COMMUNICATION THEORY

EC8491

Communication Systems

- Basic components:
  - Transmitter
  - Channel or medium
  - Receiver
- **Noise** degrades or interferes with transmitted information.

Communication Systems

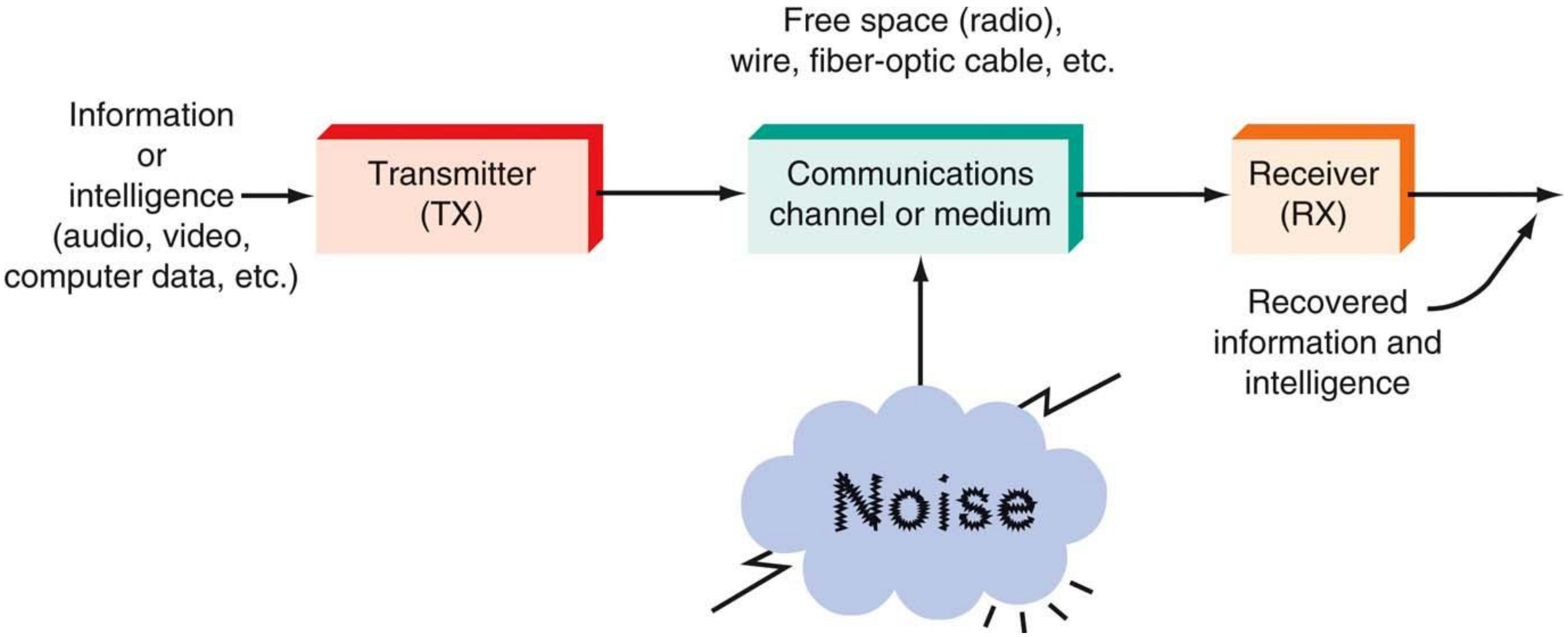

Figure 1-2: A general model of all communication systems.

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.

- Transmitters are made up of oscillators, amplifiers, tuned circuits and filters, modulators, frequency mixers, frequency synthesizers, and other circuits.

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

Communication Systems

Transceivers

- A **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

Communication Systems

Attenuation

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

Communication Systems

Noise

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

Communication Systems

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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.

Types of Electronic Communication

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)

