Communication Systems

Lecture 1
Introduction

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Course Info

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References	**Multiple references will be used:** • **L.Frenzel - Principles of electronic communication systems** • **Wayne Tomasi - Advanced Electronic Communications Systems**
Assessment 90/60	1. **Final Term Exam (90)** 2. **Mid Term Exam (20)** 3. **Other Assignments (40)**

Chapter 1

Introduction to Electronic Communication

Principles of Electronic Communication Systems

Louis E. Frenzel, Jr.

Topics Covered in Chapter 1

- 1-1: Significance of Human Communication
- 1-2: Communication Systems
- 1-3: Types of Electronic Communication
- 1-4: Modulation and Multiplexing
- 1-5: The Electromagnetic Spectrum
- 1-6: Bandwidth

1-1: Significance of Human Communication

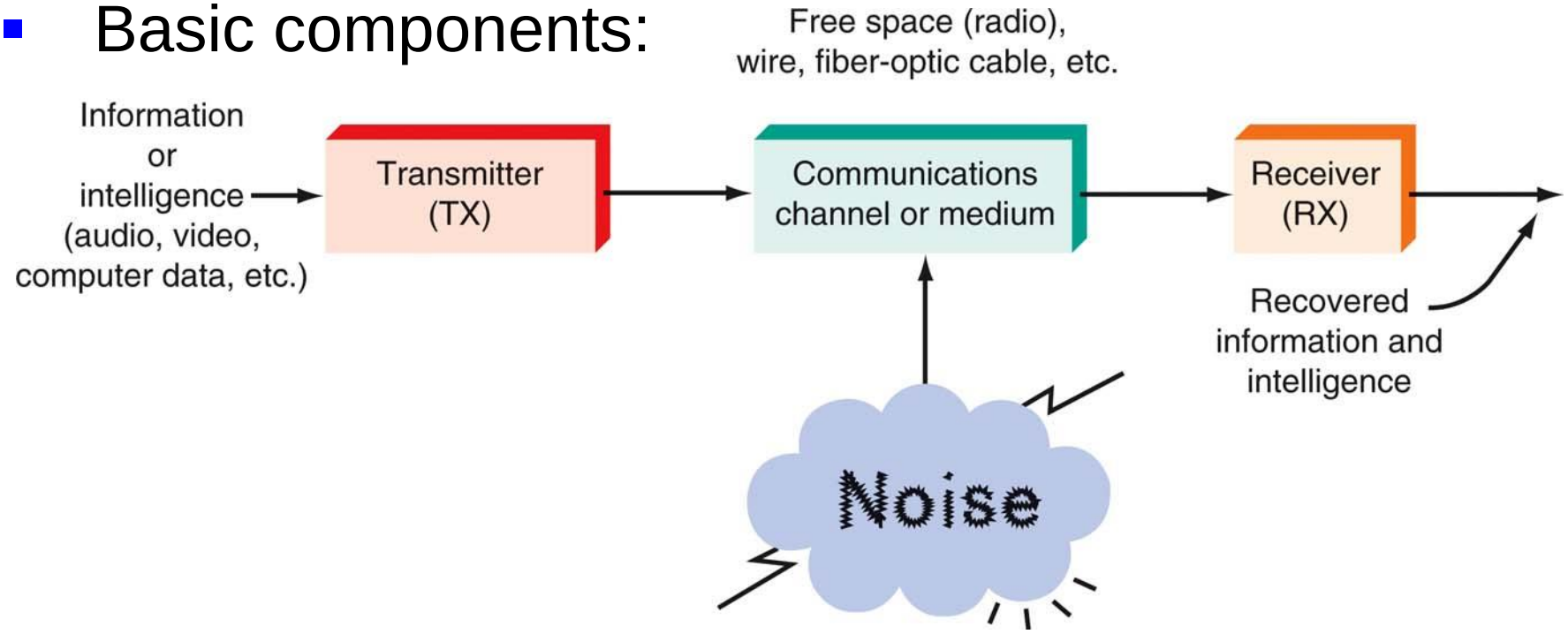
- People communicate to convey their thoughts, ideas, and feelings to others.
- Communication is the process of exchanging information.
- Two of the main barriers to human communication are language and distance.

1-1: Significance of Human Communication

- Methods of communication:
  1. Face to face
  2. Signals
  3. Written word (letters)
  4. Electrical innovations:
     - Telegraph
     - Telephone
     - Radio
     - Television
     - Internet (computer)

1-2: Communication Systems

- Basic components:

