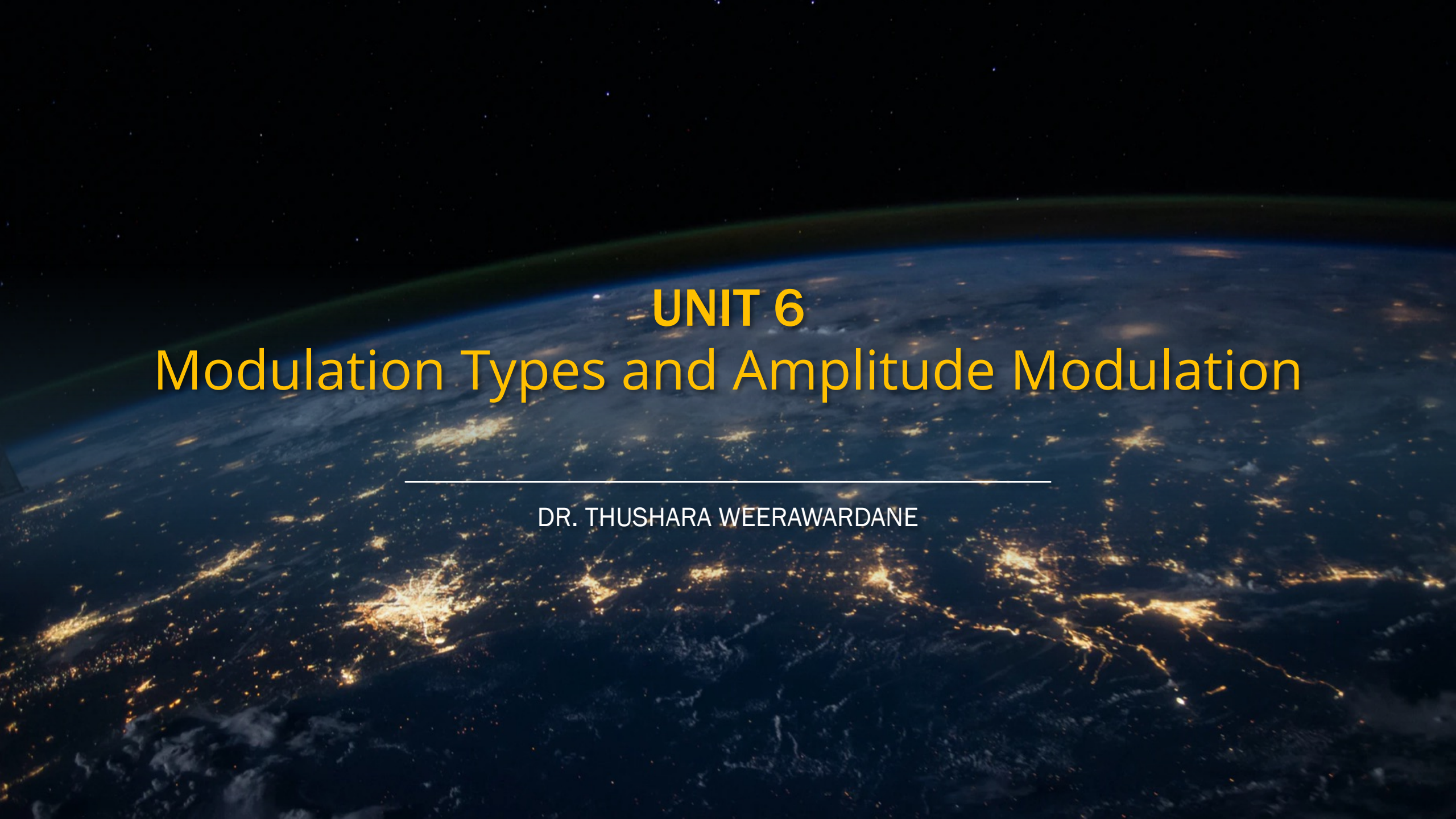


UNIT 6
Modulation Types and Amplitude Modulation

DR. THUSHARA WEERAWARDANE

Outcomes

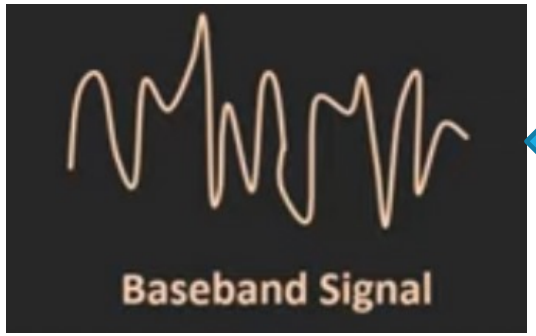
- Define Types of Communication
- Differentiate Modulation Techniques
- Discuss Amplitude Modulation and Applications
- Study Transmitter and Receiver Techniques
- Analyze Different Amplitude modulation schemes and Their Usage

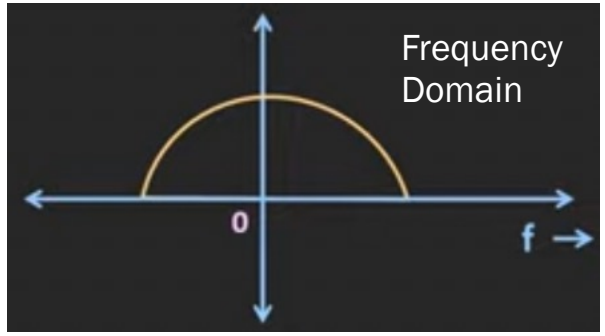
Type of Communication

Baseband Communication

Carrier Communication

Baseband Communication

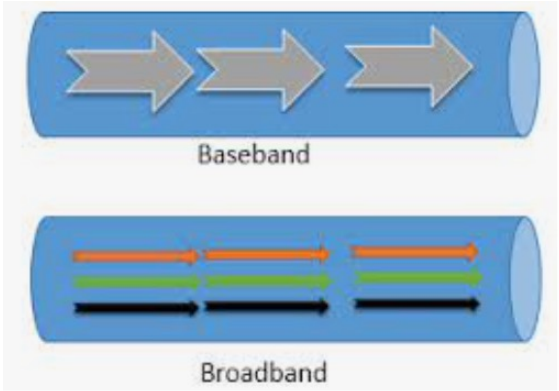


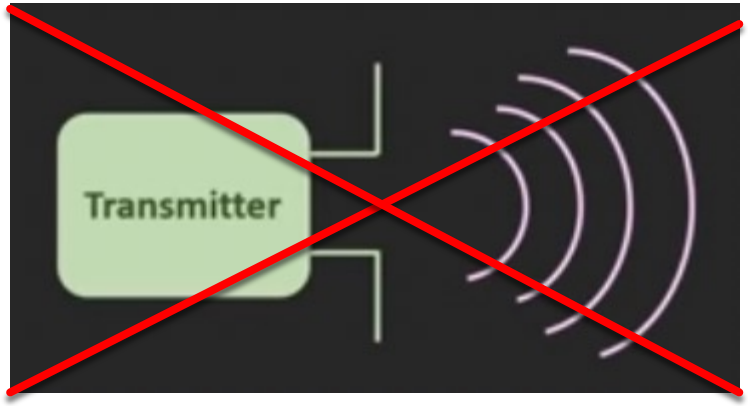


P2P Transmission

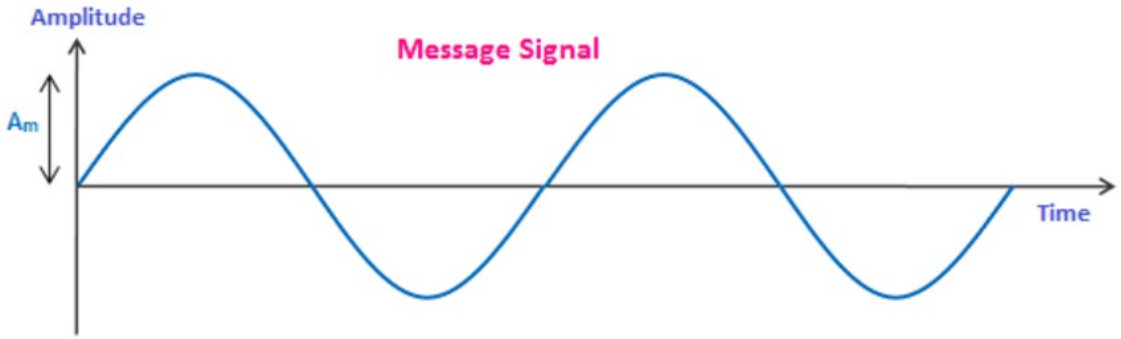
- Ethernet
- coaxial
- twisted-pair

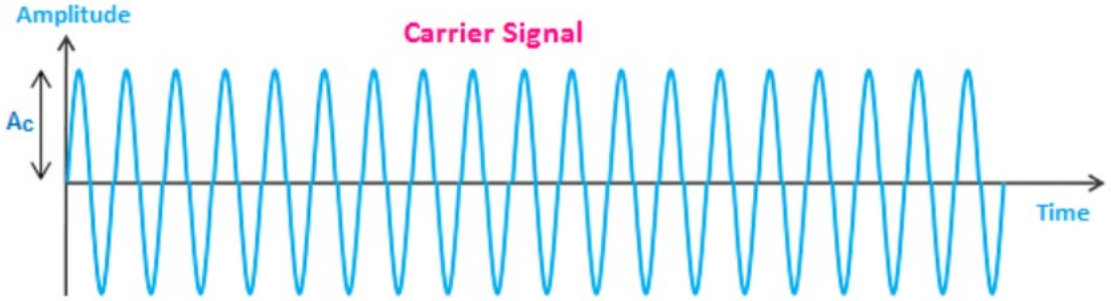
- fiber-optic (broadband)

