Unit 1

Elements of Communication System

Communication process- Concept of element of communication system and its block diagram.

What is Communication?

It is a process of sharing or exchange of information between two entities situated at a point. The two entities may be two persons, two machines or one person - one machine types. In communication the sharing of information occurs through the means such as words, actions, signs etc.

Need of Communication:

It helps people to share their ideas and feelings.

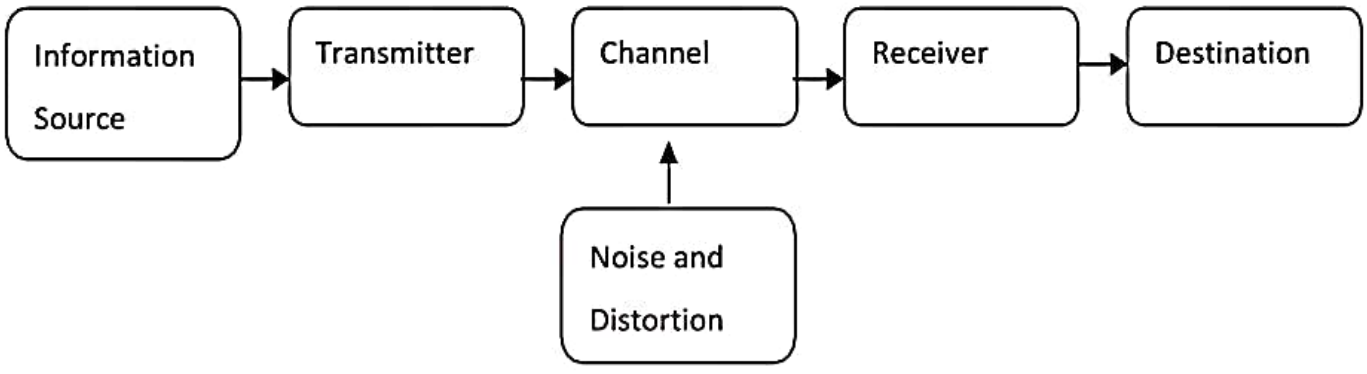
It also helps us to understand emotion and thoughts.

Process of Communication:

When it is required to share or exchange information between two entities one of the entities act as sender and another one as a receiver. The information initially remain in non-transferable form. The sender converts the non-transferable information into a transferable one. Then it sends or transmit the information towards the receiver through the interface which is known as a medium or channel. So a sender is otherwise called as a transmitter.

The medium or channel carries the information to the receiver. The receiver receives the information and converts that from transferable form to a non-transferable form. After that the receiver processes the information and converts that into usable form. It can also save the information for future use. From source to destination the moment of information occurs in different form of signals.

Block diagram of a communication system:



Elements of Communication System:

There are six elements of a general communication system those are:

Source of information

It provides the signal in its raw natural form. The source of information can be a natural type or manmade type. Initially the information can be of speech, music, and picture or of video type

Transmitter

It receive the information from source as its original form but the information in the form of sound, picture or data signal cannot be transmitted as it is. So it has to convert into a suitable electrical signal before transmitting through the medium or channel. As transmitter converts information from its original form into a transferable electrical form it is sometimes called as input transducer

Communication Channel on Medium

It is the interface between transmitter and receiver it carries the transmitted signal from transmitter to receiver. In general a communication channel is of physical type in which both the transmitter and receiver are connected with conducting wires, cables, optical fibres etc.

In conducting wires and cables the signal flows in the form of electrical signal. In optical fibre case, the signal flows in the form of ray of light. For long distance communication the channel is of wireless type which carries radio signal or electromagnetic signal through it.

Noise or interference

Noise is an unwanted signal which gets added with the transmitted signal while transmitting through the channel. Due to the addition of unwanted noise the quality of transmitted signal degrades. Sometimes signal may get lost within the channel. Noise can be treated as internal noise in case of wired medium or physical medium. For non-physical or wireless medium the noise is treated as external noise.

