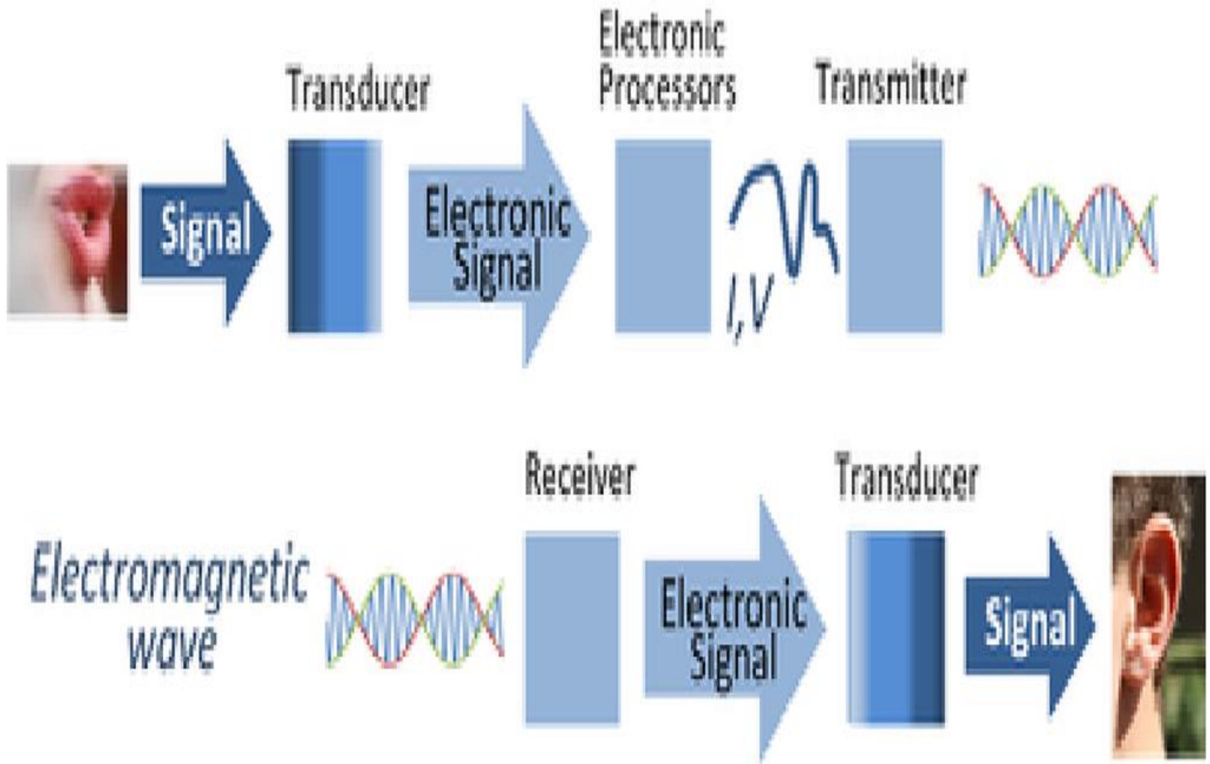
Principle of Communication

3RD SEMESTER

Communication:

The process of transmitting, processing and receiving the information is called communication



Need of modulation:-

Modulation – Definition – Need for Modulation – Types of Modulation

A message signal cannot travel a long distance because of its low signal strength. In addition to this, physical surroundings, the addition of external noise and travel distance will further reduce the signal strength of a message signal. So in order to send the message signal to a long distance, we need to increase the signal strength of a message signal. This can be achieved by using a high frequency or high energy signal called carrier signal. A high energy signal can travel to a larger distance without getting affected by external disturbances. We take the help of such high energy signal to transmit the message signal. This high energy or high frequency signal is known as carrier signal.

The low energy message signal is mixed with the high energy or high frequency carrier signal to produce a new high energy signal which carries information to a larger distance.

The question arises how the message signal should be added to the carrier signal. The solution lies in changing some characteristics (amplitude, frequency or phase) of a carrier signal in accordance with the amplitude of the message signal. This process is called modulation. Modulation means to "change".

The Message signal contains information whereas the carrier signal contains no information. Carrier signal is used just to transmit the information to a long distance. At the destination, the message signal is consumed whereas the carrier signal is wasted.

In modulation process, the characteristics of the carrier signal is changed but the message signal characteristics will not be changed. The carrier signal does not contain any information so even if we change the characteristics of the carrier signal, the information contained in it will not be changed. However, the message signal contains information so if we change the characteristics of the message signal, the information contained in it will also changes. Therefore, we always changes the characteristics of the carrier signal but not the message signal.

Modulation allows the transmission to occur at high frequency while it simultaneously allows the carrying of the message signal.

Modulation Definition

Modulation is the process of mixing a low energy message signal with the high energy carrier signal to produce a new high energy signal which carries information to a long distance.

or

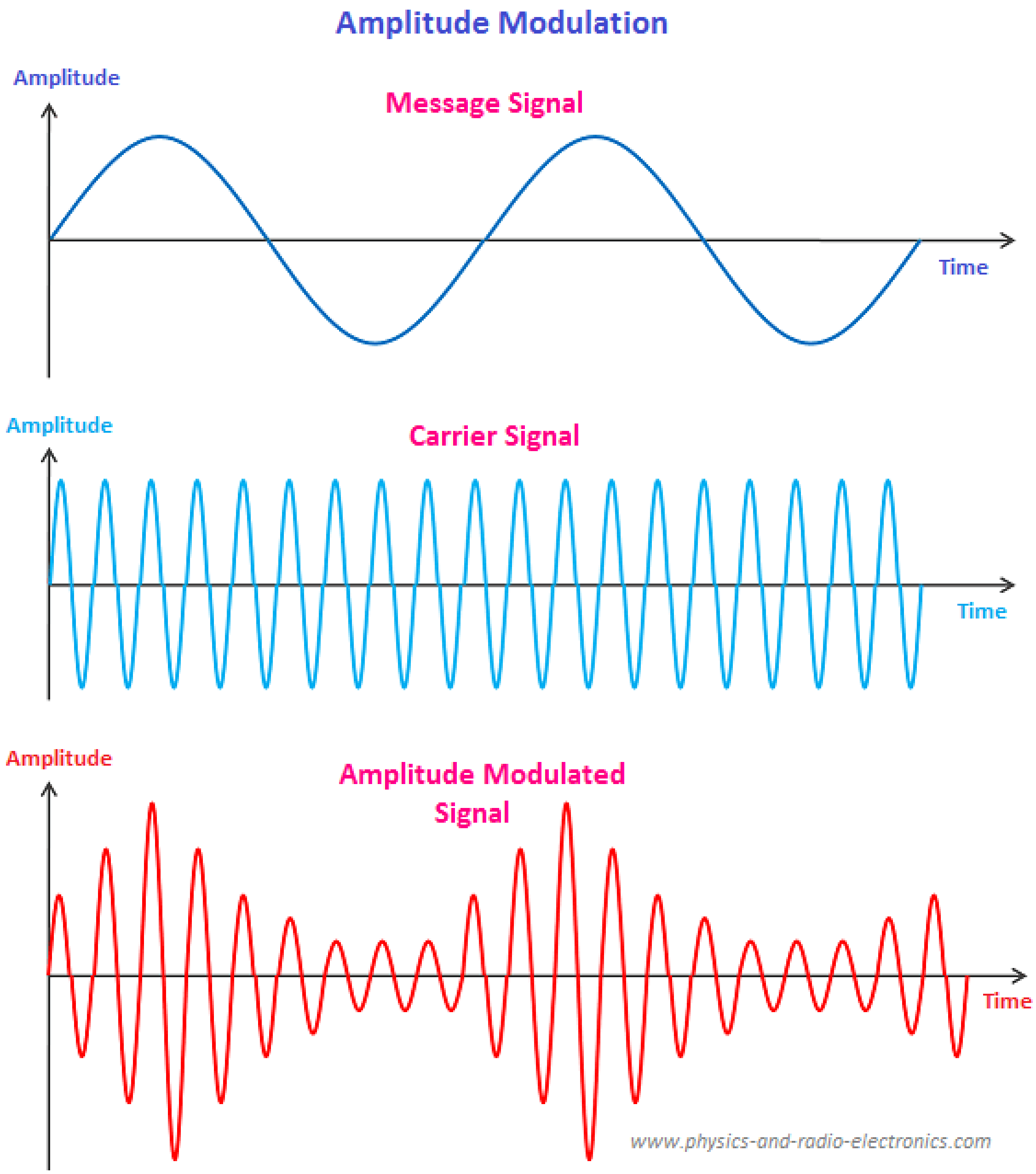
Modulation is the process of changing the characteristics (amplitude, frequency or phase) of the carrier signal, in accordance with the amplitude of the message signal.