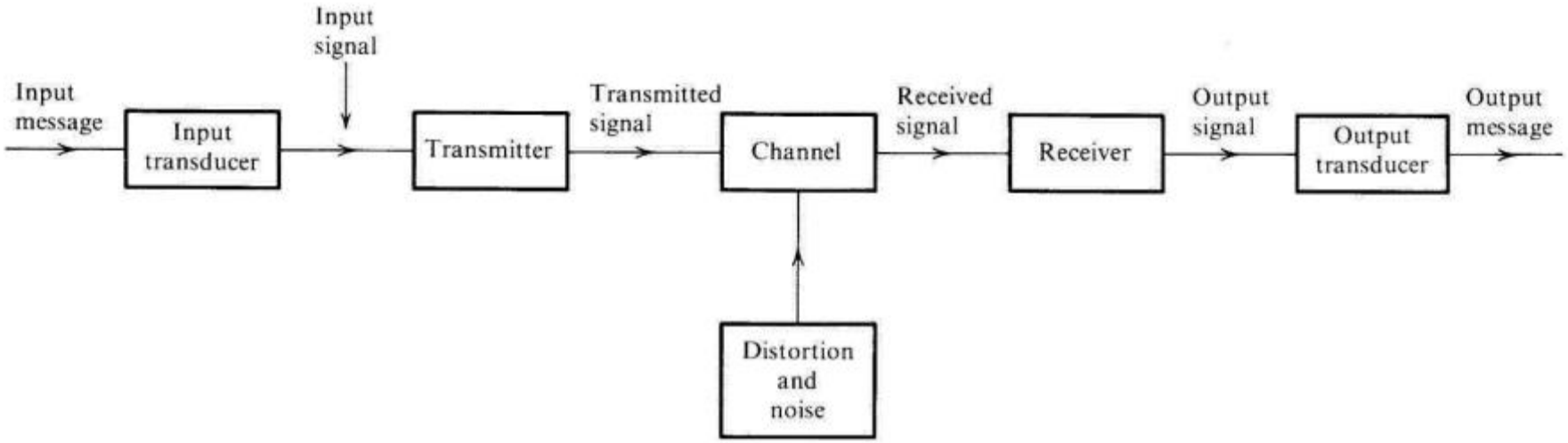


- The process of communication begins when a source (Human, Computer, Sensor, etc.) generates some kind of message or data that must be received by others
- The message is referred to as *information*, or an intelligence signal.

1-2: Communication Systems

- This message, in the form of an electronic signal, is fed to the transmitter, which transmits it over the communication channel.
- The message is picked up by the receiver and relayed to another human or computer.
- Along the way, a random undesirable signals (noise) is added in the communication channel and in the receiver that degrades or interferes with the transmitted information.

1-2: Communication Systems



- If the data is nonelectrical (human voice, television picture), it must be converted by an input transducer into an electrical waveform referred to as the baseband signal
- For voice messages, a microphone is used to translate the sound into an electronic audio signal.
- For TV, a camera converts the light information in the scene to a video signal

1-2: Communication Systems

Transmitter

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

1-2: Communication Systems

Communication Channel

- The **communication channel** is the medium by which the electronic signal is sent from one place to another.
- Types of media include
  - Electrical conductors (Coaxial cables, Twisted pairs, AC power lines)
  - Optical Fiber
  - Underwater
  - Free space (usually referred to as Wireless or Radio)
  - Free-Space Optics (FSO)

1-2: Communication Systems

Attenuation

- A **channel** acts partly as a filter to attenuate the signal and distort its waveform
- Signal **attenuation,** or degradation, exists in all media
- The signal attenuation increases with the length of the channel. It is usually proportional to the square of the distance between the transmitter and receiver.
- The waveform is distorted because of different amounts of attenuation and phase shift suffered by different frequency components (Frequency-Selective Channels)
- Signals amplification, in both the transmitter and the receiver, is required for successful transmission.

1-2: Communication Systems

Noise

- **Noise** is random, undesirable electronic energy that degrades the system performance.
- The causes may be **external** and/or **internal**

Internal noise:

- Results from thermal motion of electrons in conductors, random emission, and diffusion or recombination of charged carriers in electronic devices
- **Internal noise can be reduced but can never be eliminated**

External noise:

- Interference from nearby channels
- Human-made noise generated by fluorescent lights, etc.
- Natural noise from lightning, solar radiation
- **External noise can be minimized or even eliminated**

1-2: Communication Systems

Receivers

- A **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/destination.
- Receivers contain amplifiers, oscillators, mixers, tuned circuits and filters, and a **demodulator** or detector that recovers the original intelligence signal from the modulated carrier.

1-2: Communication Systems

Transceivers

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

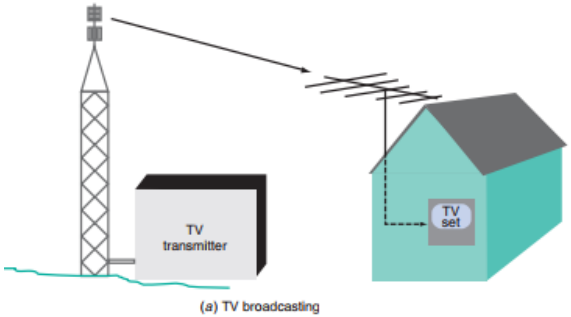
1-3: Types of Electronic Communication

- 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.

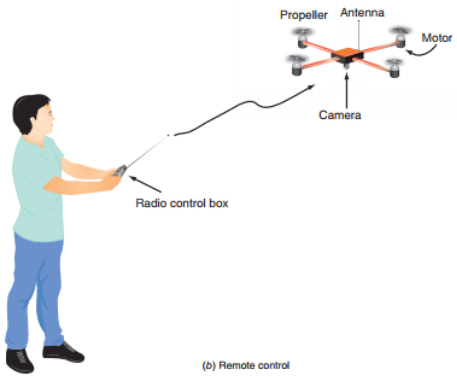
1-3: Types of Electronic Communication

Simplex

- Is The simplest method of electronic communication
- This type of communication is one-way, where one end transmits while the other receives only.
- Examples are:
  - ✓Radio
  - ✓TV broadcasting
  - ✓Remote Control



(a) TV broadcasting

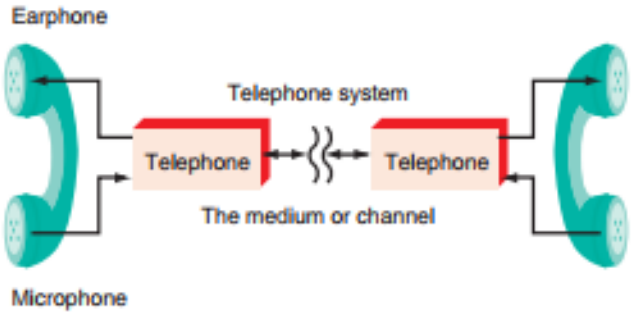


(b) Remote control

1-3: Types of Electronic Communication

Duplex Communication

- 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)