Types of Electronic Communication

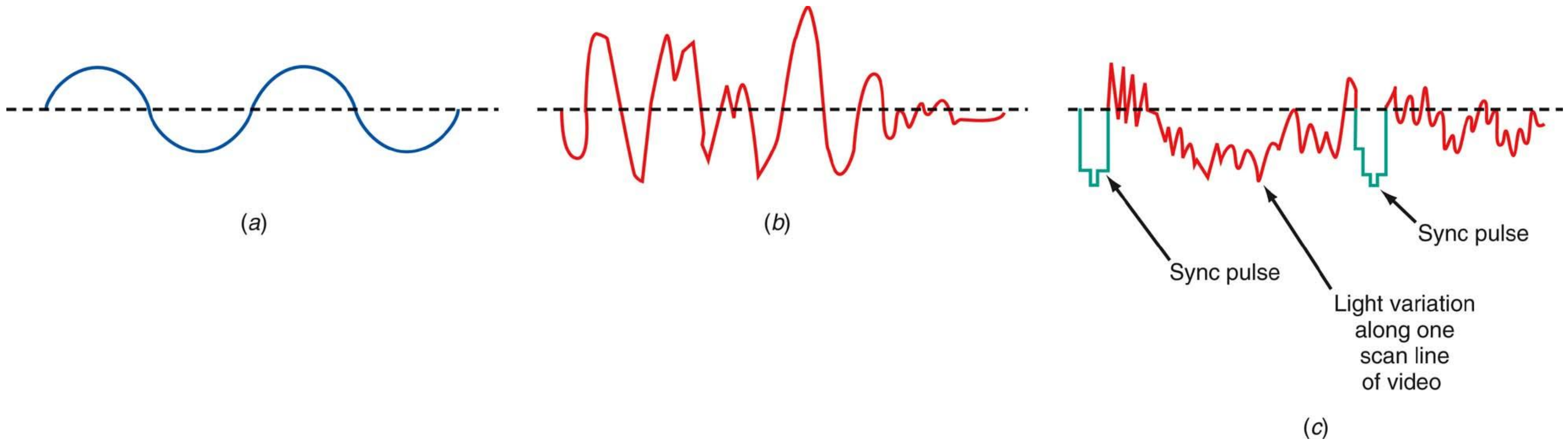


Figure 1-5: Analog signals (a) Sine wave “tone.” (b) Voice. (c) Video (TV) signal.

Types of Electronic Communication

Digital Signals

- Digital signals change in steps or in discrete increments.
- Most digital signals use binary or two-state codes. Examples are:
  - Telegraph (Morse code)
  - Continuous wave (CW) code
  - Serial binary code (used in computers)

