
# East West University

*Department of Computer Science and Engineering*

**Report**

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***Submitted By:***

**Md. Fatin Istiaq 2015-1-60-044**

**Md. Tohidul Islam 2015-1-60-032**

***Submitted To:***

**Maheen Islam**

**Assistant Professor**

**Department of Computer Science and Engineering**

**East West University**

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## Abstract:

Signal modulation is a widely used technique in data communication and it is used to establish a reliable communication between sender and receiver. To convert analog data to analog signal different modulation technique is used. Here we will discuss Amplitude Modulation (AM) and Frequency Modulation (FM) technique, their application, advantages and disadvantages.

## Introduction:

A signal is an electrical or electromagnetic current that is used for carrying data from one device or network to another. A message carrying signal has to get transmitted over a distance and for it to establish a reliable communication, it needs to take the help of a high frequency signal which should not affect the original characteristics of the message signal. In the AM, amplitude of carrier signal wave is varied in accordance with the modulating or message signal by keeping the phase and frequency of the signals constant. On the other hand, FM is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. Both the techniques have some merits and demerits.

## Background Study:

A signal is created when a command or data is sent to a device. It has implementation in electrical and electronic components as well, but it mainly refers to analog and digital communication technologies and devices. Each signal carries data in some form. The data is fed into the signal using analog or digital modulation techniques, depending upon the source and destination device and/or medium. Here the goal is to show how a signal is modulated. Here we use two different modulation technique- Amplitude Modulation and Frequency Modulation. First we have to know what is modulation. Modulation is a technique in which message signal is transmitted to the receiver with the help of carrier signal. Here in modulation, we combine both carrier signal and message signal. You may get the doubt that what is the need of modulation. Just imagine that you have a paper which contains the message and you would like to send it to your friend standing 40 feet from your place. You can't just through the paper to your friend because paper will not travel that much distance but if you take small stone and cover the paper with it and through it to your friend, it will definitely reach the target. In the same way, we need a carrier signal to transmit our message. Sometimes, message signal is also called as modulating signal. The exact definition of modulation is given below:
"Modulation is a process of message signal and modulating is varied according to the carrier signal for transmission purpose. The message signal can varied in accordance to the carrier signal that is in terms of angular or amplitude. So we are modulating the signal."

## Why Need Modulation:

The baseband signals are incompatible for direct transmission. For such a signal, to travel longer distances, its strength has to be increased by modulating with a high frequency carrier wave, which doesn't affect the parameters of the modulating signal.

## Signals in the Modulation Process:

Following are the three types of signals in the modulation process.

## Message or Modulating Signal:

The signal which contains a message to be transmitted, is called as a message signal. It is a baseband signal, which has to undergo the process of modulation, to get transmitted. Hence, it is also called as the modulating signal.

## Carrier Signal:

The high frequency signal which has a certain phase, frequency, and amplitude but contains no information, is called a carrier signal. It is an empty signal. It is just used to carry the signal to the receiver after modulation.

## Modulated Signal:

The resultant signal after the process of modulation, is called as the modulated signal. This signal is a combination of the modulating signal and the carrier signal.

## Amplitude Modulation:

In the amplitude modulation, amplitude of carrier signal wave is varied in accordance with the modulating or message signal by keeping the phase and frequency of the signals constant. The carrier signal frequency would be greater than the modulating signal frequency.

