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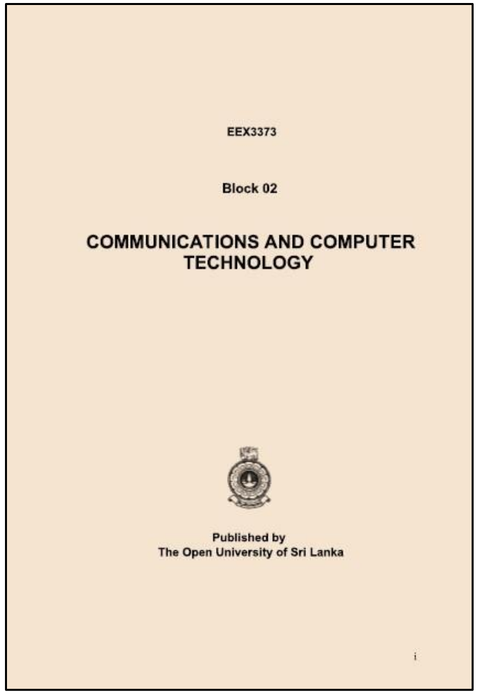
இலங்கை திறந்த பல்கலைக்கழகம்
The Open University of Sri Lanka

EEX3373
Communication and Computer Technology
Day School 04

Center for IT Educational Services (CITES)
Faculty of Engineering Technology
Open University of Sri Lanka

CONTENT

- Session 12: Introduction to wired and wireless communications
- Session 13: Modulation Techniques in communication systems
- Session 14: Power calculations in communication systems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Block 02

COMMUNICATIONS AND COMPUTER TECHNOLOGY

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Elements of a Communication System

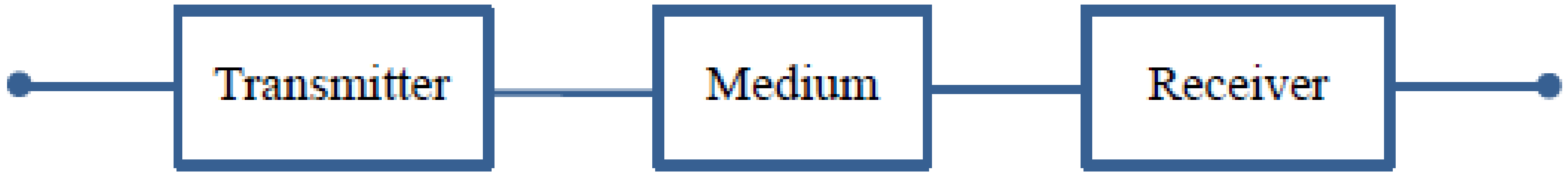
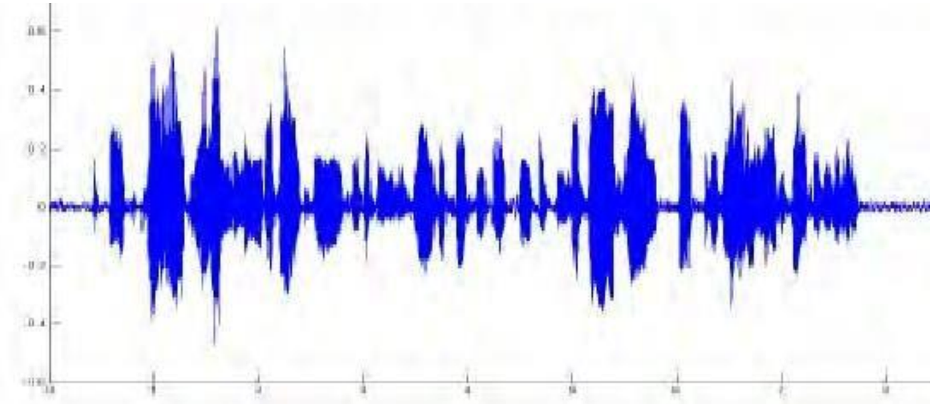


Figure 12.1 Basic communication system

Wired Communication | Electrical Communication

- Signal travels through the wire in electric form.
- Need a device to convert speech signal into an electrical signal at the sender's end.
- Need another device to convert the electrical signal back to a speech signal at the receiver's end.
- These devices are called as transducers.
    - Ex: Microphone, speaker, etc.



