MODULATION

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Introduction

Modulation is the process of combining the low frequency signal (Information signal) with a very high frequency radio wave called carrier wave. The resultant wave is called modulated carrier wave. Modulator is used to do this process. That is, modulator is an electronic devise which combine the information signal and the carrier wave form. This job is done at the transmitting station.

Need For Modulation

Modulation enables a low frequency signal to travel very large distance through space with help of a high frequency carrier wave. Every FM stations, Television broadcast centers, mobile companies, etc.....are using this process. In Globalization world, this acts a main role.

Essential explanations for Modulation

Oscillators

Oscillators is an electronic device which generates high frequency wave form (Radio frequency wave) called carrier wave form. The output of the oscillator is amplified by R.F (Radio Frequency) power amplifier and then passed on to the antenna. Antenna radiates this carrier frequency signal in to space. This wave can travels at speed of 3*108 m/s. It is in audiable. There are two types of oscillators, Sinusoidal Oscillators and Relaxation Oscillators. Sinusoidal Oscillators generate sine wave forms. Mostly It is used in Analogue transmitting. Relaxation Oscillators generate pulse, square and sawtooth wave forms. Mostly it is used in Digital transmitting.

Analogue Signal

Analogue signal is one that varies in a continuous manner such as voice or music. One of the most analogue signal wave form is the sinusoidal wave or sine wave.

Digital Signal

Digital signal consists of data held in one or two states low and high or interval apart.

Types of Modulation

Considering the form of the carrier signal, mainly it can be divided into two types. Analogue modulation and Digital modulation.

Analogue Modulation:

For a sine wave,

$$e = E\sin(2\pi ft + \phi)$$

Where; E=Amplitude, f=Frequency, Q=Phase

There are three types of Analogue modulation;

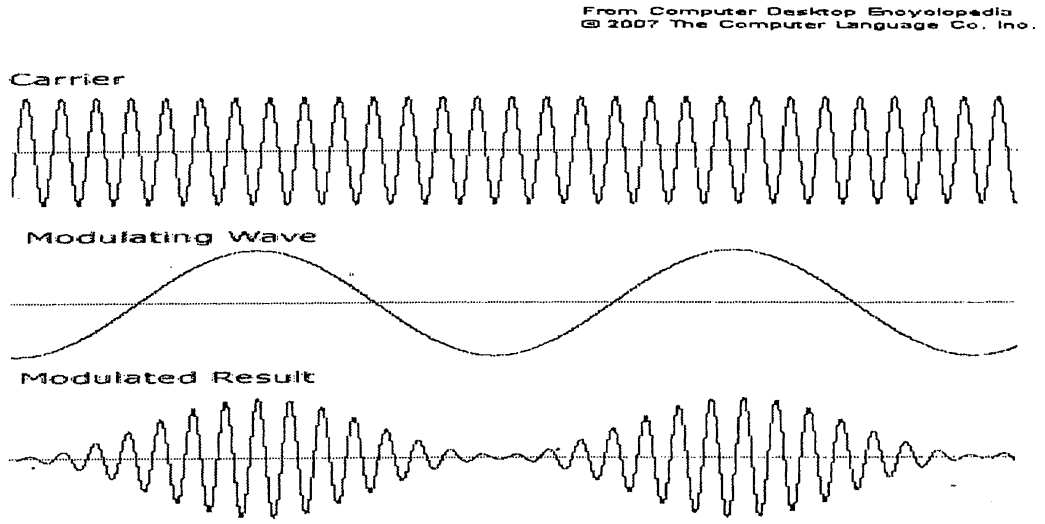
- Amplitude modulation
- Frequency modulation
- Phase modulation

Amplitude Modulation (AM)

The information signal or audio frequency signal changes the amplitude of the carrier wave without changing its frequency or phase.

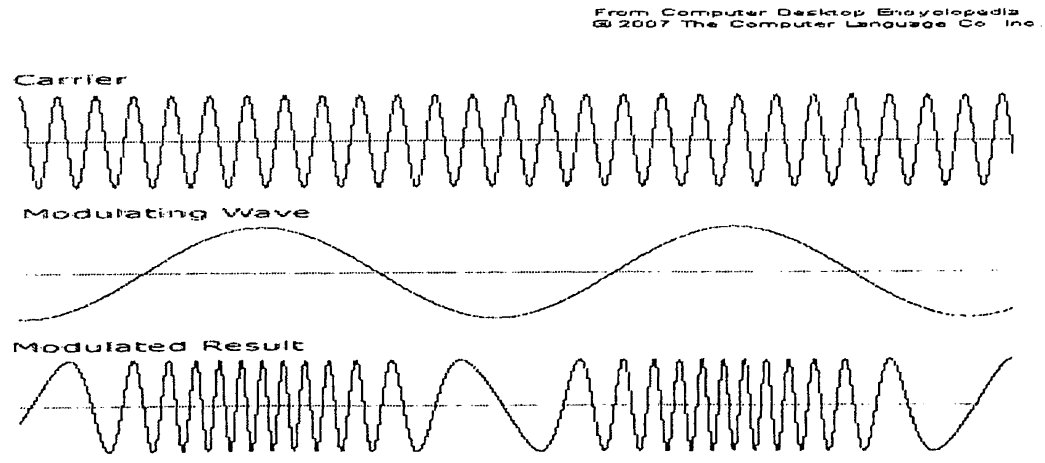
In the mid-1870s, a form of amplitude modulation—initially called "undulatory currents"—was the first method to successfully produce quality audio over telephone lines. Beginning with Reginald Fessenden's audio demonstrations in 1906, it was also the original method used for audio radio transmissions, and remains in use today by many forms of communication—"AM" is often used to refer to the medium wave broadcast band. [1]

Figure 1. AM



Frequency Modulation (FM)

The information signal or audio frequency signal changes the frequency of the carrier wave without changing its amplitude or phase.



FM is commonly used at VHF radio frequencies for high-fidelity broadcasts of music and speech. Normal (analog) TV sound is also broadcast using FM. A narrow band form is used for voice communications in commercial and amateur radio settings. The type of FM used in broadcast is generally called wide-FM, or W-FM. In two-way radio, narrowband narrow-fm (N-FM) is used to conserve bandwidth. In addition, it is used to send signals into space. [2]

Figure 2. FM

Phase Modulation (PM)

The information signal or audio frequency signal changes the phase of the carrier wave without changing its frequency or amplitude.

Unlike its more popular counterpart, frequency modulation (FM), PM is not very widely used. This is because it tends to require more complex receiving hardware and there can be ambiguity problems in determining whether,for example,the signal has changed phase by +180° or -180°. [3]

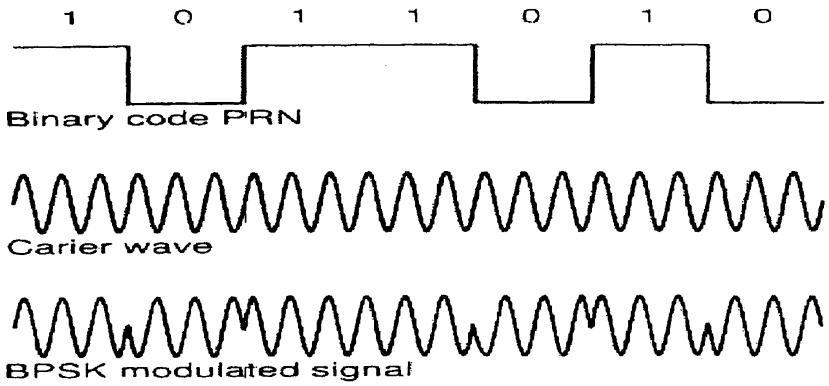


Figure 3. PM

Digital Modulation

There are four types of Digital modulation;

- pulse amplitude modulation
- pulse duration modulation or pulse width modulation
- pulse position modulation
- pulse code modulation

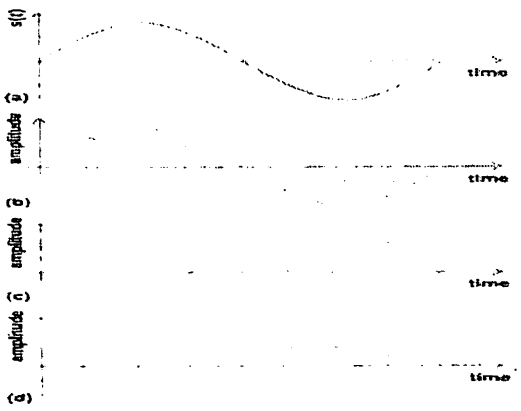


Figure (a). Modulating signal

Figure (b). PAM signal

Figure (c). PWM/PDM signal

Figure (d). PPM signal

Pulse Amplitude Modulation (PAM)

In pulse amplitude modulation, the amplitude of individual pulses in the pulse train is varied from its default value in accordance with the instantaneous amplitude of the modulating signal at sampling intervals. The width and position of the pulses is kept constant.