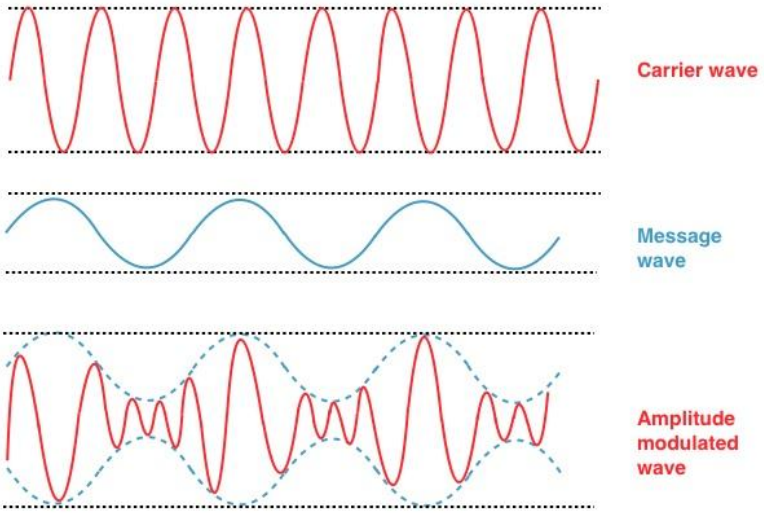


**Figure-01: Amplitude Modulation**

Amplitude modulation is first type of modulation used for transmitting messages for long distances by the mankind. The AM radio ranges in between 535 to 1705 kHz which is great. But when compared to frequency modulation, the Amplitude modulation is weak, but still it is used for transmitting messages. Bandwidth of amplitude modulation should be twice the frequency of modulating signal or message signal. If the modulating signal frequency is 10 kHz then the Amplitude modulation frequency should be around 20 kHz. In AM radio broadcasting, the modulating signal or message signal is 15 kHz. Hence the AM modulated signal which is used for broadcasting should be 30 kHz.

## Applications of Amplitude Modulation:

- Used to carry message signals in early telephone lines.
- Used in Navy and Aviation for communications as AM signals can travel longer distances.
- Widely used in amateur radio.

## Advantages of Amplitude Modulation:

- Simple to implement: For amplitude modulation, we use simple and low cost circuit; we don't need any special equipment and complex circuits that are used in frequency modulation.
- Lower bandwidth: Bandwidths limit is also big advantage for Amplitude modulation, which doesn't have in frequency modulation.
- Propagate longer distances: Because of amplitude modulation wavelength, AM signals can propagate longer distances.

## Disadvantages of Amplitude Modulation:

- Inefficient in terms of its power usage: More power is required during modulation because Amplitude modulated signal frequency should be double than modulating signal or message signal frequency. Due to this reason more power is required for amplitude modulation.
- Poor sound quality: AM has poor sound quality due to lower bandwidth.
- Adding of noise for amplitude modulated signal will be more when compared to frequency modulated signals. Data loss is also more in amplitude modulation due to noise addition. Demodulators cannot reproduce the exact message signal or modulating signal due to noise.

## Mathematical Expression:

Modulating signal,

$m(t) = A_m \sin\omega_m t$

Carrier signal,

$C(t) = A_C \sin\omega_C t$

The equation of Amplitude Modulated wave,

$C_m(t) = (A_C + A_m \sin\omega_m t) \sin\omega_C t$

$\therefore C_m(t) = A_C(1 + Am/Ac \sin\omega_m t) \sin\omega_C t$

$A_m/A_c = \mu$

$\mu$ = Modulation index

$C_m(t) = A_C(1 + \mu \sin\omega_m t) \sin\omega_C t$

$C_m(t) = A_C \sin\omega_C t + \mu A_C \sin\omega_m t \cdot \sin\omega_C t$

$\therefore C_m(t)\ A_C \sin\omega_C t + \mu\ Ac/2 \cos(\omega_C - \omega_m)t - \mu\ Ac/2 \cos(\omega_C + \omega_m)t$

It is a combination of 3 waves moving together with frequencies $\omega_C$, $(\omega_C - \omega_m)$ and $(\omega_C + \omega_m)$.

## Frequency Modulation:

In telecommunications and signal processing, frequency modulation (FM) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. This contrasts with amplitude modulation, in which the amplitude of the carrier wave varies, while the frequency remains constant.