1-3: Types of Electronic Communication

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 (CB)
  - Family radio
  - Amateur radio

1-3: Types of Electronic Communication

Analog Signals

- An **analog signal** is a smoothly and continuously varying voltage or current (y-axis).
- It takes any value within some range

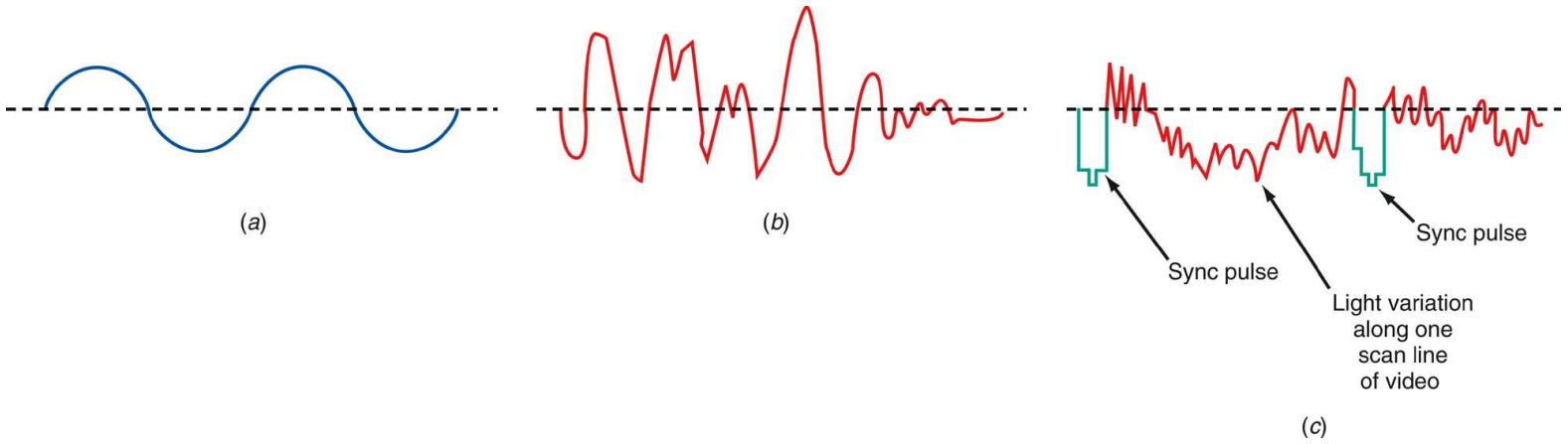


Figure 1-5: Analog signals (a) Sine wave “tone.” (b) Voice. (c) Video (TV) signal.

1-3: Types of Electronic Communication

Digital Signals

- Digital signals change in steps or in discrete increments.
- Most digital signals use binary or two-state codes.

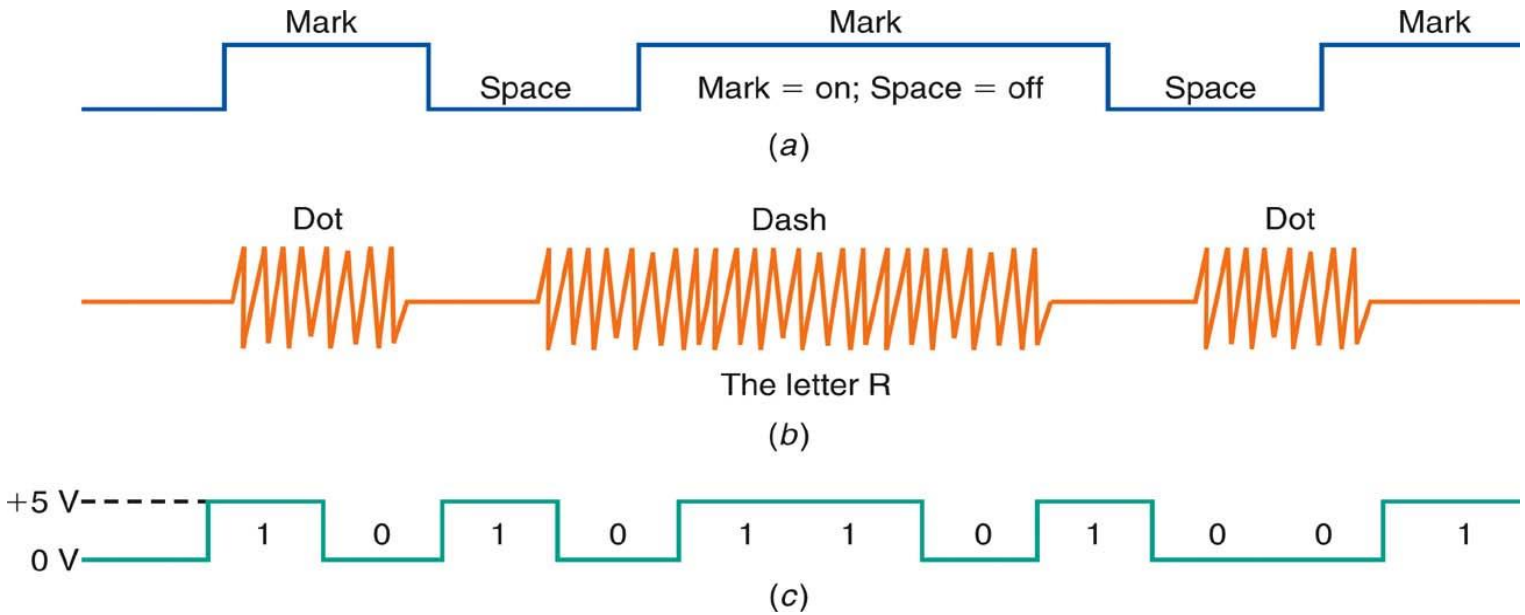


Figure 1-6: Digital signals (a) Telegraph (Morse code). (b) Continuous-wave (CW) code. (c) Serial binary code.