Electrical Communication System

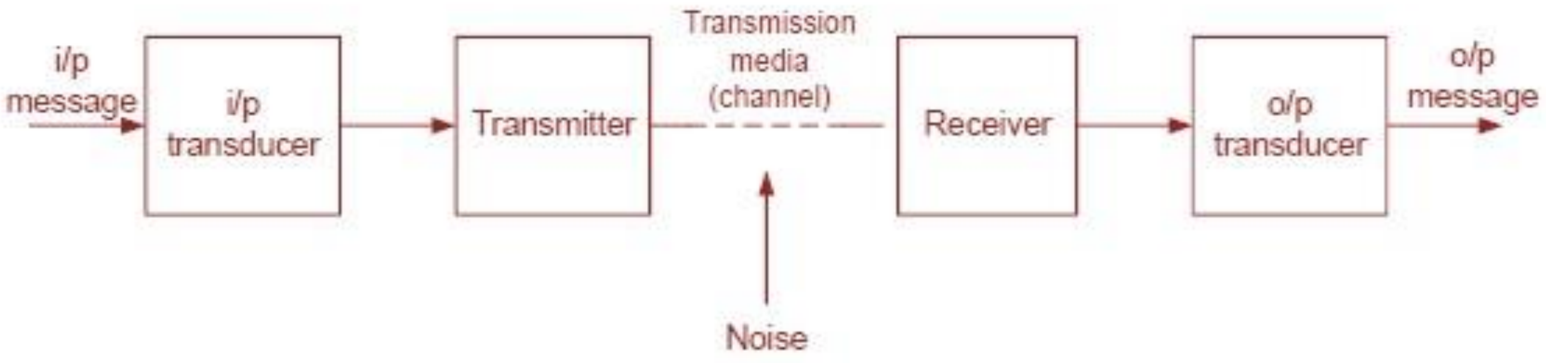


Figure 12.2 Basic block diagram of an electrical communication system

- Input transducer converts the original information signal into an electrical (in optical systems, inputs converts to optical signal).
- An electrical signal may be any one or more of the following types which are time variant signals. (i.e., varies with time).

Types of Signals

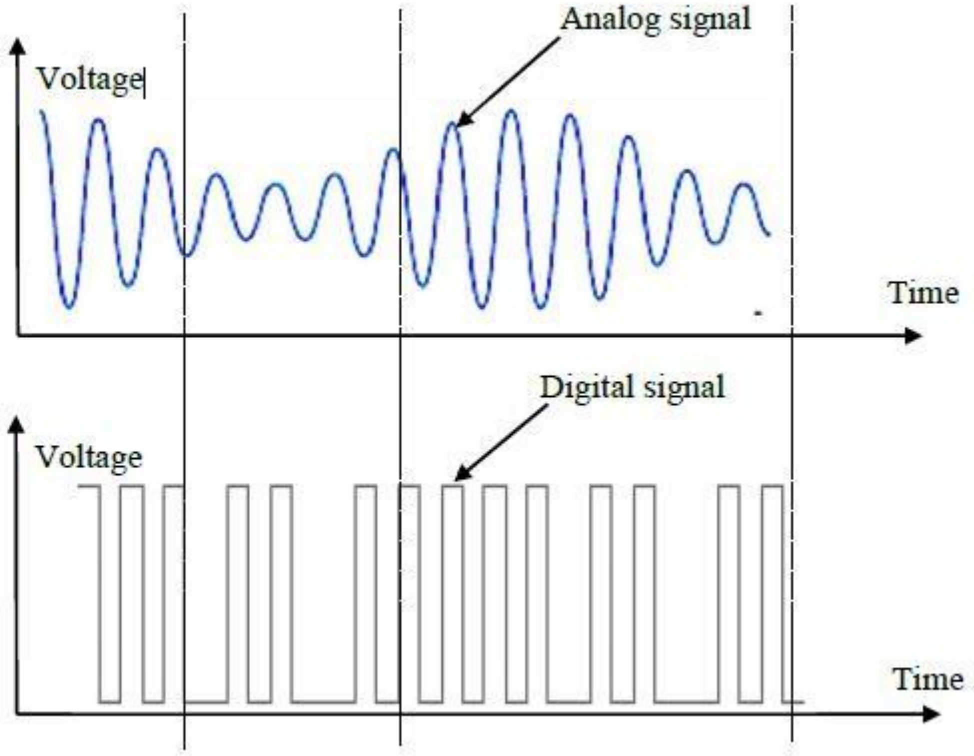
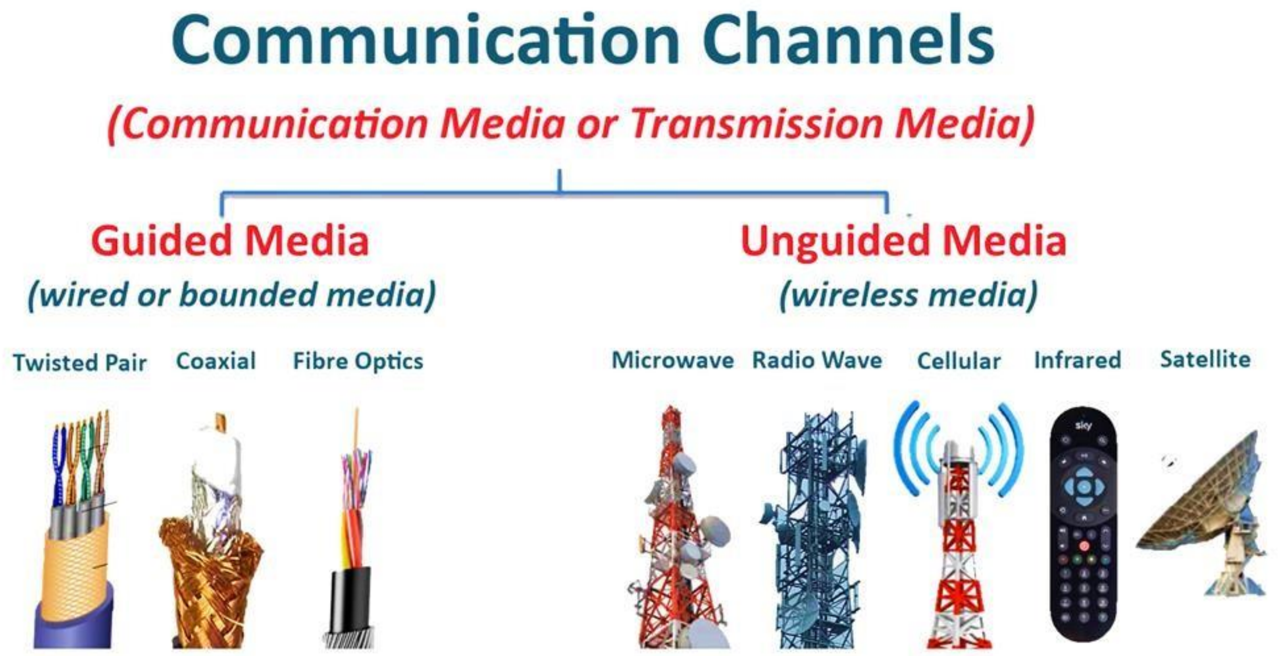


