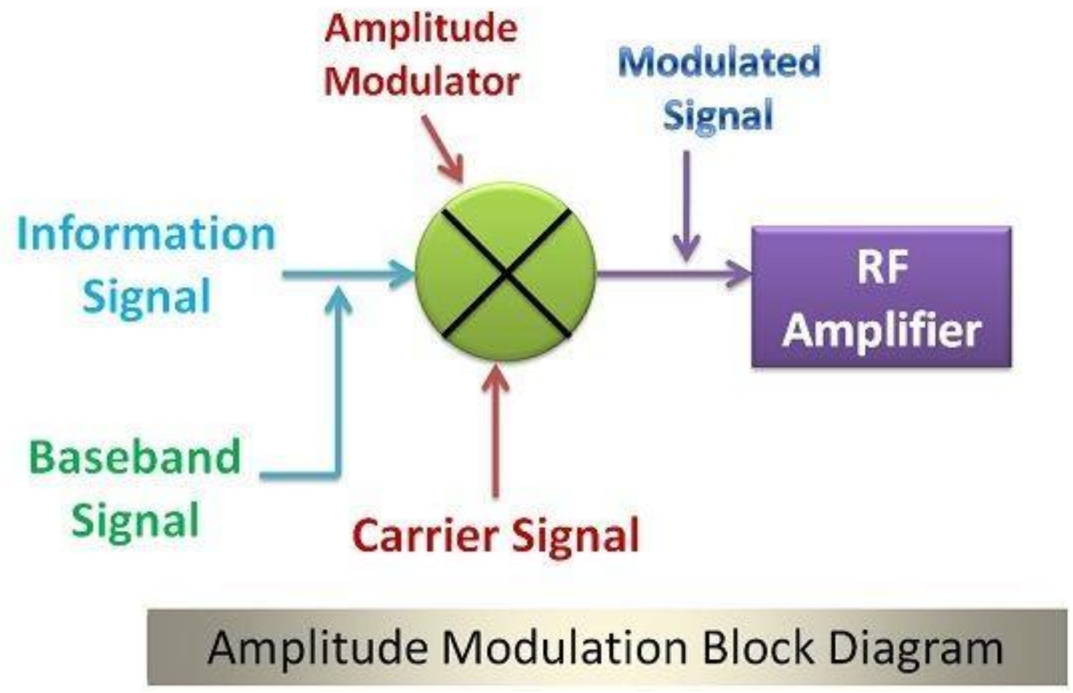
Difference between Amplitude Modulation and Frequency Modulation

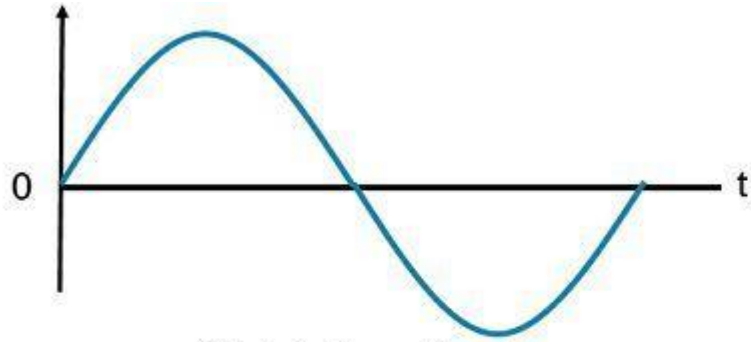
Amplitude Modulation and frequency modulation, both are the type of transmission techniques for transmitting information from sender to receiver. But the similarities between the two ends here. Amplitude modulation involves the modulation of the carrier signal according to the amplitude of the baseband signal. However, the frequency and phase of the carrier signal will not be changed.

On the contrary, frequency modulation involves the modulation of the carrier signal according to the frequency of the baseband or information signal. Thus, the major difference between the amplitude modulation and frequency modulation is that the amplitude modulation is the process of modulating the amplitude of the carrier signal, while frequency modulation is the modulation of the frequency of the carrier signal.

