CHAPTER 4

Signal Transmission

(Part 2 of 2)

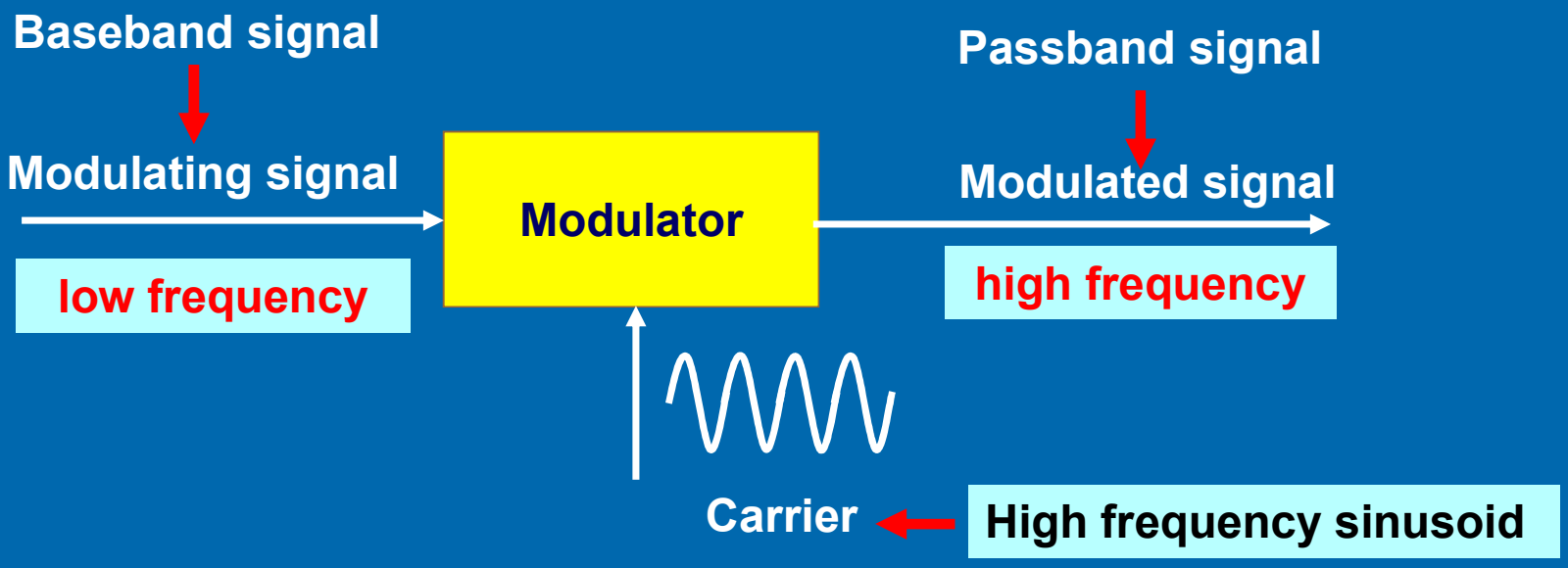
Official (Closed), Non-sensitive

4.4 Modulation

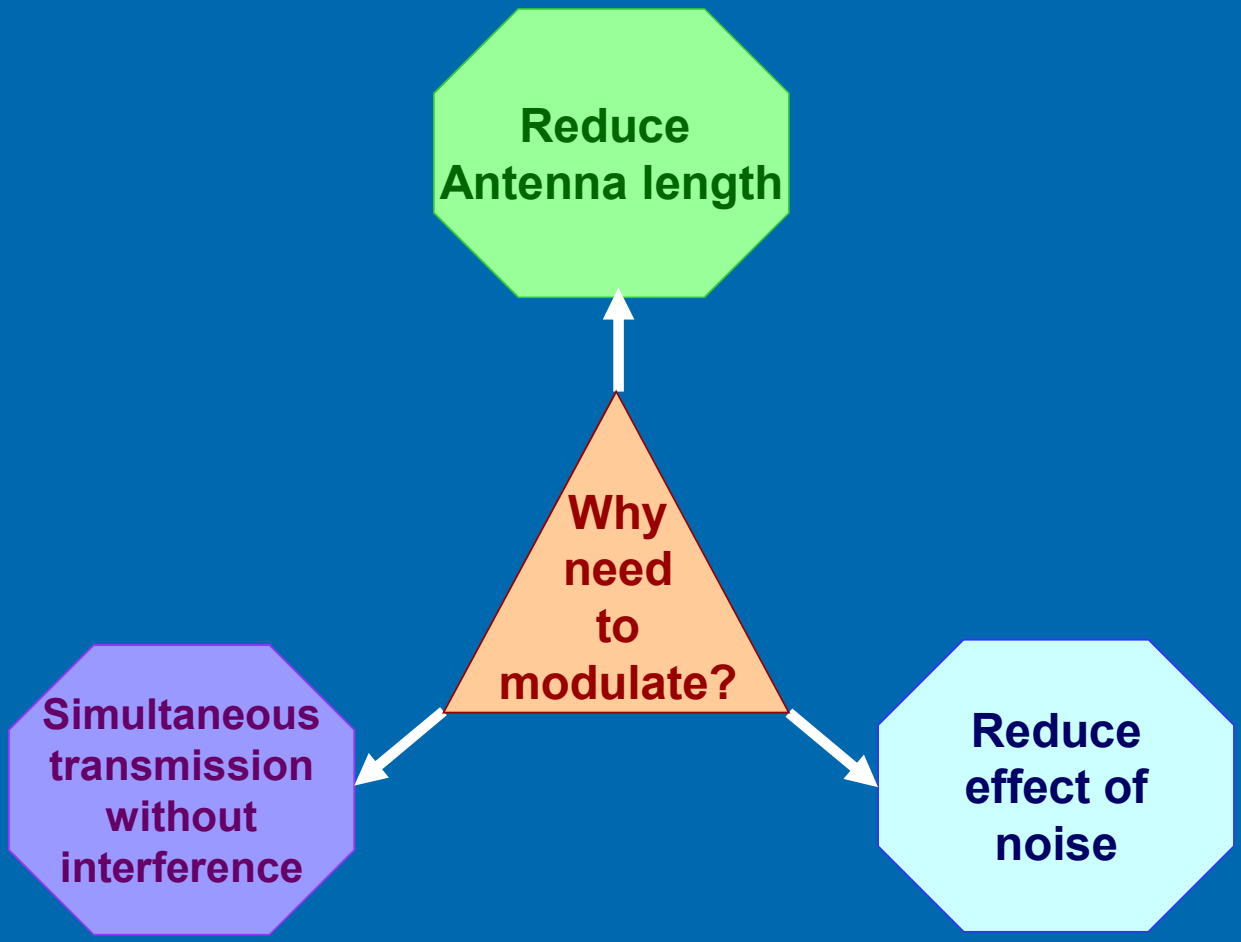
Modulation

The process of shifting the frequency of baseband signal to a higher frequency band

Varying the amplitude, phase or frequency of a high frequency sinusoid (carrier) in accordance with the baseband signal.



4.5 The Need for Modulation



4.5 The Need for Modulation

Modulation for practical antenna length

Efficient transmission

The ability of the waves to travel very far without the need for high transmission power.

Antenna length required for efficient radio transmission:

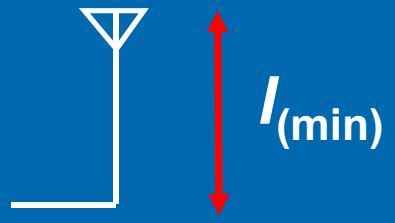
$$\text{Antenna length} \geq 0.1\lambda$$

$$\lambda = \frac{V_{(prop)}}{f}$$

The higher the frequency, the shorter the antenna is required.