Types of Electronic Communication

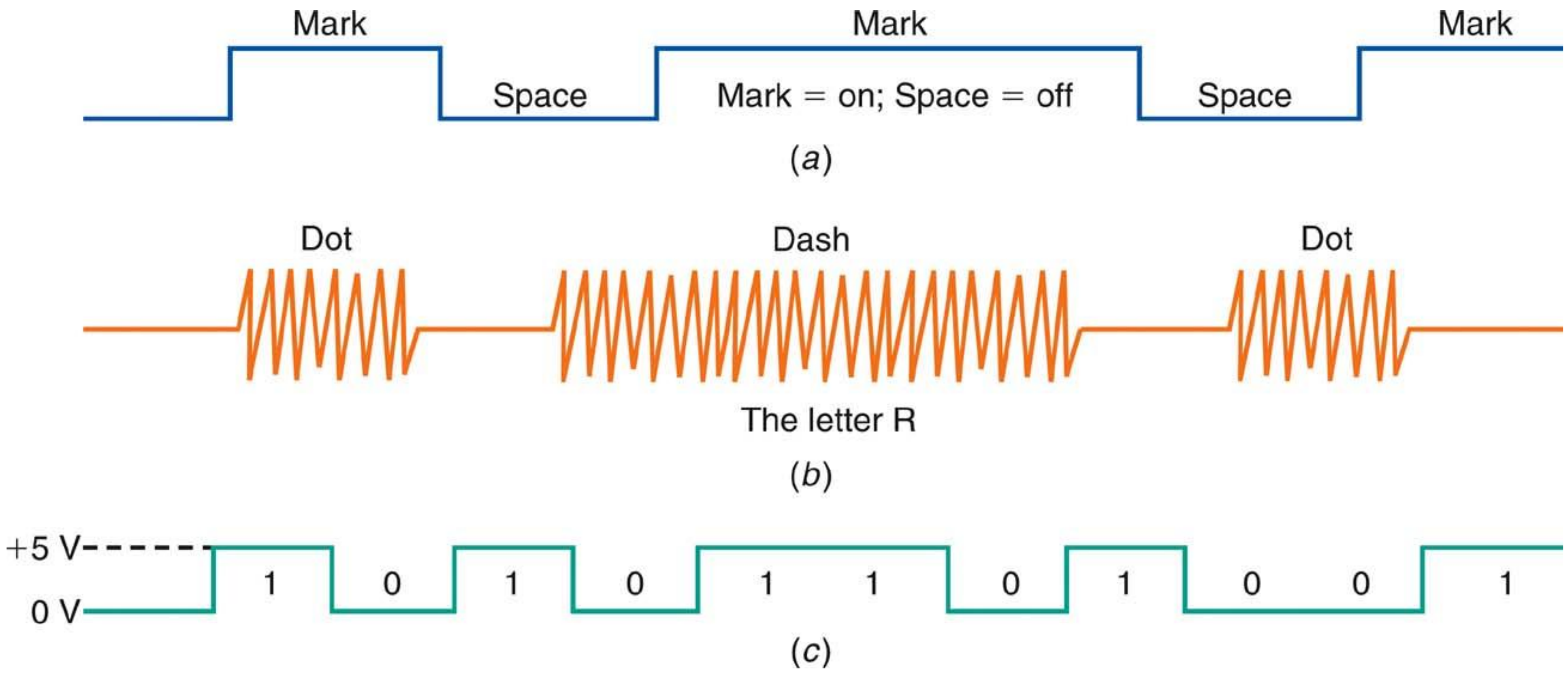


Figure 1-6: Digital signals (a) Telegraph (Morse code). (b) Continuous-wave (CW) code. (c) Serial binary code.

Types of Electronic Communication

Digital Signals

- 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.
    - 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.

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.

Modulation and Multiplexing