Figure 12.3 Analog and a digital signal respectively

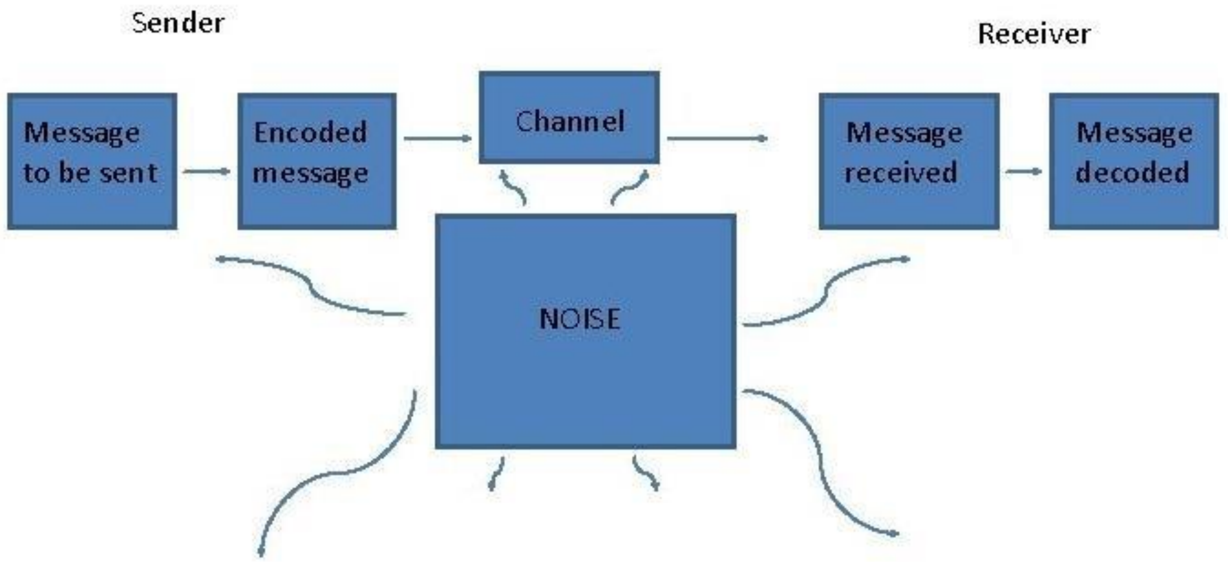
Communication Channel

- The Channel provides the connection between the source and destination.
- It is a path between transmitter and receiver.



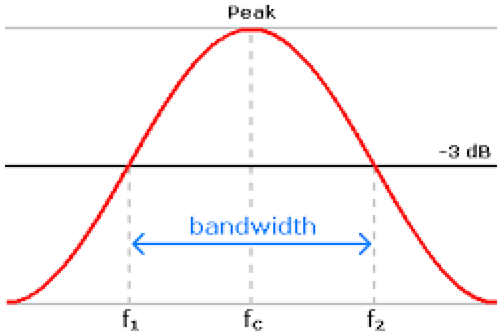
Noise

- Unwanted signals that disturb communications.
  - External Noise
  - Internal Noise
- Noise limits the operating range of the systems.
- Noise affects the quality of the signal.



Bandwidth

- Can be divided as Signal bandwidth and Channel bandwidth.
- Signal bandwidth is the range of frequencies that makes up a signal.
  - Human voice 100 Hz – 10 000 Hz
  - Human hearing 20 Hz – 15 000 Hz
  - Commercial speech 300 Hz – 3400 Hz
  - Mains electricity 50 Hz – 60 Hz



- Channel bandwidth is information-carrying capacity.
  - Measured in cycles per second (hertz or Hz).
- In Digital transmissions, measured in bits per second (bps).

Modulation Techniques
in
Communication Systems

Modulation

- Why Modulation?
- By using modulation, the signals are transmitted through space to long distances.
- Information is first 'loaded' or 'embedded' to a high frequency, high energy signal known as the carrier signal.
- Need to demodulate the signal in the receiving end.

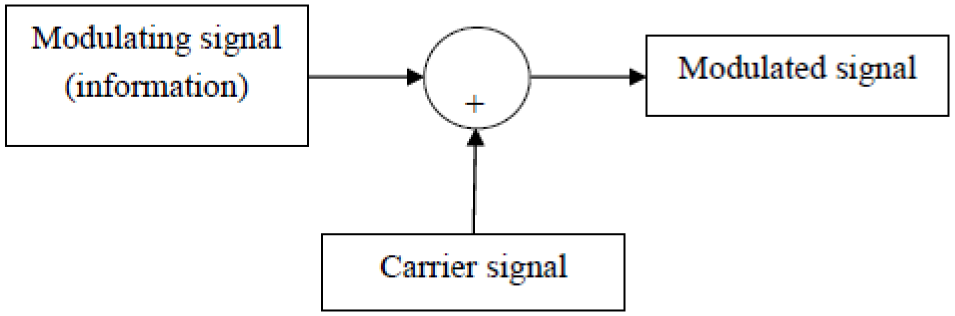


Figure 13.1 Modulation and the process

Demodulation

- Why Demodulation?