The **minimum antenna length l_{min}** for efficient transmission and good reception:

$$l_{(min)} = 0.1\lambda = 0.1 \times \frac{V_{(prop)}}{f}$$



4.5 The Need for Modulation

Modulation for practical antenna length

Speech, music, video and data:

→ **contain low frequency components**

→ **requires very long antenna**

For a signal of frequency 100 Hz, the minimum antenna length required

$$\text{minimum antenna length} = 0.1\lambda = 0.1 \times c/f$$
$$= 0.1 \times 3 \times 10^8/100$$
$$= 300 \text{ km}$$

Impractical !

How to reduce antenna length for low frequency signals?

4.5 The Need for Modulation

Modulation for practical antenna length

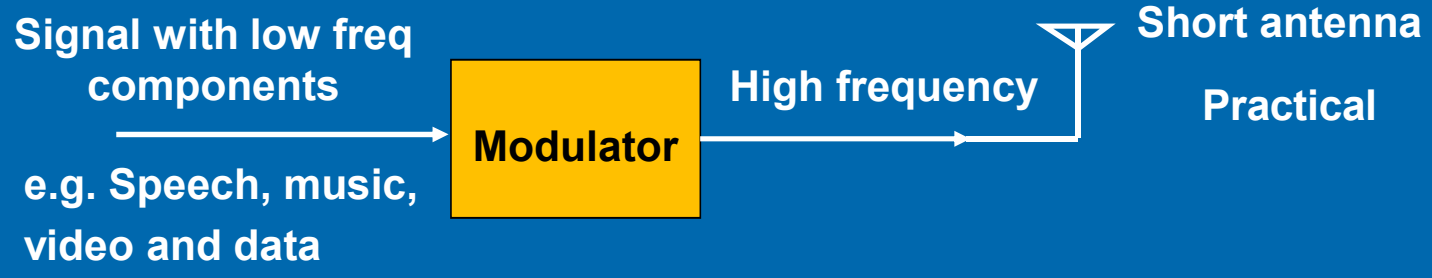
How to reduce antenna length for low frequency signals?

Ans: Shift the baseband signal to a higher frequency band.

If the 100 Hz signal is shifted to a 100 MHz, the minimum antenna length

$$\text{minimum antenna length} = 0.1\,\lambda = 0.1 \times c/f$$
$$= 0.1 \times 3 \times 10^8/100 \times 10^6 \text{ m}$$
$$= 0.3 \text{ m}$$