1-3: Types of Electronic Communication

Signal Conversion

- Many transmissions are of signals that originate in digital form but must be converted to analog form to match the transmission medium.
  - Digital data over the telephone network.
- Analog signals can also be transmitted digitally.
  - They are first digitized with an analog-to-digital (A/D) converter.
  - The data can then be transmitted and processed by computers and other digital circuits.

1-4: Modulation and Multiplexing

- **Modulation** and **multiplexing** are electronic techniques for transmitting information efficiently from one place to another.
- **Modulation** makes the information signal more compatible with the medium.
- **Multiplexing** allows more than one signal to be transmitted concurrently over a single medium.

1-4: Modulation and Multiplexing

Baseband versus Broadband Transmission

- Baseband Transmission: **Baseband** information can be sent directly and unmodified over the medium
  - ✓ In telephone or intercom systems, the voice is placed on the wires and transmitted.
  - ✓ In some computer networks, the digital signals are applied directly to coaxial or twisted-pair cables for transmission.

- Broadband Transmission: **Baseband** Can be used to modulate a carrier for transmission over the medium.
  - ✓ The high frequency carrier is an electromagnetic wave that is able to travel longer distances through space.

1-4: Modulation and Multiplexing

Broadband Transmission

- A broadband transmission takes place when a carrier signal is modulated, amplified, and sent to the antenna for transmission.
- The two most common methods of modulation are:
  - Amplitude Modulation (AM)
  - Frequency Modulation (FM)
- Another method is called **phase modulation (PM),** in which the phase angle of the sine wave is varied.

1-4: Modulation and Multiplexing

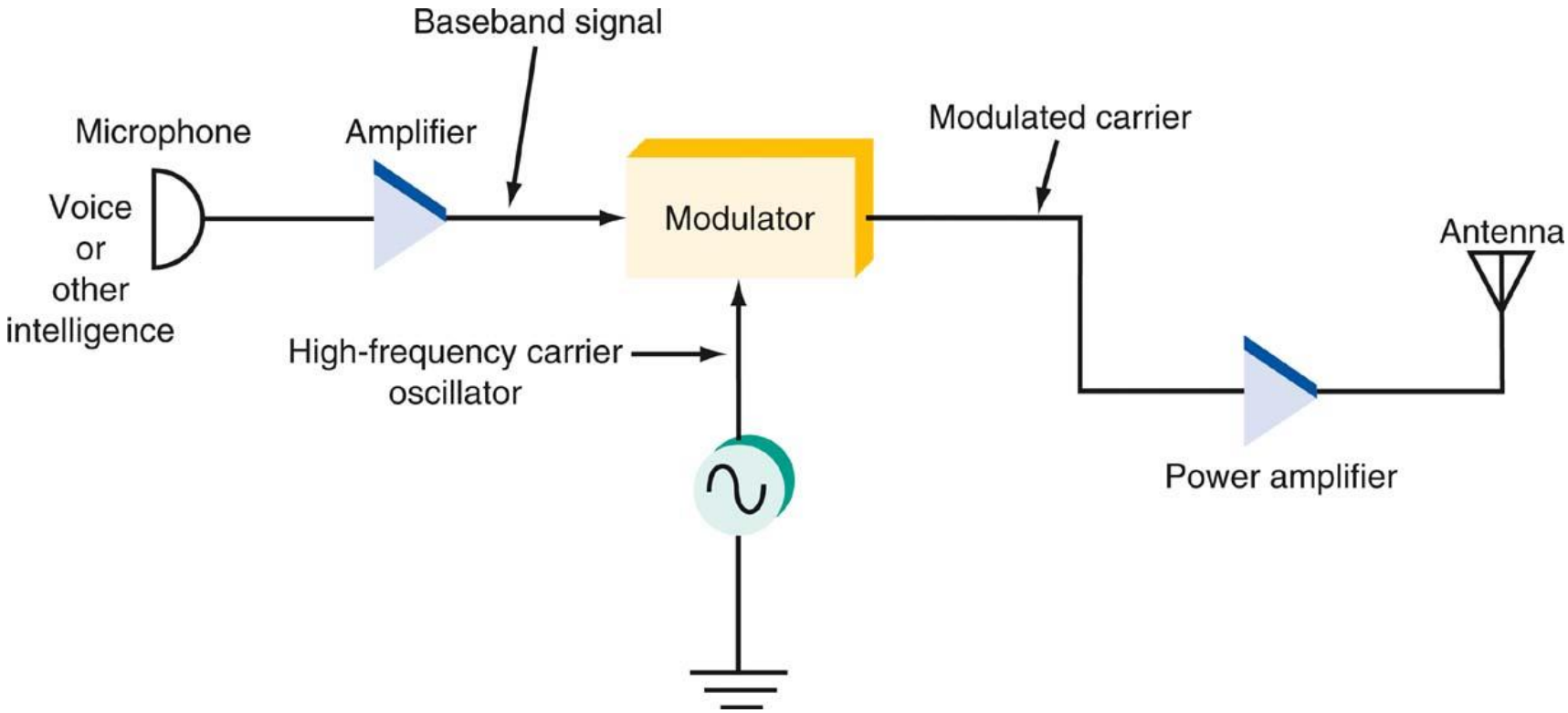


Figure 1-7: Modulation at the transmitter.