In analog frequency modulation, such as FM radio broadcasting of an audio signal representing voice or music, the instantaneous frequency deviation, the difference

between the frequency of the carrier and its center frequency, is proportional to the modulating signal.

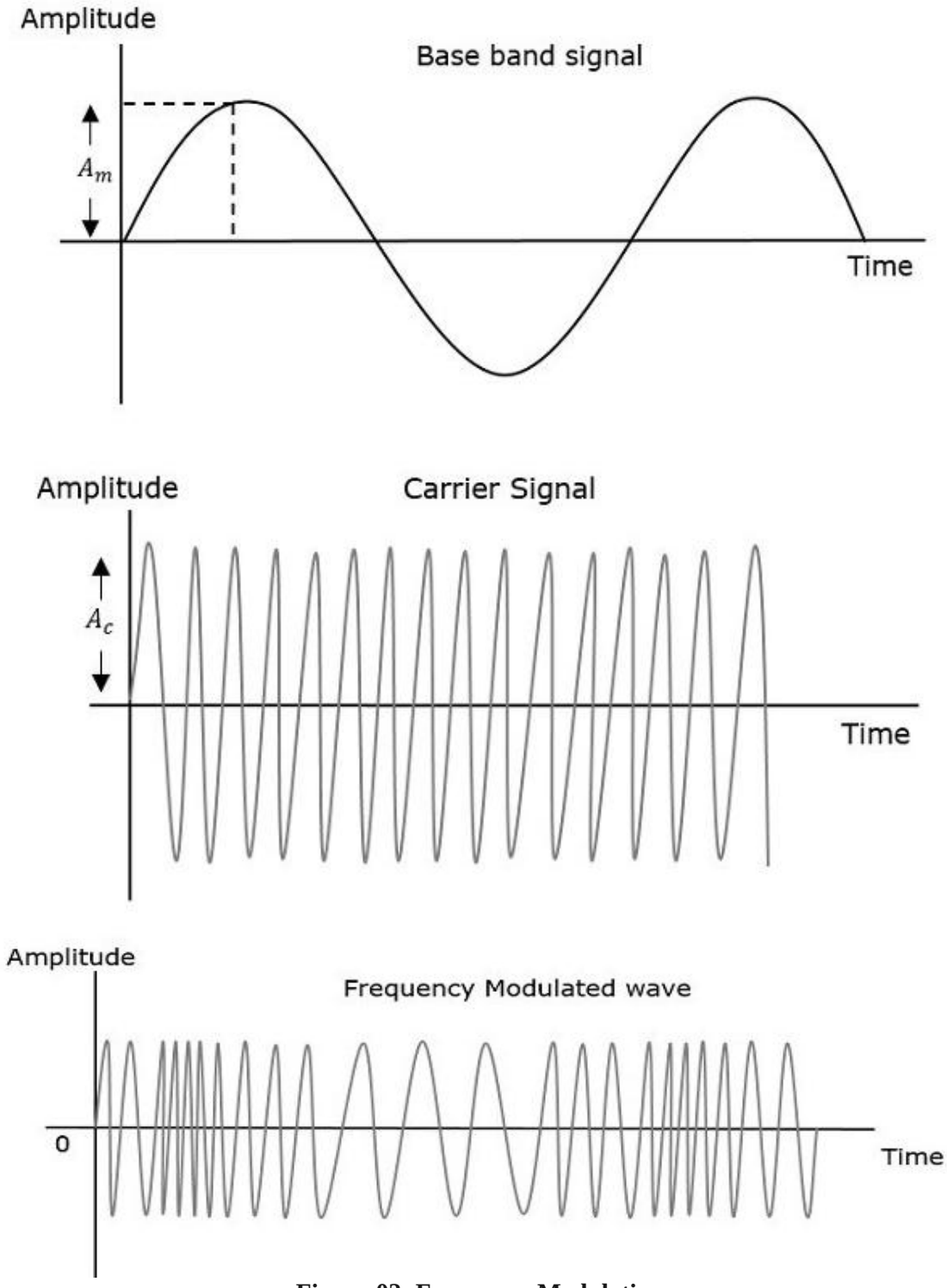


**Figure-02: Frequency Modulation**

## Application of Frequency Modulation:

- Mobile communications such as police wireless, ambulances, taxicabs, etc.
- Entertainment, broadcasting applications such as FM radio, TV, etc.