Broadband Transmission

- A **carrier** is a high frequency signal that is modulated by audio, video, or data.
- A **radio-frequency (RF) wave** is an electromagnetic signal that is able to travel long distances through space.

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.

Modulation and Multiplexing

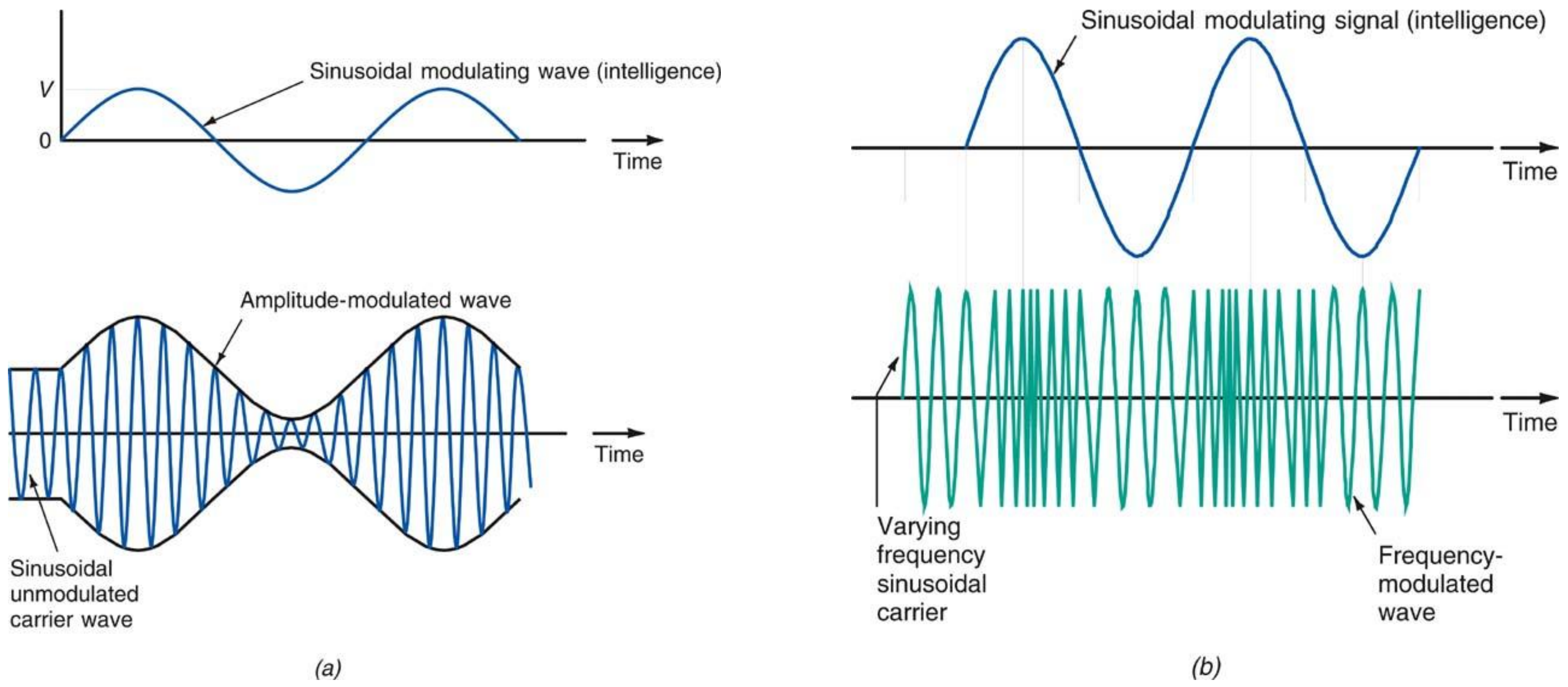


Figure 1-8: Types of modulation. (a) Amplitude modulation. (b) Frequency modulation.