Practical to construct and use



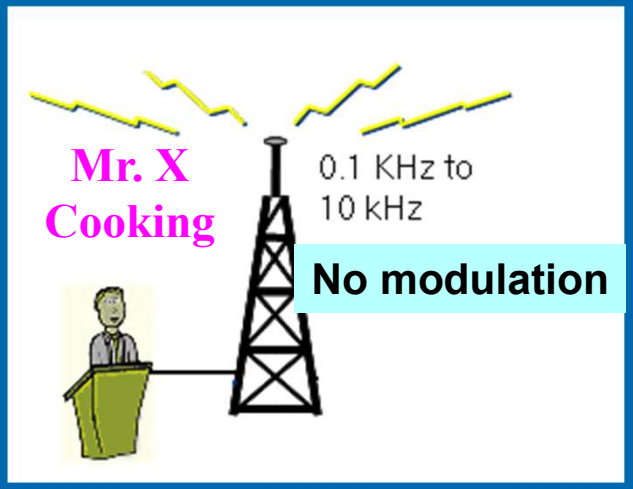
4.5 The Need for Modulation

Modulation for Simultaneous Transmission without Interference

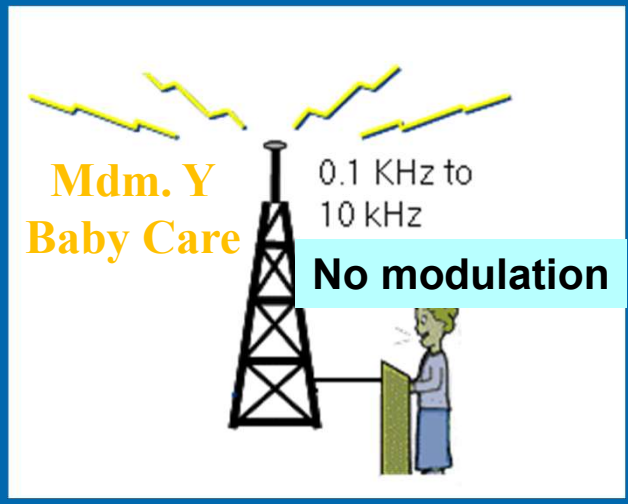
When two or more stations broadcast speech simultaneously, it is impossible for one to listen to one station without hearing the other stations.

Co-channel Interference/ Cross talk

The signals occupy the same frequency band (0.1 - 10 kHz).



Ms W, Listener

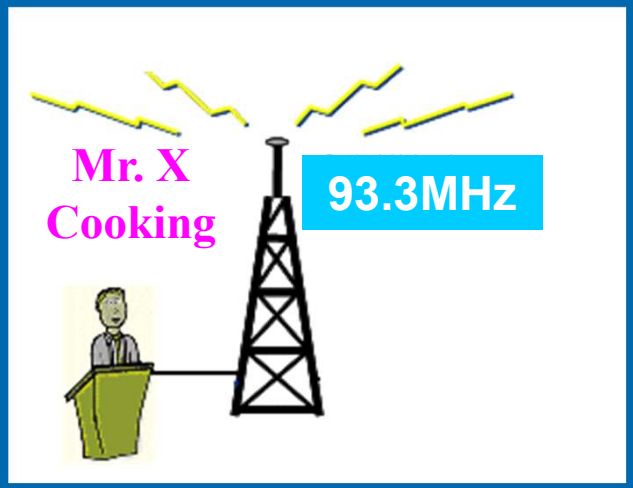


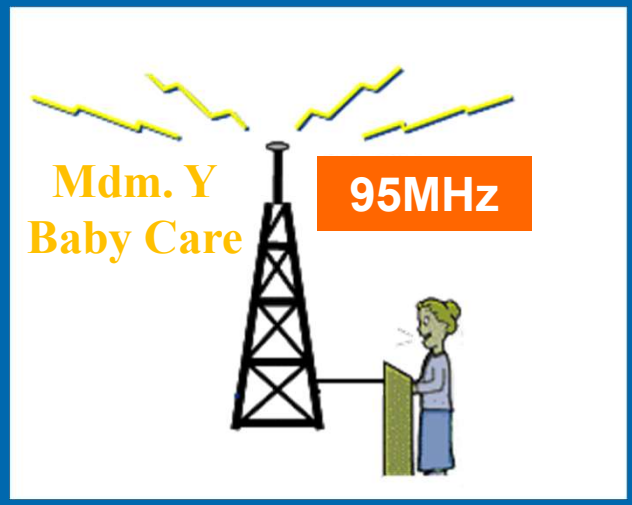
4.5 The Need for Modulation

Modulation for Simultaneous Transmission without Interference

- When each station is modulated onto a different carrier frequency, all the stations can be broadcast simultaneously without interference.

Assign different carrier frequency to each channel using modulation.



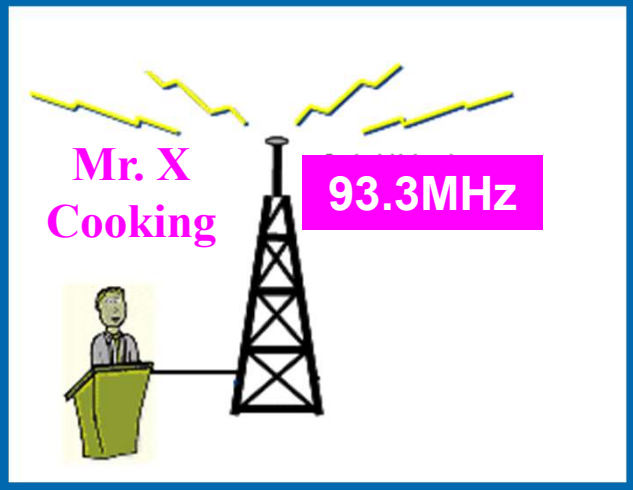


4.5 The Need for Modulation

Modulation for Simultaneous Transmission without Interference

The listener can tune to a station of her choice without interference from other stations.