Receiver

It does the opposite process of transmitter. After receiving signal from communication channel it converts electrical signal back into the information signal. So sometimes the receiver is called as output receiver.

Destination

It helps in reproduction of signal or information in usable form or original form

It can also store the information for future use

Classification of Communication System

The classification of a communication system can be done according to the type of signal or type of channel or type of number of users seen.

Analogue and Digital Communication System

Depending on the operating signal a communication system can be treated as analogue or digital .In analog communication system, data or information is shared as an electrical or electronic signal of varying frequency and amplitude. Television broadcast and telephone transmission are most common example of analog communication system. On the other hand in a digital communication system the data or information is shared in the form of digital signal(i,e train of pulses). Most common example of digital communication system are internet, mobile communication, DTH etc.

Wired or Line Communication And Wireless or Space Communication

Depending upon the type of interface between transmitter and receiver a communication system can be treated as wired or wireless communication system. When the interface of channel is a physical link then a communication system is called as wired or line communication system

Common example of wired communication system are telephone networks, cable television, internet, fibre optic communication etc. Similarly, when the interface or channel is of non- physical type then a communication system is called as wireless or space communication system. Most common example of wireless communication system are radio broadcast, satellite communication, mobile communication, GPS etc.

One-Way, Two-Way and Multi-Way Communication System

Depending upon the type and number of users a communication system can be treated as one-way, two-way or multi-way communication system. If a communication system contains only two users and out of which if one user is permanently behaves as sender and other user permanently behaves as receiver then the system will be treated as one-way communication system.

Example: Television and Radio Communication

If a communication system contains only two users and both the users can behave as sender as well as receiver as per requirement then the system will be treated as two-way communication system

Example: Mobile Communication

If a communication system contains multiple number of users both in sender side as well as receiver side and all the users can behave as both sender as well as receiver as per the requirement then the system will be treated as multi-way communication system.

Example: Internet Conferencing, Video Conferencing

MODULATION:

Modulation means a change. In communication engineering modulation is a process of changing some characteristics of a carrier signal in accordance with the instantaneous value of a message signal. A carrier signal is a high frequency high powered periodic signal used to carry a low frequency low powered message signal to a far point. A message signal or modulating signal is a low frequency low powered signal which does not have the capability to propagate to a far point alone. Now during modulation some characteristics like phase, frequency, amplitude etc. of a carrier wave changes so as to generate a new signal which has the capability of movement or propagate to a larger distance. This newly generated signal is known as modulated signal which has the property that it can carry the information of message signal within it.

Need of Modulation

In modern communication most of the communication system needs to transmit a low frequency message signal to a large distance, very quickly, without any interference with utmost security. For this modulation plays an important role in designing of a system and achieving some requirements.

The following are the major points for which modulation is essential, those are

Practicality of Antenna

Reduction of Interference

Reduction of Noise

Multiplexing

Practicality of Antenna

Now a days when most of the communication systems are wireless type, antenna plays a major role in transmitting a signal. In wireless communication modulated signal transmitted through the wireless medium (i,e space) in the form of electromagnetic waves are radio waves. The function of antenna is to convert the electrical signal into electromagnetic signal at the transmitting end and vice versa at the receiving end. Now the shape of this transmitting antenna depends upon the frequency and wavelength of the operating signal The length of the antenna is directly proportional to the wavelength and inversely proportional to the frequency of operating signal. The fundamental length of antenna is $\lambda/4$ (i,e. one fourth of wavelength).Now if we want to transmit a low frequency message signal alone then an antenna of very high length and size is required to design. Designing a large size of antenna is time consuming, difficult and costly. It is also difficult to install a large size of antenna at the top of a building or a tower. So if a message signal put into a process of modulation then frequency translation occurs and a high frequency modulated signal will results. Now to transmit a high frequency modulated signal the antenna required will be of low length and size.