The Electromagnetic Spectrum

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

The Electromagnetic Spectrum

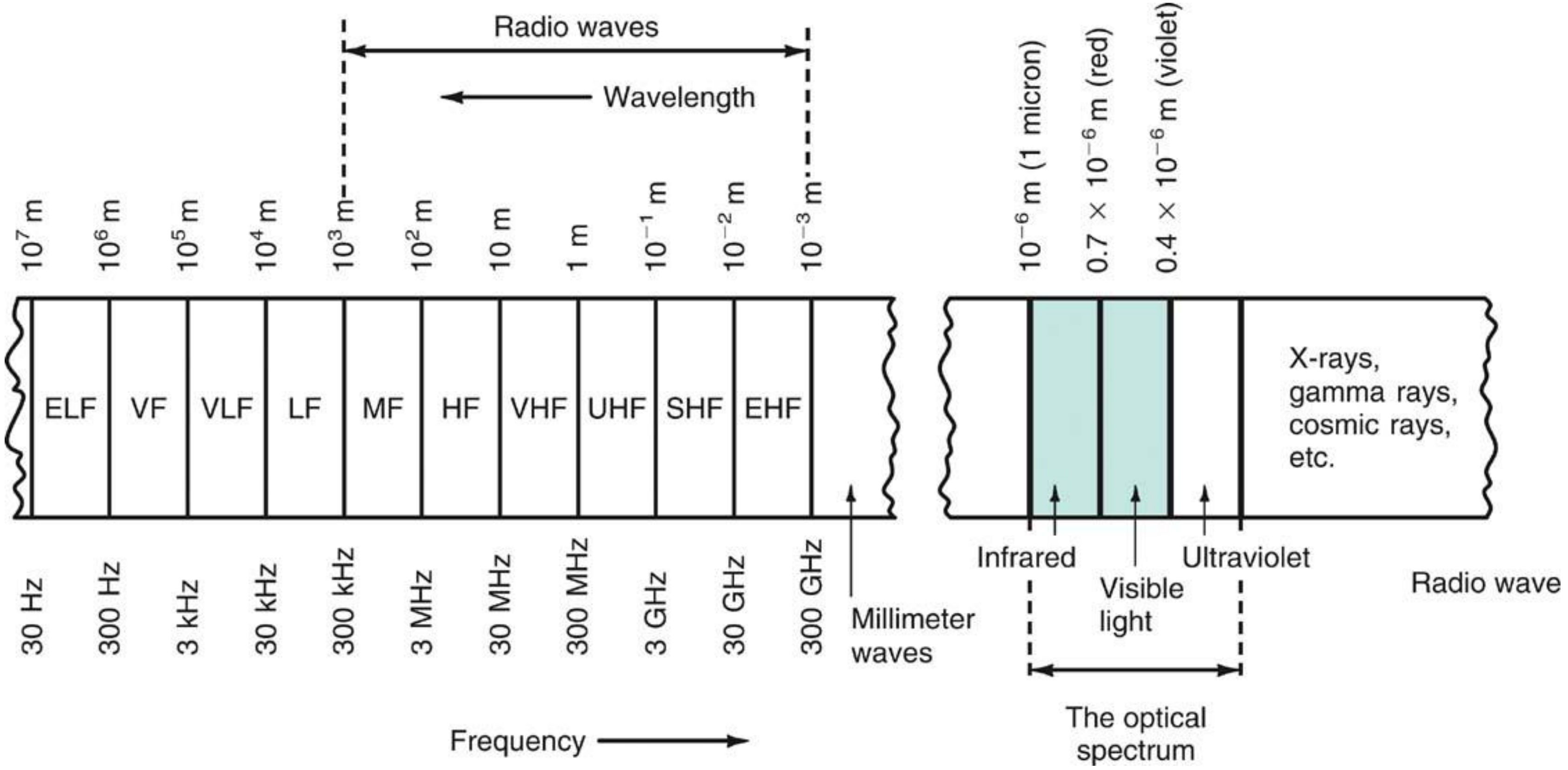


Figure 1-13: The electromagnetic spectrum.

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).

The Electromagnetic Spectrum

Frequency and Wavelength: Wavelength

- **Wavelength** is the distance occupied by one cycle of a wave and is usually expressed in meters.
- Wavelength is also the distance traveled by an electromagnetic wave during the time of one cycle.
- The wavelength of a signal is represented by the Greek letter lambda (λ).