Tuned to **93.3MHz**



Ms W
Listener

4.5 The Need for Modulation

Modulation for Simultaneous Transmission without Interference

Modulation allows simultaneous transmission of signals without interference by the use of different carrier frequencies.

4.5 The Need for Modulation

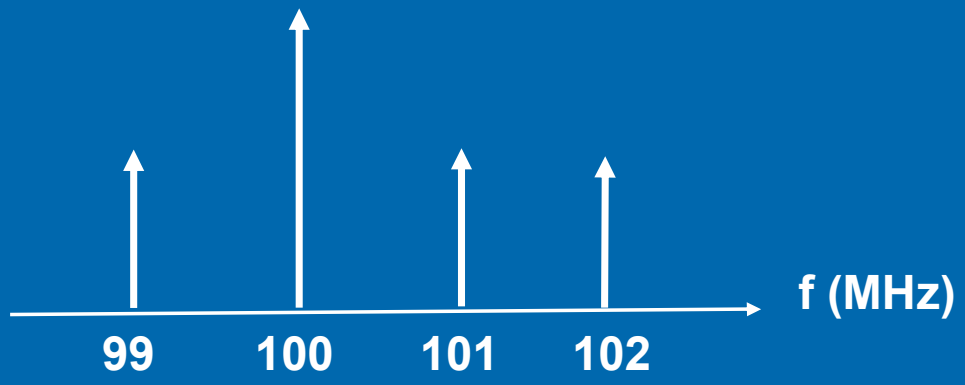
Modulation to Reduce the Effects of Noise

- Certain types of modulation (such as FM) can minimise the effects of noise.

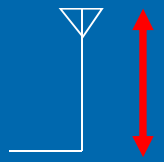
Example 4.2

A signal has 4 frequency components as shown.

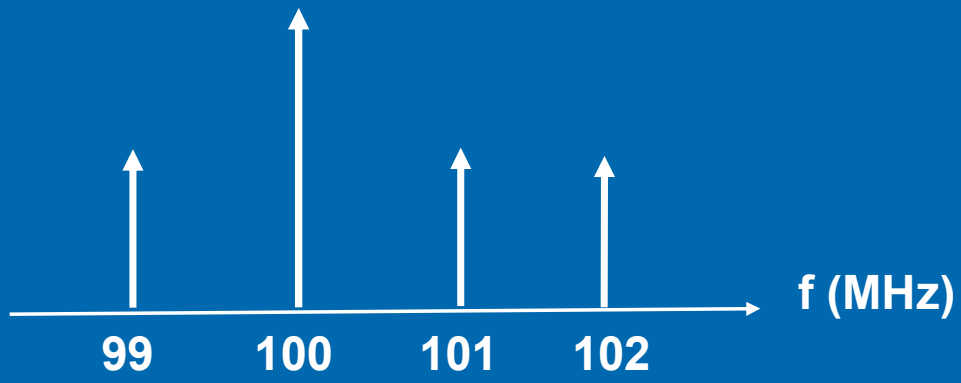
What is the minimum antenna length to transmit the signal efficiently?



Solution



$$L_{(min)} = 0.1\lambda = \frac{0.1c}{f}$$



For 99MHz, min. length required = L_1 = 0.1c/99MHz = 0.303m

For 102MHz, min. length required = L_2 = 0.1c/102MHz = 0.294m

For 100 & 101MHz, min. length required will be between L_1 and L_2.

Use L_1 because it will be long enough for ALL the 4 frequency components.

L_2 will be too short for the 99, 100 & 101MHz component.

4.6 Types of Modulation

- A modulator combines the low frequency modulating signal with a high frequency carrier to produce a high frequency passband signal.