A device that performs modulation is called modulator.

Example:

The modulation process can be understood with a simple example. The below figure shows the amplitude modulation.

Amplitude modulation is a type of modulation where the amplitude of the carrier signal is varied (changed) in accordance with the amplitude of the message signal while the frequency and phase of carrier signal remain constant.



The first figure shows the modulating signal or message signal which contains information, the second figure shows the high frequency carrier signal which contains no information and the last figure shows the resultant amplitude modulated signal.

From the above three figures, it can be observed that the amplitude of the carrier signal is varied in accordance with the instant amplitude of the message signal.

Types of Signals in Modulation

In modulation process, three types of signals are used to transmit information from source to destination. They are:

1) Message signal

2) Carrier signal

3) Modulated signal

1) Message signal

The signal which contains a message to be transmitted to the destination is called a message signal. The message signal is also known as a modulating signal or baseband signal.

The original frequency range of a transmission signal is called baseband signal. The message signal or baseband signal undergoes a process called modulation before it gets transmitted over the communication channel. Hence, the message signal is also known as the modulating signal.

2) Carrier signal

The high energy or high frequency signal which has characteristics like amplitude, frequency, and phase but contains no information is called a carrier signal. It is also simply referred to as a carrier. Carrier signal is used to carry the message signal from transmitter to receiver. The carrier signal is also sometimes referred to as an empty signal.

3) Modulated signal

When the message signal is mixed with the carrier signal, a new signal is produced. This new signal is known as a modulated signal. The modulated signal is the combination of the carrier signal and modulating signal.

Need for Modulation

Modulation is extremely necessary in communication system because of the following reasons:

1) Avoids mixing of signals

2) Increase the range of communication

3) Wireless communication

4) Reduces the effect of noise

5) Reduces height of antenna

1) **Avoids mixing of signals**

One of the basic challenges facing by the communication engineering is transmitting individual messages simultaneously over a single communication channel. A method by which many signals or multiple signals can be combined into one signal and transmitted over a single communication channel is called multiplexing.

We know that the sound frequency range is 20 Hz to 20 KHz. If the multiple baseband sound signals of same frequency range (I.e. 20 Hz to 20 KHz) are combined into one signal and transmitted over a single communication channel without doing modulation, then all the signals get mixed together and the receiver cannot separate them from each other. We can easily overcome this problem by using the modulation technique.

By using modulation, the baseband sound signals of same frequency range (I.e. 20 Hz to 20 KHz) are shifted to different frequency ranges. Therefore, now each signal has its own frequency range within the total bandwidth.

After modulation, the multiple signals having different frequency ranges can be easily transmitted over a single communication channel without any mixing and at the receiver side, they can be easily separated.

2) **Increase the range of communication**

The energy of a wave depends upon its frequency. The greater the frequency of the wave, the greater the energy possessed by it. The baseband audio signals frequency is very low so they cannot be transmitted over large distances. On the other hand, the carrier signal has a high frequency or high energy. Therefore, the carrier signal can travel large distances if radiated directly into space.

The only practical solution to transmit the baseband signal to a large distance is by mixing the low energy baseband signal with the high energy carrier signal. When the low frequency or low energy baseband signal is mixed with the high frequency or high energy carrier signal, the resultant signal frequency will be shifted from low frequency to high frequency. Hence, it becomes possible to transmit information over large distances. Therefore, the range of communication is increased.

3) **Wireless communication**

In radio communication, the signal is radiated directly into space. The baseband signals have very low frequency range (I.e. 20 Hz to 20 KHz). So it is not possible to radiate baseband signals directly into space because of its poor signal strength. However, by using the modulation technique, the frequency of the baseband signal is shifted from low frequency to high frequency. Therefore, after modulation, the signal can be directly radiated into space.

4) **Reduces the effect of noise**

Noise is an unwanted signal that enters the communication system via the communication channel and interferes with the transmitted signal.

A message signal cannot travel for a long distance because of its low signal strength. Addition of external noise will further reduce the signal strength of a message signal. So in order to send the message signal to a long distance, we need to increase the signal strength of the message signal. This can be achieved by using a technique called modulation.

In modulation technique, a low energy or low frequency message signal is mixed with the high energy or high frequency carrier signal to produce a new high energy signal which carries information to a long distance without getting affected by the external noise.

5) **Reduces height of antenna**

When the transmission of a signal occurs over free space, the transmitting antenna radiates the signal out and receiving antenna receives it. In order to effectively transmit and receive the signal, the antenna height should be approximately equal to the wavelength of the signal to be transmitted.

Now,

$$\text{Wavelength}\ (\lambda) = \frac{\text{Velocity (V)}}{\text{Frequency (C)}} = \frac{3 \times 10^8}{\text{frequency (Hz)}}\ \text{metres}$$

When the transmission of signal occurs over free space, the transmitting antenna radiates the signal out and receiving antenna receives it. In order to effectively transmit and receive the signal, the antenna height should be approximately equal to the wavelength of a signal to be transmitted.

The audio signal has a very low frequency (I.e. 20 Hz to 20 kHz) and longer wavelength, so if the signal is transmitted directly into space, the length of the transmitting antenna required would be extremely large.

For instance, to radiate an audio signal frequency of 20 kHz directly into space, we would need an antenna height of 15,000 meters.

$$\text{Wavelength}\ (\lambda) = \frac{\text{Velocity (V)}}{\text{Frequency (C)}} = \frac{3\times10^8}{20\ \text{kHz}} = \frac{3\times10^8}{20\times10^3} = 15{,}000\ \text{metres}$$

For instance, to radiate a frequency of 20 kHz directly into space, we would need an antenna length of

$$\text{Wavelength}\ (\lambda) = \frac{\text{Velocity (V)}}{\text{Frequency (C)}} = \frac{3\times10^8}{200\ \text{MHz}+20\ \text{Hz}} = \frac{3\times10^8}{(200\times10^6)+20} = 1.5\ \text{metre}$$

The antenna of this height is practically impossible to construct.

On the other hand, if the audio signal (20 Hz) has been modulated by a carrier wave of 200 MHz. Then, we would need an antenna height of 1.5 meters.