The PAM transmitter design is very simple since the very act of sampling the modulating signal at regular intervals produces pulse amplitude modulation. Main advantages of PAM are simple transmitter and receiver designs. PAM is used to carry information as well as to generate other pulse modulations. [4]

Pulse Duration Modulation (PDM) or Pulse Width Modulation (PWD)

The width or duration of each pulse in a pulse train is made proportional to the instantaneous value of the modulating signal at the instant of the pulse. Either the leading edges, the trailing edges, or both edges of the pulses may be modulated to produce the variation in pulse width or duration. [5]

Pulse Position Modulation (PPM)

The amplitude and width of the pulse is kept constant in the system. The position of each pulse in a pulse train is varied by each instantaneous sampled value of the modulating signal. PPM has the advantage of requiring constant transmitter power since the pulses are of constant amplitude and duration. It is widely used but has the disadvantage of depending on transmitter-receiver. [6]

Pulse Code Modulation

PAM, PWM and PPM transmissions are also noisy. In 1937, Mr. A. H. Reeves came up with idea about a noise free transmission system. According to him, analogue signal has to be converted to digital signal and then transmit. This process is called "Digitization". It is done by the Digitizer and it has three consecutive steps.

- Sampling- Very short samples are drawn from a source signal with regular intervals. Sampling may be 'flat topped' or 'natural'.
- Quantization- Each sample is measured by means of scale division and approximated to the nearest quantization level.
- Coding or Encoding- The quantized sample is given a designation in binary format.

This system is called as PCM

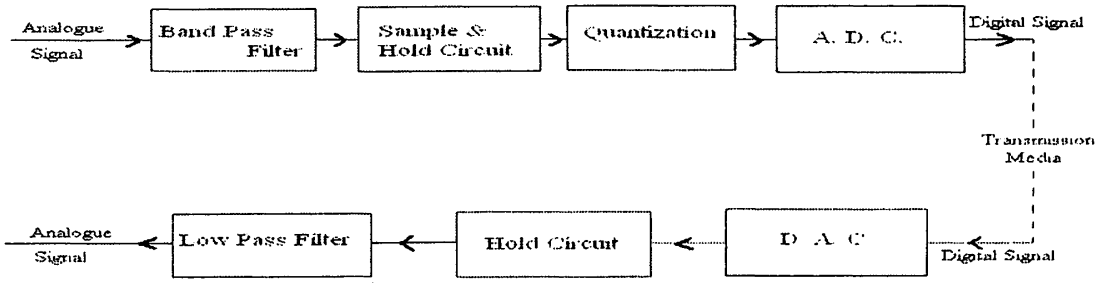


Figure 4. PCM

Figure 4 shows the block diagram of practical PCM system. The band pass filter limits the input analogue signal to the standard voice band frequency range(300-3400)Hz. The sample and hold circuit periodically samples the analogue input and converts those samples into PAM signal. Then it is quantized. Finally the analogue to digital (ADC) converts the quantized levels to a serial binary data for transmission.

The transmission medium is a metallic wire or optical fiber.

At the receivers end the digital to analogue converter (DAC) converts the serial binary data into PAM signal. The hold circuit and low pass filter converts the PAM signal back to its original analogue form.

References:

1). http://en.wikipedia.org/wiki/Amplitude_modulation
2). http://en.wikipedia.org/wiki/Frequency_modulation
3). http://en.wikipedia.org/wiki/Phase_modulation
4). http://www.aubraux.com/dsp/dsp-modulation-pulse-amplitude-pam.php
5). http://www.tpub.com/content/neets/14184/css/14184_133.htm