Reduction of Interference

Interference is the process of mixing of two or more number of signals among themselves. In wireless communication when a signal propagates through open space, there is always a probability of interference with external signals. If a message signal which is generally comes under audio frequency range is transmitted through an open space then it can easily be attenuated when interfered by external signal. By modulation, frequency translation of audio frequency message signal occurs from low band to a high band so the modulated signal can not be easily interfered or affected by the external signals.

Reduction of Noise

Noise is the unwanted signal when intermix with the transmitted signal the power level of the transmitted signal gets attenuated. In open space communication the mixing of unwanted noise is maximum in probability so the probability of loss of transmitted signal is also high.

To avoid such probability the power level of the transmitted signal must be kept as high as possible. So incase of transmitting modulated signal in place of low frequency message signal the probability of loss of power can be minimise.

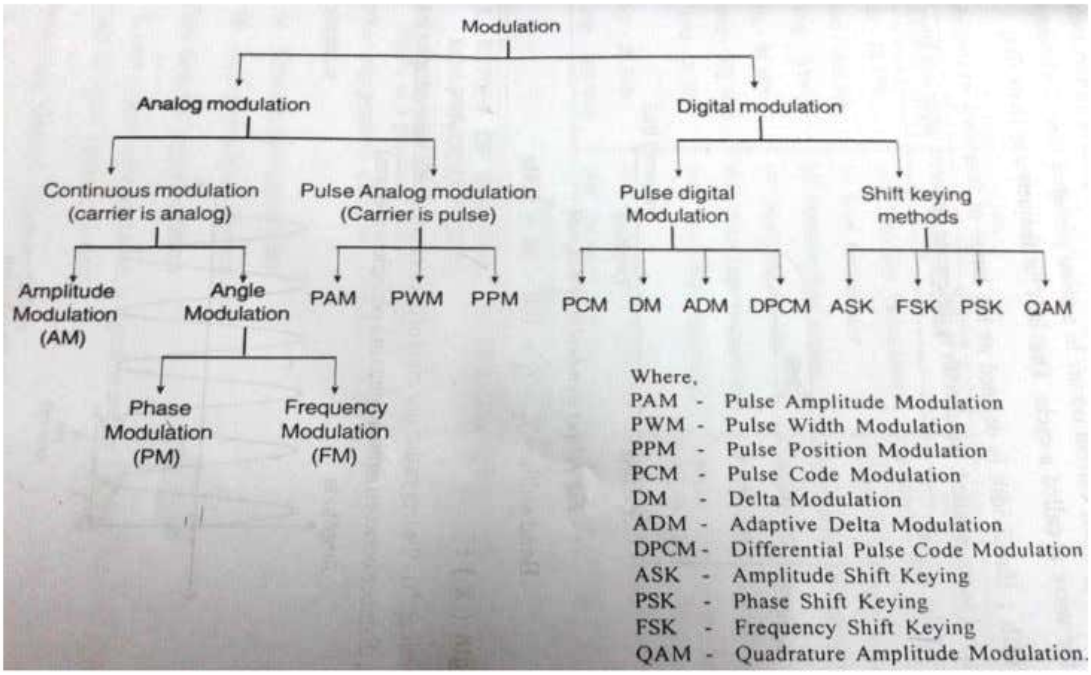
Multiplexing

It is a phenomenon of transmitting more than one number of signal simultaneously at a time. But if we transmit multiple message signal simultaneously without modulation then there will be the interference of all the Signals and any low frequency message signal may get lost. Now when a message signal is modulated with a carrier signal an envelope forms which secures the message within it. So if different message signals modulates with different carriers then they will attain different envelopes. After which if the signals will be transmitted simultaneously then there will be no interference.

Classification of Modulation

The process of modulation can be classified according to the type of message signal or modulating signal used along with the type of carrier signal used.

Tree of modulation:



Modulation can be classified into Analogue Modulation and Digital Modulation in terms of message signal used. Similarly modulation can be classified into Analogue Modulation and Pulse Modulation in terms of the carrier signal used.