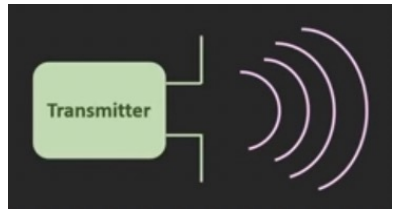


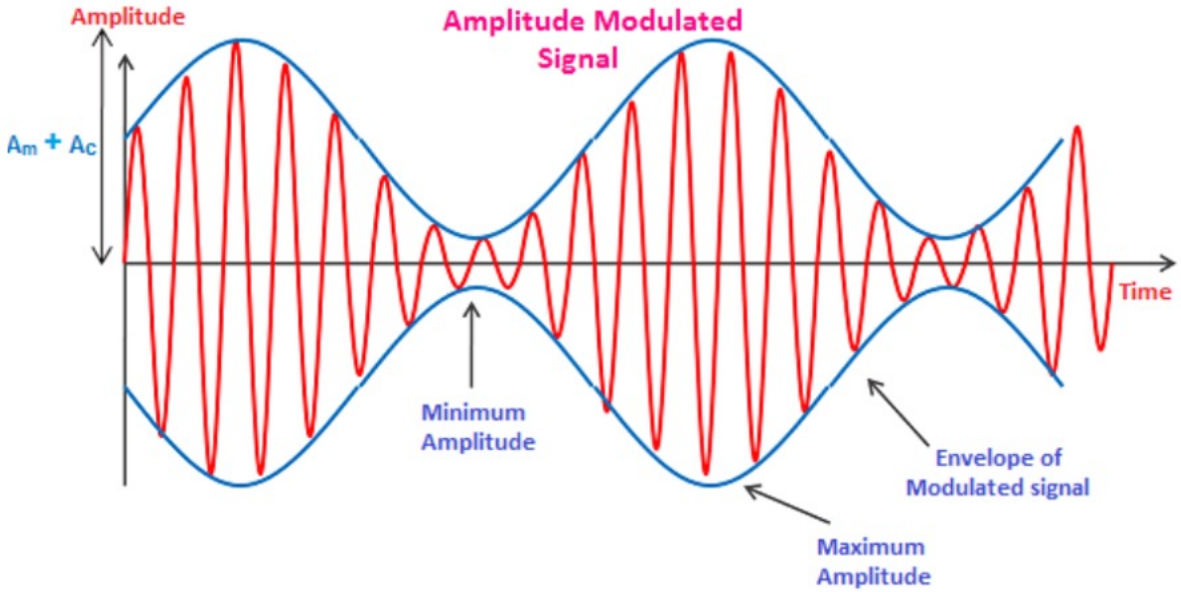


Carrier Communication









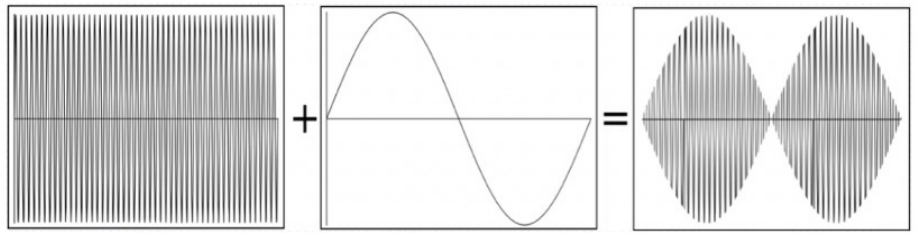
High power transmission

Modulation?

Modulation is a process of modification of carrier signal with respect to modulating (message) signal

$$Asin(\omega t + \phi) \text{ or } Acos(\omega t + \phi)$$

- We send the information by changing some fundamental characteristics of the carrier wave
  - Amplitude
  - Frequency and
  - Phase



- The faster we can change the carrier, the more information we can transmit

Why Modulation is needed

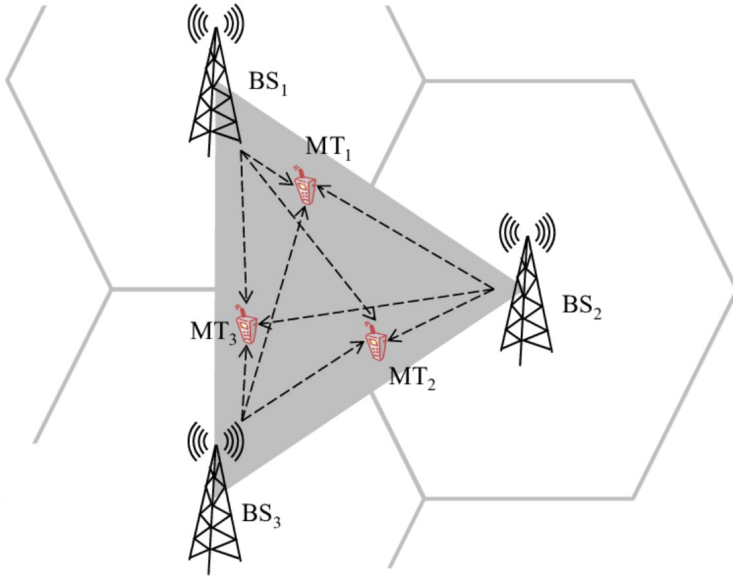
- Height of the Antenna
  - Compare antenna height for 3kHz signal and 3 GHz Signal

    $(C = f\boldsymbol{\lambda}, Antenna\ Height\ \boldsymbol{\lambda}/4)$
- Radiated power by Antenna
  - Power transmitted $\boldsymbol{\alpha}$ $(1/\lambda^2)$
- Reduce Interference
  - Same frequency bands are overlapping
  - Different carrier frequency can be used for multiplexing
- High Bandwidth
  - High frequency results in High Bandwidth

Plank constant

Energy $E = h\nu$

frequency



Type of Modulation

Analog Modulation

Continuous Wave Modulation

Carrier signal

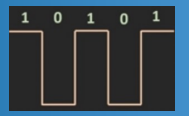
AM – Amplitude Modulation
FM – Frequency Modulation
PM – Phase Modulation

Pulse Modulation

Carrier signal

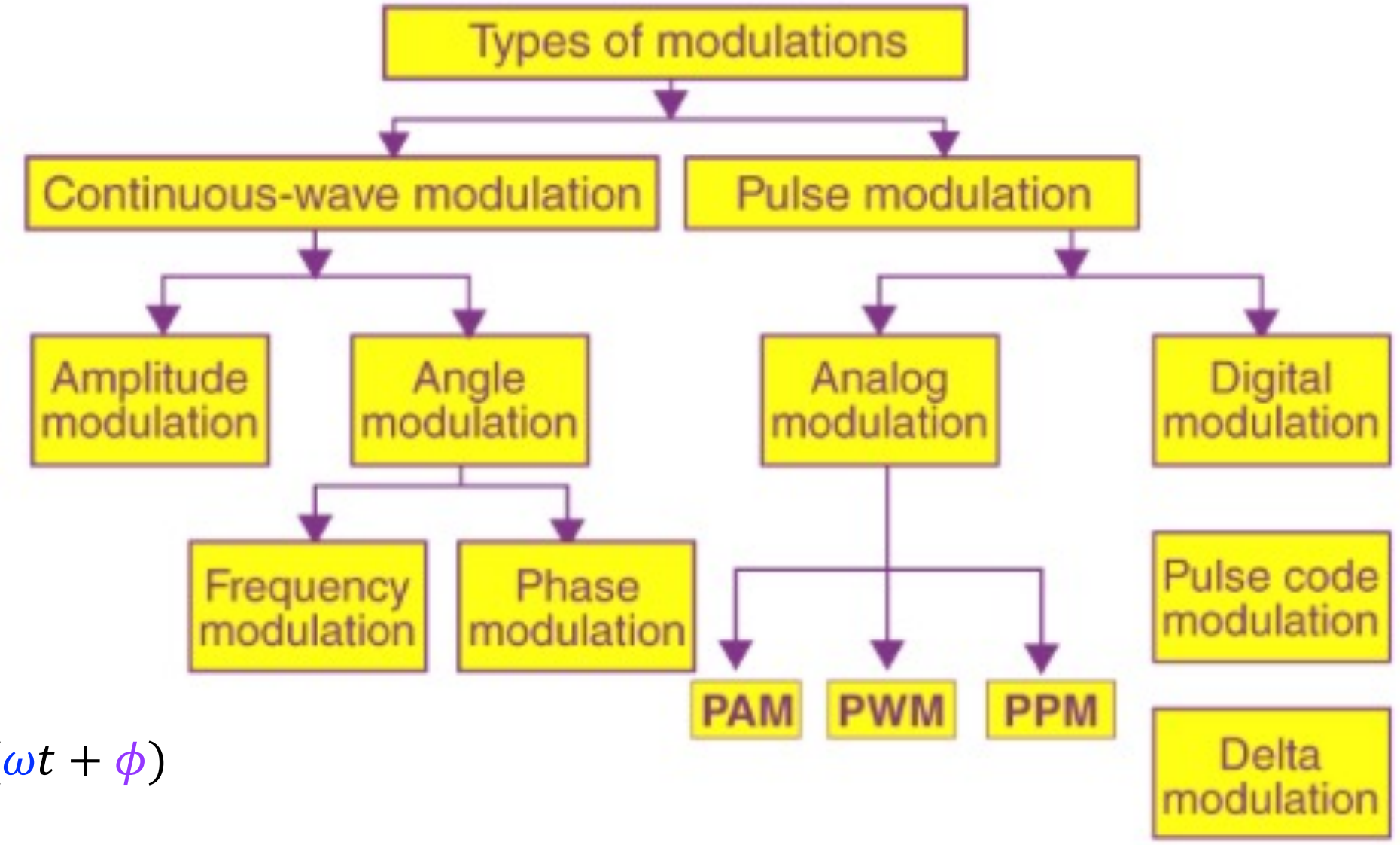
PAM – Pulse Amplitude Modulation
PWM – Pulse Width Modulation
PPM – Pulse Position Modulation

Digital Modulation



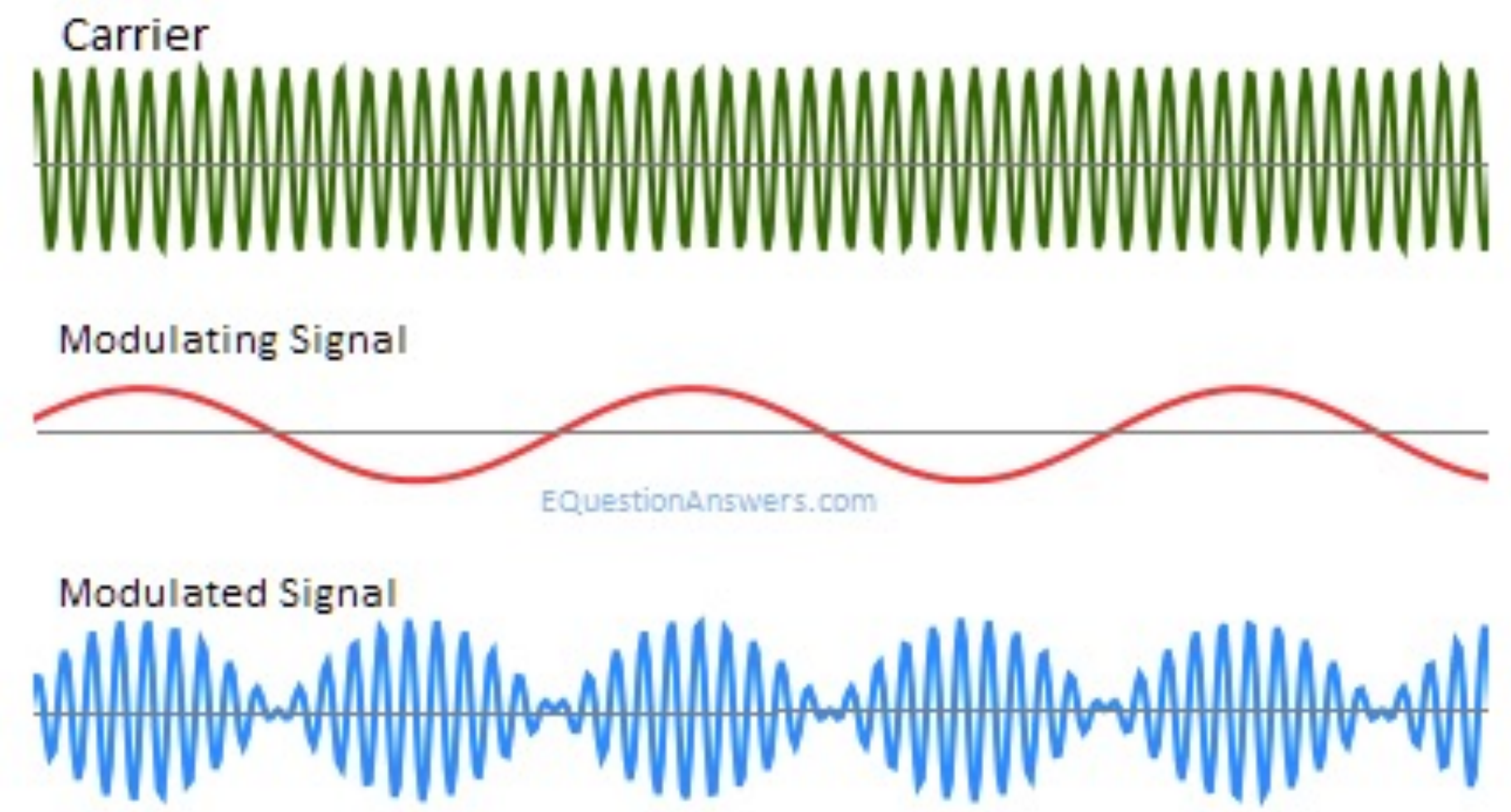
ASK – Amplitude Shift Keying
FSK – Frequency Shift Keying
PSK – Phase Shift Keying