The Electromagnetic Spectrum

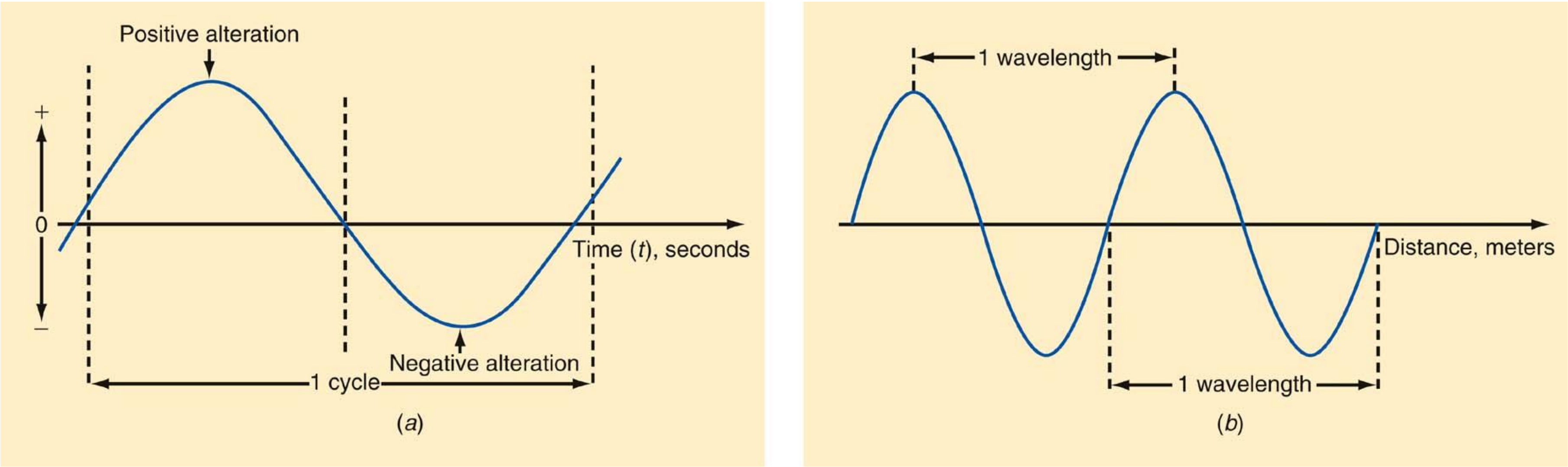


Figure 1-15: Frequency and wavelength. (a) One cycle. (b) One wavelength.

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)

The Electromagnetic Spectrum

Frequency Ranges from 30 Hz to 300 GHz

- The electromagnetic spectrum is divided into segments:

Extremely Low Frequencies (ELF)	30–300 Hz.
Voice Frequencies (VF)	300–3000 Hz.
Very Low Frequencies (VLF)	include the higher end of the human hearing range up to about 20 kHz.
Low Frequencies (LF)	30–300 kHz.
Medium Frequencies (MF)	300–3000 kHz AM radio 535–1605 kHz.

The Electromagnetic Spectrum

Frequency Ranges from 30 Hz to 300 GHz

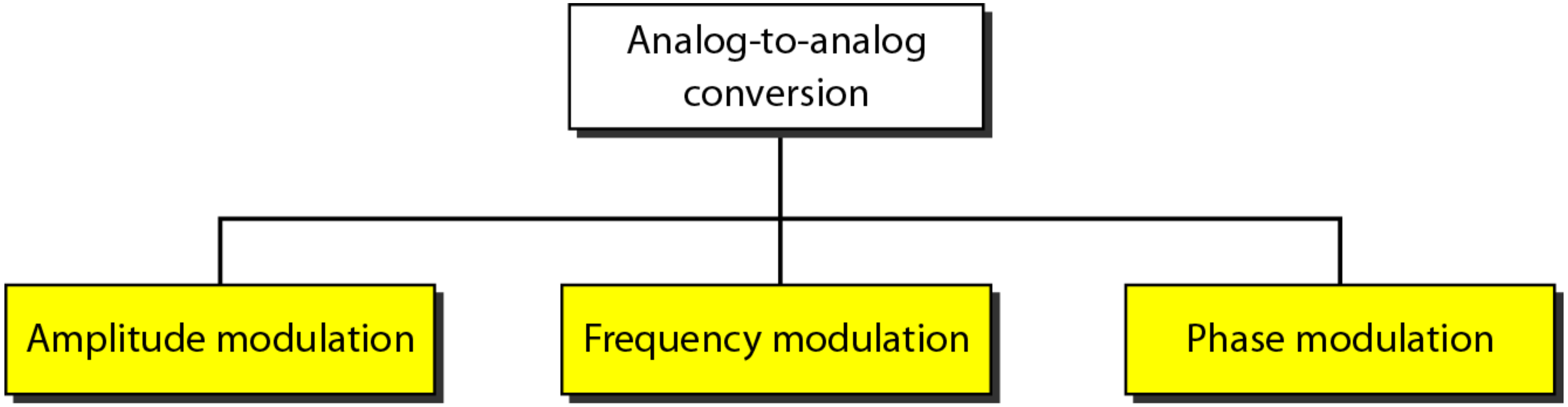
High Frequencies (HF) (short waves; VOA, BBC broadcasts; government and military two-way communication; amateur radio, CB.	3–30 MHz
Very High Frequencies (VHF) FM radio broadcasting (88–108 MHz), television channels 2–13.	30–300 MHz
Ultra High Frequencies (UHF) TV channels 14–67, cellular phones, military communication.	300–3000 MHz