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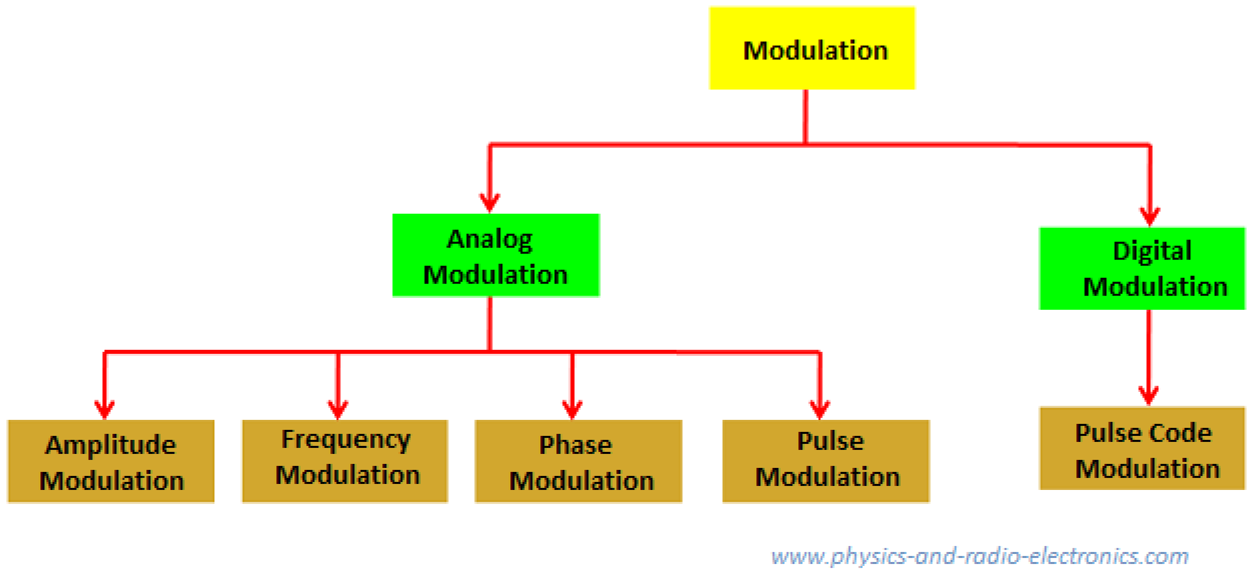
The antenna of this height is easy to construct.

Types of Modulation



Basically, the modulation is classified into two types: analog modulation and digital modulation.

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Analog modulation

In analog modulation, the analog signal (sinusoidal signal) is used as a carrier signal that modulates the analog message signal. In analog modulation, the characteristics (amplitude, frequency or phase) of the carrier signal is varied in accordance with the amplitude of the message signal.

There are four basic types of analog modulation:

1) Amplitude modulation

2) Frequency modulation

3) Phase modulation

4) Analog pulse modulation

1) **Amplitude modulation**

Amplitude modulation is a type of modulation where the amplitude of the carrier signal is varied (changed) in accordance with the amplitude of the message signal while the frequency and phase of carrier signal remain constant.

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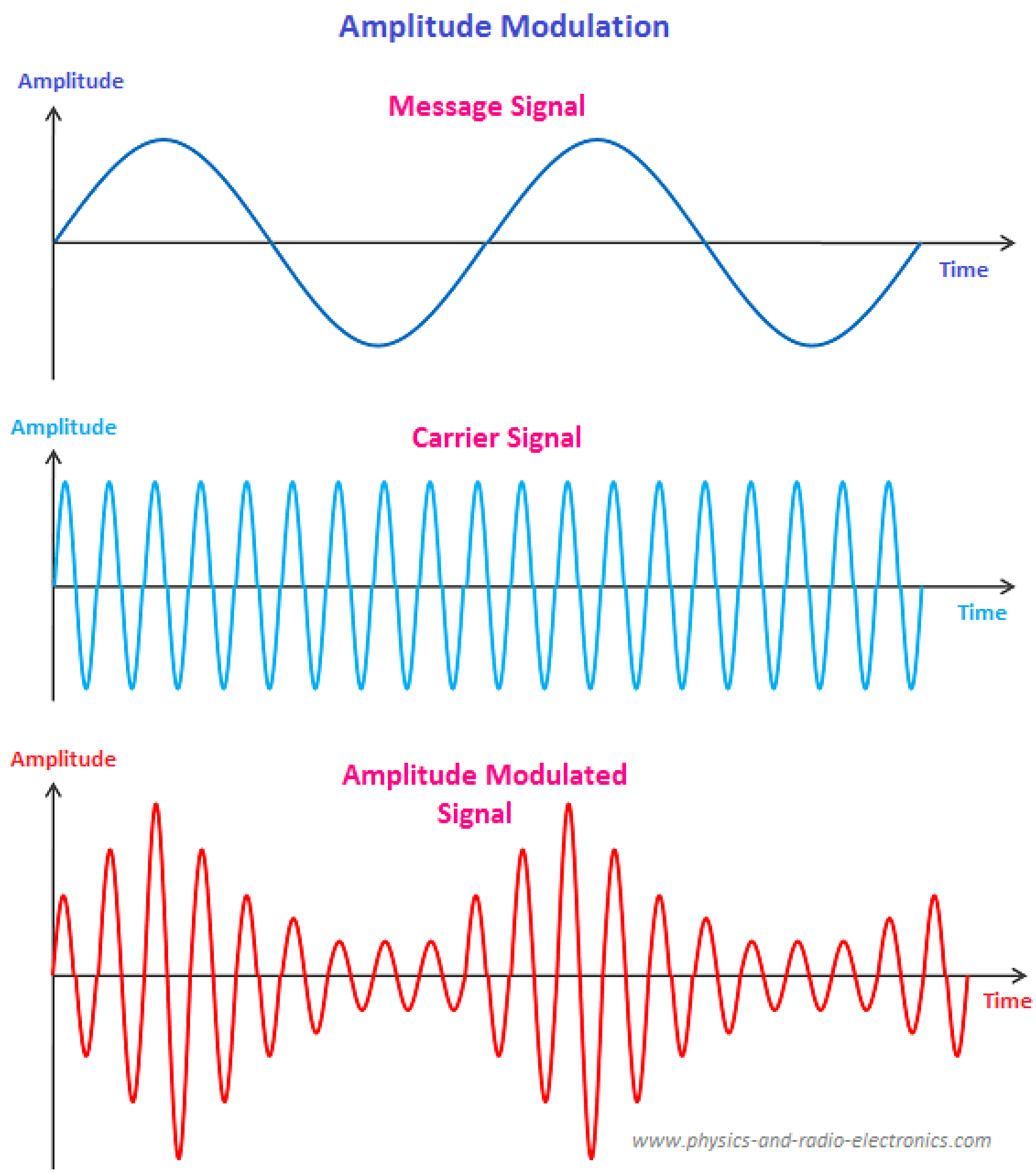


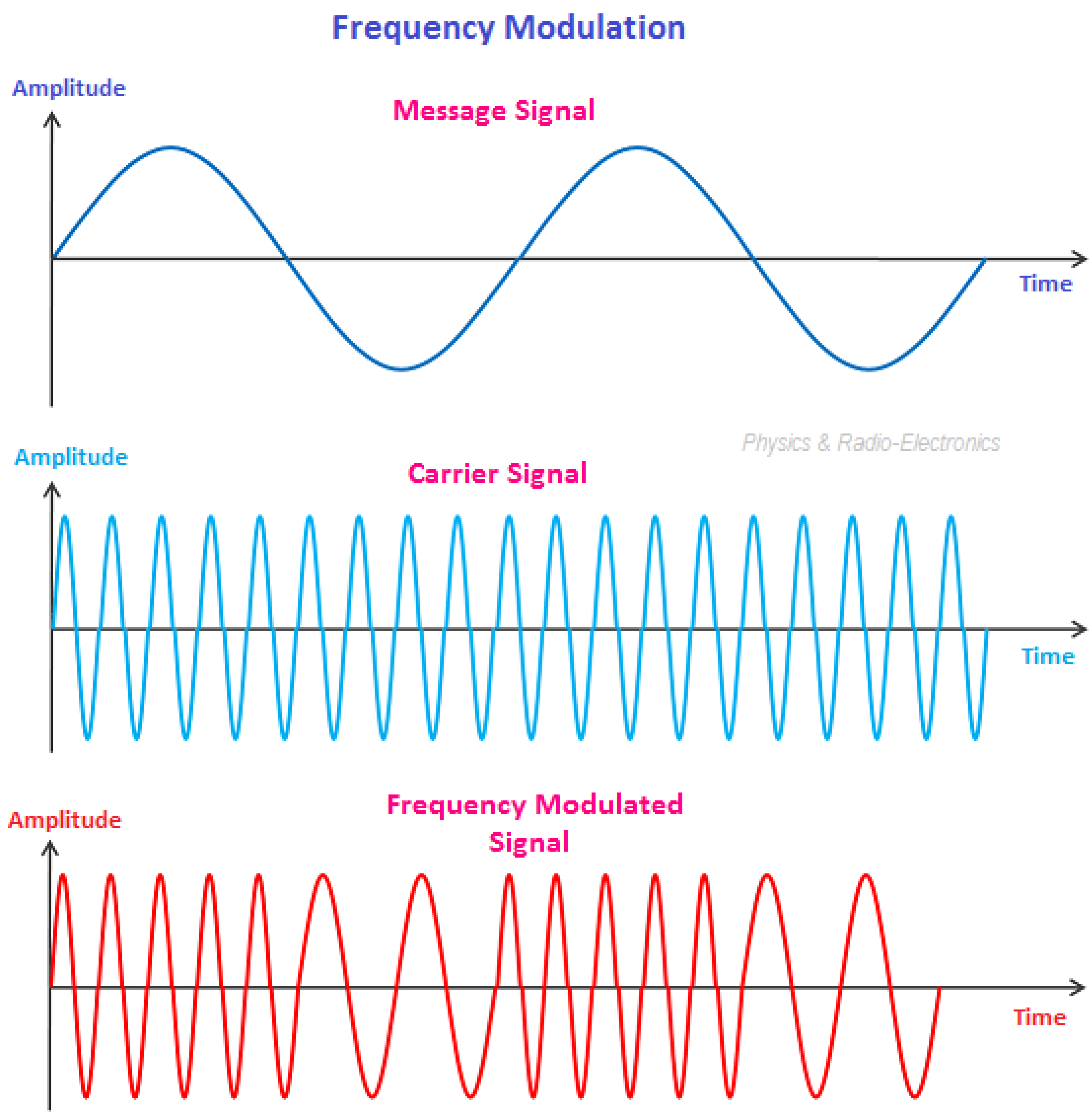
The above figure shows the amplitude modulation.

The first figure shows the modulating signal or message signal which contains information, the second figure shows the high frequency carrier signal which contains no information and the last figure shows the resultant amplitude modulated signal.

From the above three figures, it can be observed that the amplitude of the carrier signal is varied in accordance with the instant amplitude of the message signal.

2) **Frequency modulation**

Frequency modulation is a type of modulation where the frequency of the carrier signal is varied (changed) in accordance with the amplitude of the message signal while the amplitude and phase of carrier signal remain constant.



Frequency modulation is a type of modulation where the frequency of the carrier signal is varied (changed) in accordance with the amplitude of the message signal while the amplitude and phase of carrier signal remain constant.

The above figure shows the frequency modulation.

The first figure shows the modulating signal or message signal, the second figure shows the high frequency carrier signal which contains no information and the last figure shows the resultant frequency modulated signal.

From the above three figures, it can be observed that the frequency of the carrier signal is varied in accordance with the instant amplitude of the message signal.

3) **Phase modulation**

Phase modulation is a type of modulation where the phase of the carrier signal is varied (changed) in accordance with the amplitude of the message signal while the amplitude of carrier signal remains constant.

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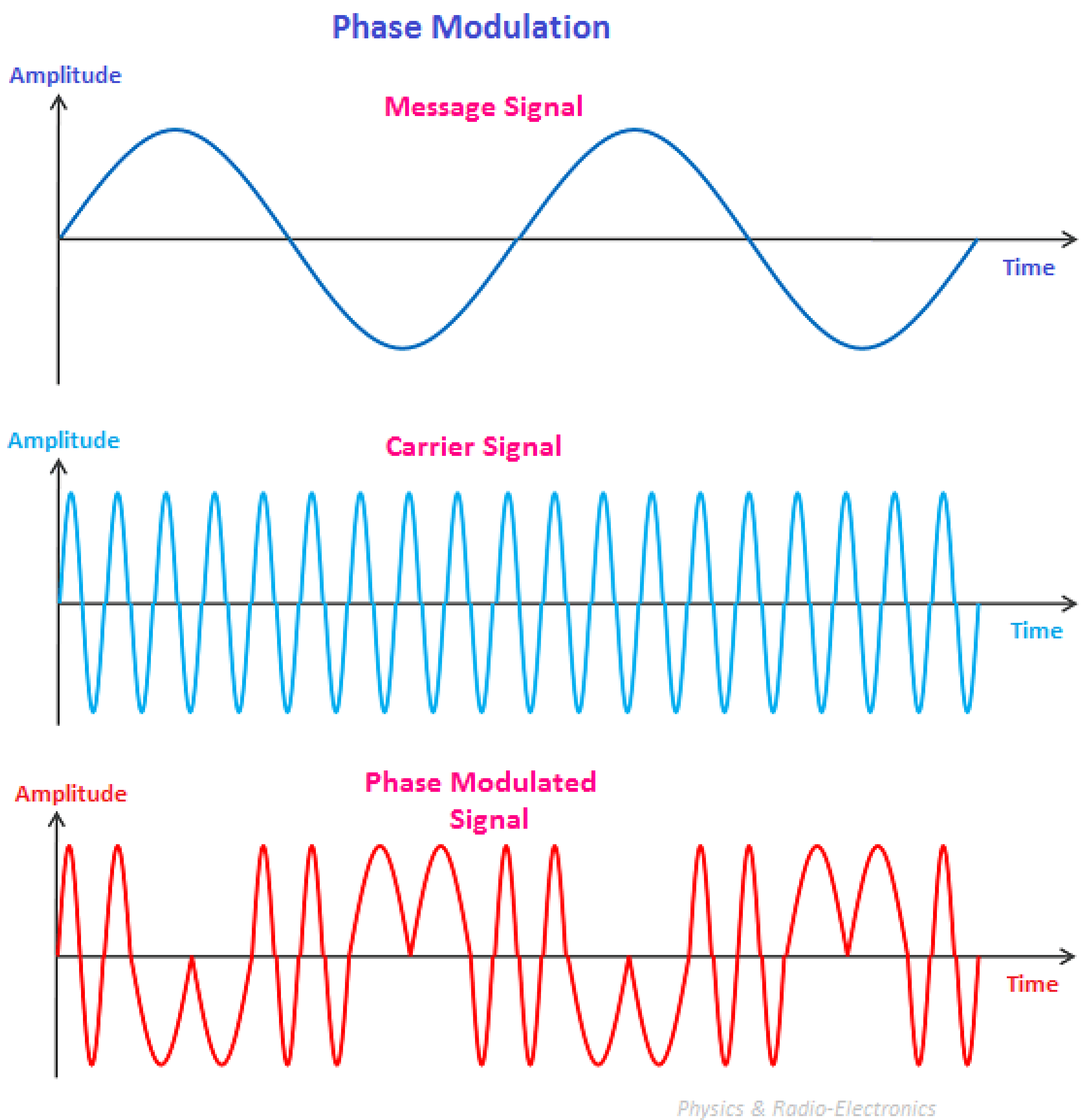


The above figure shows the phase modulation.

The first figure shows the modulating signal or message signal, the second figure shows the high frequency carrier signal which contains no information and the last figure shows the resultant phase modulated signal.

From the above three figures, it can be observed that the phase of the carrier signal is varied in accordance with the instant amplitude of the message signal.

In this type of modulation, when the phase is changed it also affects the frequency so this modulation also comes under frequency modulation.

The frequency and phase modulation comes under angle modulation. When the frequency or phase of the carrier signal is varied (changed) in accordance with the amplitude of the message signal, then it is called angle modulation.

4) **Analog pulse modulation**

In amplitude, frequency and phase modulation techniques, the carrier and message signals are continuous signals (sinusoidal signals). However, in analog pulse modulation, the carrier signal is a discontinuous signal (series of pulses) and message signal is a continuous signal (sinusoidal signal).

Analog pulse modulation is the process of changing the characteristics (pulse amplitude, pulse width or pulse position) of the carrier pulse, in accordance with the amplitude of the message signal.

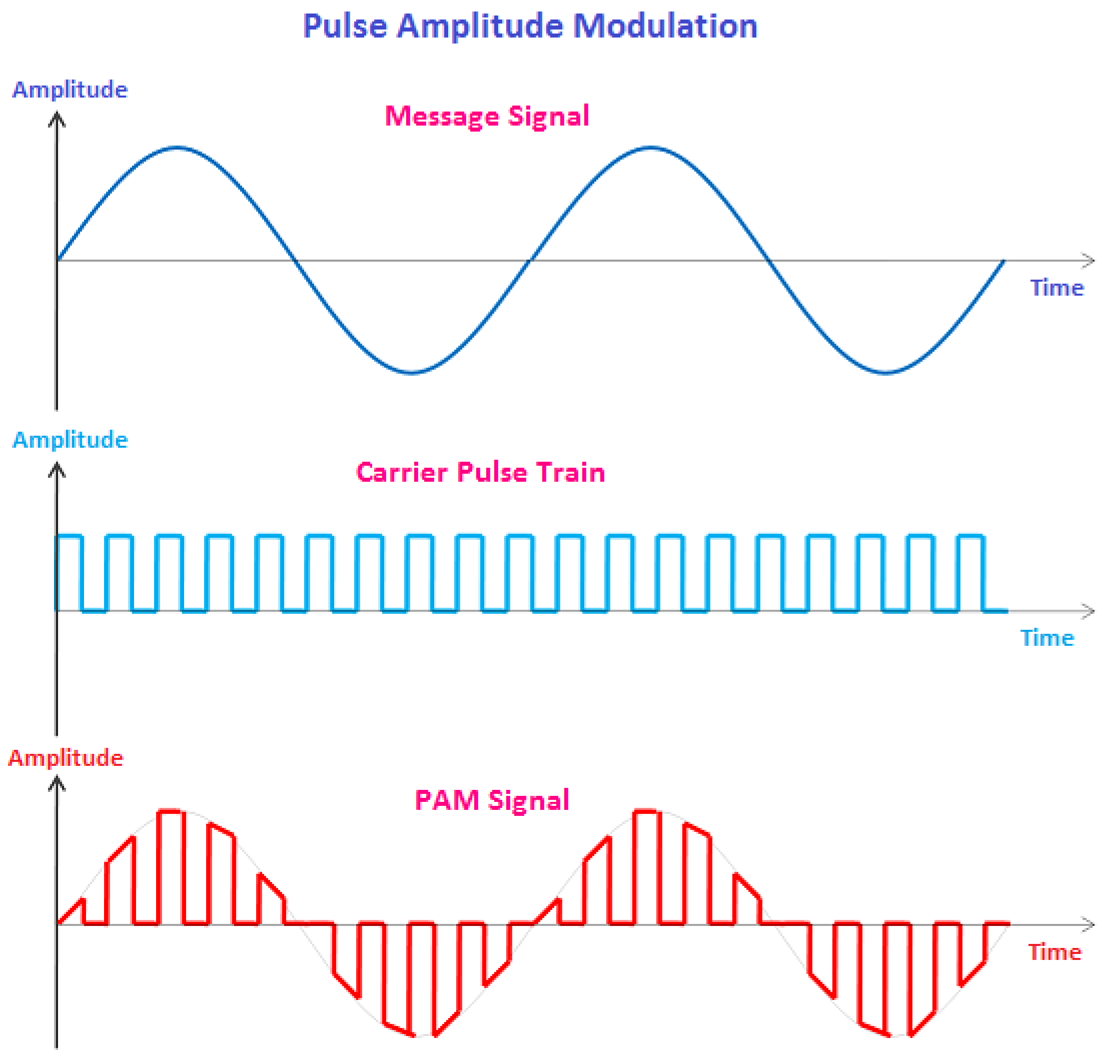
The analog pulse modulation is again classified as,

1. Pulse amplitude modulation

2. Pulse width modulation

3. Pulse position modulation

Example:



The analog pulse modulation can be understood with a simple example. The below figure shows the pulse amplitude modulation.

the amplitude of the series of carrier pulses are varied (changed) in accordance with the instant amplitude of the message signal while the width and positions of the carrier pulses remain constant.

The first figure shows the message signal (continuous signal), the second figure shows the carrier pulse train (series of pulses) which contains no information and the last figure shows the resultant pulse amplitude modulated (PAM) signal.

From the above three figures, it can be observed that the amplitude of the series of carrier pulses are varied (changed) in accordance with the instant amplitude of the message signal while the width and positions of the carrier pulses remain constant.

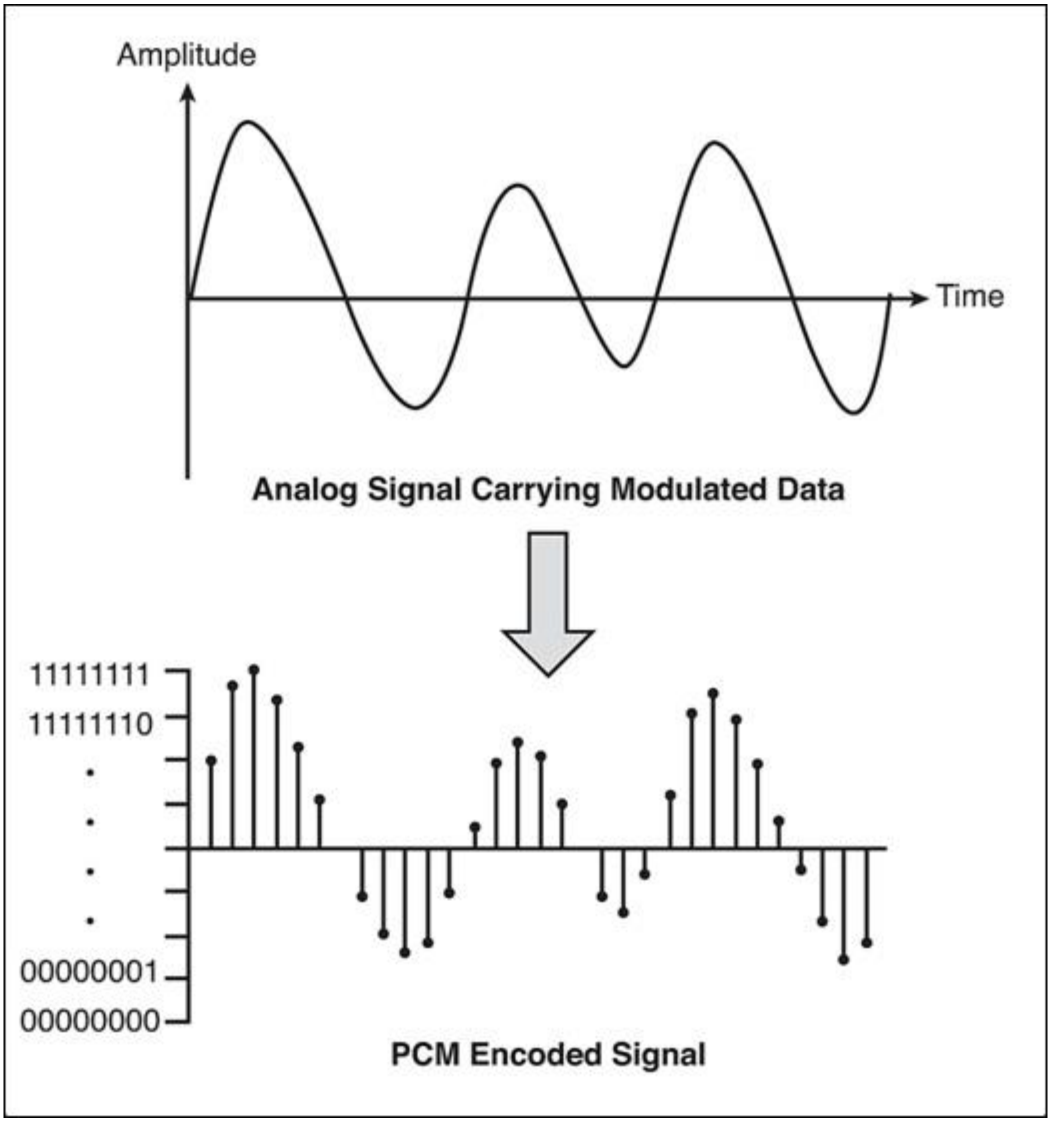
Analog modulation is more sensitive to noise. Noise is an unwanted signal that enters the communication system via the communication channel and interferes with the transmitted signal. The noise signal degrades the transmitted signal (signal containing information). Therefore, this drawback can be overcome by the digital modulation technique.

Digital modulation

The digital modulation technique is employed for efficient communication. The main advantage of the digital modulation over analog modulation include high noise immunity, available bandwidth, and permissible power. In digital modulation, the modulating signal or message signal is converted from analog to digital.

Pulse Code Modulation (PCM)

In digital modulation, the modulation technique used is Pulse Code Modulation (PCM). The pulse code modulation is the method of converting an analog signal into a digital signal I.e. 1s and 0s. As the resultant signal is a coded pulse train, this is called as pulse code modulation



Advantages of Pulse Code Modulation:

Pulse code modulation will have low noise addition and data loss is also very low.

We can repeat the exact transmitted signal at the receiver. This is called repeatability. And we can retransmit the signal with any distortion loss also.

Pulse code modulation is used in music play back CD's and also used in DVD for data storing whose sampling rate is bit higher.

Pulse code modulation can be used in storing the data.

PCM can encode the data also.

Multiplexing of signals can also be done using pulse code modulation. Multiplexing is nothing for adding the different signals and transmitting the signal at same time.

Pulse code modulation requires large bandwidth

Pulse code modulation permits the use of pulse regeneration.

Disadvantages of Pulse Code Modulation:

Specialized circuitry is required for transmitting and also for quantizing the samples at same quantized levels. We can do encoding using pulse code modulation but we need to have complex and special circuitry.

Pulse code modulation receivers are cost effective when we compared to other modulation receivers.

Developing pulse code modulation is bit complicated and checking the transmission quality is also difficult and takes more time.

Large bandwidth is required for pulse code modulation when compared to bandwidth used by the normal analog signals to transmit message.

Channel bandwidth should be more for digital encoding.

PCM systems are complicated when compared to analog modulation methods and other systems.

Decoding also needs special equipment’s and they are also too complex.

Applications of Pulse Code Modulation (PCM):

Pulse code modulation is used in telecommunication systems, air traffic control systems etc.

Pulse code modulation is used in compressing the data that is why it is used in storing data in optical disks like DVD, CDs etc. PCM is even used in the database management systems.

Pulse code modulation is used in mobile phones, normal telephones etc.

Remote controlled cars, planes, trains use pulse code modulations.

Generation of AM Waves:-

The circuit that generates the AM waves is called as amplitude modulator and in this post we will discuss two such modulator circuits namely :

Square Law Modulator

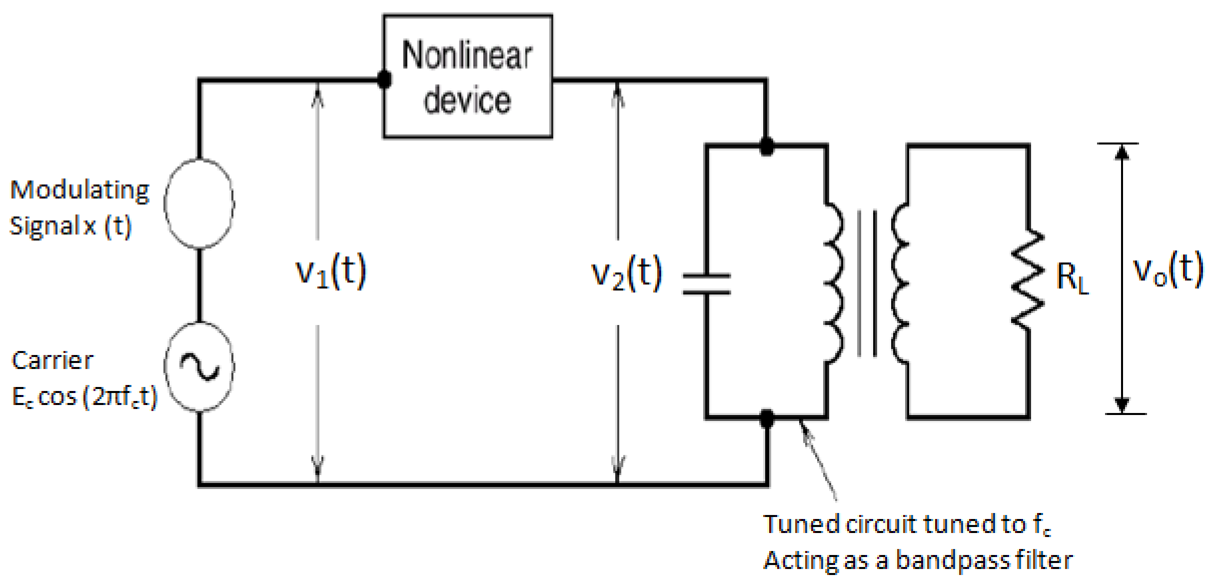
Switching Modulator

Both of these circuits use a non-linear elements such as a diode for their implementation . Both these modulators are low power modulator circuits .

Square Law Modulator

Generation of AM Waves using the square law modulator could be understood in a better way by observing the square law modulator circuit shown in fig .

square law modulator



It consists of the following :

A non-linear device

A bandpass filter

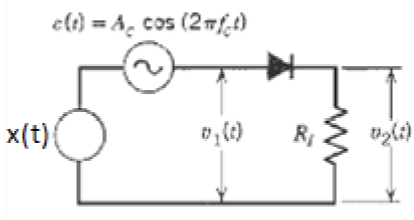
A carrier source and modulating signal

The modulating signal and carrier are connected in series with each other and their sum V1(t) is applied at the input of the non-linear device, such as diode, transistor etc.

Switching Modulator

Generation of AM Waves using the switching modulator could be understood in a better way by observing the switching modulator diagram. The switching modulator using a diode has been shown in fig

switching modulator idealized input-output relation



This diode is assumed to be operating as a switch .

The modulating signal x(t) and the sinusoidal carrier signal c(t) are connected in series with each other.

The amplitude of carrier is much larger than that of x(t) and c(t) decides the status of the diode (ON or OFF) .

Working Operation and Analysis

Let us assume that the diode acts as an ideal switch . Hence, it acts as a closed switch when it is forward biased in the positive half cycle of the carrier and offers zero impedance . Whereas it acts as an open switch when it is reverse biased in the negative half cycle of the carrier and offers an infinite impedance .

Let us assume that the diode acts as an ideal switch . Hence, it acts as a closed switch when it is forward biased in the positive half cycle of the carrier and offers zero impedance . Whereas it acts as an open switch when it is reverse biased in the negative half cycle of the carrier and offers an infinite impedance .

FM modulator

Armstrong FM modulator:

Frequency modulation generates high quality audio and greatly reduces the amount of noise on the channel when compared with amplitude modulation. Early broadcasters used amplitude modulation because it was easier to generate than frequency modulation and because the receivers were simpler to make. The electronics theory indicated that a frequency modulated signal would have infinite bandwidth; for an amplitude modulated signal, the bandwidth is approximately twice the highest modulating frequency.