PCM – Pulse Code Modulation (Delta Modulation and Adaptive delta Modulation)

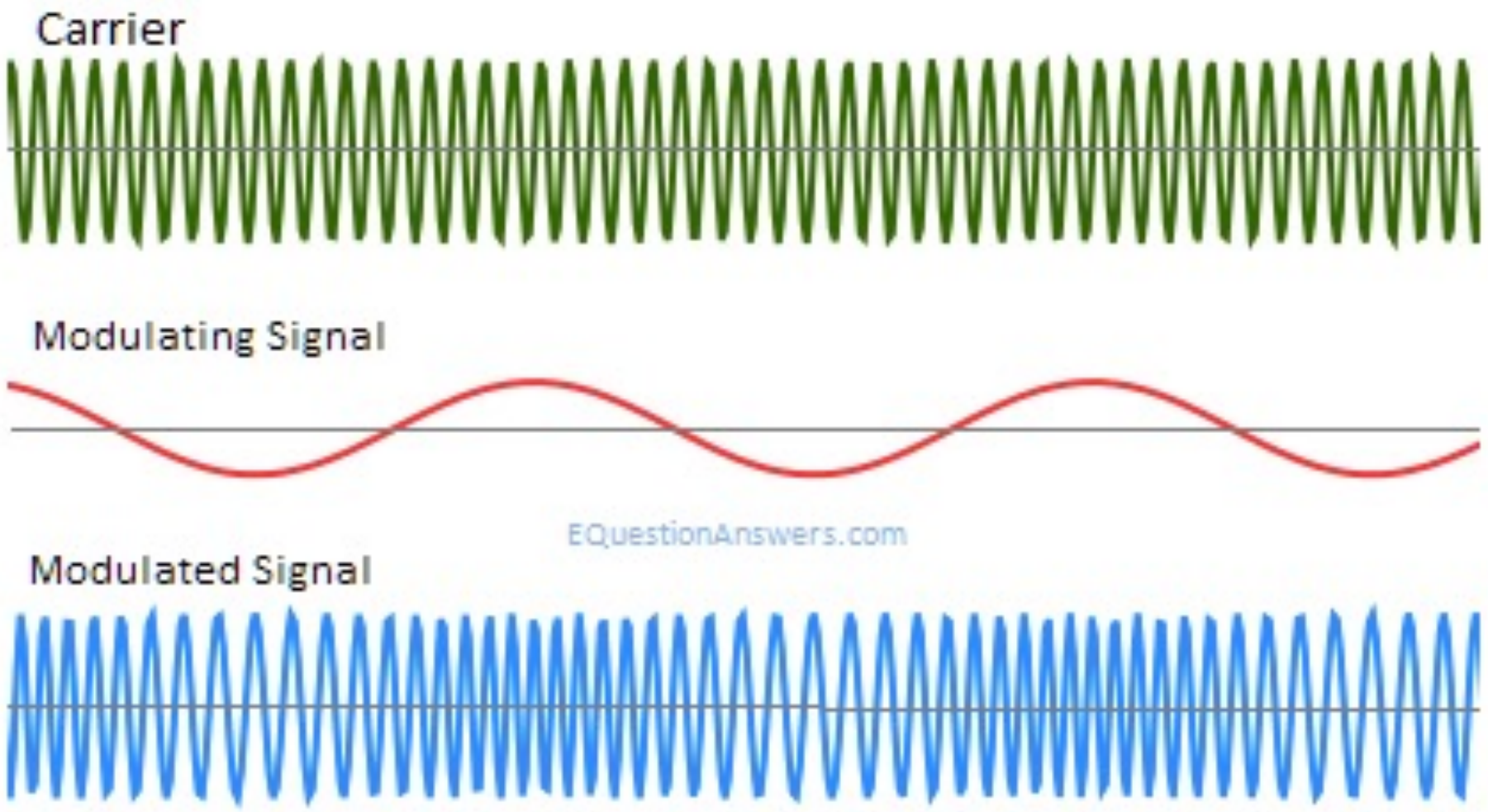


$Acos(\omega t + \phi)$

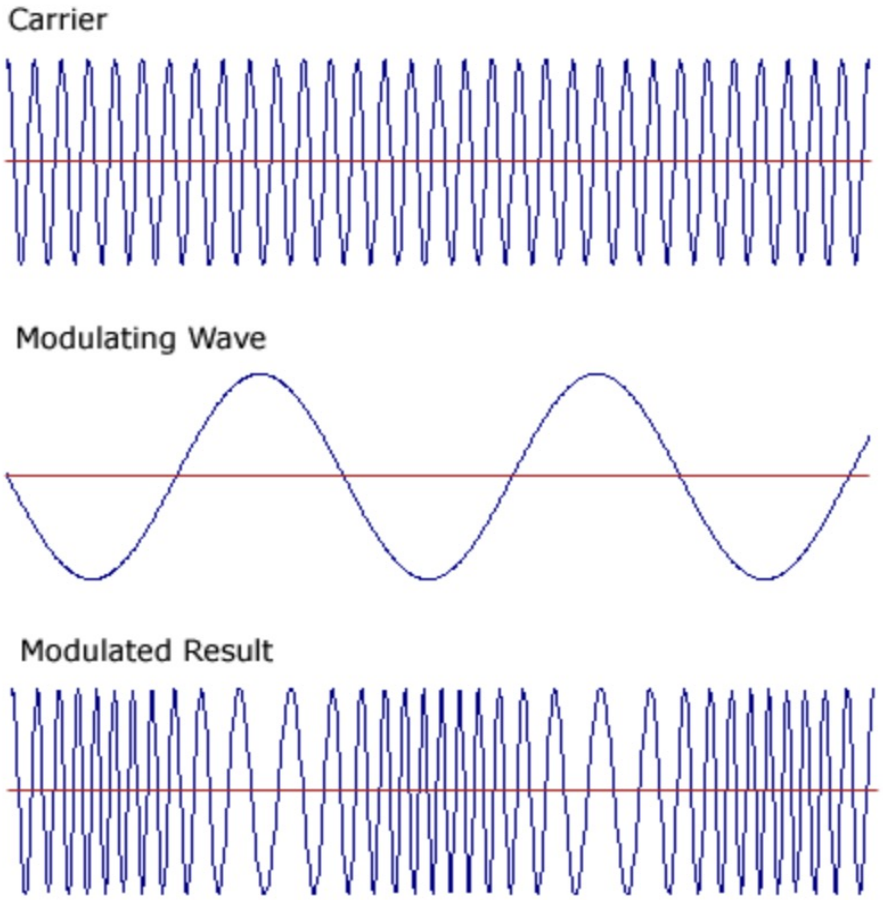
Example of Amplitude Modulation

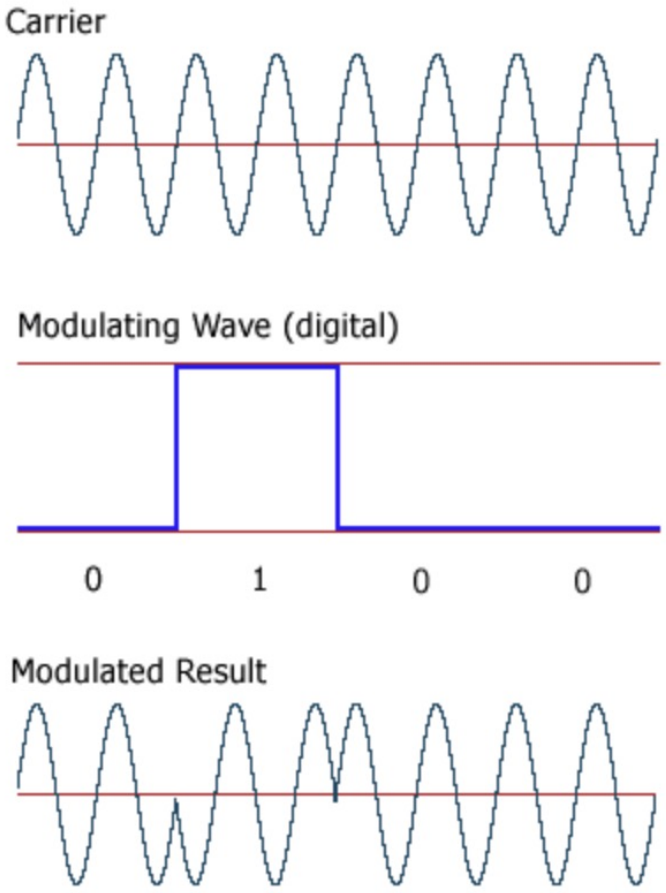


Example of Frequency Modulation

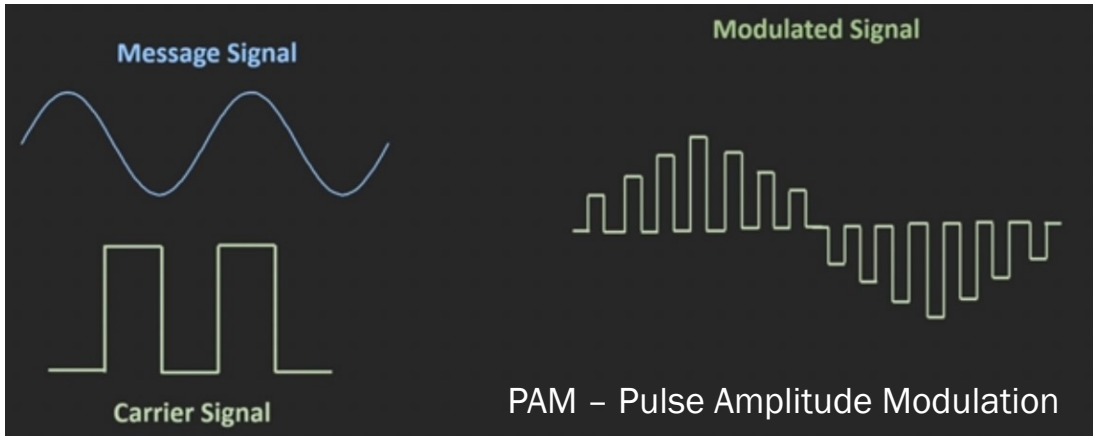


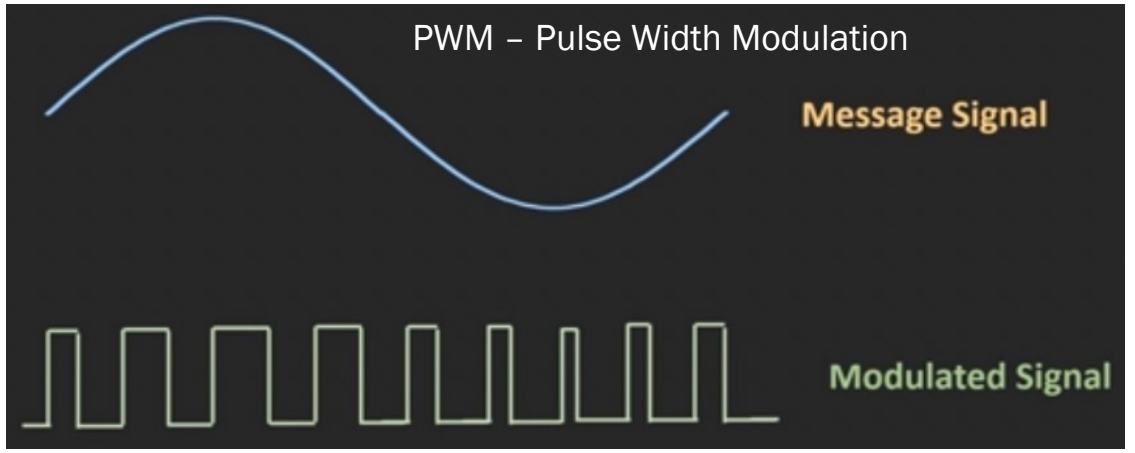
Example of Phase Modulation

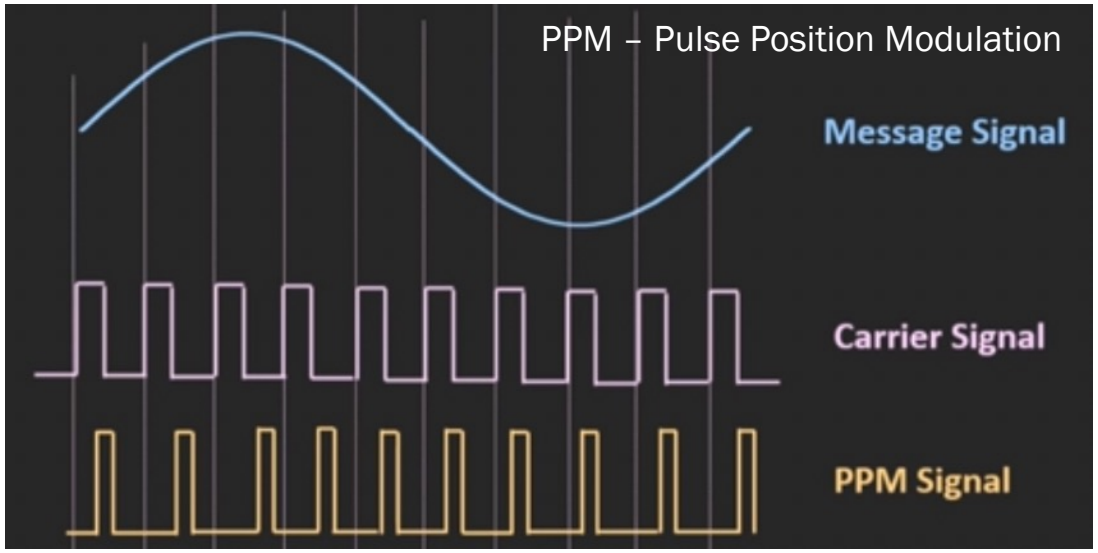


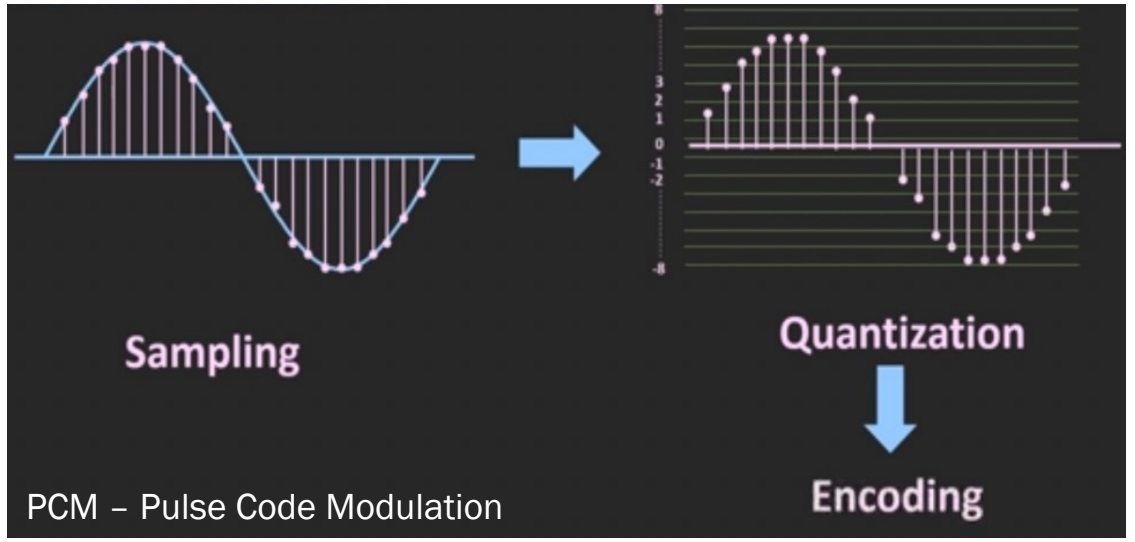


Pulse Modulations (PAM, PWM, PPM and PCM)