1-4: Modulation and Multiplexing

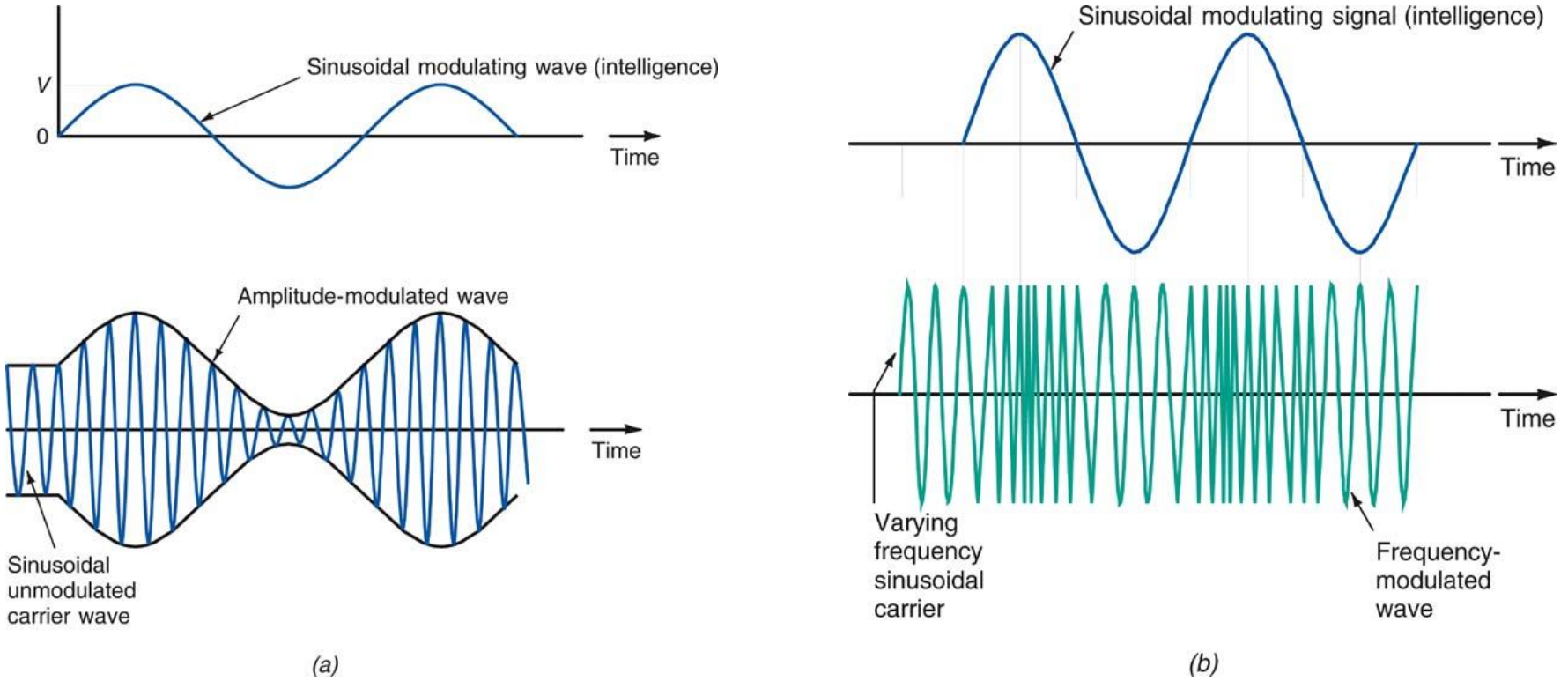


Figure 1-8: Types of modulation. (a) Amplitude modulation. (b) Frequency modulation.

1-4: Modulation and Multiplexing

- **Demodulation** or detection takes place in the receiver when the original baseband (e.g. audio) signal is extracted.