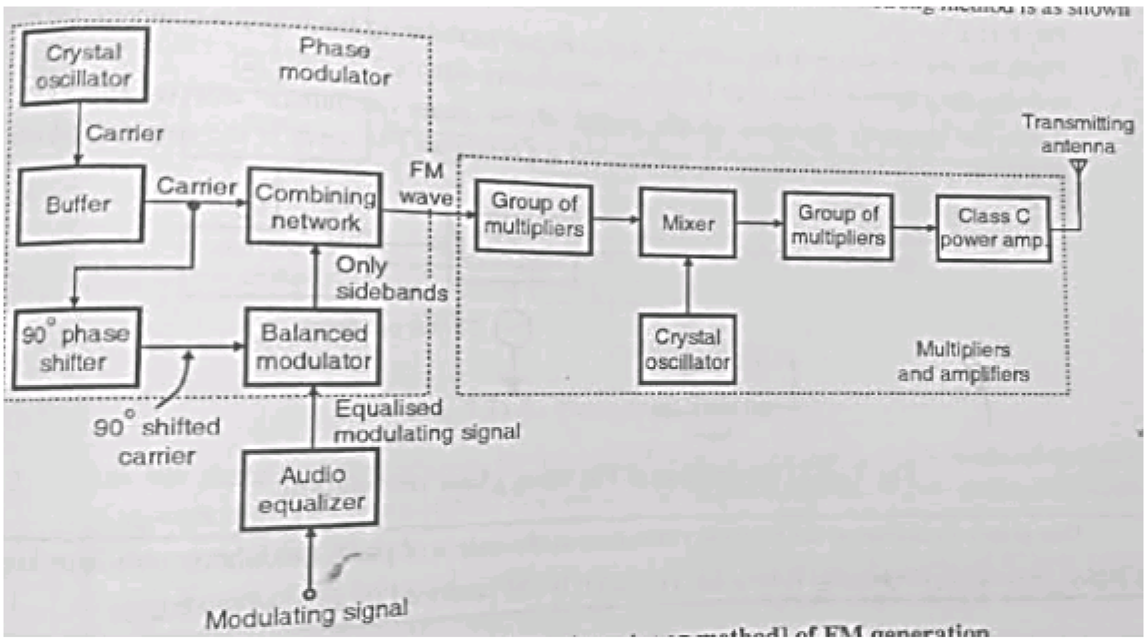


Fig: Indirect method [Armstrong method] of FM generation

working:-

The Armstrong method begins by generating a carrier signal at a very low frequency, say 500 kilohertz. This frequency is below the AM broadcast band and much below the current FM broadcast band of 88 to 108 megahertz. This carrier signal is applied to two stages in the transmitter: a balanced modulator and a mixer.

To understand how a balanced modulator works it is necessary to understand amplitude modulation and how it works. Most people describe amplitude modulation as a method of changing the strength of the carrier (amplitude) in sync with the modulating audio. This is true, the power output does change with modulation, but it changes because any AM modulator generates two sidebands, one above and one below the carrier. As power goes into these sidebands, the power output increases. The amplitude modulated signal, then, consists of a constant strength carrier and two sidebands. The sidebands carry the information and the carrier just goes along for the ride. The carrier can be removed at the transmitter and reinserted at the receiver to allow the transmitter to put all the power in the sidebands.

A frequency modulator also generates sidebands, but instead of one sideband on each side of the carrier, it generates many sidebands on each side of the carrier. The FM bandwidth is wider because of the many sidebands. The power output from an FM transmitter is constant with modulation, so as power goes into the sidebands, the carrier power is reduced.

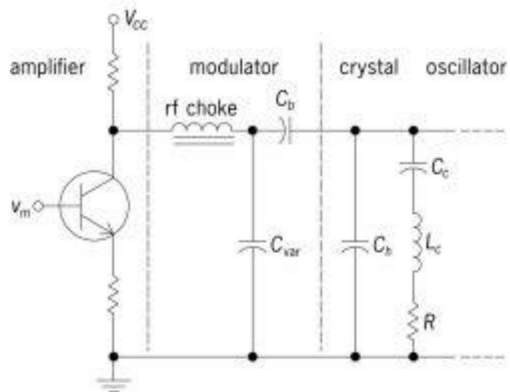
A balanced modulator mixes the audio signal and the radio frequency carrier, but suppresses the carrier, leaving only the sidebands. The output from the balanced modulator is a double sideband suppressed carrier signal and it contains all the information that the AM signal has, but without the carrier. It is possible to generate an AM signal by taking the output from the balanced modulator and reinserting the carrier.[3]

In the Armstrong method, the audio signal and the radio frequency carrier signal are applied to the balanced modulator to generate a double sideband suppressed carrier signal. The phase of this output signal is then shifted 90 degrees with respect to the original carrier. The balanced modulator output can either lead or lag the carrier's phase. The double sideband signal and the original carrier signal are then applied to the mixer, and the original carrier—90 degrees out of phase—is reinserted. The output from the mixer is a frequency modulated signal.

Reinserting the carrier without the phase shift produces an AM signal. Reinserting the carrier with the 90 degree phase shift produces a PM signal. If the intelligence is integrated before being applied to the resulting phase modulator, this equivalent to a FM signal.

Varactor diode FM modulator

An electronic circuit or device producing frequency modulation. This device changes the frequency of an oscillator in accordance with the amplitude of a modulating signal. If the modulation is linear, the frequency change is proportional to the amplitude of the modulating voltage.



High-frequency oscillators usually employ either LC (inductance-capacitance) tuned circuits or piezoelectric crystals to establish the frequency of oscillation. This frequency can be controlled by changing the effective capacitance or inductance of the tuned circuit in accordance with the modulating signal. Practical circuits usually employ a varactor diode to change the oscillator in accordance with a modulating voltage.

The oscillators in high-frequency electronic systems, such as frequency-modulating (FM) transmitters, usually employ piezoelectric crystals for precise control of the carrier frequency. These crystals are equivalent to a series LC tuned circuit with an extremely high Q. The crystal holder has a small capacitance which is in parallel with the crystal and therefore causes parallel resonance at a slightly higher frequency than the series resonant frequency of the crystal. The actual oscillator frequency is between these two resonant frequencies and is controllable by the parallel capacitance.

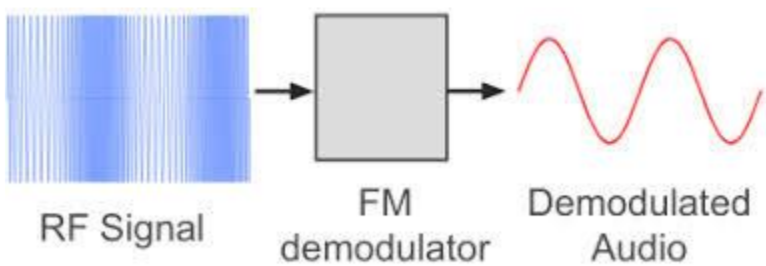
The junction capacitance of a semiconductor diode varies with the diode voltage, and a reverse-biased diode may be used to control the oscillator frequency to produce frequency modulation. Low-loss diodes designed for this service are known as varactor diodes and have trade names such as Varicaps or Epicaps. A basic varactor modulating scheme is shown in the illustration. In this circuit, the transistor that drives the varactor modulator provides reverse bias as well as the modulating voltage vm. The radio-frequency (rf) choke provides very high impedance at the oscillator frequency to isolate the transistor amplifier output impedance from the oscillator circuit but to allow the modulating signal to pass through with negligible attenuation. Only the frequency-determining part of the oscillator is shown. The symbols Cc, Lc, and R represent the electrical equivalents of the compliance, mass, and loss, respectively, of the crystal; Ch is the crystal-holder capacitance and Cb is a dc blocking capacitor. See Varactor

Basic varactor modulator circuit

The varactor-diode modulator is also commonly used to control the frequency of local oscillators in radio receiving equipment where programmed, push-button, or remote tuning is desirable. In these applications, conventional LC tuned circuits may be used.

FM demodulation basics

In any radio that is designed to receive frequency modulated signals there is some form of FM demodulator or detector.



This circuit takes in frequency modulated RF signals and takes the modulation from the signal to output only the modulation that had been applied at the transmitter.

The principle behind the demodulation / detection of frequency modulated, FM signals.