Analogue Modulation or Continuous Wave Modulation

It is the category of modulation in which both the message signal and carrier signal are analog in nature.Here message signal is analog in nature which changes some characteristics like amplitude, frequency and phase of an analogue carrier signal. Hence an analogue modulation can be classified into Amplitude Modulation, Frequency Modulation and Phase Modulation. The amplitude modulation is called as Linear Modulation. Whereas the frequency modulation and phase modulation combinely called as Angle Modulation.

Amplitude Modulation

It is the process in which the amplitude of a sinusoidal carrier signal changes in accordance with the instantaneous value of message signal on modulating signal.

Frequency Modulation

It is the process in which the frequency of sinusoidal carrier wave or carrier signal changes in accordance with the instantaneous value of a message or modulating signal.

Phase Modulation

It is the process in which the phase angle of sinusoidal carrier wave changes in accordance with the instantaneous value of a message or modulating signal.

Pulse Modulation or Pulse Wave Modulation

It is the category of modulation in which the message signal that used may be of analog type or Digital type but the carrier signal that used is always of digital type or train of pulses. When the message signal is of analog type along with digital type carrier signal then the pulse modulation is called as Analogue Pulse Modulation. Similarly when message signal is of digital type along with digital type carrier signal then the pulse modulation is called as Digital Pulse Modulation. Depending upon three characteristics of digital type or pulse type carrier signal the analogue pulse modulation is of three types those are:

Pulse Amplitude Modulation (PAM)

Pulse Width Modulation (PWM)

Pulse Position Modulation (PPM)

Pulse Amplitude Modulation (PAM)

It is the process in which the amplitude of rectangular pulses varies in accordance with the instantaneous value of sinusoidal signal or modulating signal.

Pulse Width Modulation (PWM)

It is the process in which the width of rectangular pulses varies in accordance with the instantaneous value of a sinusoidal message or modulating signal.

Pulse Position Modulation (PPM)

It is the process in which the position of the pulses or gap between the pulses varies in accordance with the instantaneous value of a sinusoidal message or modulating signal.

Pulse Code Modulation

It is the process in which a digital type carrier signal changes in accordance with a digital form or binary form of sinusoidal message signal or modulating signal.

Digital Modulation

It is the category of modulation in which the message signal is digital in nature where as a carrier signal is analogue in nature. Depending upon the change in amplitude, phase and frequency of analog carrier signal digital modulation is of three types, those are

Amplitude Shift Keying

Phase Shift Keying

Frequency Shift Keying

Amplitude Shift Keying

It is the process in which the amplitude of sinusoidal carrier wave changes in accordance with the digital message signal which is in the form of sequence of binary bits.

Phase Shift Keying

It is the process in which the phase of a sinusoidal carrier changes in accordance with the digital message signal which is in the form of a sequence of binary bits.

Frequency Shift Keying

It is the process in which the frequency of a sinusoidal carrier changes in accordance with the digital message signal which is in the form of a sequence of binary bits.

Signal

It is a function of one or more independent variables which contain some information. The independent variables may be time, temperature, position, pressure, distance etc. The most common independent variable is time.

Classification of Signal

Continuous Time and Discrete Time Signal

A signal is said to be continuous when it is defined for all instance of time it means a signal is having value continuously with respect to time.

Examples are: sine wave, cosine wave, current etc.

Similarly a signal is said to be discrete when it is defined at only discrete instant of time. It means a signal is having different values at different instant of time.

Examples are: All digital signals

Real and Complex Signal

A signal is said to be a real signal if its value is real number. Similarly a signal is said to be a complex signal if its value is a complex number.

Example of complex signals are:

Blood Velocity

Modulation in Telecommunication

Deterministic and Non-deterministic Signal

A signal is said to be deterministic if there is no uncertainty with respect to its value at any instant of time. It means for such type of signal, its value can be predicted at a specific time. Generally the pattern of such type of signal is regular in nature.