- Modulation can be grouped under two categories:

  Analog Modulation

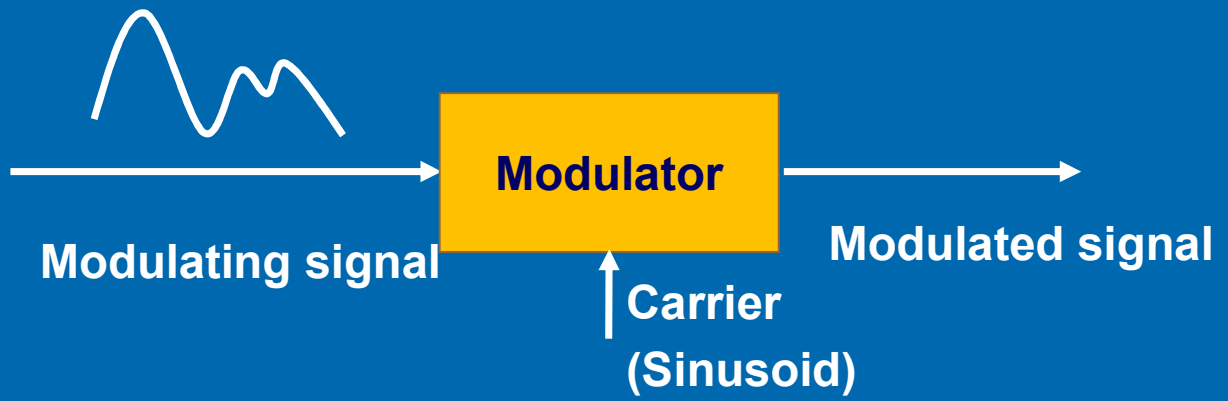
  Digital Modulation

4.6 Types of Modulation

Analog Modulation

Analog Modulation

- Modulating signal is analog.



- There are three basic analog modulation techniques used in analog communication systems:

Amplitude modulation (AM) — Radio broadcasting in MF band

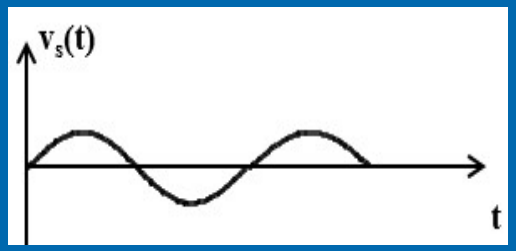
Frequency modulation (FM) — Radio broadcasting in the VHF band as well as in cordless phones and walkie-talkies.

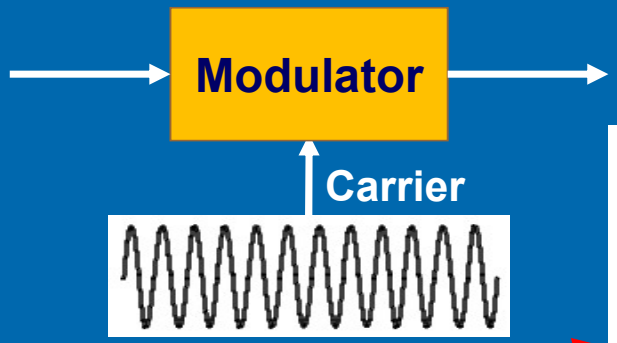
Phase modulation (PM) (not included in the syllabus)