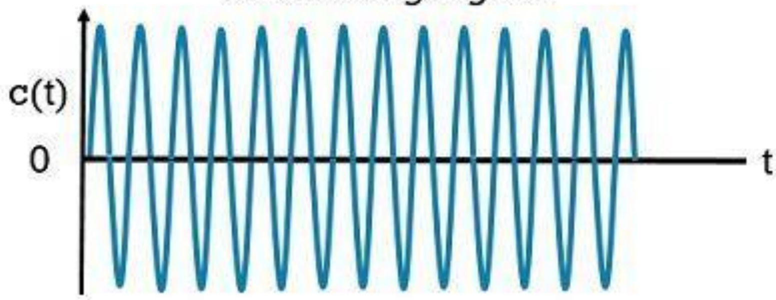
Another significant term which creates the difference between these two modulation techniques is the bandwidth requirement. The bandwidth requirement in case of amplitude modulation is very less as compared to frequency modulation.

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.

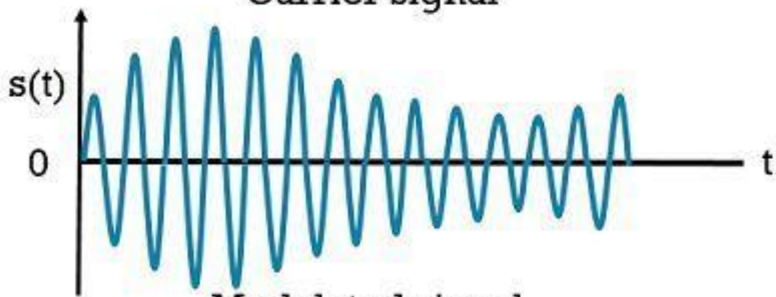




Modulating signal



Carrier signal



Modulated signal

The frequency of the information signal which is also known as the baseband signal is extremely low. The frequency of the signal is directly related to the energy of the signal. Thus, if signal frequency is very low then the signal will get attenuate after travelling a certain distance. In order to avoid the attenuation of the signal, it is superimposed on the high-frequency carrier wave.

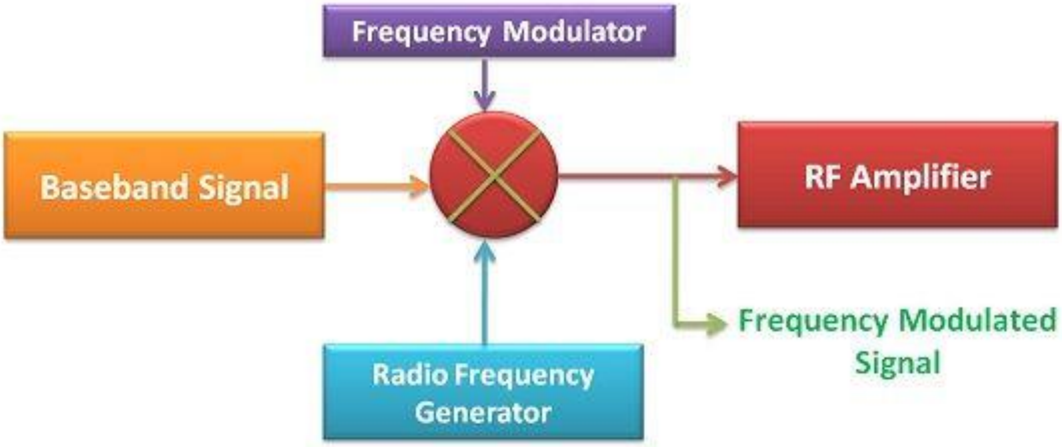
In case of amplitude modulation, the amplitude of the carrier wave modulates, i.e. it varies with the amplitude of the information signal. Thus, the modulation is called amplitude modulation. It is to be noted that the frequency and the phase of the carrier remain constant during amplitude modulation.

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.