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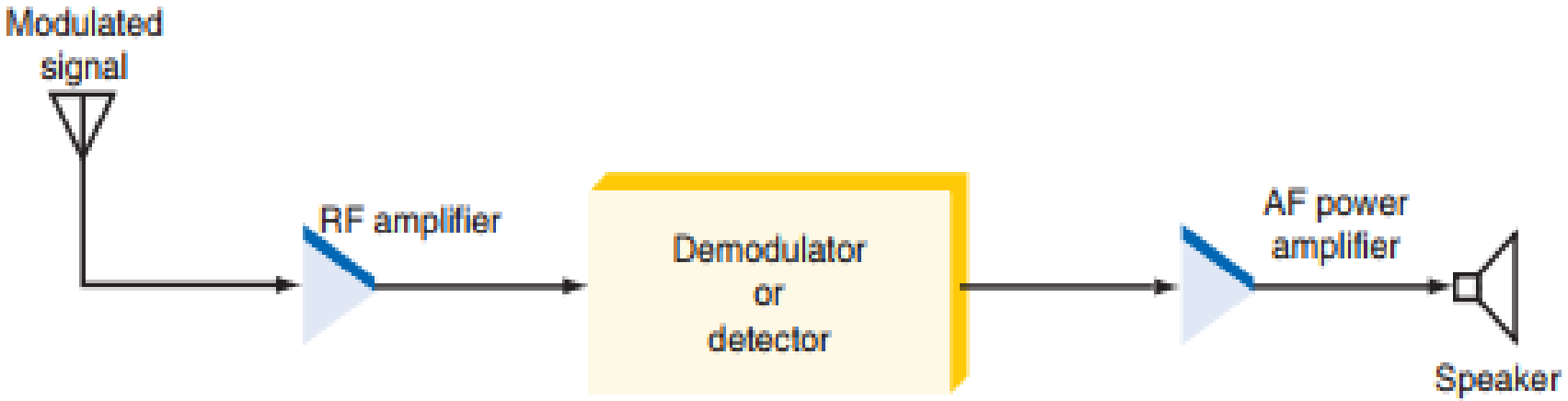
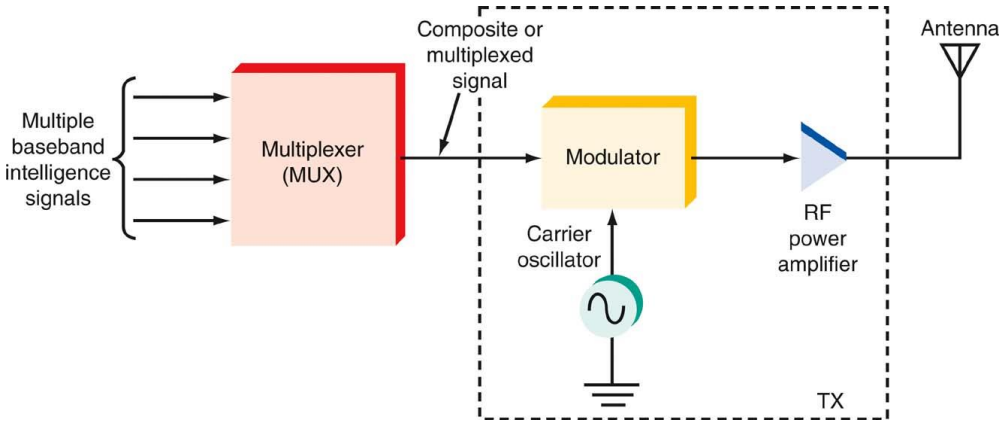
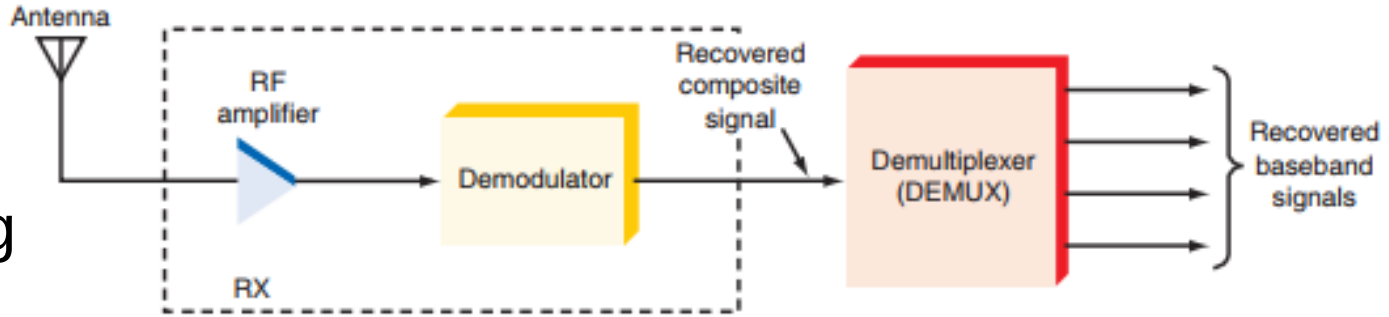


1-4: Modulation and Multiplexing

Multiplexing: is the process of allowing two or more signals to share the same medium or channel.



Multiplexing



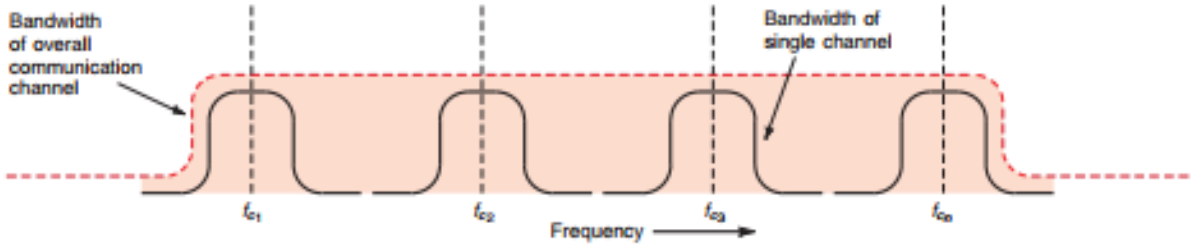
Demultiplexing

1-4: Modulation and Multiplexing

Frequency Division Multiplexing (FDM)

- In FDM, the intelligence signals modulate subcarriers on different frequencies that are then added together, and the composite signal is used to modulate the carrier.