The Electromagnetic Spectrum

Frequency Ranges from 30 Hz to 300 GHz

Microwaves and Super High Frequencies (SHF) Satellite communication, radar, wireless LANs, microwave ovens	1–30 GHz
Extremely High Frequencies (EHF) Satellite communication, computer data, radar	30–300 GHz

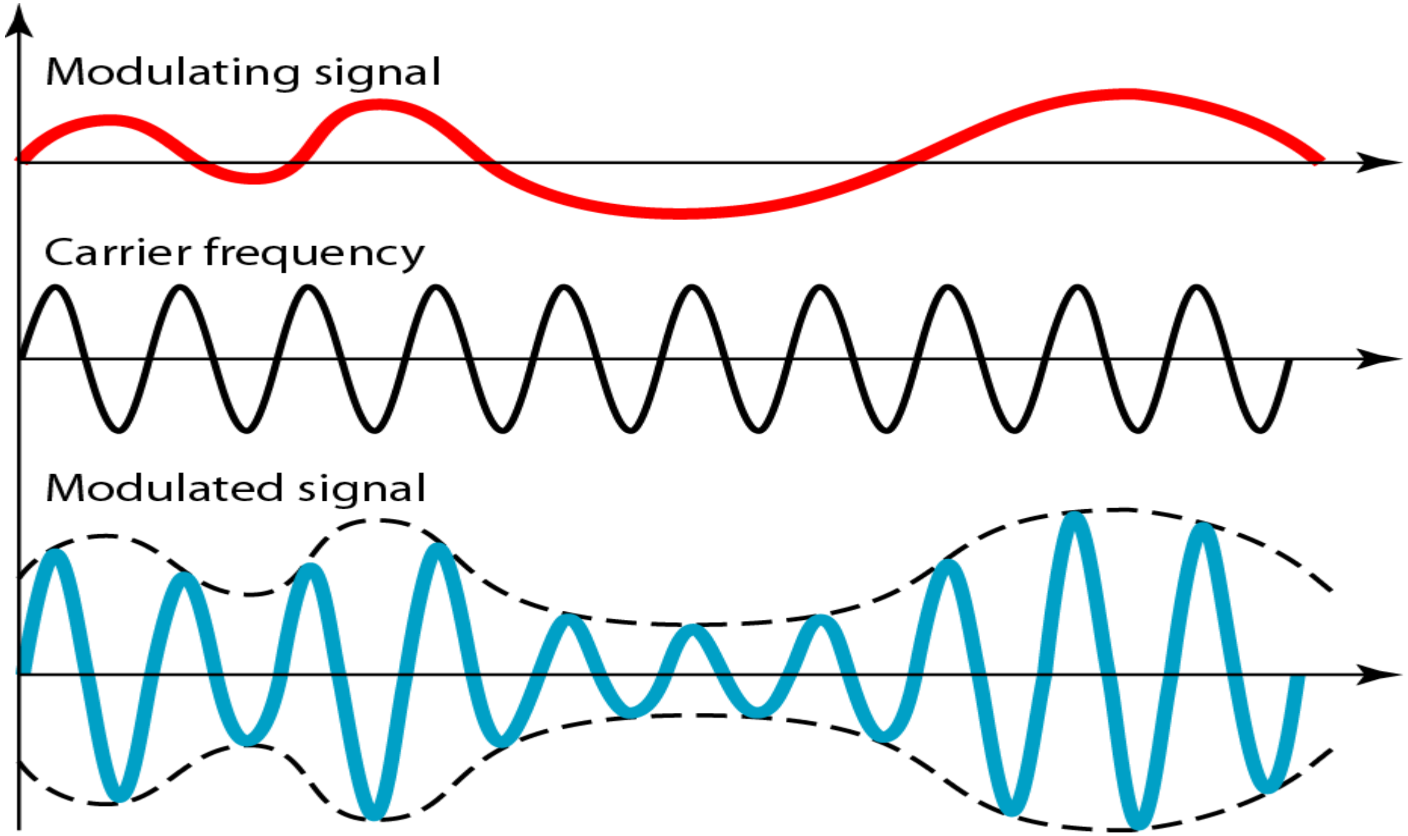
Types of analog-to-analog modulation

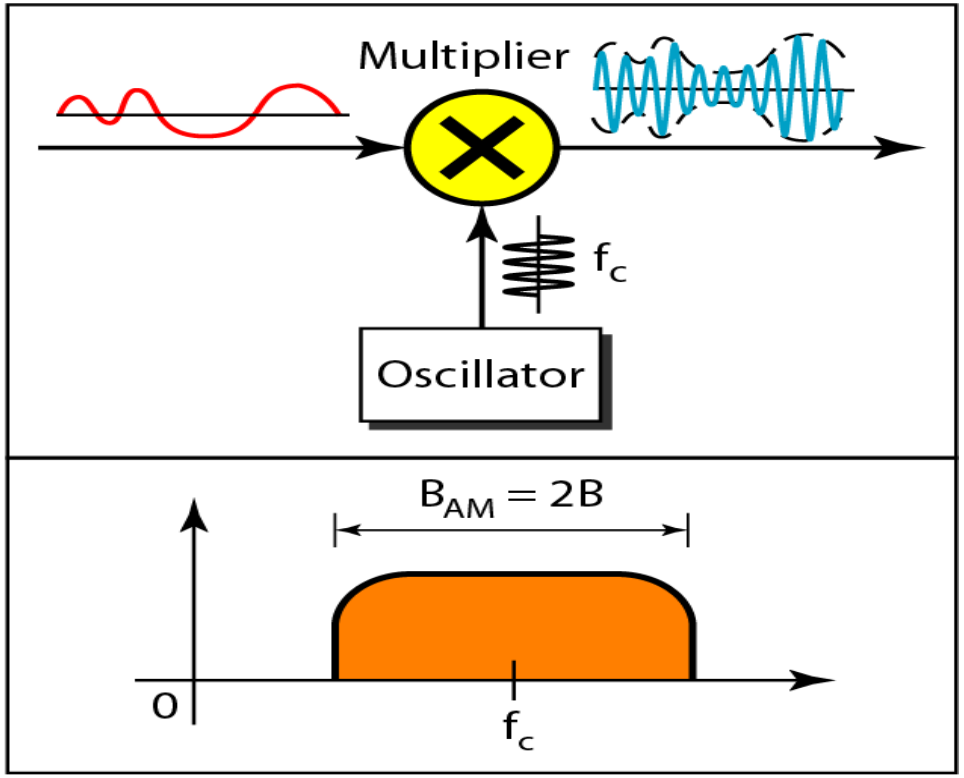


Amplitude Modulation

- A carrier signal is modulated only in amplitude value
- The modulating signal is the envelope of the carrier
- The required bandwidth is 2B, where B is the bandwidth of the modulating signal
- Since on both sides of the carrier freq. f_c, the spectrum is identical, we can discard one half, thus requiring a smaller bandwidth for transmission.