- At the destination point the information signal is separated from the carrier signal.

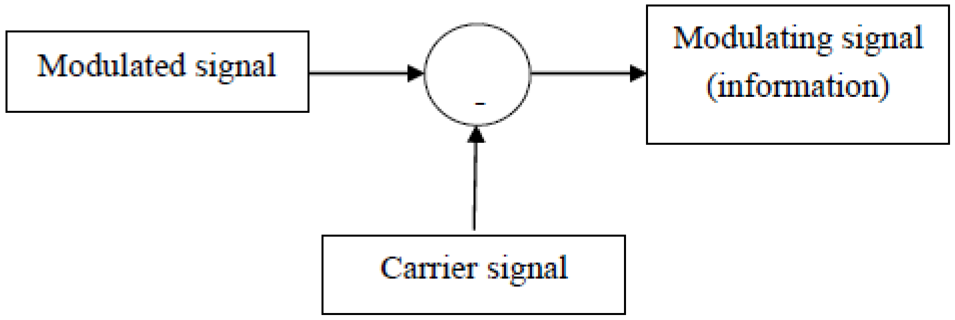
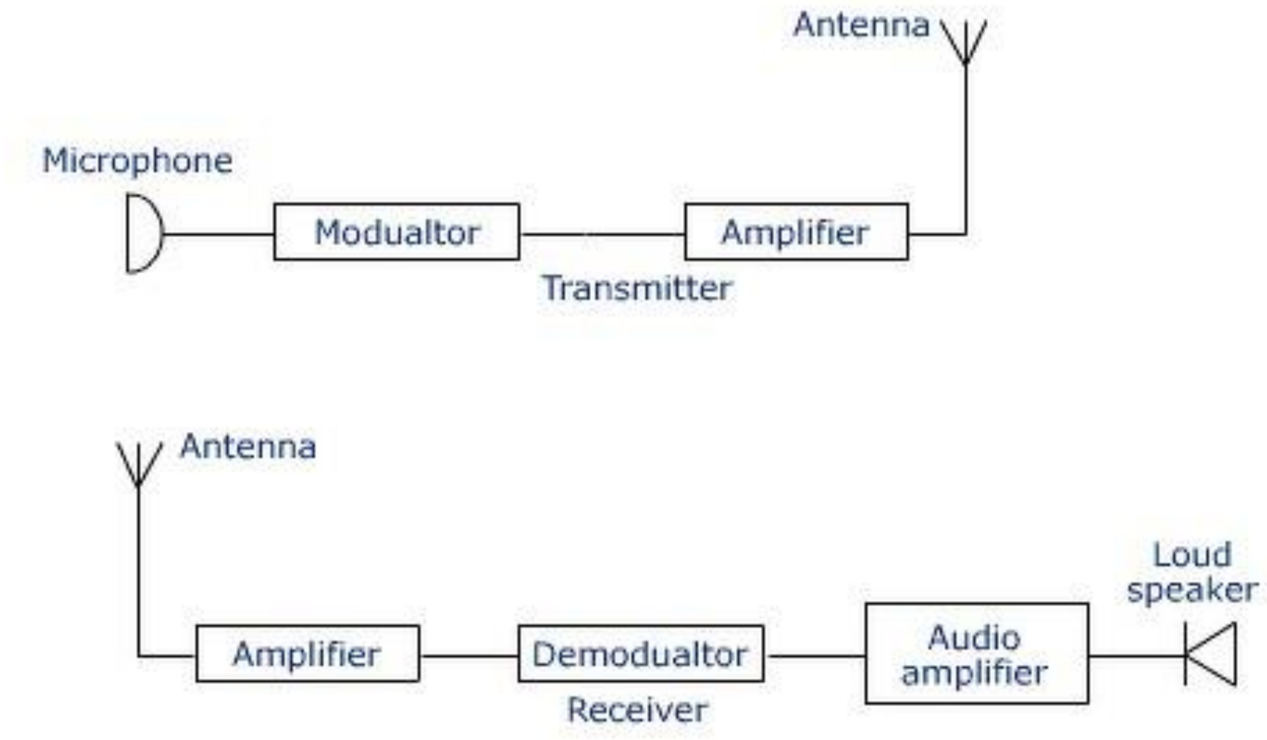


Figure 13.2 Demodulation process

Modulation and Demodulation

Ex:

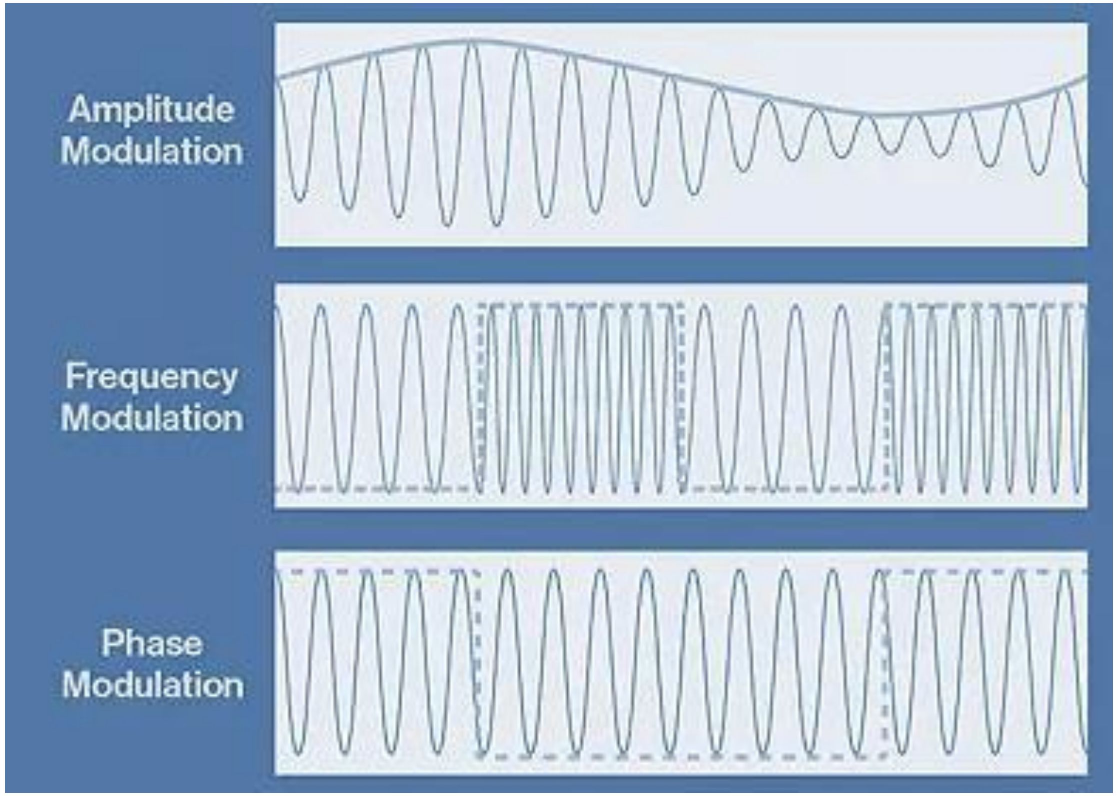


Analog Modulation

- Use sinusoidal signals as the carrier.
- A sinusoidal signal can be described using amplitude and angle (frequency and phase).
- These parameters of the high frequency carrier are varied for transmitting information.
- Analog modulation may be divided into Amplitude Modulation and Angle Modulation.
- Angle modulation can be again divided into Frequency Modulation and phase Modulation.

Analog Modulation Types

- Amplitude modulation.
- Frequency modulation.
- Phase modulation.



Amplitude modulation (AM)

- Amplitude of the carrier signal is varied according to the information signal (modulating signal).

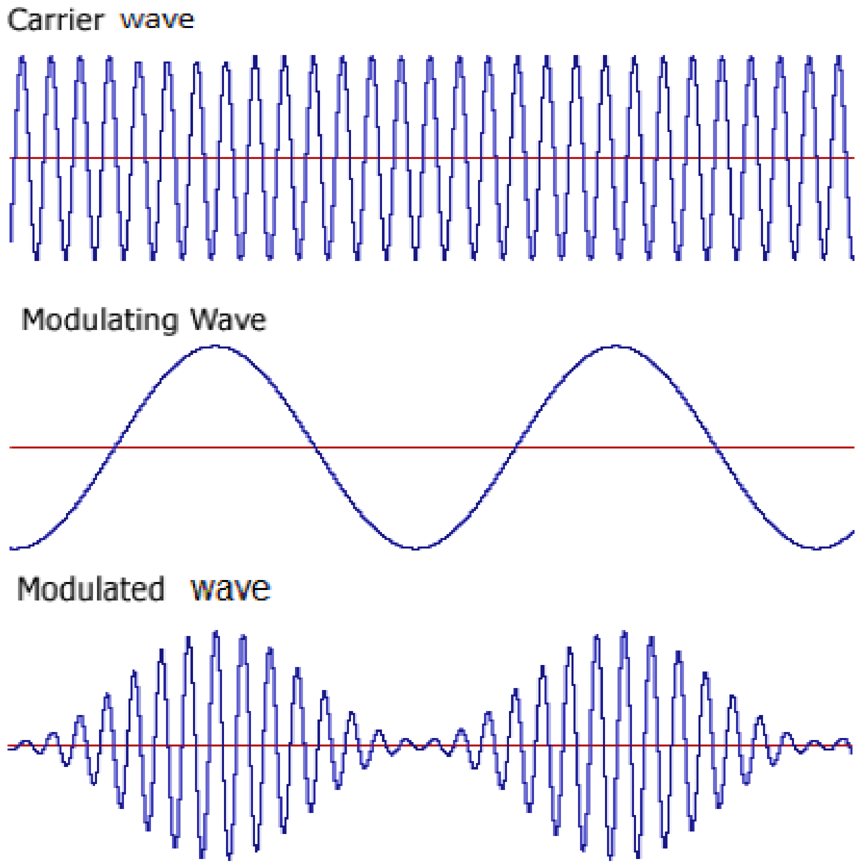


Figure 13.3 Amplitude modulation

$$e_m = E_m \, sin\omega_m t$$
$$e_c = E_c \, sin\omega_c t$$

Where; E_m is maximum amplitude of modulating signal
E_c is maximum amplitude of carrier signal
ω_m is frequency of modulating signal and
ω_c is frequency of carrier signal

$$E_{AM} = E_c + e_m + E_m \, sin\omega_m t$$
$$e_{AM} = E_{AM} \sin\varphi = E_{AM} sin\omega_c t = (E_c + E_m \sin\omega_m t)\sin\omega_c t$$