Examples are:

Sinusoidal Wave

Triangular Wave

Square Wave

Similarly a signal is said to be a non-deterministic if there is uncertainty with respect to its value at any instant of time. so its value cannot be predicted at a specific time. Generally the pattern of such type of signal is random in nature.

Examples are:

Thermal noise in electrical circuit

Lightning during rainy season

Periodic and Aperiodic Signal

A signal is said to be periodic if its occurrence repeats at a regular interval of time.so it is a repetitive signal. Mathematically it should satisfy the following condition

$X(t) = X(t+T)$

where t- time instant

T- time interval

Examples are

Sinusoidal Signal

Non-sinusoidal Signal

Similarly a signal is said to be an aperiodic if its occurrence does not repeat at a regular interval of time.So its occurrence is random in nature. It satisfy the relationship

Analogue and Digital Signal and Its conversion

Analog Signal

It is a signal whose value varies continuously with time. It means at a particular time instant an analog signal has a value. This value changes continuously in between two time instances.

Eexamples are:

Temperature of atmosphere

Pressure of atmosphere

Speech

Digital Signal

It is a signal in which the value does not varies with respect to time. It means at a particular time instant if signal is present then at another time instant it may or may not present. It is basically represented by sequence of numbers.

Analog to Digital Conversion

In real world most of the data or information is present in analogue form. but to manipulate and process data for better understanding it is required to convert analog signal into digital form. Generally an analogue signal is a signal which is continuous in time domain and continuous in amplitude domain also. A digital signal is discrete in time domain and discrete in amplitude domain also. An analogue signal cannot directly been converted into a digital signal. Rather it first converted into an intermediate form in which signal remain continuous in amplitude but discrete in time domain. An analog signal is converted into an intermediate signal by the process of Sampling. After which the intermediate signal is converted into a digital signal by the process of Quantization.

Sampling

It is a process of conversion of continuous time signal into discrete time signal. It is a process to measure instantaneous values over a continuous time.

Quantization

It is a process of conversion of large amplitude level of a discrete time signal into small set of discrete levels. This discrete output amplitude levels are countable.

Bandwidth Limitation

Bandwidth limitation is the factor that characterize the capacity of a transmitting channel to carry certain range of frequency. Beyond the specific range if a signal having other frequency tries to pass through any channel then that gets blocked. So a bandwidth is the difference between the upper limiting frequency and the lower limiting frequency of a signal. The band of frequencies or bandwidth required for a particular transmission is called channel. The rate of data flow or channel capacity of a channel can be determined by the following formula

Capacity, $C = B \log [1+S/N]$

Where, C- Channel Capacity

B- Bandwidth of a Channel

S- Signal Power associated with Channel

N- Noise Power associated with Channel

Unit 2

Amplitude Modulation system

The process of changing amplitude of carrier signal in accordance with the instantaneous values of message signal is called as amplitude modulation. In case of amplitude modulation both the message signal and carrier signal are sinusoidal in nature. Depending upon the instantaneous value of sinusoidal message signal the amplitude of the carrier signal varies and a new single with new amplitude results this new signal is called as a Modulated Signal. The amplitude of carrier signal and modulated signal differs from each other whereas the frequency and phase of modulated signal remain same as that of the carrier signal

