MODULE 5

COMMUNICATION SYSTEMS

Quote of the day

“Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand”

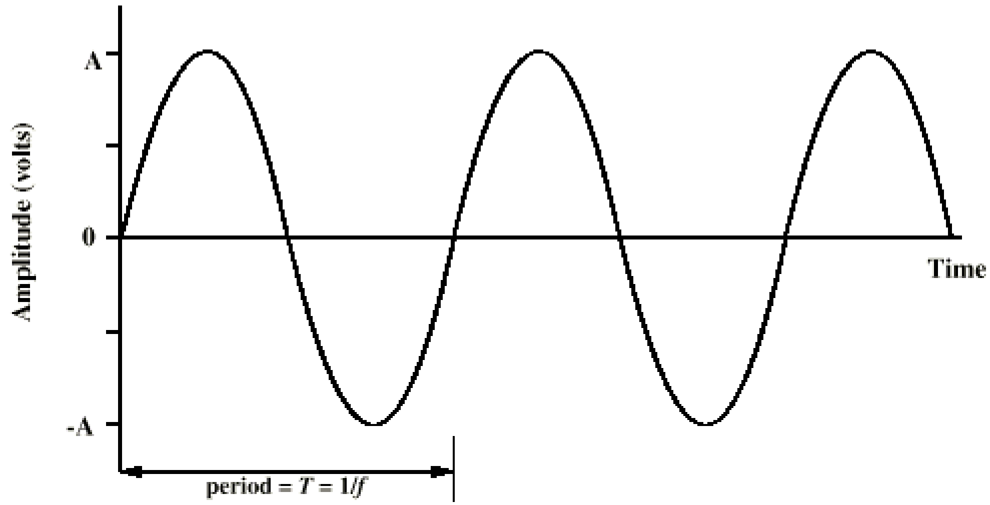
—Albert Einstein.

ANALOG TRANSMISSION OF DATA

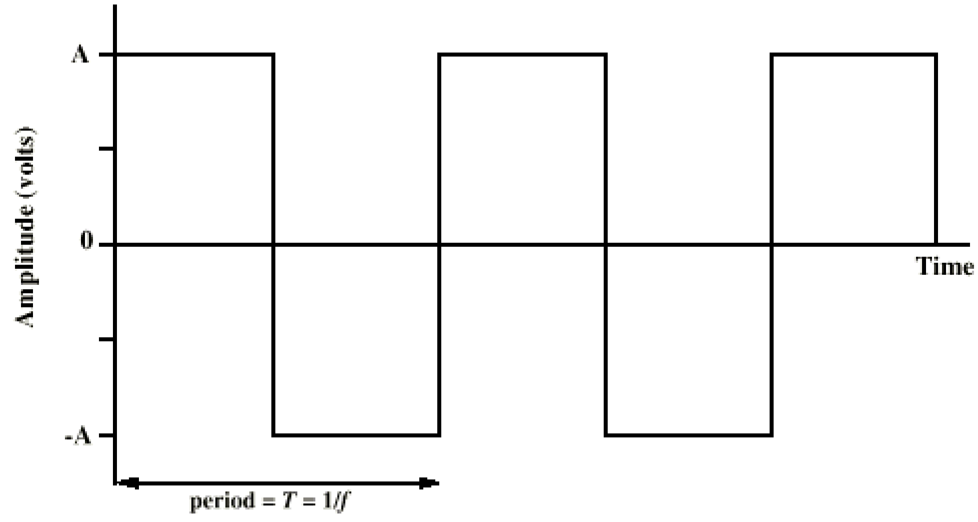
- Analog Transmission occurs when the signal sent over the transmission media continuously varies from one state to another in a wave-like pattern (e.g. Sine wave, triangular wave).

- Before we get further into Analog transmission, we need to understand various characteristics of analog transmission.

Periodic Signals



(a) Sine wave

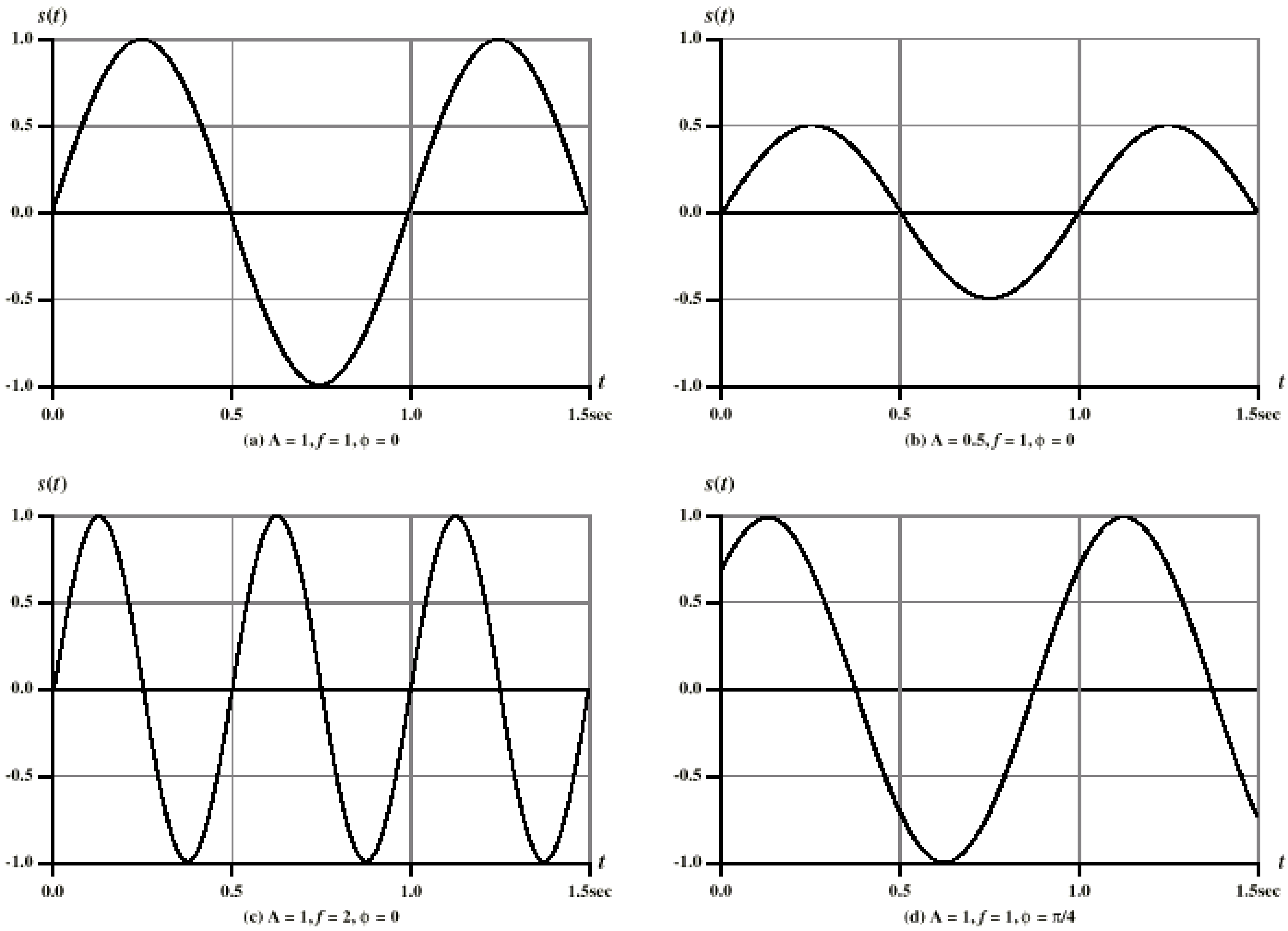


(b) Square wave

Sine Wave

- General Sine wave: $s(t) = A\sin(2\pi ft + \phi)$
- Peak Amplitude (A)
  - maximum strength of signal
  - volts
- Frequency (f)
  - Rate of change of signal
  - Hertz (Hz) or cycles per second
  - Period = time for one repetition (T)
  - T = 1/f
- Phase (ϕ)
  - Relative position in time, from 0-2*pi

Varying Sine Waves



Wavelength

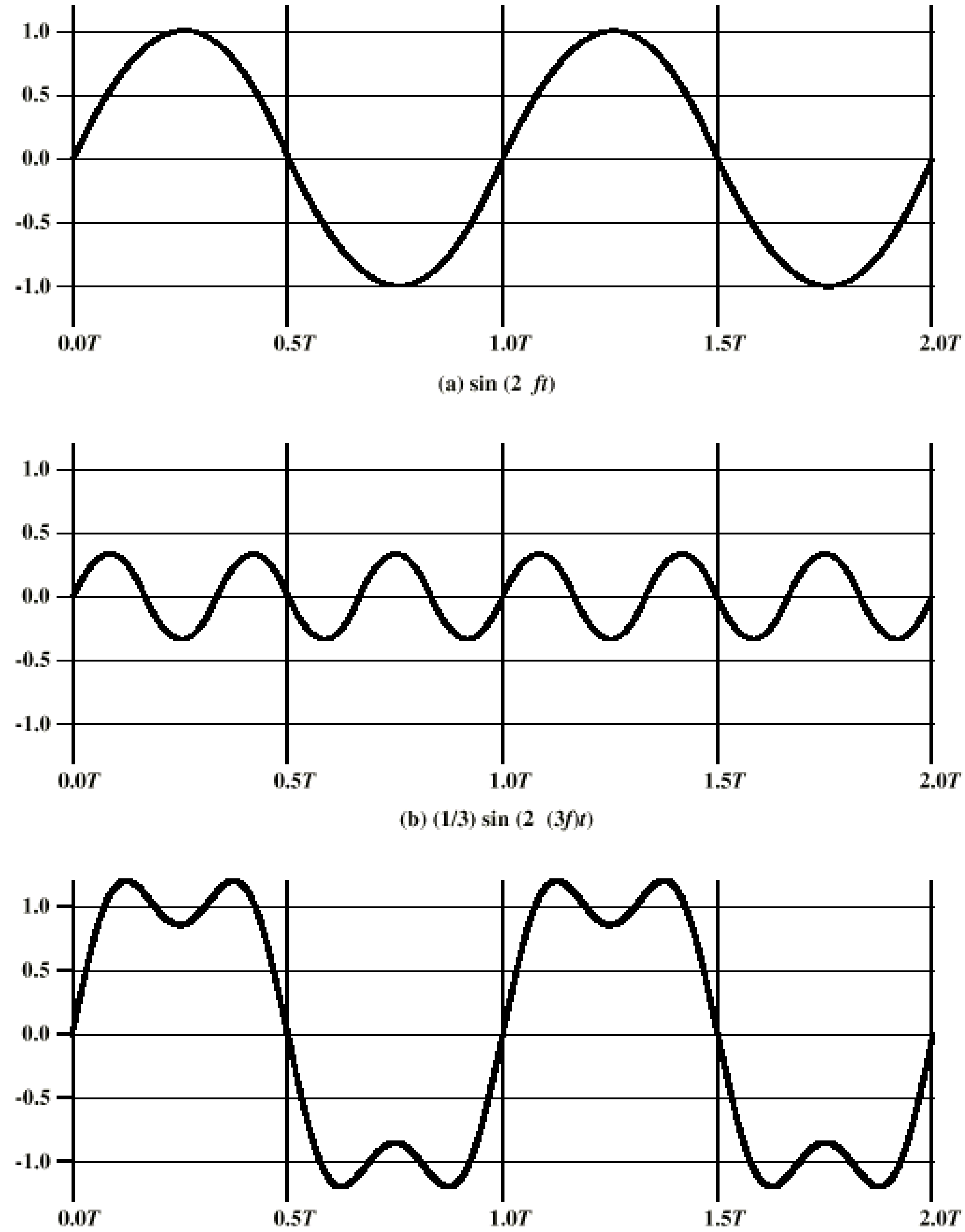
- Distance occupied by one cycle
- λ = Wavelength
- Assuming signal velocity *v*
  - $\lambda = vT$
  - $\lambda f = v$
  - $c = 3*10^8\ ms^{-1}$ (speed of light in free space)
  - $\lambda = c/f$

Addition of Frequency Components

Notes:

2nd freq a multiple of 1st
1st called fundamental freq
Others called harmonics

Period of combined =
Period of the fundamental



(a) sin (2 ft)

(b) (1/3) sin (2 (3f)t)

(c) (4/) [sin (2 ft) + (1/3) sin (2 (3f)t)]

Frequency Domain

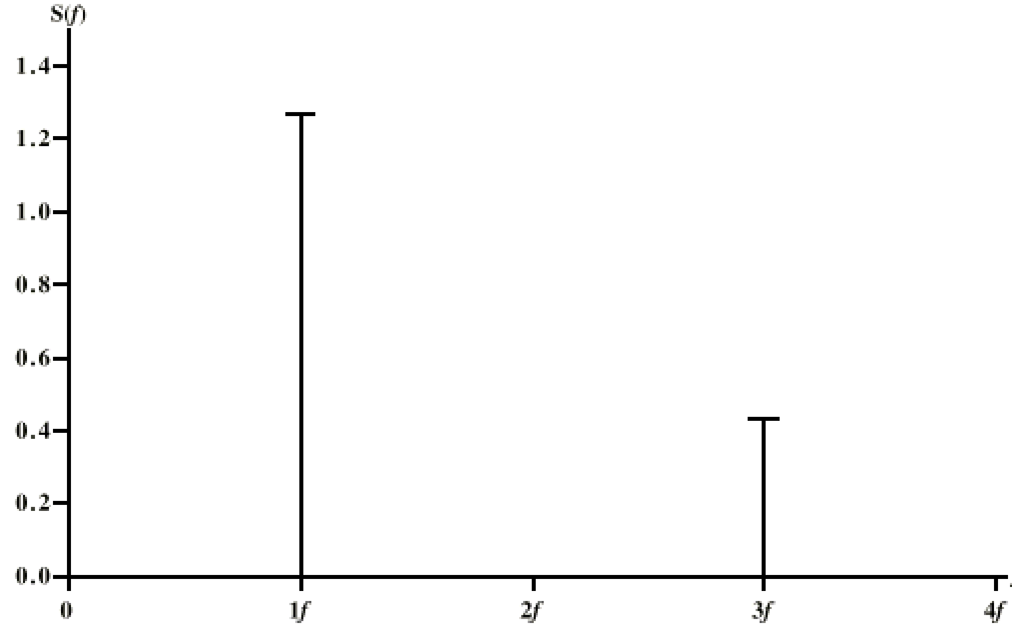
Discrete Freq Rep:

$$s(t) = 4/\pi[\sin(2\pi ft) + 1/3\sin(2\pi(3f)t)]$$

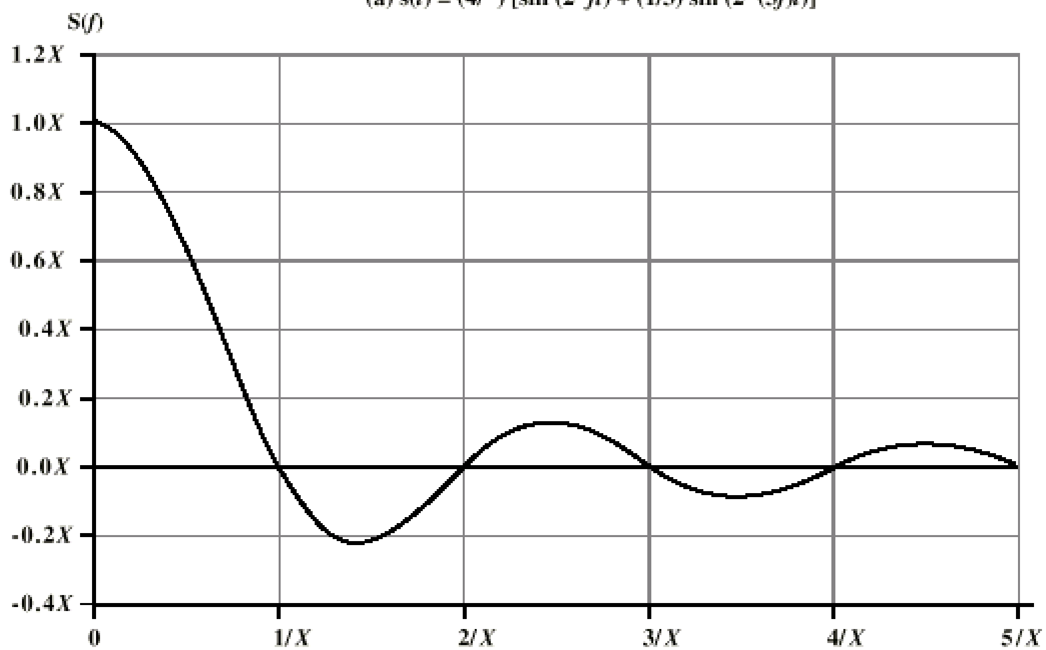
Any continuous signal can be represented as the sum of sine waves! (May need an infinite number..)

Discrete signals result in Continuous, Infinite Frequency Rep:

s(t)=1 from –X/2 to X/2



(a) s(t) = (4/) [sin (2 ft) + (1/3) sin (2 (3f)t)]



(b) s(t) = 1 – X/2 t X/2

Data Rate and Bandwidth

- Any transmission system has a limited band of frequencies
- This limits the data rate that can be carried
- Spectrum
  - range of frequencies contained in signal
- Absolute bandwidth
  - width of spectrum
- Effective bandwidth
  - Often just *bandwidth*
  - Narrow band of frequencies containing most of the energy

ELEMENTS OF COMMUNICATION SYSTEMS

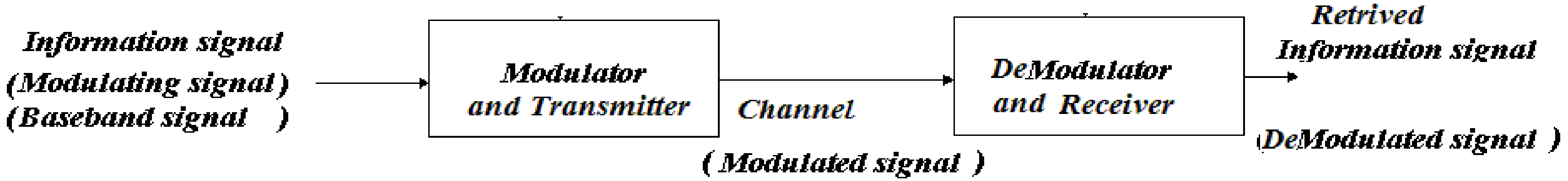


Fig. Communication system

What is modulation?

- Modulation is the process of putting information onto a high frequency carrier for transmission **(frequency translation).**

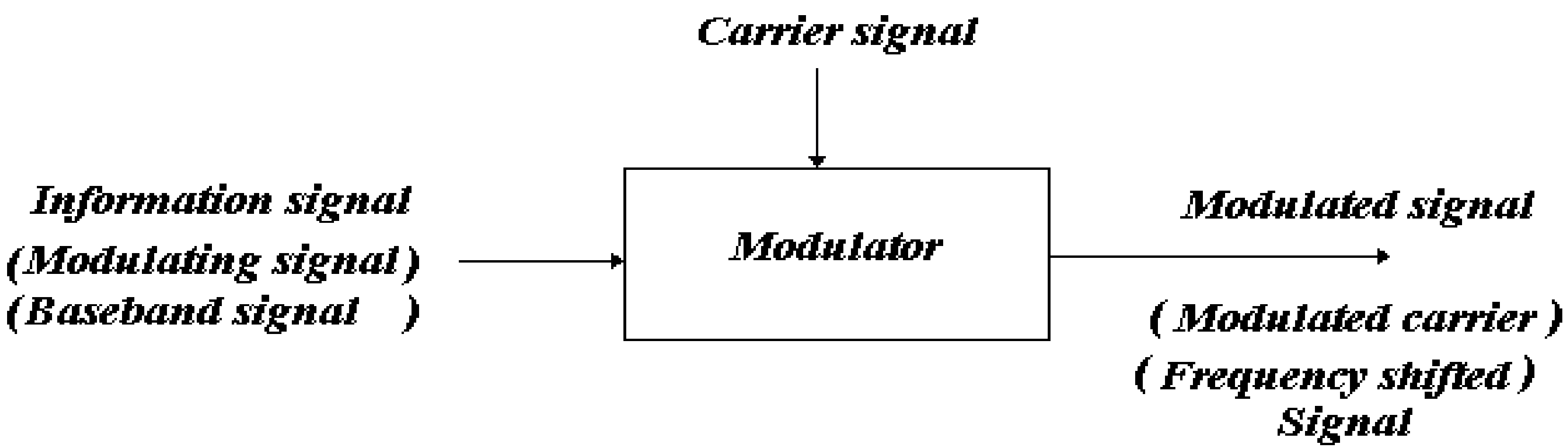
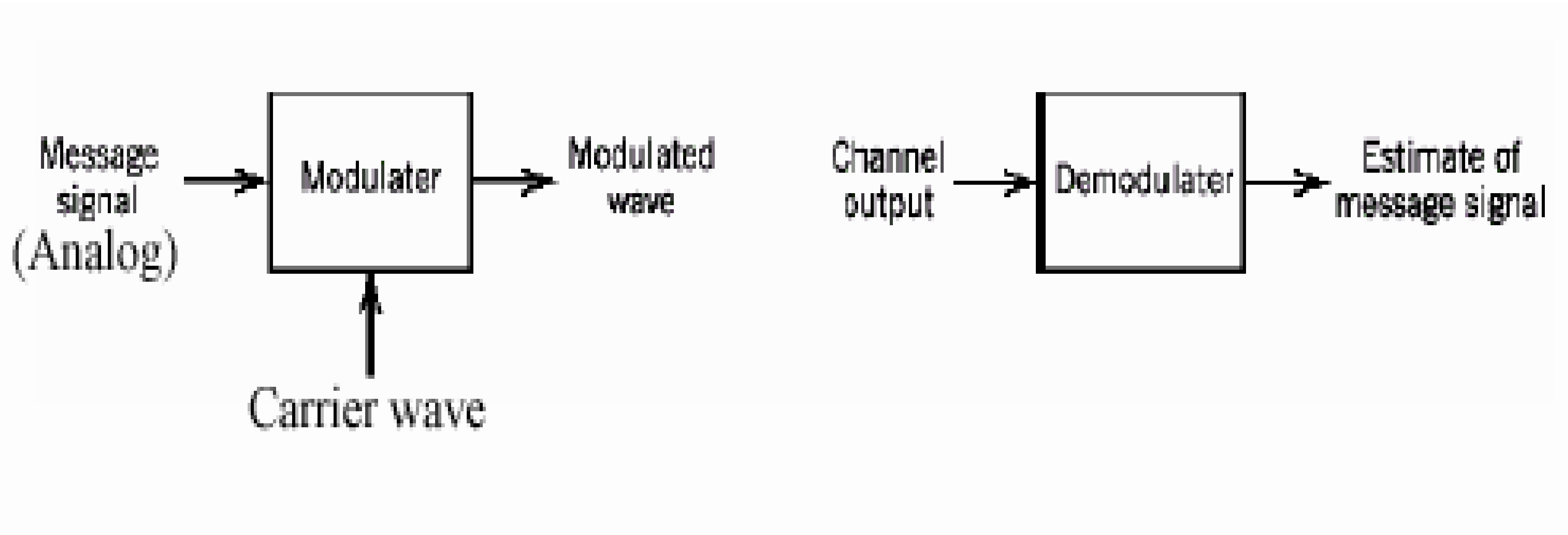


Fig. Process of Modulation

Demodulation

- Once this information is received, the <u>low frequency information must be removed from the high frequency</u> carrier. This process is known as "***<u>Demodulation</u>***".



What are the Different of Modulation Methods?

1. **Analog modulation**- The modulating signal and carrier both are analog signals

   Examples: Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM)

2. **Pulse modulation-** The modulating signal is an analogue signal but Carrier is a train of pulses

   Examples : Pulse amplitude modulation (PAM), Pulse width modulation (PWM), Pulse position modulation (PPM)

What are the reasons for modulation?

1. **Practicability of transmission over the longer distance**

The distance that can be travelled by a signal in an open atmosphere is directly proportional to its frequency and inversely proportional to its wavelength.

Speech and music signals are in range of (20Hz-20KHz) and hence they can only travel for few meters on their own.

2. Practicability of Antennas

- *For efficient radiation and reception the Transmitting and receiving antennas would have lengths equal to the quarter wavelength of the frequency used.*
- *Transmitting and receiving very low frequencies require antennas with miles in wavelength.*
- *For baseband speech, with a signal at 3kHz, i.e.($3x10^3$Hz)*

$$wavelength \quad \lambda = \frac{3x10^8}{3x10^3} = 10^5 \text{ metres or 100km.}$$

- *Aerials of this size are impractical although some transmissions at Very Low Frequency (VLF) for specialist applications are made.*

3.Reduction of cross interference

- *All message signals like speech and music(20Hz-20KHz) , video(few MHz for) are concentrated within the same range of transmitting frequencies.*
- *So all signals from different sources in the city would hopelessly and inseparably mixed up.*
- *In order to separate these various signals it is necessary to convert them all to different portions of the electromagnetic spectrum.*
- *Each will be given separate carrier frequency, this overcomes the difficulty of poor radiation at low frequencies and reduces interference.*

Frequency range with applications

Frequency Range	Spectrum Nomenclature	Typical Application
30-300Hz	Extremely Low Frequency(ELF)	Power Line Communication (Transmission)
0.3-3KHz	Voice Frequency(VF)	Face to face speech communication, Intercom
3-30KHz	Very Low Frequency(VLF)	Submarine Communication, Navigation
30-300KHz	Low Frequency (LF)	Marine Communication
0.3-3 MHz	Medium Frequency(MF)	AM Broadcasting
3-30 MHz	High frequency(HF)	Landline telephony
30-300 MHz	Very High Frequency(VHF)	TV and FM Broadcasting
0.3-3GHz	Ultra High Frequency(UHF)	TV and Cellular Telephony
3-30GHz	Super High Frequency(SHF)	Microwave oven, Radar
30-300 GHZ	Extremely High Frequency(EHF)	Satellite communication and Radar

What are the Basic Types of Analogue Modulation Methods ?

Consider the carrier signal below:

$$e_c(t) = E_c(t) \cos(2\pi f_c t + \theta)$$

1.Changing of the carrier amplitude $E_c(t)$ produces

Amplitude Modulated signal **(AM)**

2.Changing of the carrier frequency f_c produces

Frequency Modulated signal **(FM)**

3.Changing of the carrier phase θ produces

Phase Modulated signal **(PM)**

Figure *Amplitude modulation*

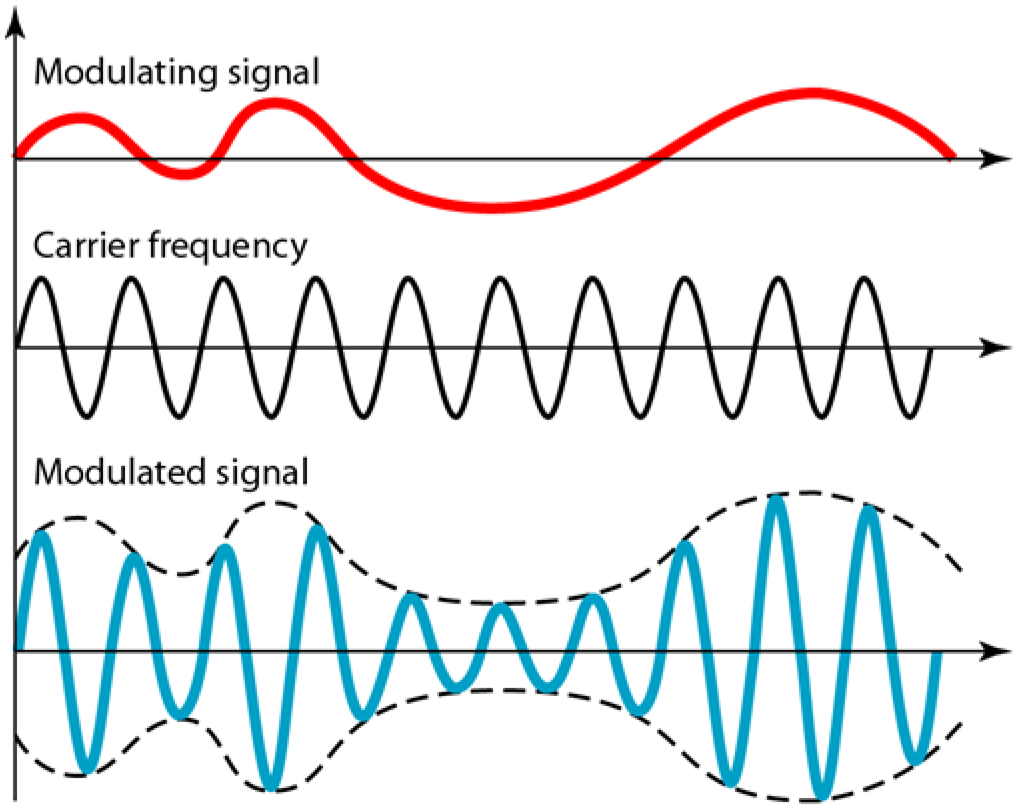


Figure *Frequency modulation*

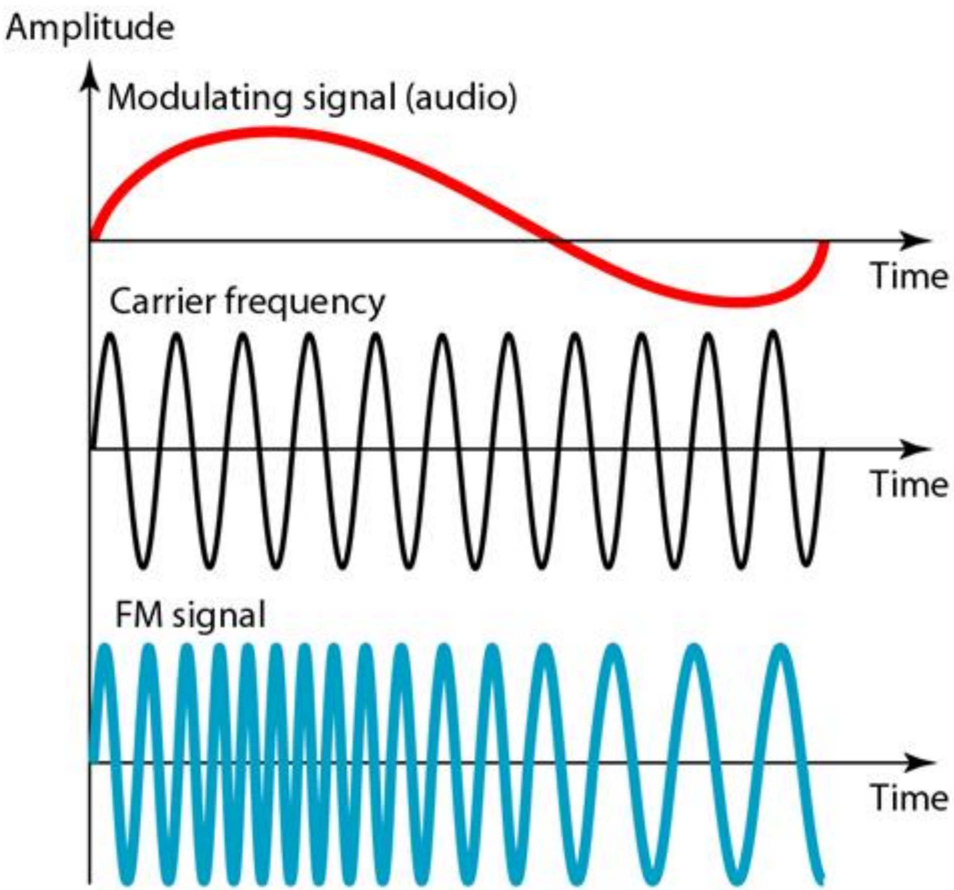
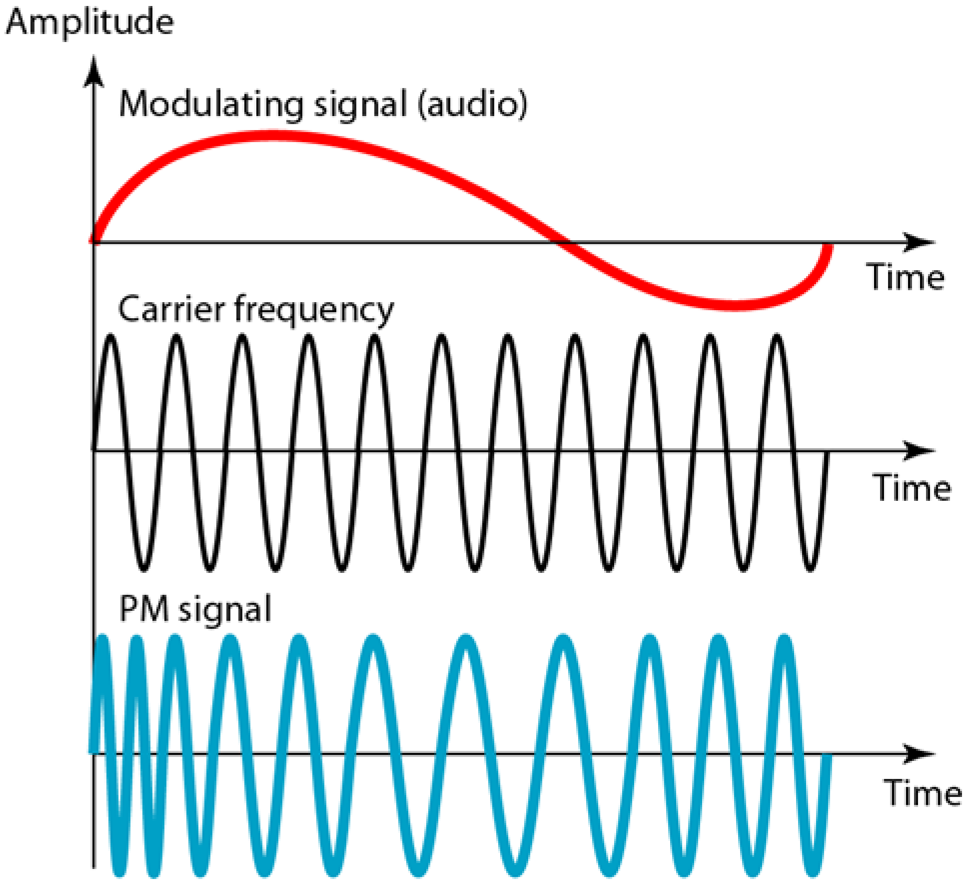


Figure *Phase modulation*

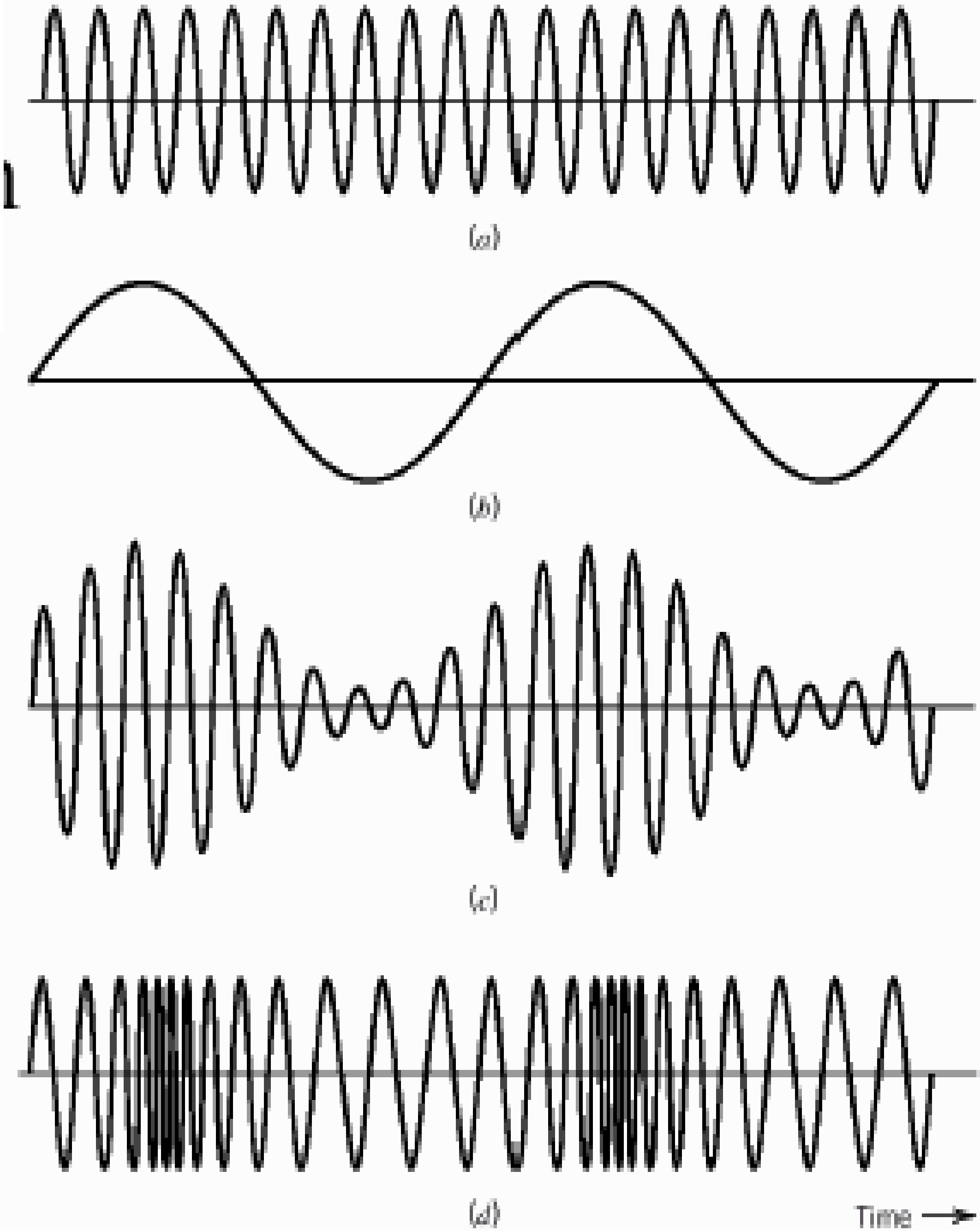


Sinusoidal carrier

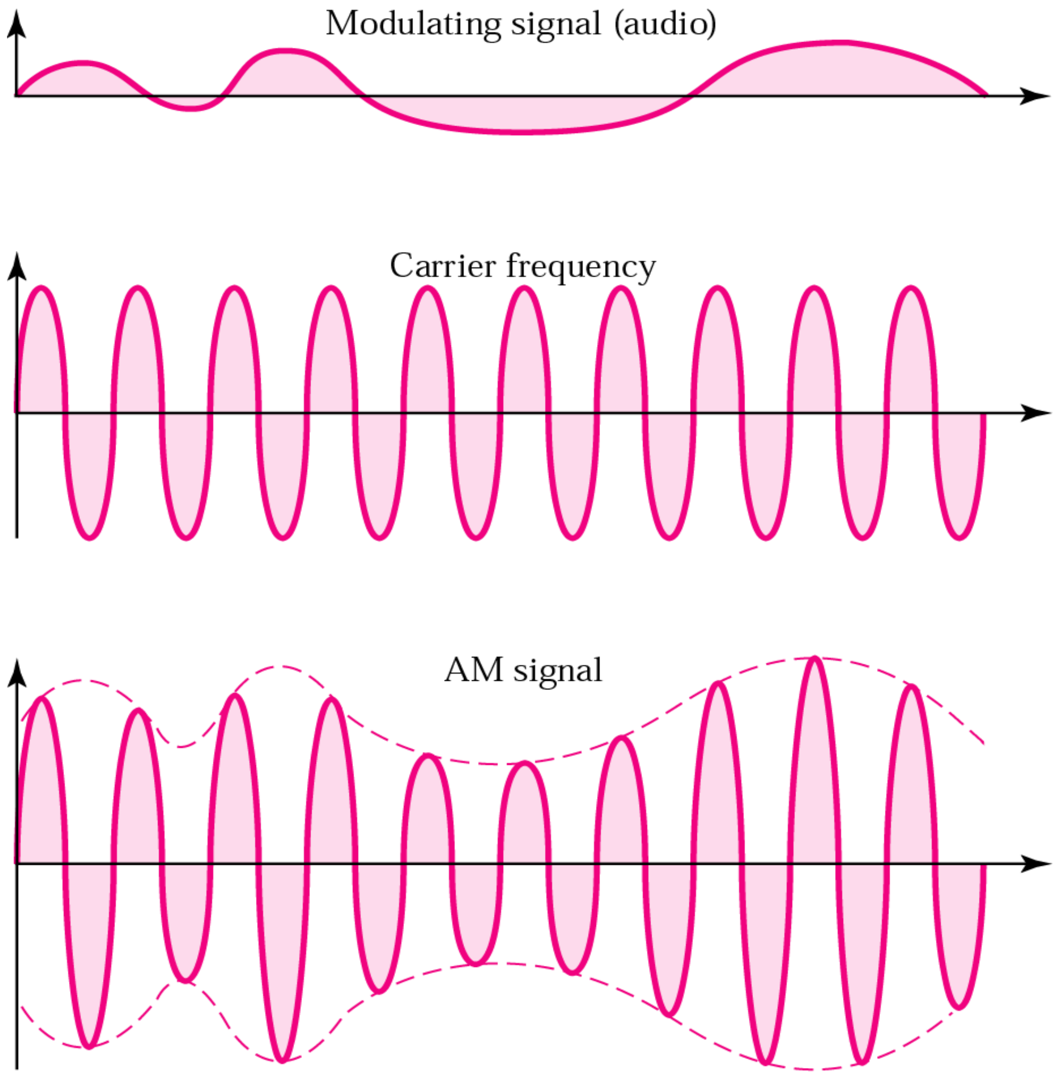
Baseband signal

Amplitude Modulation

Frequency Modulation



Conventional Amplitude Modulation



Derive the Frequency Spectrum for Full-AM Modulation (DSB-LC)

1 Consider the <u>carrier signal</u> is

$$e(t) = E_c \cos(\omega_c t) \quad \text{where } \omega_c = 2\pi f_c$$

2 In the same way, consider a <u>modulating signal</u> <u>(information</u> <u>signal</u>) can also be expressed as

$$e_m(t) = E_m \cos \omega_m t$$

3 The amplitude-modulated wave can be expressed as

$$e(t) = \left[E_c + e_m(t)\right]\cos(\omega_c t)$$

4 By substitution

$$e(t) = \left[E_c + E_m \cos(\omega_m t)\right]\cos(\omega_c t)$$

5 Let us define the modulation index m.

$$m = \frac{E_m}{E_c}$$

6 Therefore the full AM signal may be written as

$$e(t) = (E_c + mE_c \cos(\omega_m t))\cos(\omega_c t)$$

$$e(t) = E_c \cos(\omega_c t) + mE_c \cos(\omega_m t)\cos(\omega_c t)$$

Applying the trigonometric formula for 2nd term of this expression

$$\cos A \cos B = 1/2[\cos(A+B) + \cos(A-B)]$$

$$e(t) = E_c(\cos\omega_c t) + \frac{mE_c}{2}\cos(\omega_c + \omega_m)t + \frac{mE_c}{2}\cos(\omega_c - \omega_m)t$$