = 400 \text{ m}$$

For MHz (750 kHz = 0.75 MHz):

$$\lambda = \frac{300}{0.75} = 400 \text{ m}$$

Example 1-3

A signal travels a distance of 75 ft in the time it takes to complete 1 cycle. What is its frequency?

$$1 \text{ m} = 3.28 \text{ ft}$$

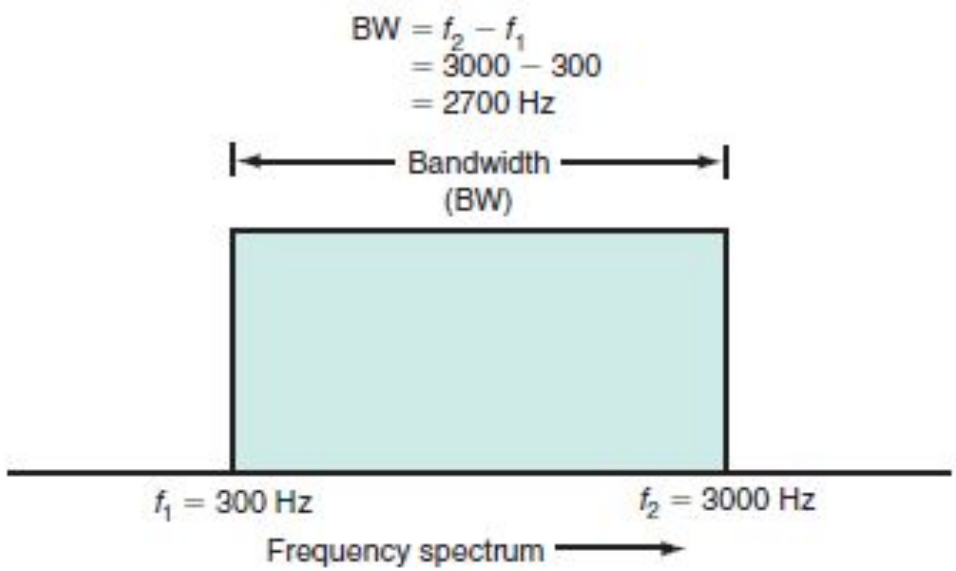
$$\frac{75 \text{ ft}}{3.28} = 22.86 \text{ m}$$

$$f = \frac{300}{22.86} = 13.12 \text{ MHz}$$

Bandwidth

Bandwidth (BW) is that portion of the electromagnetic spectrum occupied by a signal. It is also the frequency range over which a receiver or other electronic circuit operates. More specifically, bandwidth is the difference between the upper and lower frequency limits of the signal or the equipment operation range. Fig. 1-16 shows the bandwidth of the voice frequency range from 300 to 3000 Hz. The upper frequency is f_2 and the lower frequency is f_1. The bandwidth, then, is

$$BW = f_2 - f_1$$



Example 1-6

A television signal occupies a 6-MHz bandwidth. If the low-frequency limit of channel 2 is 54 MHz, what is the upper-frequency limit?

$$\mathrm{BW} = 54\ \mathrm{MHz} \qquad f_1 = 6\ \mathrm{MHz}$$

$$\mathrm{BW} = f_1 - f_2$$

$$f_2 = \mathrm{BW} + f_1 = 6 + 54 = 60\ \mathrm{MHz}$$

% of spectrum

- At 1000 kHz, the 10-kHz-wide AM signal discussed earlier represents 1 percent of the spectrum:

$$\begin{aligned}\% \text{ of spectrum} &= \frac{10 \text{ kHz}}{1000 \text{ KHz}} \times 100 \\ &= 1\%\end{aligned}$$

- But at 1 GHz, or 1,000,000 kHz, it represents only one-thousandth of 1 percent:

$$\begin{aligned}\% \text{ of spectrum} &= \frac{10 \text{ kHz}}{1{,}000{,}000 \text{ kHz}} \times 100 \\ &= 0.001\%\end{aligned}$$