4.6 Types of Modulation

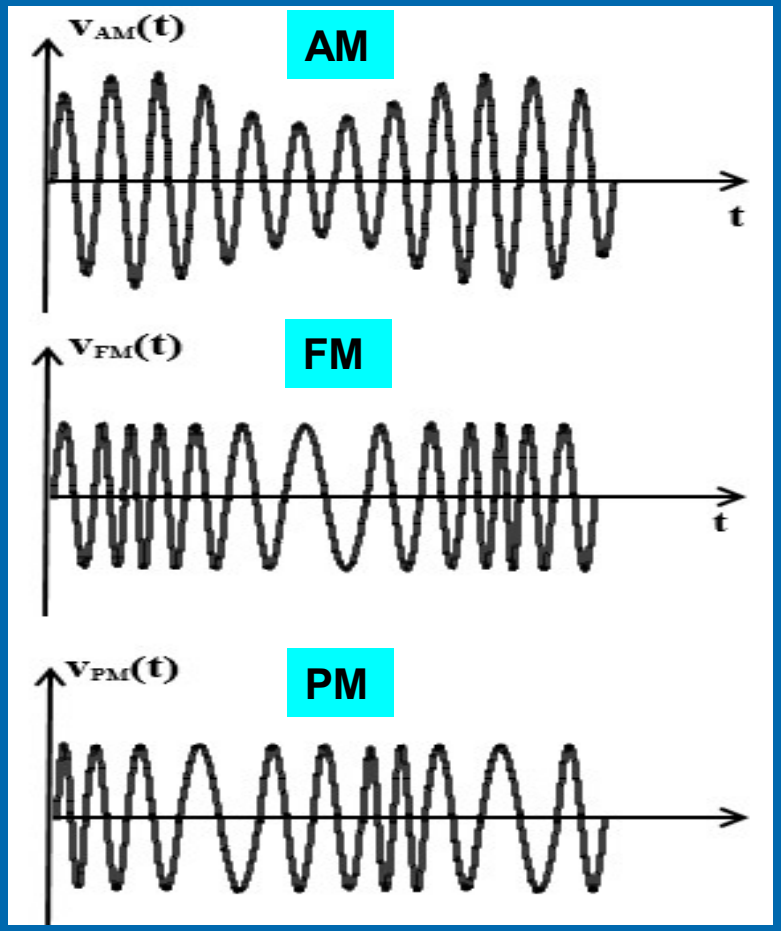
Analog Modulation

Modulating signal





Modulated signal



AM Varying the amplitude of the carrier in accordance with the analog baseband signal.

FM Varying the frequency of the carrier in accordance with the analog baseband signal.

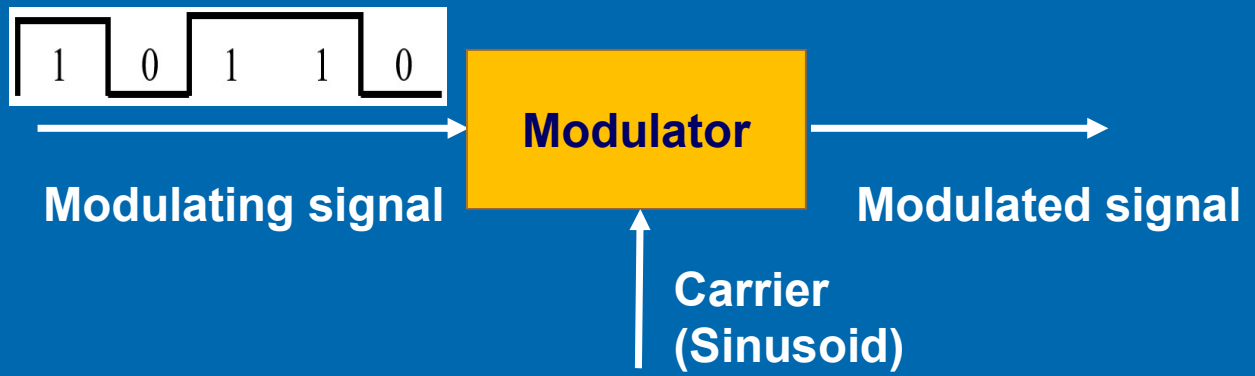
PM Varying the relative phase of the carrier in accordance with the analog baseband signal.

4.6 Types of Modulation

Digital Modulation

Digital Modulation

- Modulating signal is digital.



- There are three basic digital modulation techniques used in digital communication systems.

  - The amplitude, frequency or phase of the sinusoidal carrier is varied in accordance with the logic states of the modulating signal.