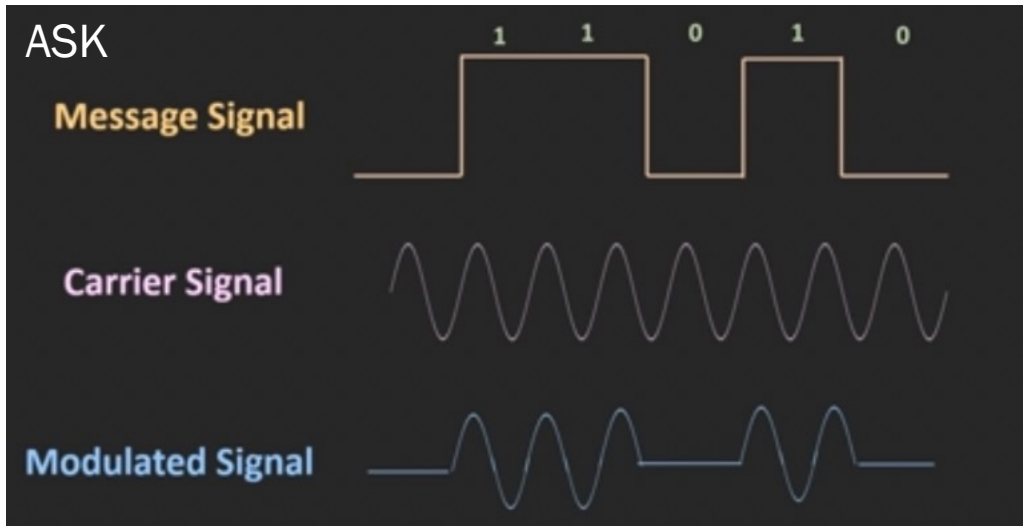


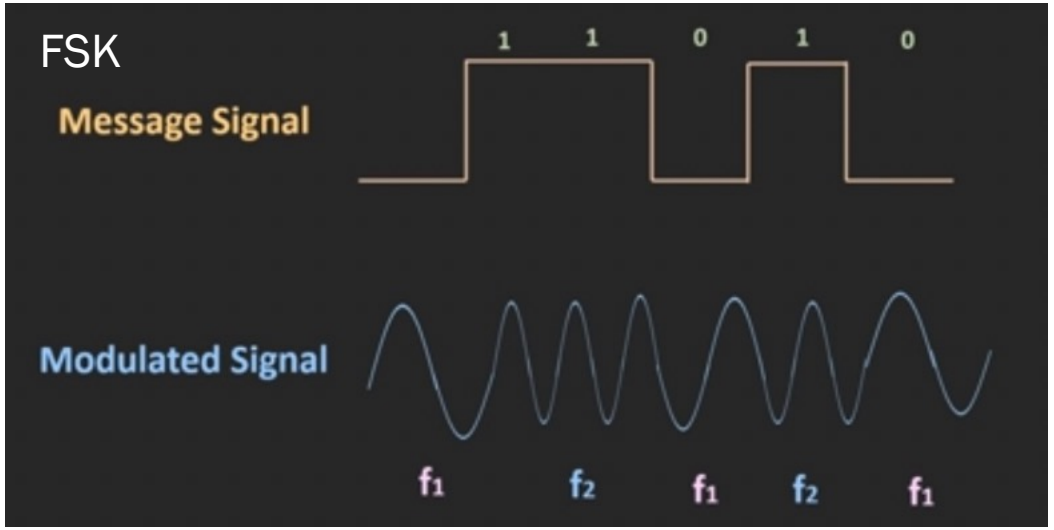


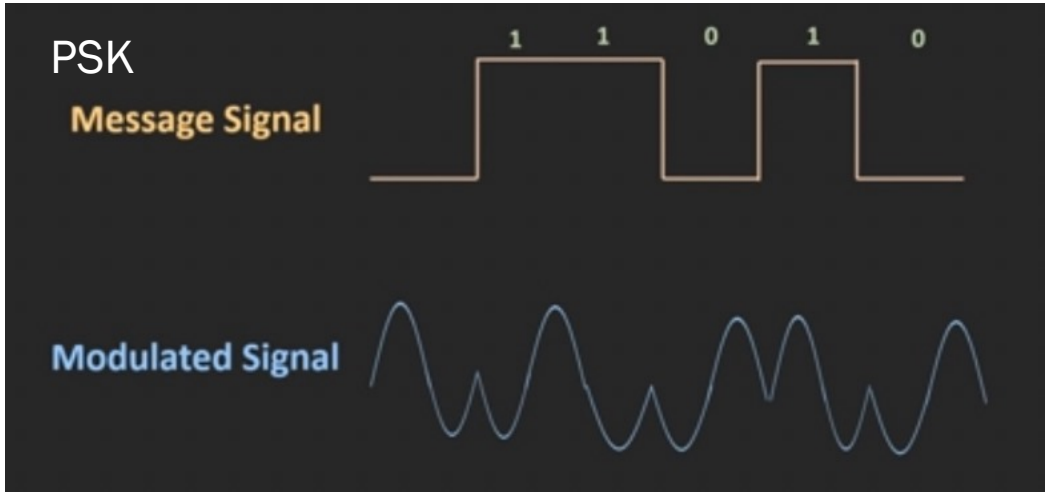




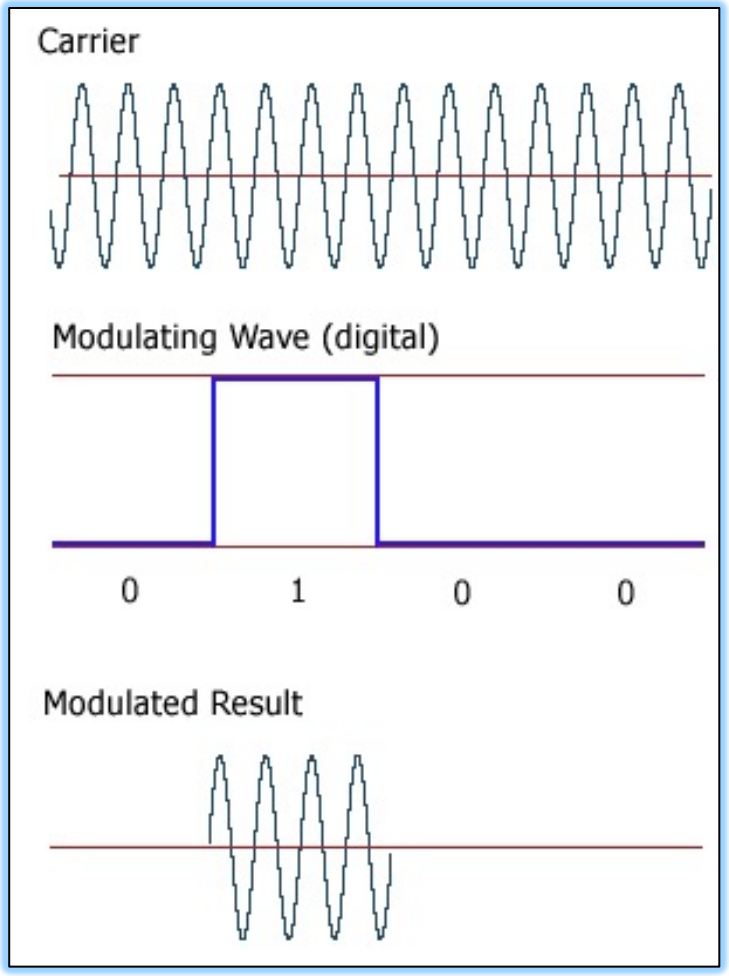
Digital Modulation Schemes



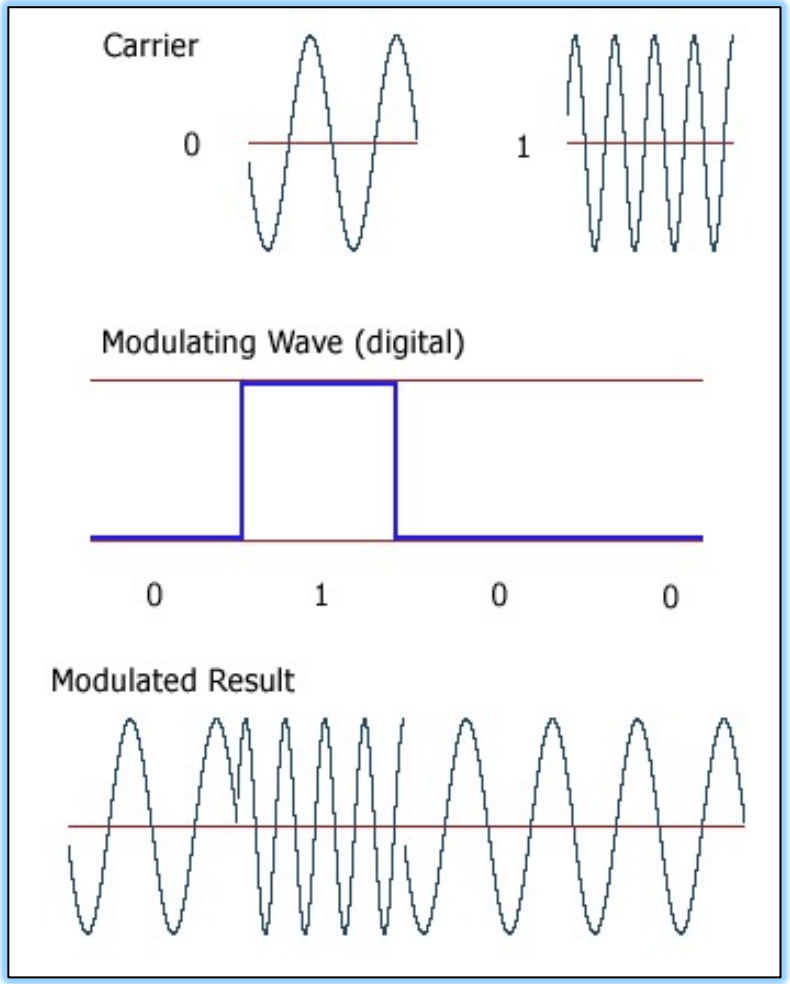




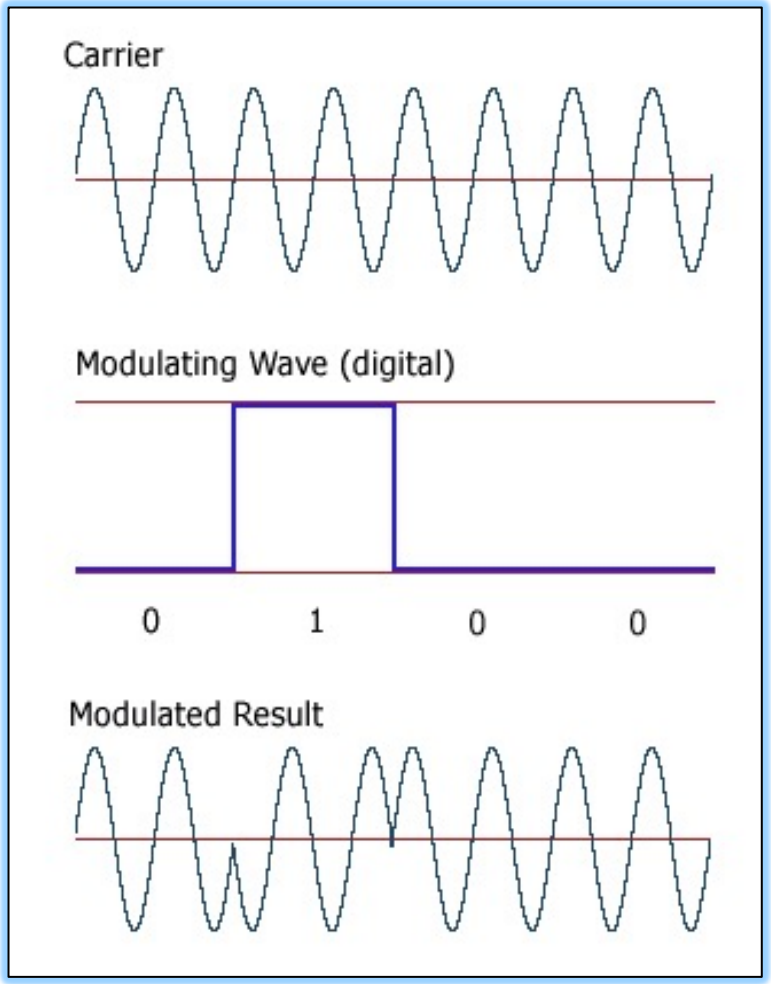
Example of ASK, FSK and PSK



ASK



FSK

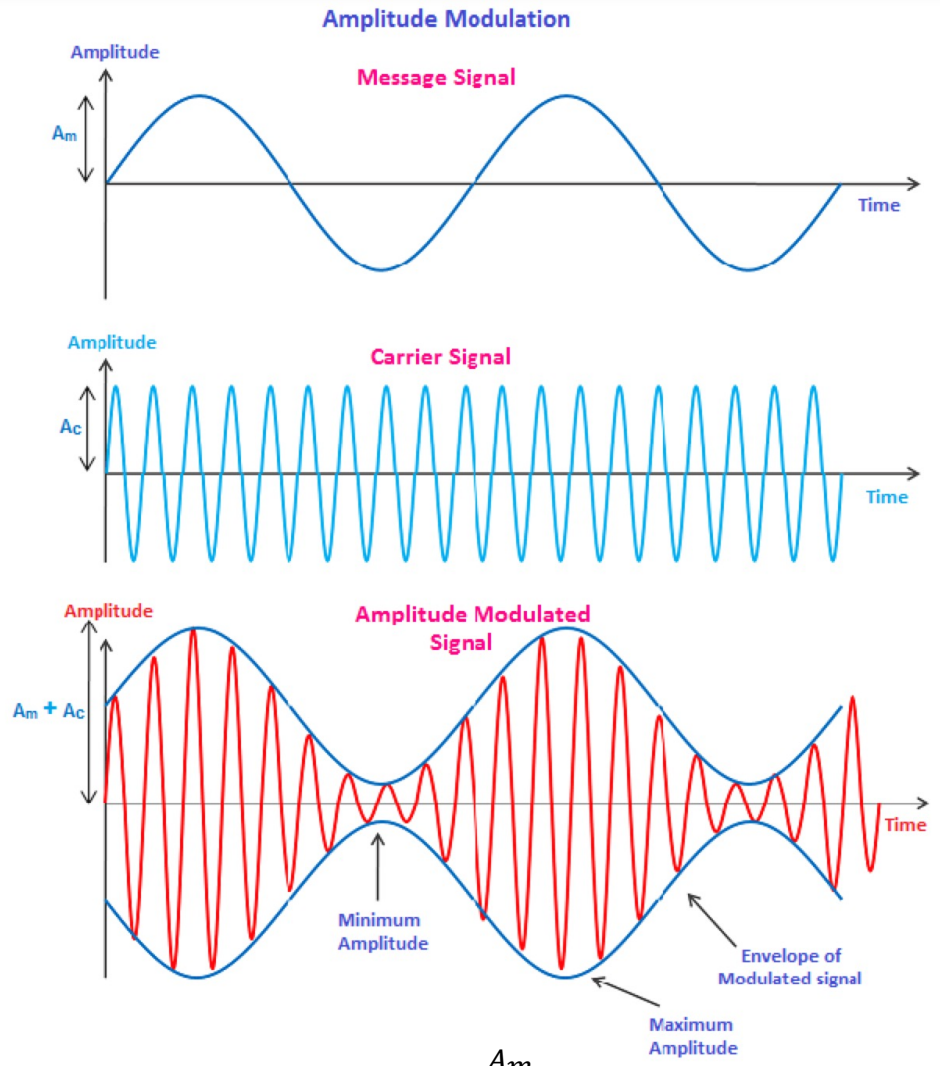


PSK

AMPLITUDE MODULATION

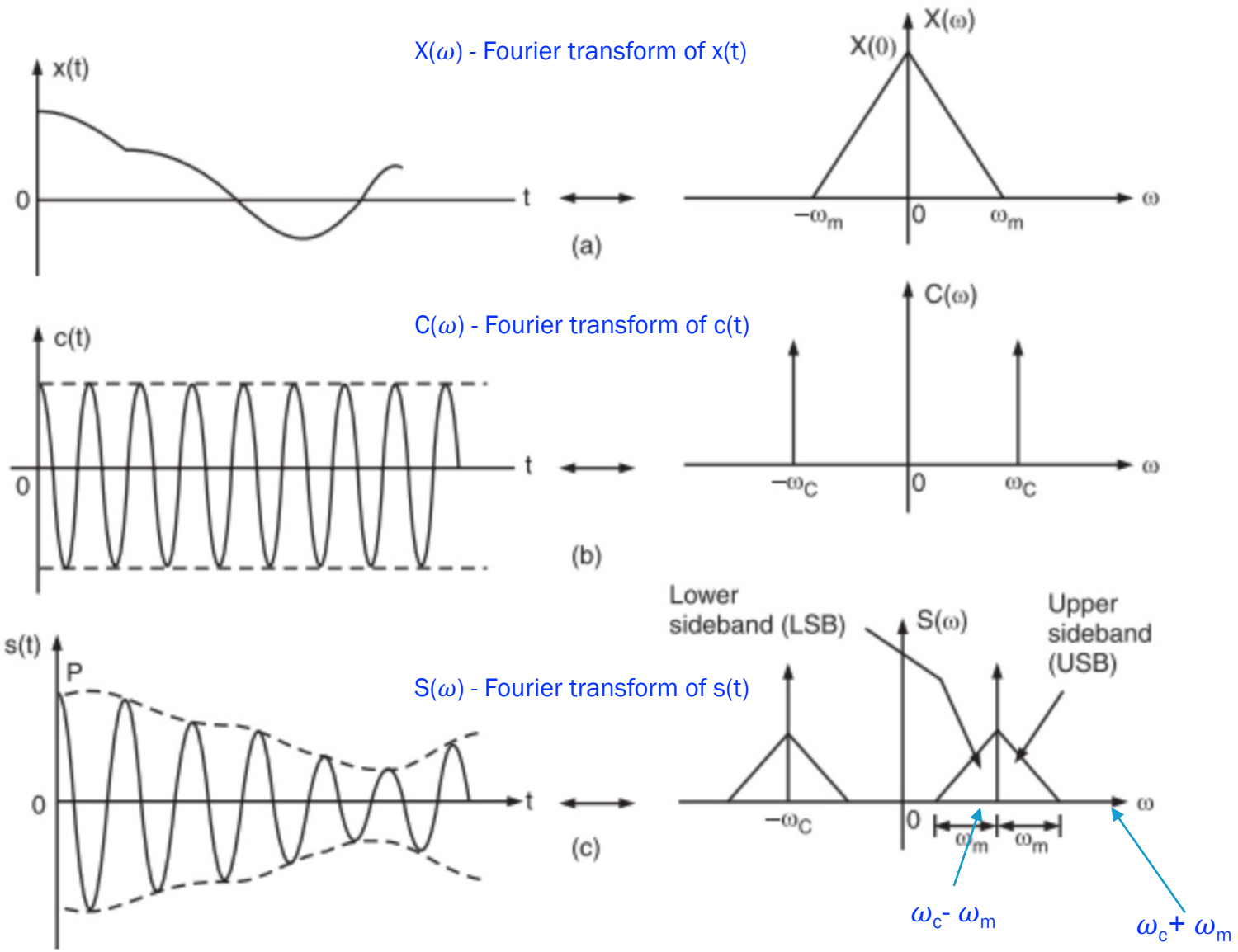
Amplitude Modulation

- **In amplitude modulation, the amplitude of the carrier wave is varied in proportion to that of the message signal, such as an audio signal.**
- AM is used in broadcasting transmission (Radio and television) over the short, medium and long wavebands.
- AM is used in the VHF transmissions for many airborne applications such as ground-to-air radio communications or two-way radio links for ground staff personnel.
- Since AM is easy to demodulate, radio receivers for amplitude modulation are therefore easier and cheaper to manufacture.
- However, amplitude modulation is sensitive to noise and electromagnetic interference.



Modulating Index, $\mu = \frac{A_m}{A_c}$

Double Sides Full Carrier (DSBFC) System



- Important Aspects AM
  - Information is located in sidebands
  - Carrier is only operating frequency
  - Bandwidth of AM signal is twice of the maximum frequency of modulating signal ($2\omega_m$)

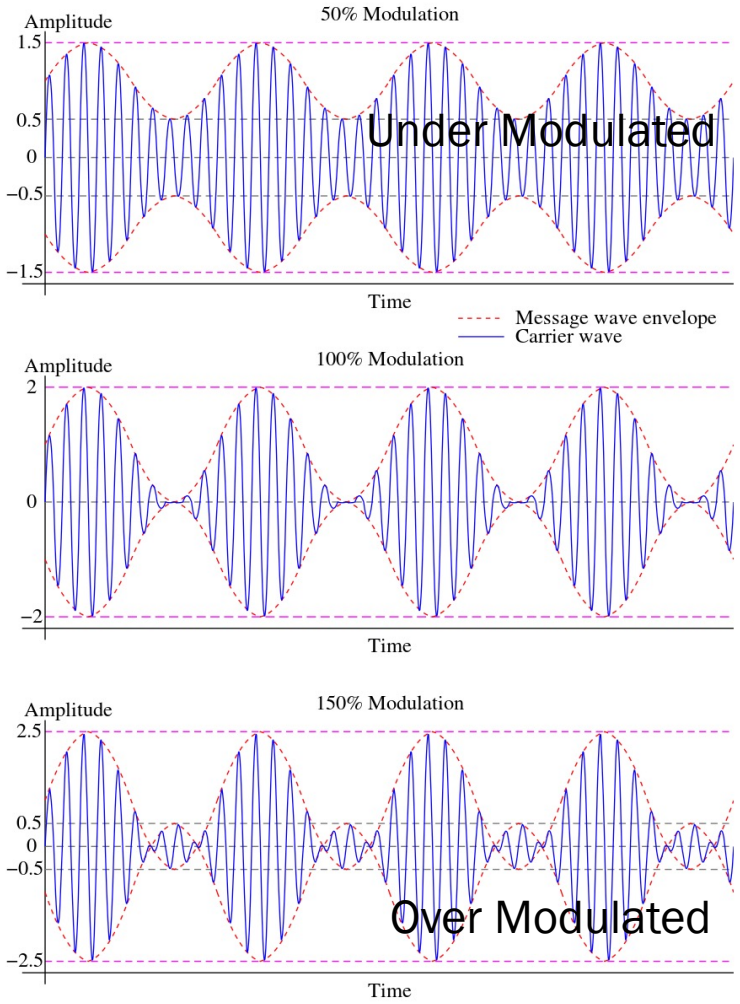
Power transmitted

$$P_{total} = P_c + P_{USB} + P_{LSB}$$

$$P_{total} = P_c + \frac{\mu^2}{4}P_c + \frac{\mu^2}{4}P_c$$

$$P_{total} = P_c + \frac{\mu^2}{2}P_c$$

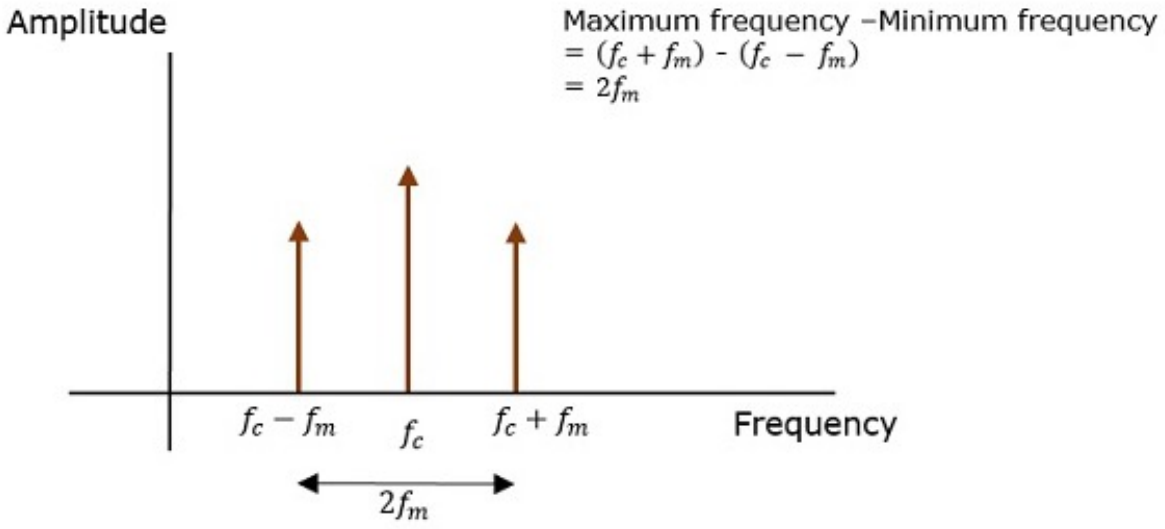
Amplitude Modulation Cont.



$\mu < 1$

$\mu = 1$

$\mu > 1$



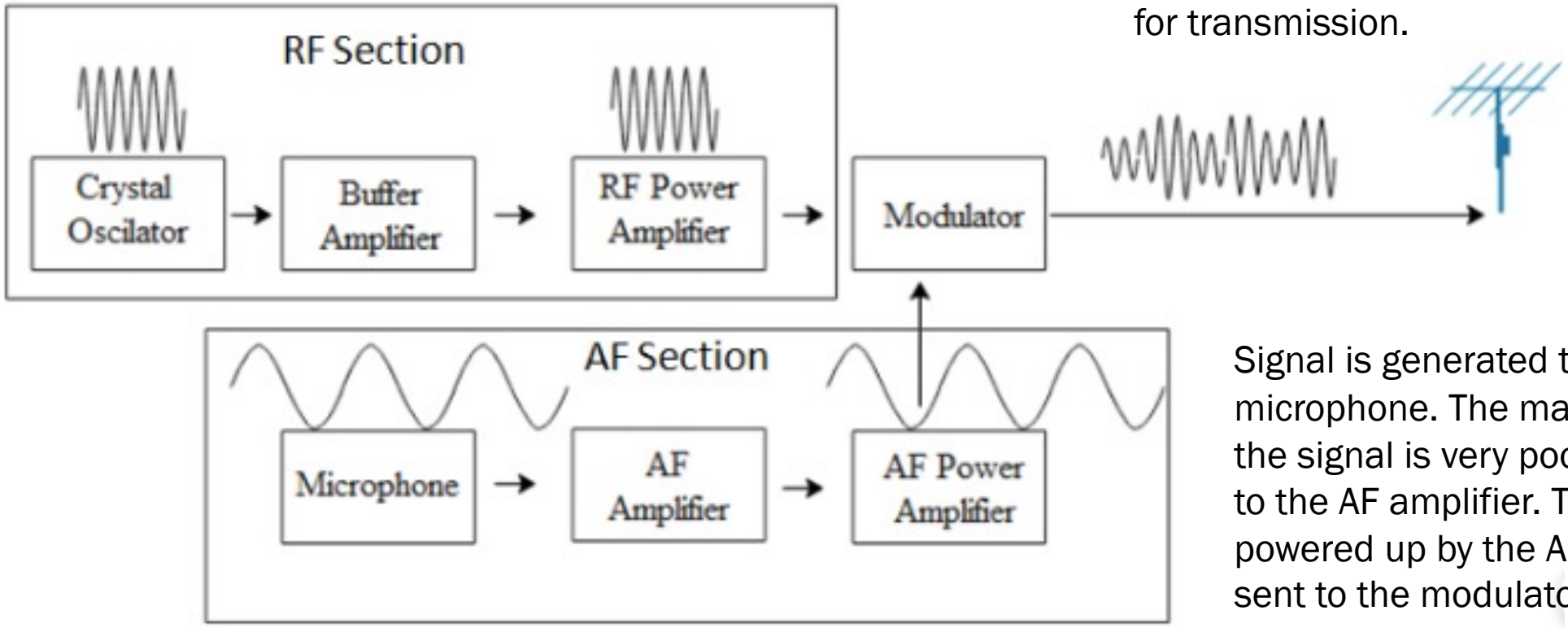
It may be noted at this point that the modulating signal frequency ranges extend from – f_m to f_m i.e., it includes negative frequencies also from $-f_m$ to 0. Practically there is no meaning of negative frequency. In fact, the negative frequency is used for mathematical convenience only.

Hence, we can say that the modulating signal contains frequencies from 0 to f_m or simply the bandwidth of modulating signal is f_m.

AM Radio Transmitter (Simplified)

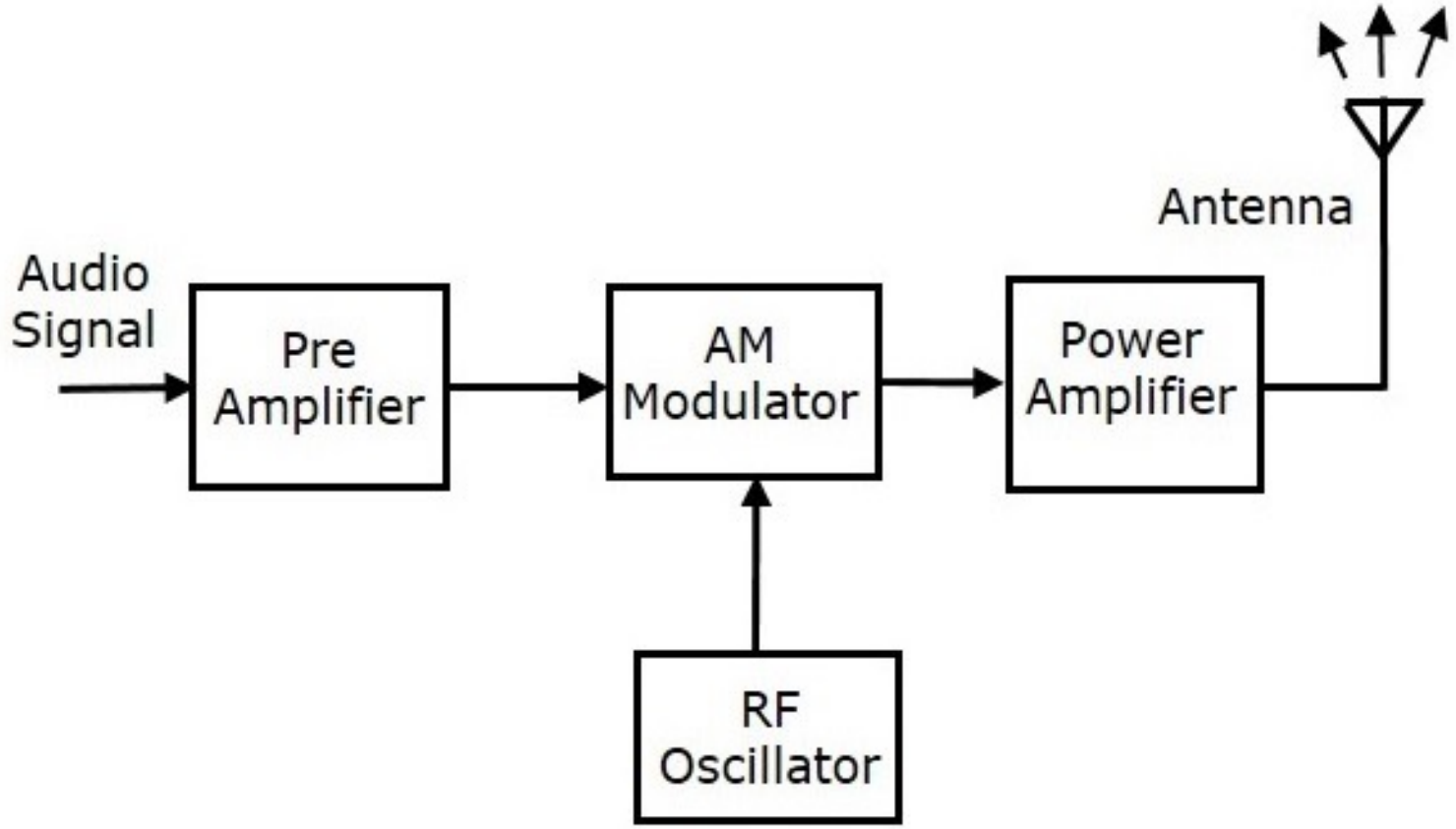
The crystal oscillator generates the high frequency carrier wave which is sent to the buffer which isolates the RF power amplifier keeping the frequency of the crystal-controlled oscillator constant.

The modulator is the place where the superposition of the carrier wave and the signal generated takes place.
Further the modulator mixes the carrier wave and the AF signal, which is fed to the antenna for transmission.



Signal is generated through the microphone. The magnitude of energy of the signal is very poor and hence, it is fed to the AF amplifier. This signal is further powered up by the AF power amplifier and sent to the modulator.

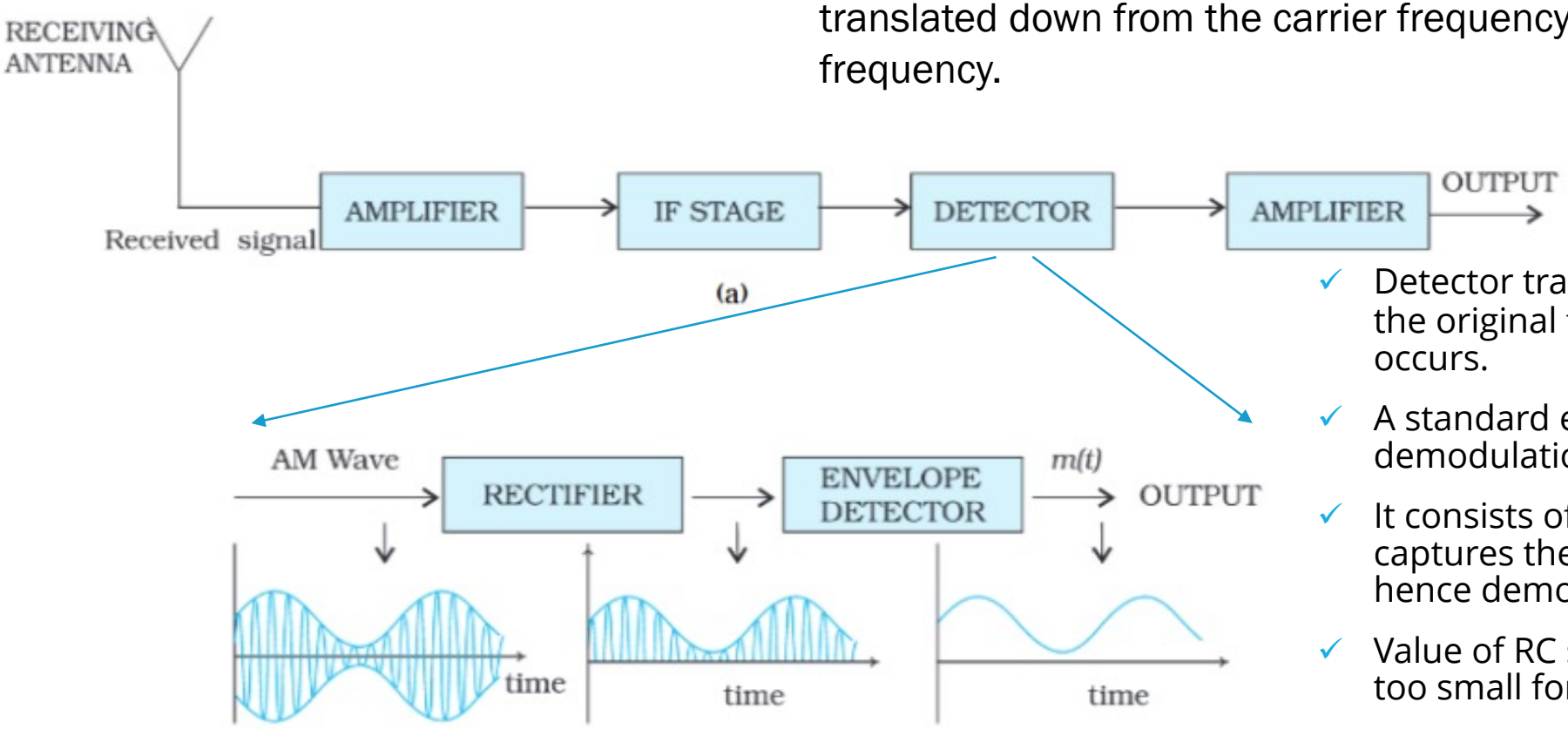
AM Radio Transmitter (Simplified)



- The AM radio transmitter consists of two sections.
  - Audio Frequency (AF) section and
  - Radio Frequency section.
  - The signal basically gets generated in the AF section and modulated in the RF section.
- Main components
  - Preamplifier
  - RF Oscillator
  - AM modulator
  - Power Amplifier
  - Antenna

AM Radio Receiver

- ✓ Receiving antenna - converts the received signal into electrical form.
- ✓ Amplifier is used to amplify the signal before processing.
- ✓ This is passed through an IF stage where the frequency band is translated down from the carrier frequency to the intermediate frequency.



- ✓ Detector translates the frequency down to the original frequency and demodulation occurs.
- ✓ A standard envelope detector used for demodulation.
- ✓ It consists of a parallel RC circuit which captures the envelope of the AM signal and hence demodulates the AM signal.
- ✓ Value of RC should neither be too large, nor too small for efficient demodulation.
- ✓ Finally, the demodulated signal is passed through an amplifier for large amplification.

Types of Amplitude Modulation

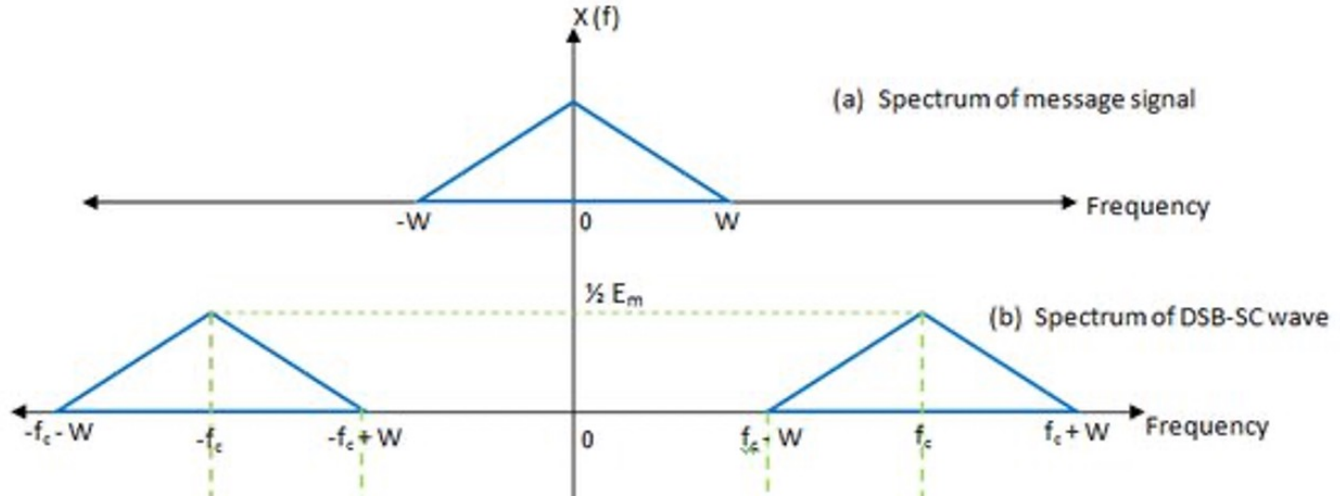
- Double sideband with full carrier modulation (AM)
- Double sideband-suppressed carrier modulation (DSB-SC)
- Single Sideband Modulation (SSB)
- Vestigial Sideband Modulation (VSB)

Double sideband-suppressed carrier modulation (DSB-SC)

- DSB-SC is the analog modulation techniques in which carrier is suppressed to save power (66% of power saved compared to AM) and only the sidebands are transmitted
- Coherent detection is needed to maintain the local oscillator in perfect synchronisation for DSB-SC: obtaining the carrier phase is biggest challenges in all demodulators.

Coherent detection increases the complexity of the receiver and increased the cost.

This is in fact the price one has to pay for suppressing the carrier at wave to save transmit power

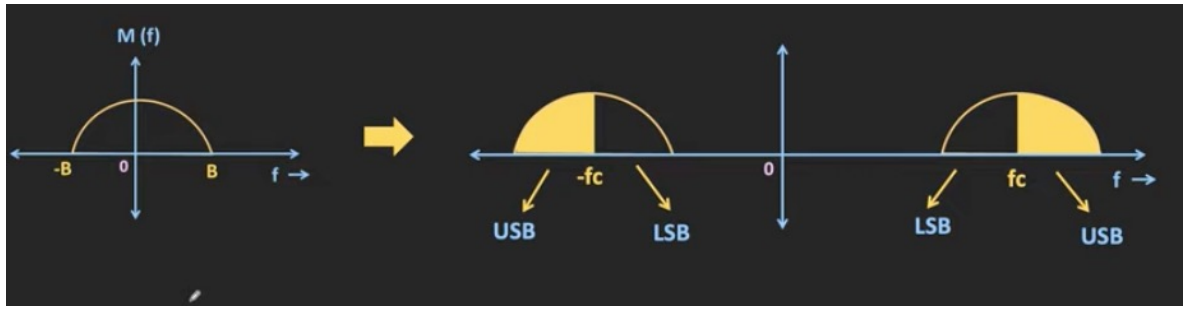


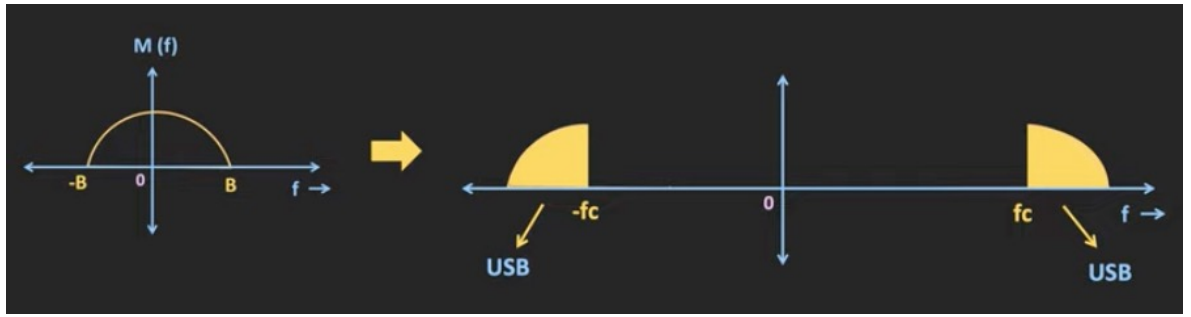
Single sideband-suppressed carrier modulation (SSB-SC)

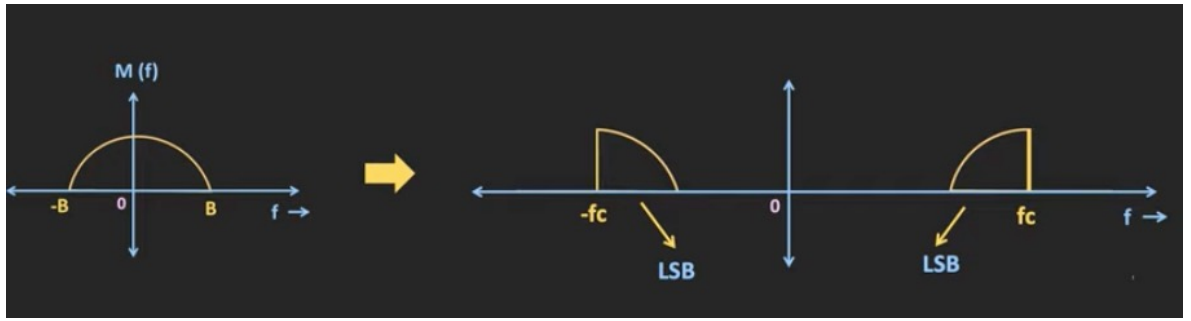
In radio communications, single-sideband modulation (SSB) or single-sideband suppressed-carrier modulation (SSB-SC) is a type of modulation used to transmit information, such as an audio signal, by radio waves. A refinement of amplitude modulation,

SSB uses less transmitter power, therefore power efficient

SSB is transmitted only single Band which has the information, therefore bandwidth efficient.







Vestigial Sideband Modulation (VSB)

Vestigial Sideband Modulation (VSB) refers to the process where the “vestige” part of a signal is modulated alongside one sideband.

A guard band of very small width is laid on either side of VSB in order to avoid the interferences.

It is a highly efficient modulation technique used for wave transmission.

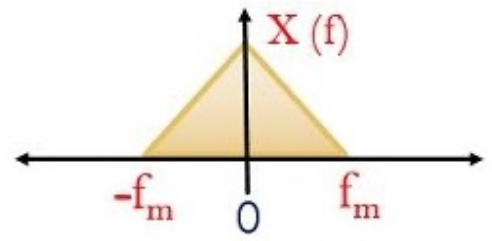
This VSB modulation is mostly used in television transmissions.

It reduces the bandwidth utilization.

The filter characteristics do not need to be highly accurate thus making its design simple.

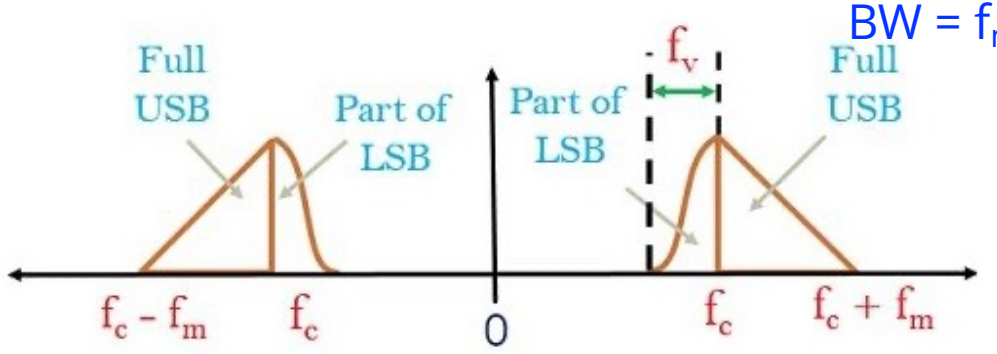
It easily transmits low-frequency components and possesses good phase characteristics.

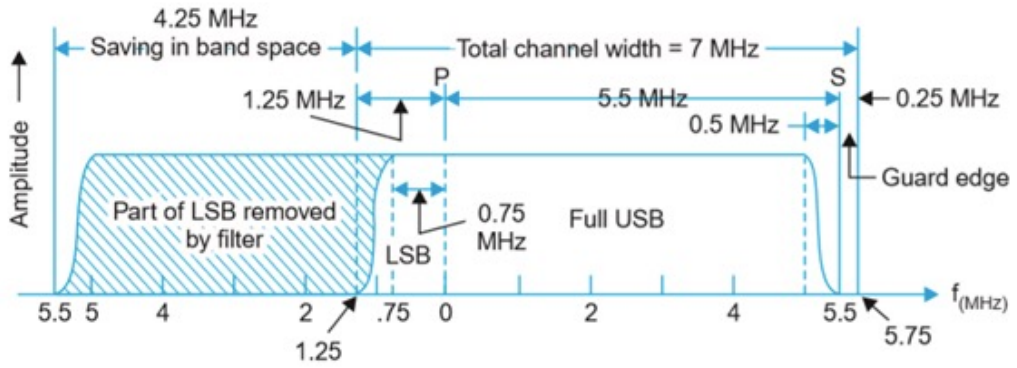
Application is transmission of TV signal



Spectrum of message signal

BW = $f_m + f_v$





Comparison of DSB-SC, SSB-SC and VSB-SC

	DSB-SC	SSB-SC	VSB-SC
Advantages	Lower power consumption Modulation system is simple	Better management of frequency spectrum Low power consumption	It is compromise between DSB and SSB. Therefore, it is easier to generate than VSB-SC
Disadvantages	Complex detection (coherent receiver with synchronization)	Complex detection, Generation of exact SSB is rather difficult (exact filter design and coherent receiver)	Demodulation system is still complex Its bandwidth is about 25% greater than SSB-SC
Applications	Analog TV systems: to transmission of color information	two-way radio (audio) transmission – Prefer long distance transmission of voice signal	Std for Analog TV broadcast system and wideband data transmission

ANY QUESTION??

THANK YOU!!

$$\sin(\alpha+\beta) = \sin\alpha\cos\beta + \cos\alpha\sin\beta$$

$$\sin(\alpha-\beta) = \sin\alpha\cos\beta - \cos\alpha\sin\beta$$

$$\cos(\alpha+\beta) = \cos\alpha\cos\beta - \sin\alpha\sin\beta$$

$$\cos(\alpha-\beta) = \cos\alpha\cos\beta + \sin\alpha\sin\beta$$

$$\tan(\alpha+\beta) = \frac{\tan\alpha + \tan\beta}{1 - \tan\alpha\tan\beta}$$

$$\tan(\alpha-\beta) = \frac{\tan\alpha - \tan\beta}{1 + \tan\alpha\tan\beta}$$

Double sideband-suppressed carrier modulation (DSB-SC)

DSB-SC is the analog modulation techniques in which carrier is suppressed to save power (66% of power saved compared to AM) and only the sidebands are transmitted

Coherent detection is needed to maintain the local oscillator in perfect synchronisation for DSB-SC: obtaining the carrier phase is biggest challenges in all demodulators.

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