## Advantages of Frequency Modulation:

- **Resilience to noise:** One particular advantage of frequency modulation is its resilience to signal level variations. The modulation is carried only as variations in frequency. This means that any signal level variations will not affect the audio output, provided that the signal does not fall to a level where the receiver cannot cope. As a result this makes FM ideal for mobile radio communication applications including more general two-way radio communication or portable applications where signal levels are likely to vary considerably. The other advantage of FM is its resilience to noise and interference.
- **Easy to apply modulation at a low power stage of the transmitter:** Another advantage of frequency modulation is associated with the transmitters. It is possible to apply the modulation to a low power stage of the transmitter, and it is not necessary to use a linear form of amplification to increase the power level of the signal to its final value.
- **It is possible to use efficient RF amplifiers with frequency modulated signals:** It is possible to use non-linear RF amplifiers to amplify FM signals in a transmitter and these are more efficient than the linear ones required for signals with any amplitude variations (e.g. AM and SSB). This means that for a given power output, less battery power is required and this makes the use of FM more viable for portable two-way radio applications.

## Disadvantages of Frequency Modulation:

- **FM has poorer spectral efficiency than some other modulation formats:** Some phase modulation and quadrature amplitude modulation formats have a higher spectral efficiency for data transmission than frequency shift keying, a form of frequency modulation. As a result, most data transmission system uses PSK and QAM.
- **Requires more complicated demodulator:** One of the minor disadvantages of frequency modulation is that the demodulator is a little more complicated, and hence slightly more expensive than the very simple diode detectors used for AM. However this is much less of an issue these days because many radio integrated circuits incorporate a built in frequency demodulator.
- **Some other modes have higher data spectral efficiency:** Some phase modulation and quadrature amplitude modulation formats have a higher spectral

efficiency for data transmission that frequency shift keying, a form of frequency modulation. As a result, most data transmission system use PSK and QAM.

- **Sidebands extend to infinity either side:** The sidebands for an FM transmission theoretically extend out to infinity. They are normally significant for wideband frequency modulation transmissions, although small for narrow band FM. To limit the bandwidth of the transmission, filters are often used, and these introduce some distortion of the signal.

## Mathematical Expression:

Baseband Signal

$$ym = Am\ sin(2\pi fmt)$$

Where,

Am = amplitude of the baseband signal

fm = frequency of baseband signal

Carrier Signal

$$yc = Ac\ \sin(2\pi fct)$$

Where,

Ac = amplitude of the carrier signal

fc = frequency of the carrier signal

Frequency Modulation Output

$$\text{yfm} = Ac\ \sin[2\pi[\text{fc} + \text{kfAm}\ \sin(2\pi\text{fmt})]\text{t}]$$

Where,

Ac = Amplitude of the modulated signal

## Conclusion:

The both amplitude modulation and frequency modulation has their own pros and cons. AM has advantages of simplicity, but it is not the most efficient mode to use, both in terms of the amount of space or spectrum it takes up, and the way in which it uses the power that is transmitted. This is the reason why it is not widely used these days both for broadcasting and for two way radio communication. Although it may not be quite as straightforward as amplitude modulation, nevertheless frequency modulation, FM, offers some distinct advantages. It is able to provide near interference free reception, and it was for this reason that it was adopted for the VHF sound broadcasts. These transmissions could offer high fidelity audio, and for this reason, frequency modulation is far more popular than the older transmissions on the long, medium and short wave bands.

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3. https://www.diffen.com/difference/AM_vs_FM