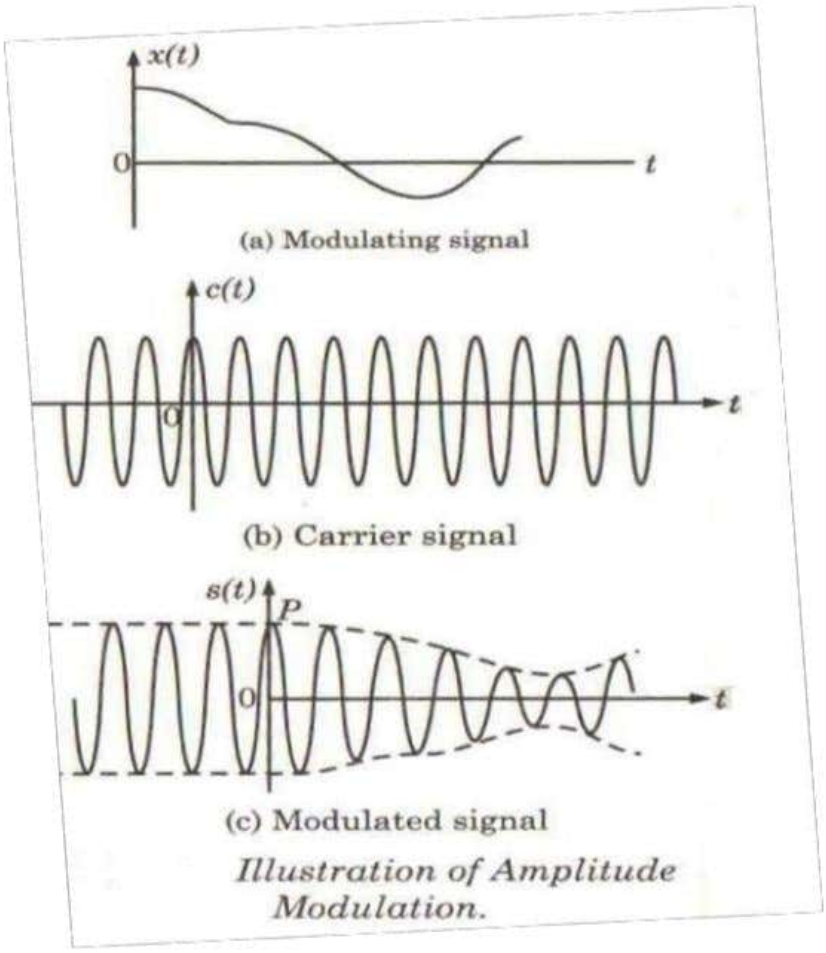


Illustration of Amplitude Modulation.

Since both message and carrier signal are sinusoidal they can be represented as

$m(t) = A_m \cos w_m t$

and $c(t) = A_c \cos w_c t$

With the principle of amplitude modulation the amplitude of carrier signal changes and a new amplitude results which can be determined as

$A = Ac + m(t)$ ---------- (eq^{n}1)

$A = Ac + Am \cos w_m t$

$A = Ac [1 + (Am/Ac) \cos w_m t]$

$A = Ac[1 + Ma \cos w_m t]$

Here Ma= Am/Ac known as Modulation Index or Modulation factor or Degree of Modulation.

Now the modulated signal M(t) can be determined as

$M(t) = A \cos w_c t$

$= Ac [1+Ma \cos w_m t] \cos w_c t$

$= Ac \cos w_c t + AcMa \cos w_c t \cos w_m t$

$= Ac \cos w_c t + [AcMa/2] [\cos(w_c+w_m)t + \cos (w_c-w_m)t]$

$= Ac \cos w_c t + [AcMa/2] [\cos(w_c+w_m)t] + [AcMa/2] [\cos (w_c-w_m)t]$

Frequency Spectrum of AM wave

It is a graph which shows the relations between the frequency and amplitude of modulated signal. From the expression of amplitude modulated signal it is clear that it contains three different frequency terms. Those are:

Carrier with frequency component w_c

Upper side band with frequency component (w_c+w_m)

Lower side band with frequency component (w_c-w_m)

Bandwidth of AM Wave

It is the range of frequency from lower side band to upper side band.It can be determined by subtracting lower cut off frequency from upper cut off frequency.

So Band Width

$B = (w_c+w_m)-(w_c-w_m)$

$= w_c + w_m - w_c + w_m$

$= 2 w_m$

So bandwidth of am signal is equal to twice of modulating frequency.