Therefore, the modulated signal e_{AM} could be expressed as follows

$$e_{AM} = E_c \, sin\omega_c t + m\frac{E_c}{2}\cos(\omega_c - \omega_m)\,t - m\frac{E_c}{2}\cos(\omega_c - \omega_m)\mathrm{t}$$

Modulation Index

The ratio of maximum amplitude of modulating signal to maximum amplitude of carrier signal is called modulation index (m).

Modulation Index, $m = \frac{E_m}{E_c}$

Calculation of Modulation Index:
This is called time domain representation of AM signal.

$$E_m = \frac{E_{max} - E_{min}}{2}$$

$$E_c = E_{max} - E_m$$

Using the above two results, we can calculate the value of Ec as follows.

$$E_c = E_{max} - \frac{E_{max} - E_{min}}{2} = \frac{E_{max} + E_{min}}{2}$$

Modulation index (m) = $\dfrac{E_m}{E_c} = \dfrac{\frac{E_{max} - E_{min}}{2}}{\frac{E_{max} + E_{min}}{2}}$

$$m = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

Amplitude modulation – SAQ 13.1

Question:

Suppose that on an AM signal, the $V_{max(p-p)}$ value read on the oscilloscope screen is 5.9 divisions and $V_{min(p-p)}$ is 1.2 divisions. What is the modulation index ?

Frequency modulation (FM)

- Frequency of the carrier signal is varied according to the modulating frequency while the amplitude of the modulated signal is kept constant.
- Then the carrier frequency will be changed by ±Δ**f**.
- It is called as the frequency deviation of the FM signal.
- The carrier's instantaneous frequency deviation from its unmodulated value varies in proportion to the instantaneous amplitude of the modulating signal.

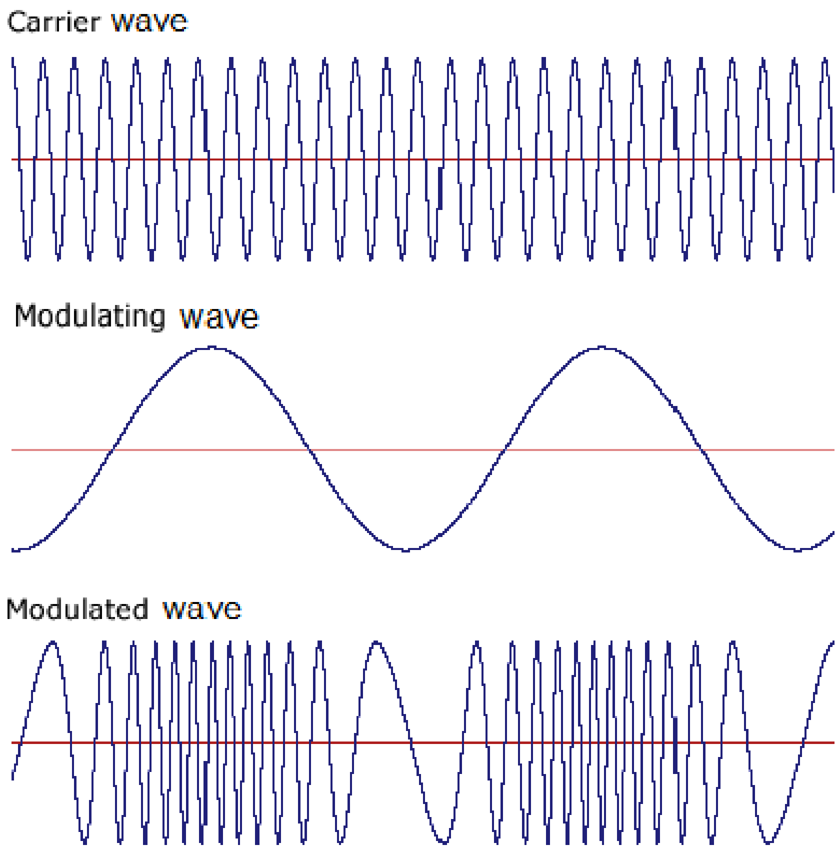


Figure 13.6 FM modulation

Frequency modulation – SAQ 13.2

The equation of a frequency modulated signal is given as

$$V_{fm}(t) = 1000 Sin\left[10^9 t + 4 \sin\left(10^4 t\right)\right]$$

Find, the carrier frequency, modulating frequency, modulation index and frequency deviation.

$$V_{fm}(t) = E_c \cos(\omega_c t + m_f \sin(\omega_m t)$$

$$m_f = \frac{\Delta f}{f_m}$$

Phase modulation

- Phase of the carrier signal is varied according to the amplitude of the modulating signal.
- Thus, if m(t) is the message signal and,

$$c(t) = A\cos\omega_C t$$

- Then the modulated signal will be,

$$F(t) = A\cos(\omega_c t + \pi)$$

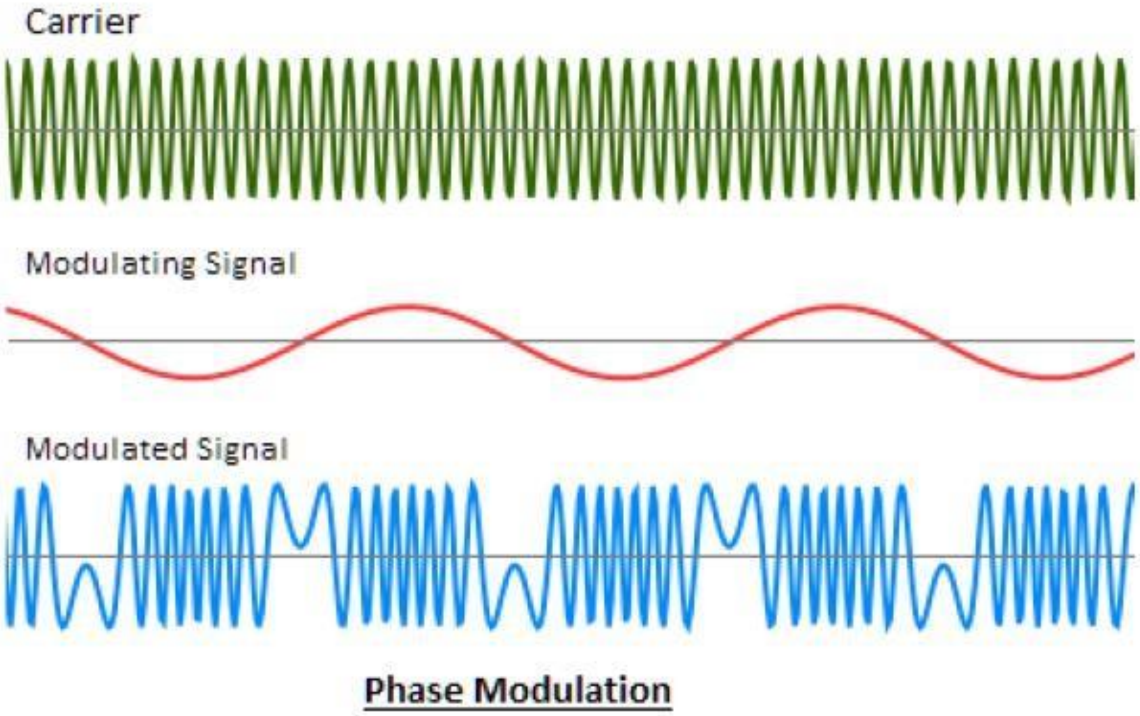


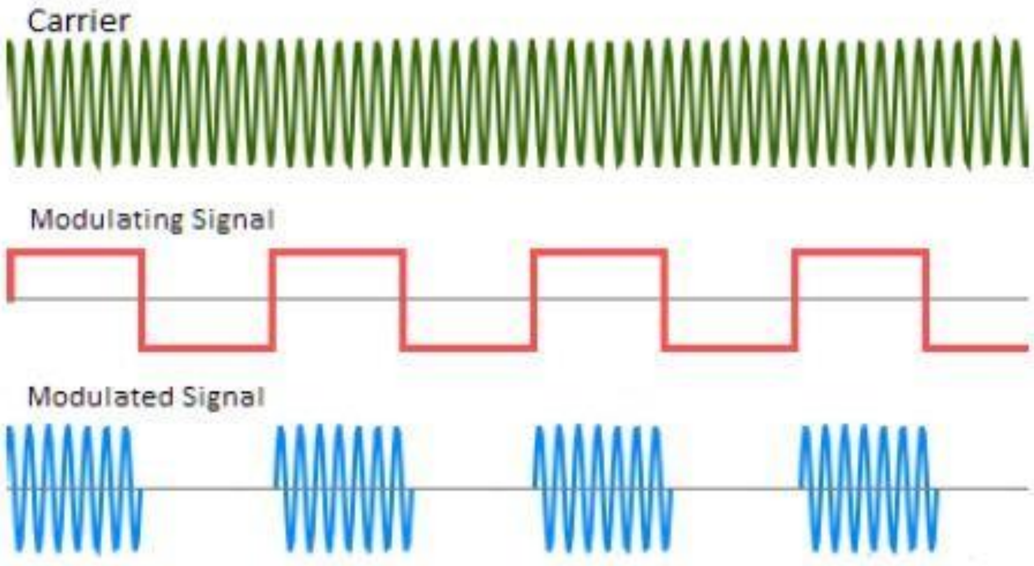
Figure 13.7: Phase modulation

Digital Modulation

- Same as the analog modulation except the modulating signal is a bit stream consist with logic ‘0’ and logic ‘1’.
- Then it will embed to the high frequency carrier and transmitted.
- Basic Digital Modulation types:
    - Amplitude shift key (ASK)
    - Frequency shift key (FSK)
    - Phase shift key (PSK)
- These methods are use for different applications according to the available bandwidth and the data rates that needed to transmit via the channel.