Amplitude Shift Keying (ASK)

Frequency Shift Keying (FSK)

Phase Shift Keying (PSK)

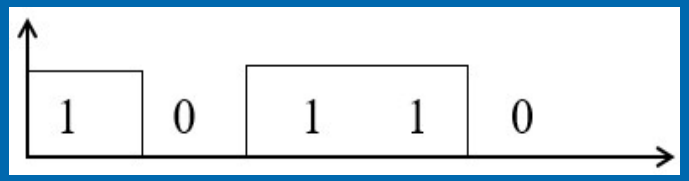
Used in digital communication system

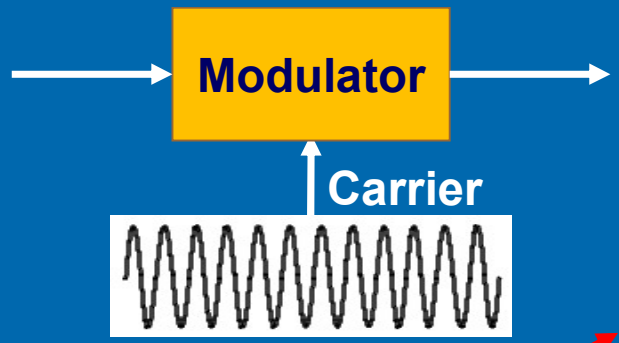
e.g. Internet, Cellular systems

4.6 Types of Modulation

Digital Modulation

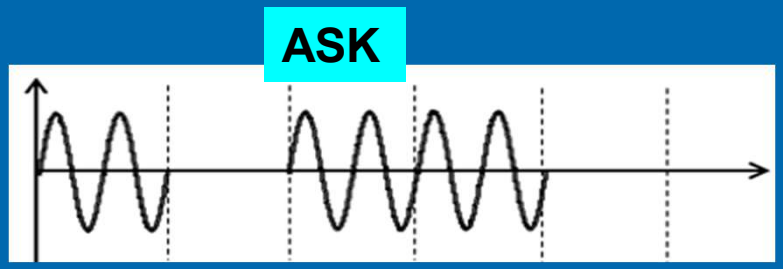
Modulating signal



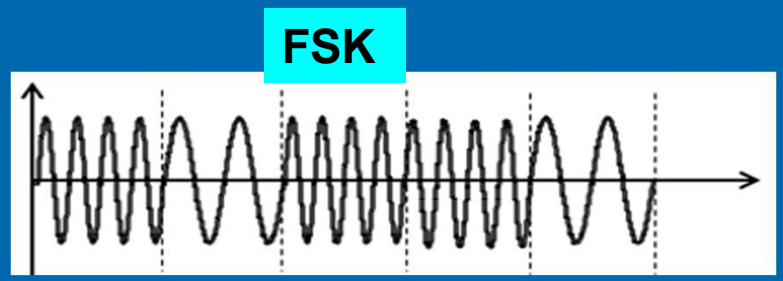


Modulated signal

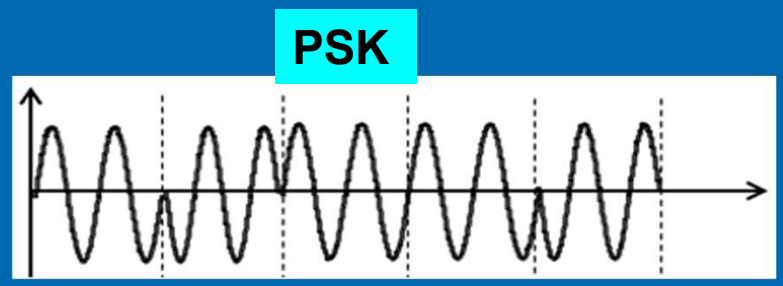
ASK Varying the amplitude of the carrier in accordance with the digital baseband signal.



FSK Varying the frequency of the carrier in accordance with the digital baseband signal.



PSK Varying the relative phase of the carrier in accordance with the digital baseband signal.



End

CHAPTER 4

(Part 2 of 2)