Modulation index or Modulation Factor

It is defined as the measure of extent of amplitude variation of carrier signal about its un modulated amplitude. We know the amplitude modulated signal and unmodulated amplitude of carrier signal are related with each other as follows

$Ac[1+Ma \cos w_m t]$

Now A- becomes a max for maximum value of $\cos w_m t$

and A becomes Amin for minimum value of $\cos w_m t$

Now for $[\cos w_m t]max = 1$

$A=Amax = Ac [1+Ma]$

Similarly, $[\cos w_m t]min = -1$

$A=Amin= Ac [1-Ma]$

Now, $Amax/ Amin = [Ac (1+Ma)]/ [Ac (1-Ma)] = [1+Ma] / [1-Ma]$

$Amax-MaAmin = Amin+ MaAmin$

$Ma Amax+ MaAmin = Amax-Amin$

$Ma[Amax+Amin] = Amax- Amin$

$Ma = [Amax- Amin]/[Amax+Amin]$

Now, from eq^n 1

$A = Ac + m(t) = Ac + Am \cos w_m t$

for maximum value, $\cos w_m t =1$

Then, $A=Amax= Ac+Am$

Similarly, for minimum value, $\cos w_m t = -1$

Then $A=Amin= Ac-Am$

Now eq^n 1 can be rewritten as

$Ma= [Amax-Amin]/[Amax+Amin]=[(Ac+Am)- (Ac-Am)]/[(Ac+Am)+(Ac-Am)]$

$Ma= 2Am/2Ac$

$Ma= Am/Ac$

so for AM, modulation index is the ratio of amplitude of message signal to that of carrier signal.

Generation of Amplitude Modulated Signal

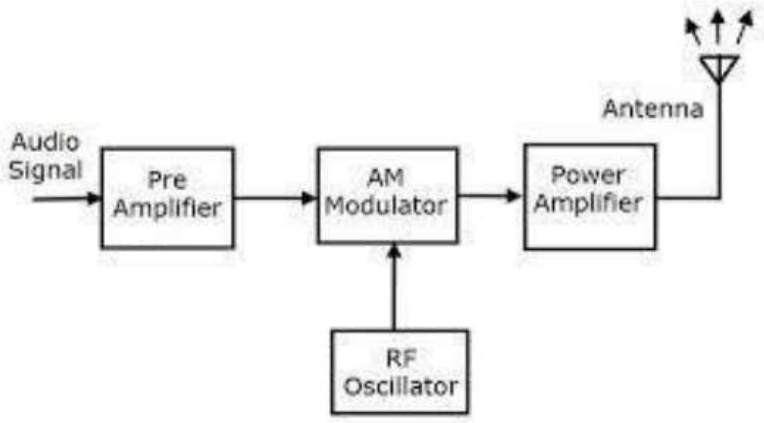
The electronic circuit which is used to generate an amplitude modulated signal is called as an Amplitude Modulator. The modulator circuit is designed to operate in two methods those are

Low Level AM Generation

High Level AM Generation

Low Level AM Generation

In this method of FM generation the modulator circuit is used to operate in a low power domain. The low-level AM generation method are basically seen in amateur radio transceivers which are basically used for non-commercial purposes. The various use of amateur radio transceivers are wireless experimentation, self-training, private recreation, contesting and emergency communication etc. In low level am generation the modulation of AM signal carried out at the beginning part of the transmitter. The modulation is carried out at low power level so during modulation the message signal and carrier signal are applied to the modulator circuit without amplification. So we cannot see any amplifier circuit before the modulated stage. The transmitter only have the amplifier circuit towards the final stage or towards the end.



High Level AM Generation

In this method of AM generation, the modulation circuit is used to operate in a high power level or domain. The high-level AM generation methods are basically seen in high level AM transmitters, which are basically used for commercial AM broadcast. In high level AM generation the modulation of AM signal carried out towards the last stage of radio transmitters. As signal modulation is carried out at high power level the message signal and carrier signal are applied to the modulation circuit after amplification. So power amplifier circuits are seen before the modulation stage.