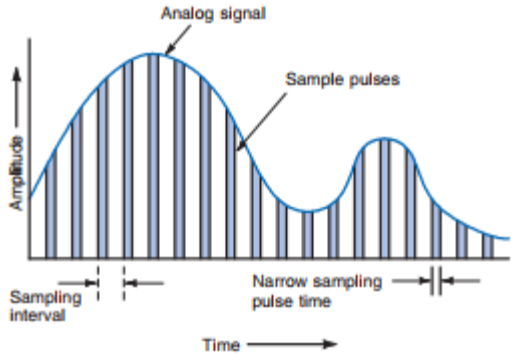
- In optical networking, wavelength division multiplexing (WDM) is equivalent to FDM for optical signal

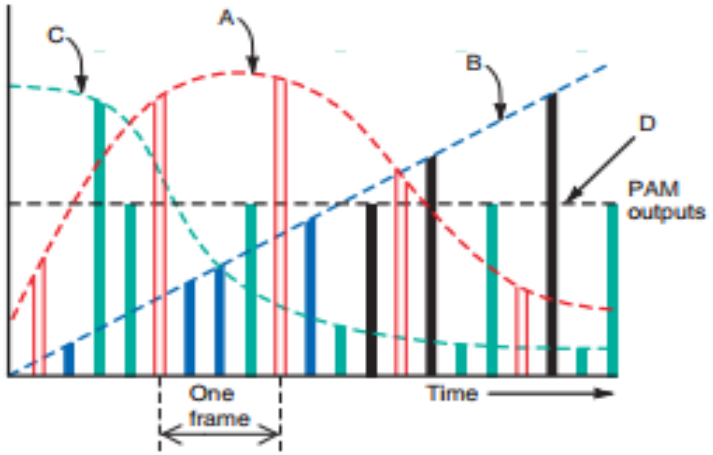


1-4: Modulation and Multiplexing

Time Division Multiplexing (TDM)

- In TDM, the multiple intelligence signals are sequentially sampled, and a small piece of each is used to modulate the carrier.
- If the information signals are sampled fast enough, sufficient details are transmitted that at the receiving end the signal can be reconstructed with great accuracy





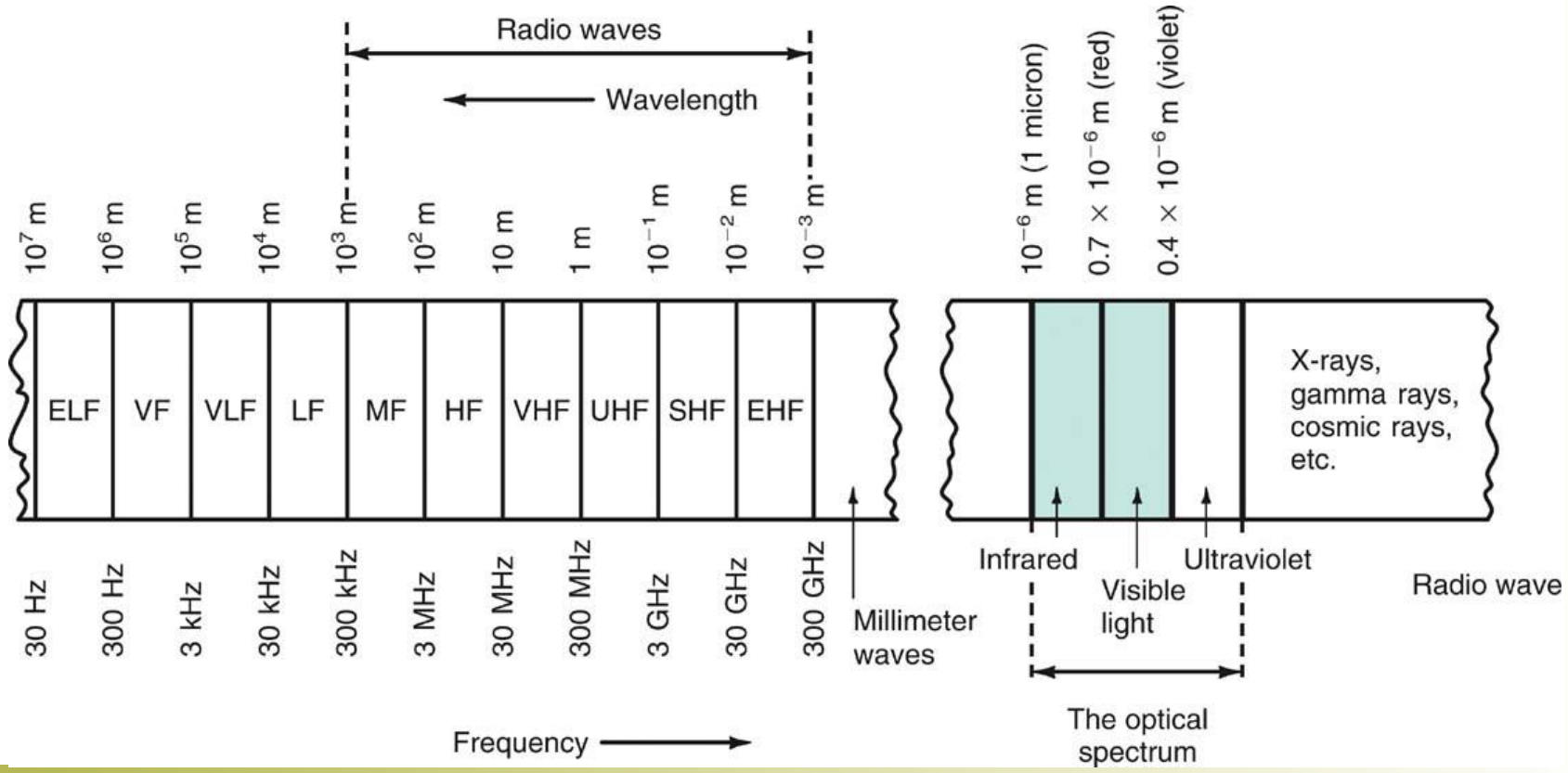
1-4: Modulation and Multiplexing

Code Division Multiplexing (CDM)

- In CDM, the signals to be transmitted are converted to digital data that is then uniquely coded with a faster binary code.
- The signals modulate a carrier on the same frequency. All use the same communications channel simultaneously.
- The unique coding is used at the receiver to select the desired signal.