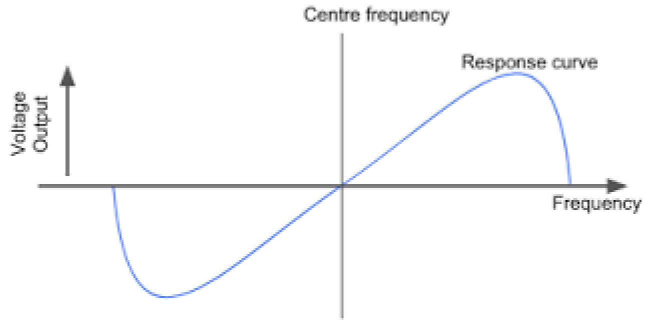
FM demodulation principle

In order to be able to demodulate FM it is necessary for the radio receiver to convert the frequency variations into voltage variations.

It is necessary to have a response that is as linear as possible over the required bandwidth.

The typical response curve for a frequency demodulator known as the S curve

Frequency demodulator S response curve



The response that is normally seen for an FM demodulator / FM detector is known as an "S" curve for obvious reasons. There is a linear portion at the centre of the response curve and towards the edge the response becomes very distorted.

Types of FM demodulator

There are several types of FM detector / demodulator that can be used. Some types were more popular in the days when radios were made from discrete devices, but nowadays the PLL based detector and quadrature / coincidence detectors are the most widely used as they lend themselves to being incorporated into integrated circuits very easily and they do not require many, if any adjustments.

Slope detection: This is a very simple form of FM demodulation and it relies on the selectivity of the receiver itself to provide the demodulation. It is not particularly effective and is not used except

Ratio detector: This type of detector was one that was widely used when discrete components were used in transistor radios.

Foster Seeley FM : In the days when radio used discrete components, this was the other main contender for the FM demodulator in radios.

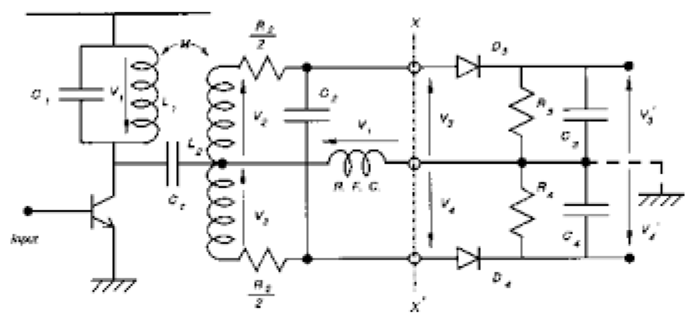
Phase locked loop demodulator: It is possible to use a phase locked loop to demodulate FM. The PLL FM detector provides excellent performance and does not require many.

Quadrature detector: The quadrature FM detector is now widely used in FM radio ICs. It is easy to implement and provides excellent levels of performance.

These FM demodulators are used in different applications. Although the PLL FM detector and the quadrature detectors are most widely used, the Foster Seeley and ratio FM detectors are still used on some occasions.

Foster-Seeley FM discriminator basics

The Foster Seeley detector or as it is sometimes described the Foster Seeley discriminator is quite similar to the ratio detector at a first look. It has an RF transformer and a pair of diodes, but there is no third winding - instead a choke is used.



FM Foster Seeley detector / demodulator / discriminator circuit

Like the ratio detector, the Foster-Seeley circuit operates using a phase difference between signals. To obtain the different phased signals a connection is made to the primary side of the transformer using a capacitor, and this is taken to the centre tap of the transformer. This gives a signal that is 90° out of phase.

When an un-modulated carrier is applied at the centre frequency, both diodes conduct, to produce equal and opposite voltages across their respective load resistors. These voltages cancel each one another out at the output so that no voltage is present. As the carrier moves off to one side of the centre frequency the balance condition is destroyed, and one diode conducts more than the other. This results in the voltage across one of the resistors being larger than the other, and a resulting voltage at the output corresponding to the modulation on the incoming signal.

The choke is required in the circuit to ensure that no RF signals appear at the output. The capacitors C1 and C2 provide a similar filtering function.

Both the ratio detector and Foster-Seeley detectors are expensive to manufacture. Any wound components like the RF transformers are expensive to manufacture when compared with integrated circuits produced in vast numbers. As a result the Foster Seeley discriminator as well as the ratio detector circuits are rarely used in modern radio receivers as FM demodulators.

Foster-Seeley detector advantages & disadvantages

As with any circuit there are a number of advantages and disadvantages to be considered when choosing between the various techniques available for FM demodulation.

Advantages of Foster-Seeley FM discriminator:

Offers good level of performance and reasonable linearity.

Simple to construct using discrete components.

Provides higher output than the ratio detector

Provides a more linear output, i.e. lower distortion than the ratio detector

Disadvantages of Foster-Seeley FM discriminator:

Does not easily lend itself to being incorporated within an integrated circuit.

High cost of transformer.

Narrower bandwidth than the ratio detector

FM Ratio Detector: FM ratio discriminator

The ratio FM detector is an easily used form of FM demodulator very appropriate for discrete components.

The ratio FM detector, discriminator or demodulator was widely used for FM demodulation for radio receivers that typically used discrete components. Now with radios using integrated circuits other forms of FM demodulator are more applicable.

When used, the FM ratio detector was able to provide good levels of performance with limited number of components.

The FM ratio detector may also be called an FM ratio demodulator or even an FM ratio discriminator.

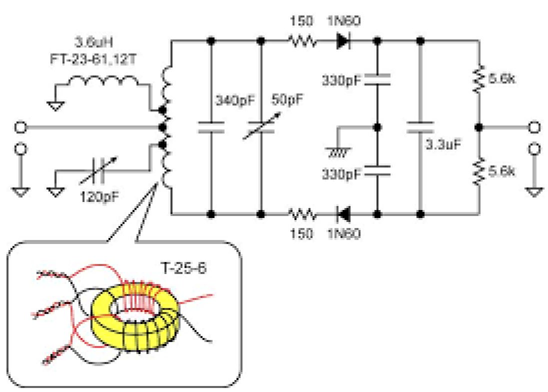
Typical transistor radio that might use a FM ratio detector

Typical transistor radio that uses a ratio FM detector

FM ratio detector basics

The two main types of FM detector or demodulator that were used in circuits using discrete components were the ratio detector and the Foster-Seeley FM detector.

Both types were widely used, but the FM ratio detector was the more common because it offered a better level of amplitude modulation rejection of amplitude modulation. This enabled the circuit to provide a greater level of noise immunity as most noise is amplitude noise. It also enabled the FM detector to operate more effectively even with with lower levels of limiting in the preceding IF stages of the receiver.



FM ratio detector / demodulator / discriminator circuit

The operation of the ratio detector centres around a frequency sensitive phase shift network with a transformer and the diodes that are effectively in series with one another. When a steady carrier is applied to the circuit the diodes act to produce a steady voltage across the resistors R1 and R2, and the capacitor C3 charges up as a result.

The transformer enables the circuit to detect changes in the frequency of the incoming signal. It has three windings. The primary and secondary act in the normal way to produce a signal at the output. The third winding is un-tuned and the coupling between the primary and the third winding is very tight, and this means that the phasing between signals in these two windings is the same.

The primary and secondary windings are tuned and lightly coupled. This means that there is a phase difference of 90° between the signals in these windings at the centre frequency. If the signal moves away from the centre frequency the phase difference will change. In turn the phase difference between the secondary and third windings also varies. When this occurs the voltage will subtract from one side of the secondary and add to the other causing an imbalance across the resistors R1 and R2. As a result this causes a current to flow in the third winding and the modulation to appear at the output.

Ratio detector advantages & disadvantages

As with any circuit there are a number of advantages and disadvantages to be considered when choosing between several options.

Advantages of the ratio FM detector

Simple to construct using discrete components.

Offers good level of performance and reasonable linearity.

Provides a good level of immunity to amplitude noise .

Ratio detector has wider bandwidth than Foster Seeley discriminator.

Disadvantages of the FM ratio detector

High cost of transformer.

Typically lends itself to use in only circuits using discrete components and not integrated within an IC.

Only 50% output of the Foster-Seeley discriminator

Higher distortion level than Foster-Seeley discriminator.