Amplitude Shift Key (ASK)

- Carrier frequency is changed according to the amplitude of the digital data.
- Then the received modulated signal is transmitted via the channel.
- Because of this switching pattern ASK method is also known as on-off keying (OOK).
- The applications:
  - infrared remote controls
  - fiber optical transmitter and receiver

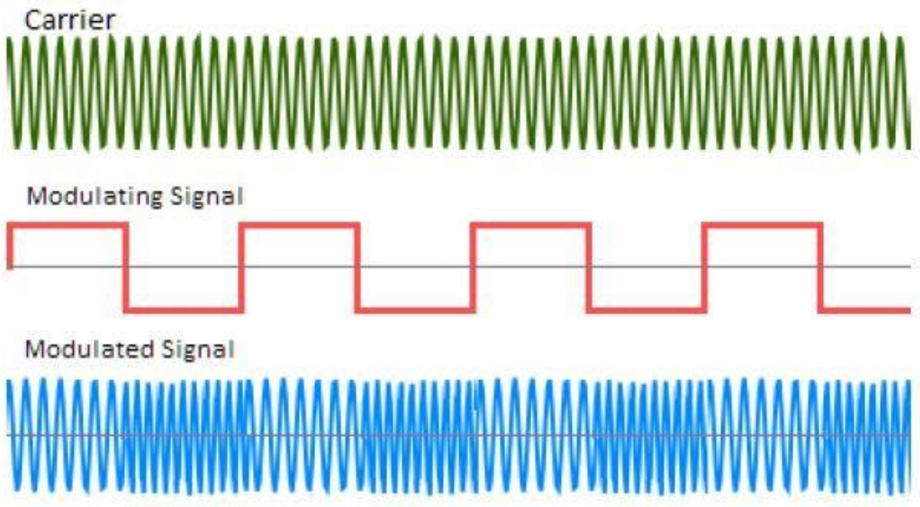


Amplitude Shift Key

Figure 13.8

Frequency Shift Key (FSK)

- Frequency is changed according to the modulating signal. This
- Mostly used in modems for telemetry applications.



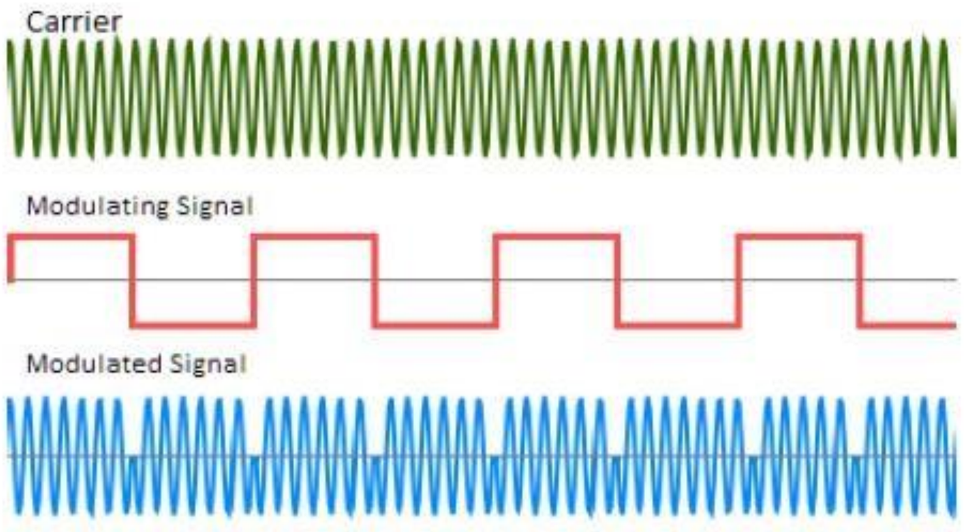
Frequency Shift Key

Figure 13.9

- According to the figure 13.9 there are two predefined frequency ω_{c0} and ω_{c1}.
- Modulated signal has the ω_{c0} frequency, when the modulating bit is '0' and
- Modulated signal has ω_{c1} frequency, when the modulating bit is '0'.
- Then the carrier transmitted $\cos \omega_{c0}$ and $\cos\omega_{c1}$ with reference to the information signal (modulating bit).

Phase Shift Key (PSK)

- Change the phase of the carrier depending on the information (modulating).
- Used in ADSL broadband modems, mobile phones and satellite Communication.



Phase Shift Key

Figure 13.10

- Uses phase shift under a logic state.
- If there is a logic '0', the modulated signal represent $\cos \omega_c t$ and logic'1' represented by the $\cos(\omega_c t + \pi)$.

Advanced Digital Modulation Techniques

- Developed because of the increment of transmitting more and more date in channels

  Ex: To accommodate high data rates and high bandwidth requirement to send video.

- Commonly used techniques
  - Binary Phase Shift Key (BPSK)
  - Quadrature Phase Shift Key (QPSK)
  - Quadrature Amplitude Modulation (QAM)

Learning Outcomes

- End of this module, you can be able to,
  - Explain the importance of modulation and the process of modulation and demodulation.
  - Explain the amplitude modulation and effect of modulation index.
  - Compare the analog and digital modulation
  - Explain the different modulation techniques and unique features
  - Identify the applications related to each modulation technique.

Signal Power in Communication Systems

- Another essential parameter to transmit a signal from one point to another in-line and radio communication.
- As the signal propagates from the source to the destination, the signal either gains or loses power depending on the design of the system.
- Very often it is necessary to know the exact power available at a particular point in the communication system.
- The use of Logarithmic units for expressing power level facilitates speedy calculation of the signal level.
- These power ratio are expressed in decibels.
- We refer to power ratios when we use amplifiers and attenuators.
- Different types of logarithmic units are used
- It is important to know how corrections are made to measurements of level of power of speech channels to allow for the response of the human ear.

THANK YOU!

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