1-5: The Electromagnetic Spectrum

- The range of electromagnetic signals encompassing all frequencies is referred to as the **electromagnetic spectrum.**



1-5: The Electromagnetic Spectrum

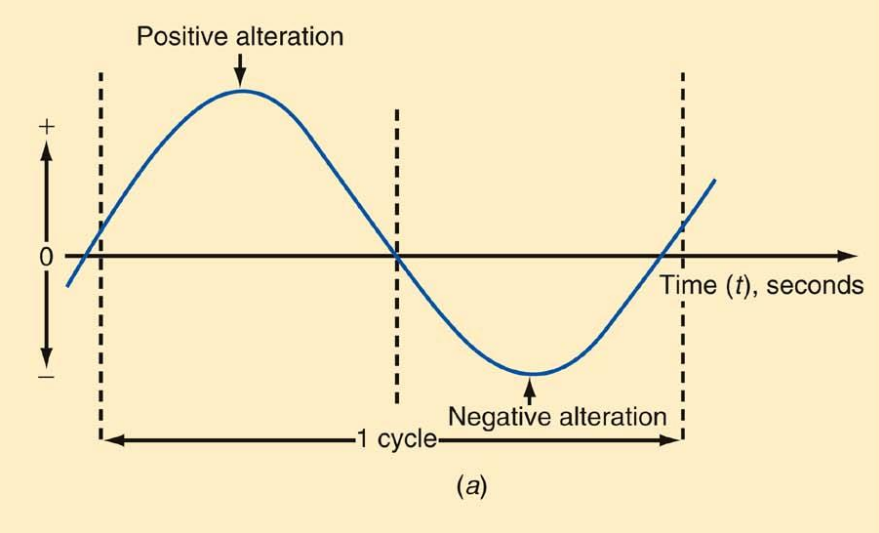
Frequency and Wavelength: Frequency

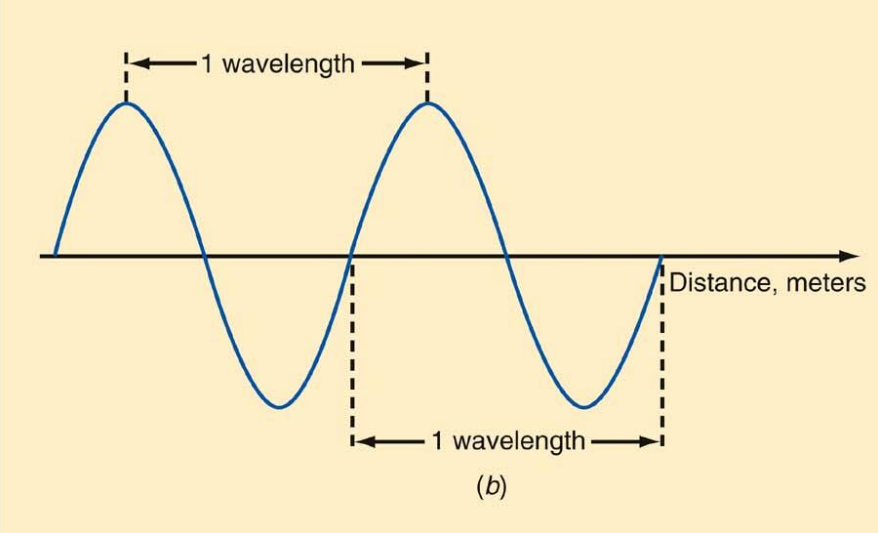
- A signal is located on the frequency spectrum according to its frequency and wavelength.
- **Frequency** is the number of cycles of a repetitive wave that occur in a given period of time.
- A cycle consists of two voltage polarity reversals, current reversals, or electromagnetic field oscillations.
- Frequency is measured in cycles per second (cps).
- The unit of frequency is the hertz (Hz).

1-5: The Electromagnetic Spectrum

Frequency and Wavelength: Wavelength

- **Wavelength** (λ) is the distance occupied by one cycle of a wave and is usually expressed in meters.





1-5: The Electromagnetic Spectrum

Frequency and Wavelength: Wavelength

Wavelength (λ) = speed of light ÷ frequency

Speed of light = 3×10^8 meters/second

Therefore:

$\lambda = 3 \times 10^8 / f$

Example:

What is the wavelength if the frequency is 4MHz?

$\lambda = 3 \times 10^8 / 4$ MHz

= 75 meters (m)

1-6: Bandwidth

- **Bandwidth (BW)** is that portion of the electromagnetic spectrum occupied by a signal.
- **Channel bandwidth** refers to the range of frequencies required to transmit the desired information.

1-6: Bandwidth

More Room at the Top

- Today, virtually the entire frequency spectrum between approximately 30 kHz and 300 MHz has been spoken for.
- There is tremendous competition for these frequencies, between companies, individuals, and government services in individual carriers and between the different nations of the world.
- The electromagnetic spectrum is one of our most precious natural resources.

1-6: Bandwidth

More Room at the Top

- Communication engineering is devoted to making the best use of that finite spectrum.
- Great effort goes into developing communication techniques that minimize the bandwidth required to transmit given information and thus conserve spectrum space.
- This provides more room for additional communication channels and gives other services or users an opportunity to take advantage of it.

1-6: Bandwidth

Spectrum Management and Standards

- **Spectrum management** is provided by agencies set up by different countries to control spectrum use.
  - USA: The Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA) are two agencies that deal in spectrum management.
  - United Nation: The International Telecommunications Union (ITU)
  - Egypt: