Types of Signals

Analog Signals

An *analog signal* is a smoothly and continuously varying voltage or current. Some typical analog signals are shown in Fig. A sine wave is a single-frequency analog signal. Voice and video voltages are analog signals that vary in accordance with the sound or light variations that are analogous to the information being transmitted.

Digital Signals

Digital signals, in contrast to analog signals, do not vary continuously, but change in steps or in discrete increments. Most digital signals use binary or two-state codes.

Analog & Digital Signals

Figure Analog signals. (*a*) Sine wave "tone." (*b*) Voice. (*c*) Video (TV) signal.

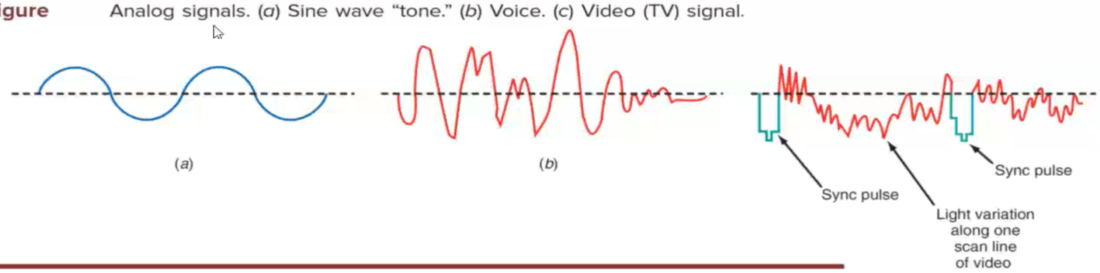
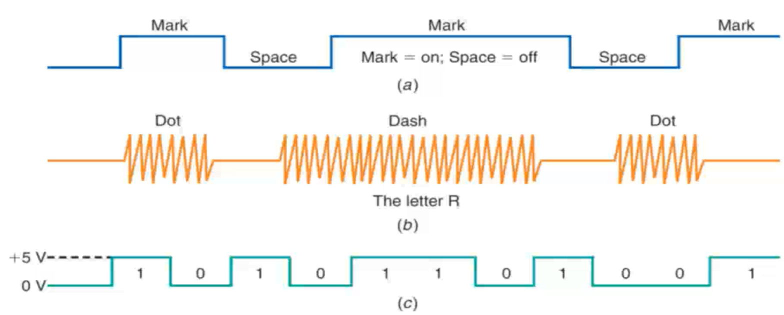


Figure Digital signals. (*a*) Telegraph (Morse code). (*b*) Continuous-wave (CW) code. (*c*) Serial binary code.



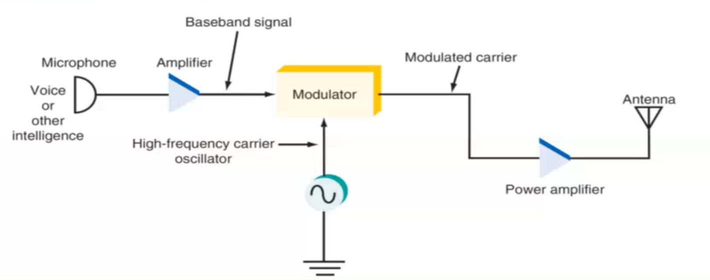
Modulation

Definition: **Modulation,** the process in which the carrier signal is varied according to the information bearing signal also called the modulating signal.

During modulation, some characteristics it can be amplitude, frequency, or phase is varied in accordance with the original information-bearing signal that has to be transmitted.

The receiver at the destination end won't be able to understand that particular modulated signal so it uses demodulator section and demodulates that signal so as to get original baseband signal.

Figure Modulation at the transmitter.



Now the thing that comes to our mind is

what a baseband signal is? 

The baseband signal is nothing but the original message signal that the user actually wants to transmit which is unconverted or we can say unmodulated.

Let's take an example and make it more clear, an audio signal can have a baseband range from 20Hz to 20KHz but during transmission when the signal gets modulated it goes to a higher inaudible range.

What is a carrier wave? 

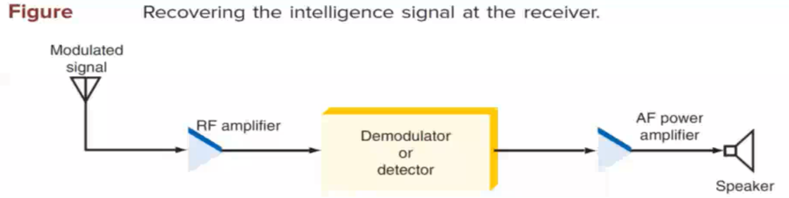
A carrier wave is a **high-frequency signal (in MHz)** that has constant amplitude and frequency and is generated from a radio frequency oscillator. These are used to modulate the original signal that contains information and has to be transmitted. It is sometimes referred to as an empty signal as it is an informationless signal.

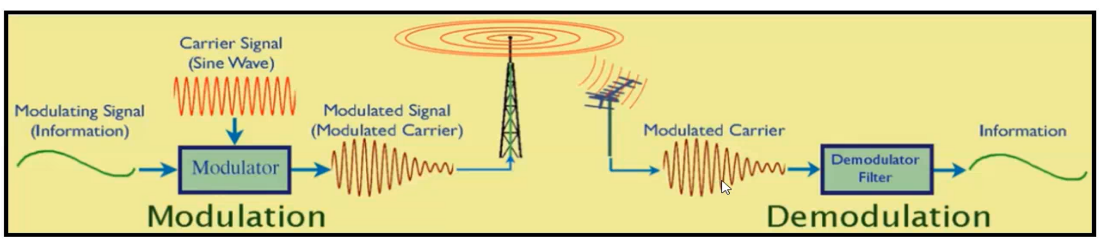
Definition of Demodulation

Demodulation is the process by which receiver regain the original message signal from the modulated one. As the name itself is indicating that ‘de’ placed before modulation in demodulation is the reverse of modulation.

There exist several techniques by which demodulation can be achieved. A **MODEM** is a device that is used for modulation and demodulation both. Hence modem is the name derived from **mo**dulator and **dem**odulator. Several techniques are used for the process of modulation and demodulation whose implementation depends on the area of need. Along with this various advantages and disadvantages are associated with different detection methods

Figure Recovering the intelligence signal at the receiver.





Key Differences Between Modulation and Demodulation

The key difference between modulation and demodulation is that **modulation is done at the transmitter side** while **demodulation is done at the receiver side** of a communication system.

Both **modulation and demodulation** occur during data transmission but the two processes **are exactly reverse of each other**. In modulation original message signal is mixed with the carrier wave whose parameters are required to be changed. As against, in demodulation the combination of carrier and message signal are separated from each other, to have original information signal.

Modulation requires a modulator section for mixing of the two signals whereas demodulation requires demodulator to recover the original signal. However, a combined equipment is used for the two known as **Modem**.

Modulation is done to convert the low-frequency signal into a high-frequency signal. While at the time of demodulation, the low-frequency signal is achieved form high-frequency signal.

Modulation is basically done to transmit data to longer distance whereas demodulation is done to regain the original message signal.

Demodulation is somewhat a **complex process** when compared with modulation.

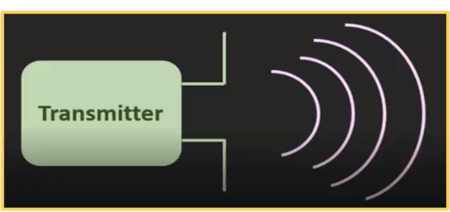
Need of Modulation

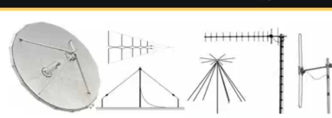
During modulation as we have discussed earlier that a low-frequency signal is modulated to have a high-frequency signal which ultimately gives us several advantages during transmission which are briefly discussed below

1. **Height of the antenna is reduced**: When we transmit a radio signal antenna height must be a **multiple of λ/4** where λ is the wavelength whose value is $\lambda = c/f$. λ is directly proportional to the speed of light and inversely proportional to the signal frequency. This means that higher the frequency lesser will be the value of λ that result in the shorter height of antenna which can be practically installed. Thus we can say modulation reduces the antenna height.
2. **Avoid mixing of signals**: It avoids the mixing of various signals. Suppose we have transmitted some baseband signals by multiple transmitters then all the signal will be in between the same frequency band i.e., in between 0 to 20KHZ which result in mixing of signals and receiver will not be able to separate them. But if we modulate all the signals with different carriers then the signals will have different frequency range so that they can be easily separated at the destination.
3. **Increase in the range**: The low-frequency message signal has another drawback that it cannot travel much longer distance during transmission as the signal gets attenuated. However, if we increase frequency then attenuation gets reduced thereby increasing the range of data transmission.
4. **Multiplexing can be done**: Modulation makes multiplexing possible. Through multiplexing, we can use the same channel to transmit various signal at the same time. But it gets successful only when the signal is modulated because modulation provides different frequency range to the signals. Due to which they can be transmitted through the same channel at the same time.

Why Modulation is Used ?

To reduce the Antenna Size





$f = 10 MHz$

$L = 7.5 m$

$L \propto \lambda$ $\quad L = \lambda/4$

$c = \lambda \times f$

c - speed of light (3×10^8 m/s)

f - frequency of the transmitted signal

λ - Wavelength of the transmitted signal

$L \propto \lambda$ $\quad L = \lambda/4$

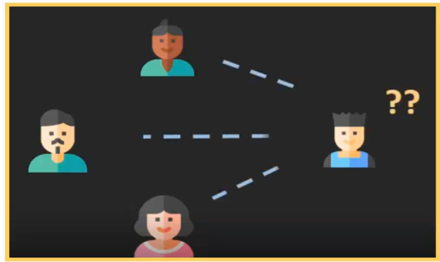
$c = \lambda \times f$ $\quad f = 10 KHz$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{10^4}$$

$\lambda = 30000 m$

$\lambda/4 = 7500$ m

To reduce the Interference



To allow multiplexing of the signals

Figure Multiplexing at the transmitter.

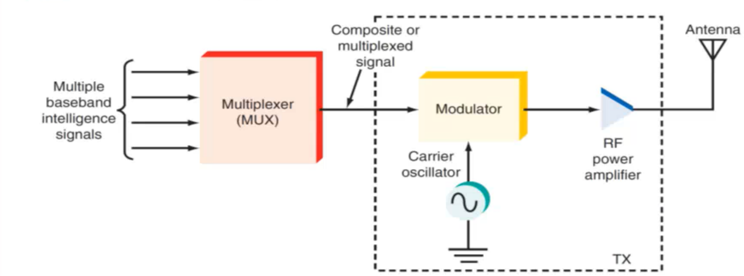
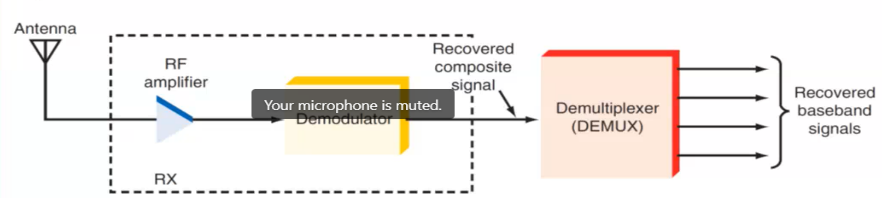
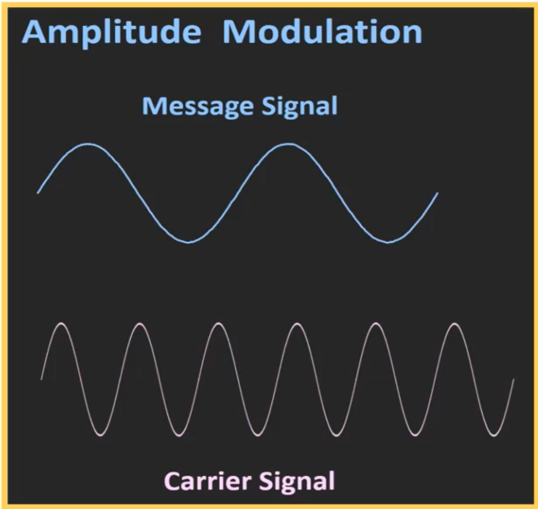
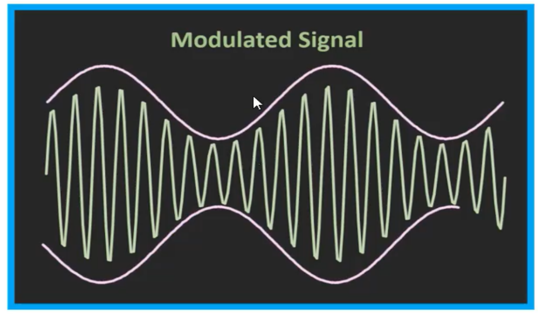


Figure Demultiplexing at the receiver.



Amplitude Modulation





Definition of Amplitude Modulation

Definition of Amplitude Modulation

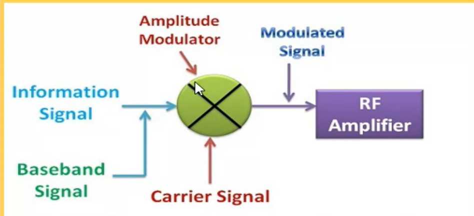
The amplitude modulation is the process of transmitting the information signal by superimposing it on the high-frequency wave called **carrier wave.** The information signal can be of any type based on the type of information it is carrying such as voice, data etc.

In case of amplitude modulation, the amplitude of the carrier wave modulates, i.e. it varies with the amplitude of the information signal. Thus, the modulation is called **amplitude modulation.** It is to be noted that the frequency and the phase of the carrier remain constant during amplitude modulation.

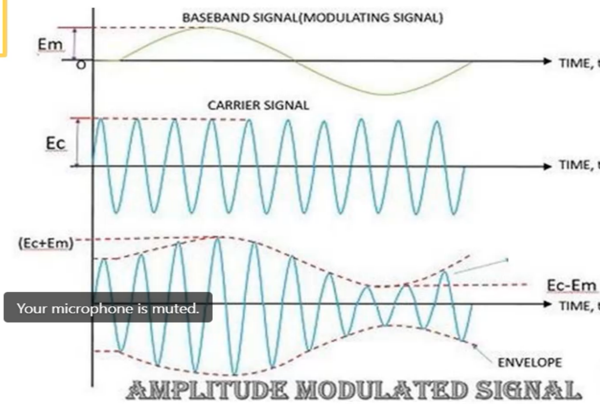
The main drawback of the using amplitude modulation technique is the **lower efficiency** and **poor quality.** The modulated signal obtained from amplitude modulator does not resemble the transmitted signal as its quality gets degraded. Besides, the noise immunity of amplitude modulators is also poor.

The advantage of using amplitude modulation technique is that it requires **low bandwidth** which makes it less costly.

Amplitude Modulation



Amplitude Modulation Block Diagram



Your microphone is muted.

Definition of Frequency Modulation

Definition of Frequency Modulation

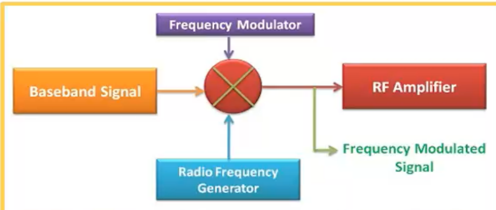
The **frequency modulation** is the technique of modulation in which the frequency of the carrier signal is varied in accordance with the frequency of the information or baseband signal keeping the amplitude of carrier signal constant.

The main advantage of using the frequency modulation technique for transmission is that quality of the transmitted signal does not deteriorate. But the frequency modulation system is complex to design thus, the cost of such system are quite high.

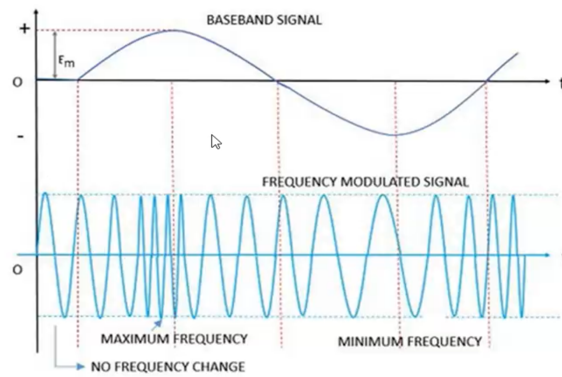
The frequency modulation system is immune to **noise distortion.** Thus, the effect of noise on the frequency modulated signal is extremely low that it can be neglected.

Your microphone is muted.

Frequency Modulation



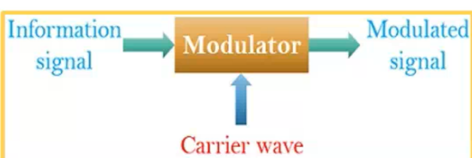
Block Diagram of Frequency Modulation



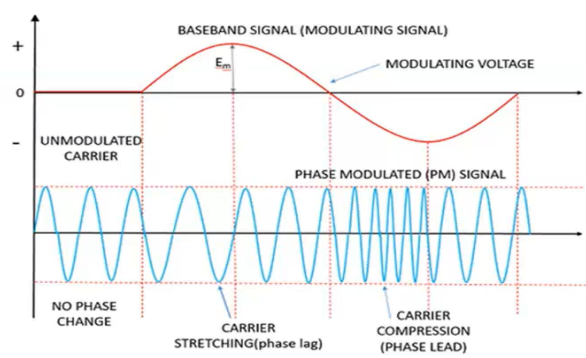
FREQUENCY MODULATED SIGNAL

Phase Modulation

Phase Modulation: Here, the phase shift of the carrier is varied according to the amplitude of carrier wave. When we apply phase modulation it leads to change in frequency too.



Process of Modulation



PHASE MODULATED SIGNAL

- **Pulse Analog Modulation**: In pulse modulation, the **carrier is in the form of pulse** rather than being a sine wave as in other types of modulation.
  - **Pulse amplitude modulation or PAM**: In this, the amplitude of carrier which is in the form of pulses is varied according to the amplitude of modulating the signal.
  - **Pulse width modulation or PWM**: The width of the pulsed carrier is varied according to the amplitude of modulating the signal.
  - **Pulse position modulation or PPM**: The position of the pulses is varied according to information-bearing signal in pulse position modulation.