Amplitude modulation

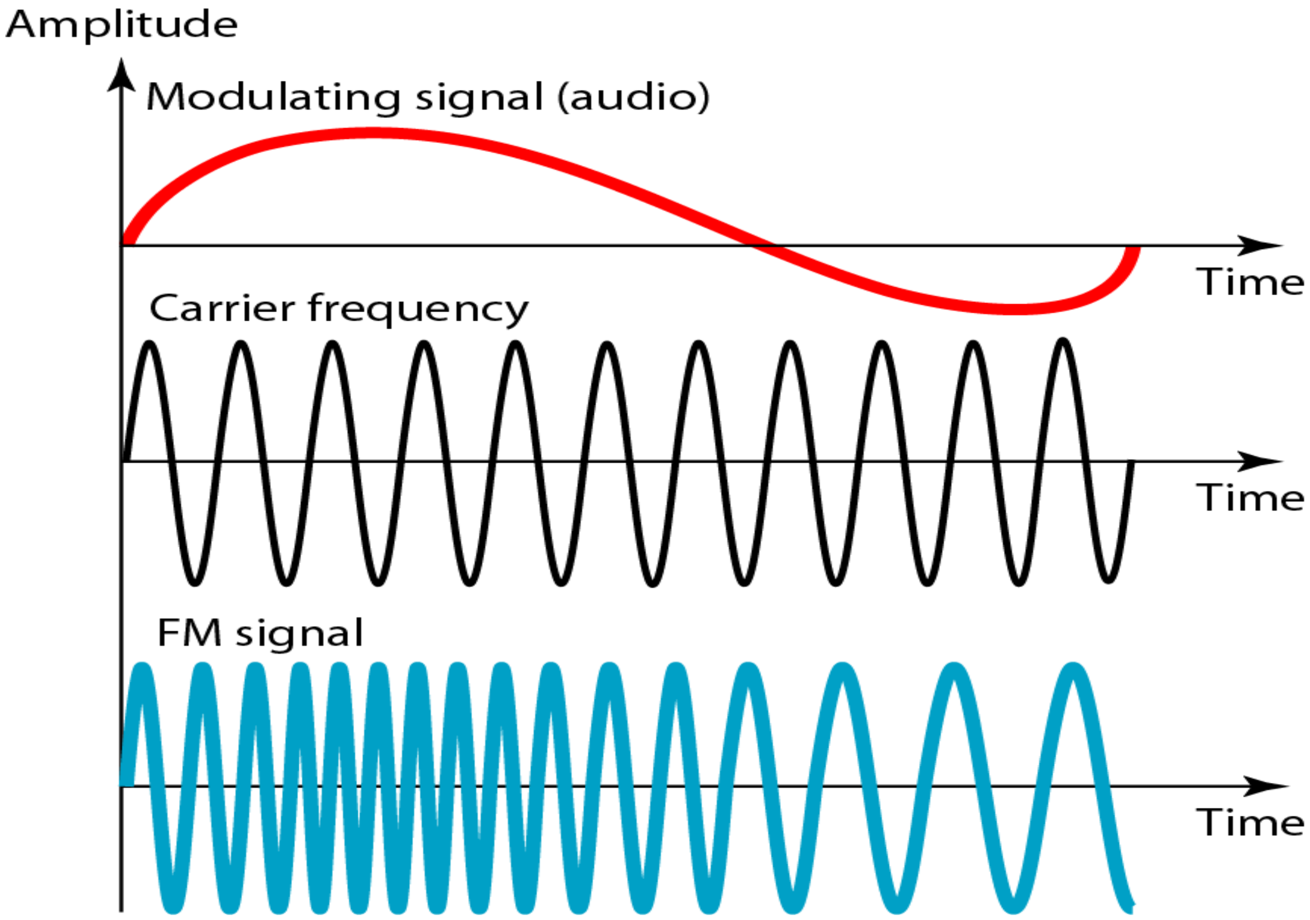


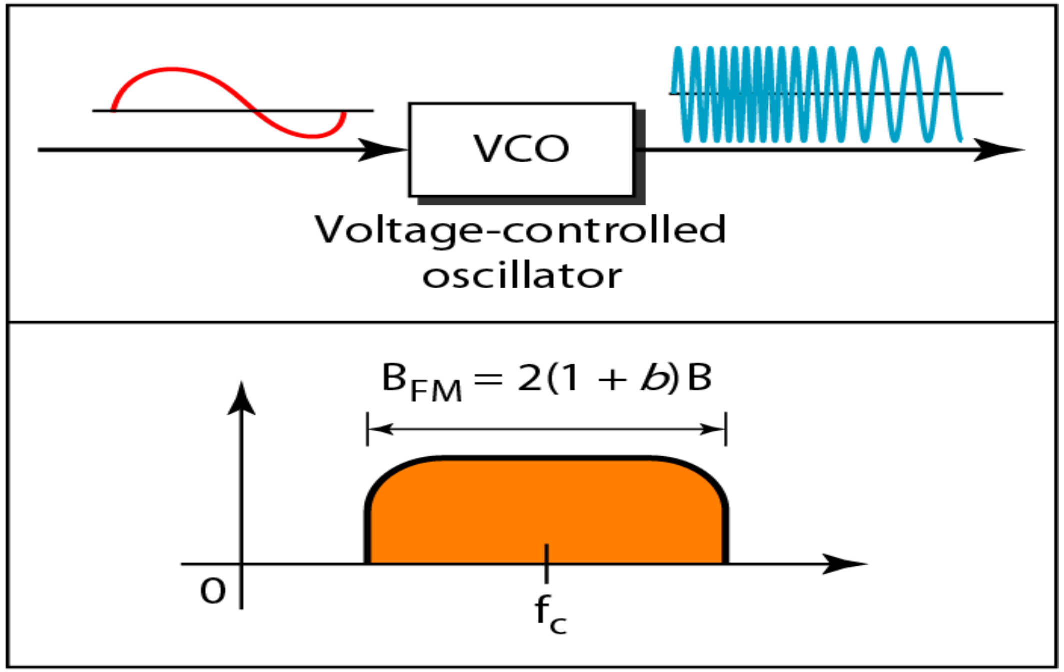


Frequency Modulation

- The modulating signal changes the freq. f_c of the carrier signal
- The bandwidth for FM is high
- It is approx. 10x the signal frequency

Frequency modulation





Phase Modulation (PM)

- The modulating signal only changes the phase of the carrier signal.
- The phase change manifests itself as a frequency change but the instantaneous frequency change is proportional to the derivative of the amplitude.
- The bandwidth is higher than for AM.

Phase modulation