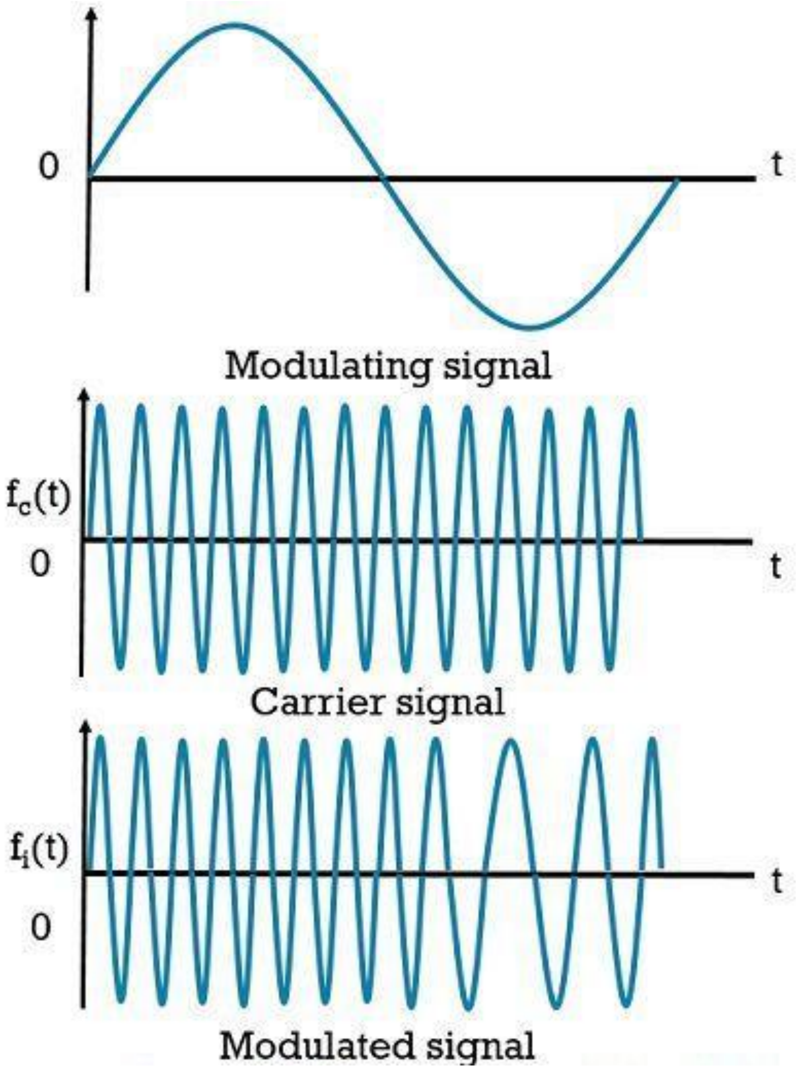
The advantage of using amplitude modulation technique is that it requires low bandwidth which makes it less costly.

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.



Block Diagram of Frequency Modulation



The frequency modulator performs the modulation task, in this carrier signal from radio frequency generator and the information signal from the information source is introduced. The modulated signal is then passed to RF amplifier which ameliorates the necessary attenuations.

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.

Key Differences between Amplitude Modulation and Frequency Modulation

1. The operation mechanism of amplitude modulation and frequency modulation creates the key difference between these transmission technologies. Amplitude modulation deals with the carrier which is modulated by the amplitude of the signal, while frequency modulation technique deals with the carrier which is modulated by the frequency of the modulated signal.
2. The quality of the received signal varies in both the techniques. The amplitude limiters can be fitted with frequency modulation system. Thus, the distortions due to noise signal can be minimized in frequency modulation system. On the contrary, the amplitude modulators cannot be equipped with amplitude limiters.
3. The frequency deviation technique also reduces the noise and can exponentially increase the quality of the signal, but the technique of frequency deviation is not possible in amplitude modulation. This makes the frequency modulation better in comparison to amplitude modulation.
4. The bandwidth requirement also plays a pivotal role in differentiating amplitude modulation and frequency modulation. The frequency modulation system requires high bandwidth in the range of 200kHz. While the amplitude modulation system requires bandwidth in the range of 10kHz for the broadcasting information signal.
5. The circuit architecture of frequency modulation system is very complex in comparison to amplitude modulation system.
6. The amplitude modulation and frequency modulation also differs in the cost of the system. The complex design of the frequency modulation system makes it costly in comparison to amplitude modulation system.

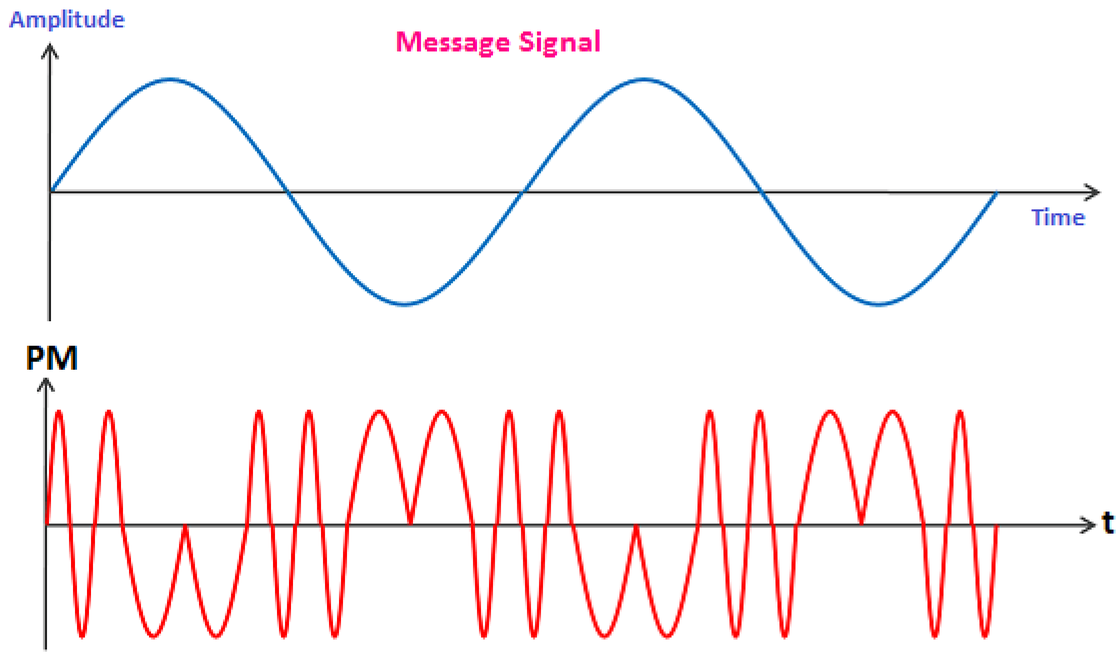
Comparison of AM and FM modulation

PARAMETERS	AMPLITUDE MODULATION	FREQUENCY MODULATION
Definition	The amplitude of the carrier wave is modulated according to the value of the amplitude of the information signal.	The frequency of the carrier wave is modulated according to the value of the frequency of the information signal.
Basic	Carrier wave amplitude is altered.	Changes carrier wave frequency.
Circuit designing	Simple	Complex
Cost of the circuit	It is less costly.	It is more costly than amplitude modulation technique.
Bandwidth requirement	The bandwidth requirement is low in the range of 10 kHz.	The bandwidth requirement is high in the range of 200 kHz.
Area of reception	The area of reception is large.	The area of reception is limited in comparison to that of amplitude modulation system.
Constant terms	The frequency and phase is constant.	The amplitude and phase is constant.
Power	The wastage of power is more in amplitude modulation because the significant part of the	The power is utilized properly, because all transmitted power is carried by the information signal.

PARAMETERS	AMPLITUDE MODULATION	FREQUENCY MODULATION
	power is carried by the carrier signal which do not contain any information.	
Noise Immunity	The amplitude modulation system is not immune from noise distortion as frequency deviation technique and amplitude delimiters cannot be utilized in amplitude modulation system.	The frequency modulation is more immune to noise distortion because we can use frequency deviation technique and amplitude delimiters.
Quality of reception	Low quality signal is obtained.	The received signal is of high quality.
Frequency range	535 - 1705 Kilo hertz or at max 1200 bits/sec.	88 - 108 Mega hertz or 1200 - 2400 bits/sec.
Bandwidth consumption	Takes up to 30 KHz.	Consumes up to 80 KHz per signal.
Distance coverage	AM waves cover a large distance.	FM covers less distance as compared AM.
Affect of obstruction	Can resist obstruction such as buildings.	Obstructions can degrade the signal strength.
Property	AM waves reflect from the upper layer of the atmosphere.	FM waves can penetrate the atmosphere.

Phase Modulation

Phase modulation is defined as the process of varying the phase of the carrier signal linearly with the instantaneous value of the message signal. The waveforms of a message signal and the phase-modulated signal are shown below:



Message signal

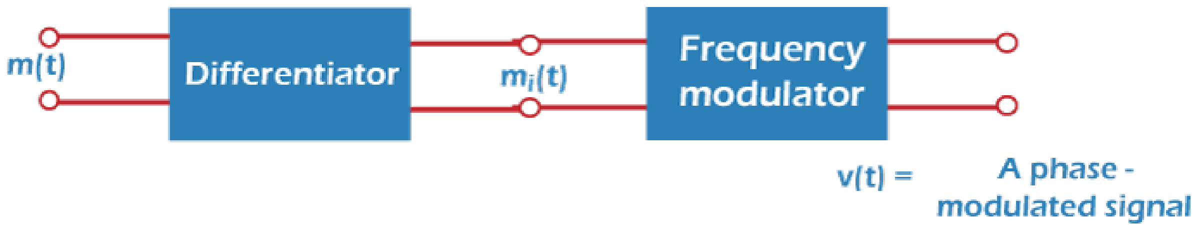
A message signal contains information or a message. It is the original signal that needs to be transmitted from the transmitter to the receiver. The transmitter converts the signal into a suitable form and sends it through the communication channel to the receiver. The communication channel is a medium for the signal to travel from one end to the other. The receiver perceives the signal, which is converted back to its original form.

A message signal suffers from attenuation and various noise factors. It is essential to modulate the message signal to remove the noise. It also helps in improving the efficiency of the signal. Hence, a message signal is often known as a modulated signal. Another name of the message signal is the baseband signal.

Carrier signal

Carrier signal is the same sinusoidal waveform signal like message signal with greater frequency. It means that the frequency of the carrier signal is higher than the message signal. The Carrier signal is sent with the message signal on the same communication channel during the modulation process. When sent with the message signal, the high-frequency carrier signal increases the frequency of the message signal. It is used in applications where the incoming message signal is low frequency, and the required output signal is high frequency.

a frequency modulator can be used as a phase modulator by passing the FM signal through a differentiator and an FM modulator.



Demodulation

Demodulation is the reverse process of modulation. Modulation is defined as the process to convert the incoming signal into the suitable form of transmission. It improves the efficiency of the incoming signal and sends it to the receiver. Demodulation converts the received signal back to its original form.

During the modulation, the message signal is superimposed on the carrier signal for efficient transmission. At the receiving end, the message signal is recovered from the carrier wave (message signal + carrier signal), which is termed as demodulation. Thus, demodulation is defined as the process to recover the original signal from the carrier wave.

The original signal is often known as the baseband signal. The modulation and demodulation process comprises of two signals, message signal and the carrier signal. Message signal contains the information that needs to be transmitted from the transmitter to the receiver. Carrier signal is a signal with similar characteristics as the message signal. It is a high frequency signal which is transmitted along with the message signal on the same communication channel.

Various demodulation techniques such as synchronous detection, carrier recovery, error detection, and error correction are incorporated by demodulators. Demodulators can perform none or any of the above functions depending on the requirements. Some demodulators are created specifically for different purpose.

Difference Between TDM and FDM

TDM (Time Division Multiplexing) and FDM (Frequency Division Multiplexing) are the two techniques of multiplexing. The common difference between TDM and FDM is that TDM share the timescale for the different signals; Whereas FDM shares the frequency scale for the different signals.

Before understanding both terms in deep let's understand the term multiplexing. Multiplexing is a technique through which several signals are concurrently transmitted over a single data link. Multiplexed system involves n number of devices which share the capacity of one link that's how a link (path) can have multiple channels.

Multiple devices fed their transmission streams to a Multiplexer (MUX) which merges them into a single stream. At the receiver, the single stream is directed to the Demultiplexer (DEMUX), which is again translated into its component transmission and sent to their intended receivers.

BASIS FOR COMPARISON	**TDM**	**FDM**
Basic	Times scale is shared.	Frequency is shared.
Used with	Digital signals and analog signals	Analog signals
Necessary requirement	Sync Pulse	Guard Band
Interference	Low or negligible	High
Circuitry	Simpler	Complex
Utilization	Efficiently used	Ineffective

Definition of TDM
Time-division multiplexing (TDM) is considered to be a digital procedure which can be employed when the transmission medium data rate quantity is higher than the data rate requisite of the transmitting and receiving devices. In TDM, corresponding frames carry data to be transmitted from the different sources. Each frame consists of a set of time slots, and portions of each source is assigned a time slot per frame.Time-division multiplexing

Types of TDM
Synchronous Time-Division Multiplexing: In this type the synchronous term signifies that the multiplexer is going to assign precisely the same slot to each device at every time even if a device has anything to send or not. If it doesn't have something, the time slot would be empty. TDM uses frames to group time slots which covers a complete cycle of time slots. Synchronous TDM uses a concept, i.e., interleaving for building a frame in which a multiplexer can take one data unit at a time from each device, then another data unit from each device and so on.
The order of the receipt notifies the demultiplexer where to direct each time slot, which eliminates the need of addressing. To recover from timing inconsistencies Framing bits are used which are usually appended to the beginning of each frame. Bit stuffing is used to force speed relationships to equalize the speed between several devices into an integer multiple of each other. In bit stuffing, the multiplexer appends additional bits to device's source stream.
Asynchronous Time-Division Multiplexing: Synchronous TDM waste the unused space in the link hence it does not assure the efficient use of the full capacity of the link. This gave rise to Asynchronous TDM. Here Asynchronous means flexible not fixed. In Asynchronous TDM several low rate input lines are multiplexed to a single higher speed line. In Asynchronous TDM, the number of slots in a frame is less than the number of data lines. On the contrary, In Synchronous TDM the number of slots must be equal to the number of data lines. That's why it, avoids the wastage of the link capacity.
Definition of FDM
Frequency-division multiplexing (FDM) is an analog technique which is implemented only when the bandwidth of the link is higher than the merged bandwidth of the signals to be transmitted. Each

sending device produces signals which modulate at distinct carrier frequencies. To hold the modulated signal, the carrier frequencies are isolated by adequate bandwidth.The modulated signals are then merged into one compound signal that can be transferred by the link. The signals travel through the bandwidth ranges referred to as channels.

Signals overlapping can be controlled by using unutilized bandwidth strips for segregating the channels, these are known as guard bands. Also, carrier frequencies should not interrupt with the original data frequencies. If any condition fails to adhere, the original signals cannot be recovered.

Key Differences Between TDM and FDM

The time-division multiplexing (TDM) includes sharing of the time through utilizing time slots for the signals. On the other hand, frequency-division multiplexing (FDM) involves the distribution of the frequencies, where the channel is divided into various bandwidth ranges (channels).

Analog signal or Digital signal any could be utilized for the TDM while FDM works with Analog signals only.

Framing bits (Sync Pulses) are used in TDM at the start of a frame in order to enable synchronization. As against, FDM uses Guard bands to separate the signals and prevent its overlapping.

FDM system generates different carriers for the different channels, and also each occupies a distinct frequency band. In addition, different bandpass filters are required. Conversely, the TDM system requires identical circuits. As a result, the circuitry needed in FDM is more complex than needed in TDM.

The non–linear character of the various amplifier in the FDM system produces harmonic distortion, and this introduces the interference. In contrast, in TDM system time slots are allotted to various signals; as the multiple signals are not inserted simultaneously in a link. Although, the non-linear requirements of both the systems are same, but TDM is immune to interference (crosstalk).

The utilization of physical link in case of TDM is more efficient than in FDM. The reason behind this is that the FDM system divides the link in multiple channels which does not make use of full channel capacity.