



Modulation - Volume II - Angle and Pulse Modulation

An Online Continuing Education Course for Engineers

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Modulation – Volume II – Angle and Pulse Modulation

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Introduction

In the first course in this series, Amplitude Modulation, you learned that modulation of a carrier frequency was necessary to allow fast communications between two points. As the volume of transmissions increased, a need for more reliable methods of communication was realized. In this course you will study angle modulation and pulse modulation. These two types of modulation have been developed to overcome one of the main disadvantages of amplitude modulation - susceptibility to noise interference. In addition, a special application of pulse type modulation for ranging and detection equipment will be discussed.

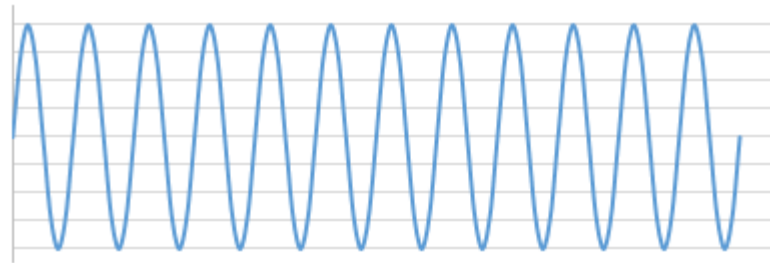
Angle Modulation is modulation in which the angle of a sine-wave carrier is varied by a modulating wave. *Frequency Modulation (FM)* and *Phase Modulation (PM)* are two types of angle modulation. In frequency modulation the modulating signal causes the carrier frequency to vary. These variations are controlled by both the frequency and the amplitude of the modulating wave. In *phase modulation* the phase of the carrier is controlled by the modulating waveform. Let's study these modulation methods for an understanding of their similarities and differences.

In frequency modulation an audio signal is used to shift the frequency of an oscillator at an audio rate. The simplest form of this is seen in *Frequency-Shift Keying (FSK)*. Frequency-shift keying is somewhat similar to continuous-wave keying (CW) in AM transmissions.

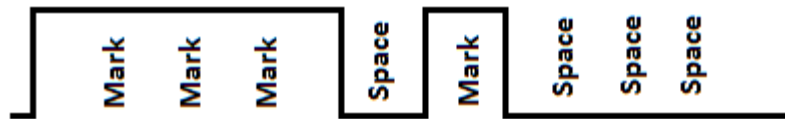
Frequency-Shift Keying

Consider Figure 1. View (A) is a radio frequency (RF) carrier which is actually several thousand or million hertz. View (B) represents the intelligence to be transmitted as *Marks and Spaces*. Recall that in CW transmission, this intelligence was applied to the RF carrier by interrupting the signal, as shown in view (C). The amplitude of the RF alternated between maximum and zero volts. By comparing views (B) and (C), you can see the mark/space intelligence of the Morse code character on the RF. The spacing of the waveform in view (D) is an example of the same intelligence as it is applied to the frequency instead of the amplitude of the RF. This is simple frequency-shift keying of the same Morse code character.

Comparison of On-Off and Frequency-Shift Keying



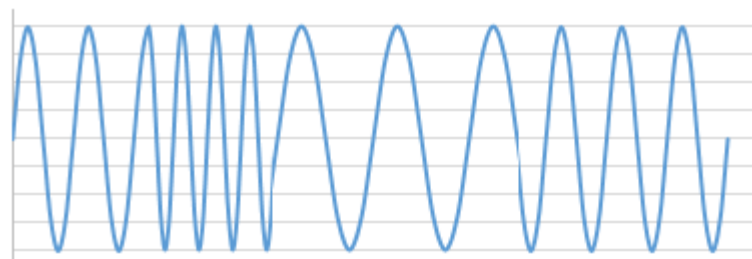
(A)
RF Carrier (CW)



(B)
Amplitude Varying (on-off) Modulating Wave



(C)
Transmitted On-Off Keyed CW Signal



(D)
Transmitted Frequency-Shift Keyed Signal (FSK)

Figure 1

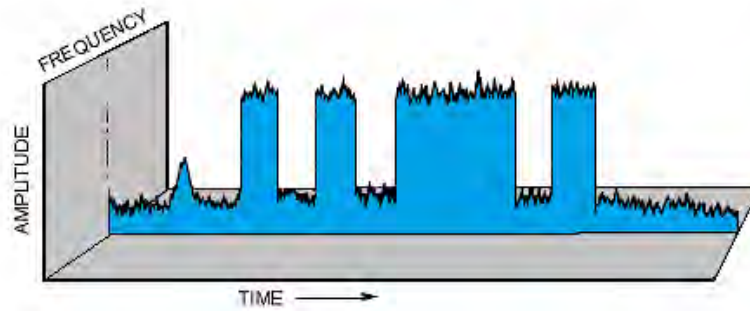
In FSK the output is abruptly changed between two differing frequencies by opening and closing the key. This is shown in view (D). For illustrative purposes, the spacing frequency in view (D) is shown as double the marking frequency. However, in practice the difference is usually less than 1,000 hertz, even when operating at several megahertz. You should also note that the limit of frequency shift is determined without reference to the amplitude of the keying signal in the FSK system. The frequency shift may be set at plus or minus 425 hertz from the allocated channel frequency. The total shift between mark and space would be 850 hertz. Either the mark or space may use the higher of the two frequencies. The upper frequency of the transmitted signal is usually the spacing interval and the lower frequency is the marking interval.

Comparing FSK and CW Signals

A comparison of on-off keyed CW (Figure 2), and FSK (Figure 3) signals will show clearly the principal features of FSK and give us a basis on which frequency modulation can be discussed. Let's use views (A), (B), and (C) of both figures to show the Morse code character "F" for an example. Figures 2 and 3 are graphic drawings of the two types of keying.

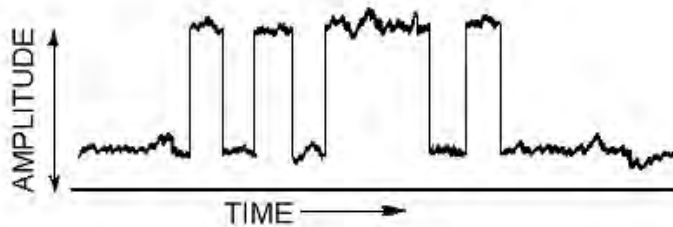
Time and amplitude are known dimensions of AM; but to explain FSK properly, we have added the third dimension of frequency.

Comparison of an AM and FM Receiver Response to an AM Signal



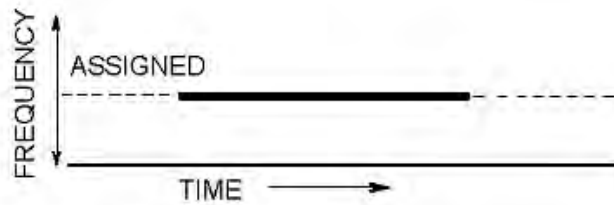
(A)

Three-Dimensional Representation of an On-Off Keyed CW Telegraph Signal



(B)

Response of an AM Demodulator to Signal



(C)

Response of an FM Discriminator to Signal

Figure 2

Comparison of AM and FM Receiver response to an FM Signal

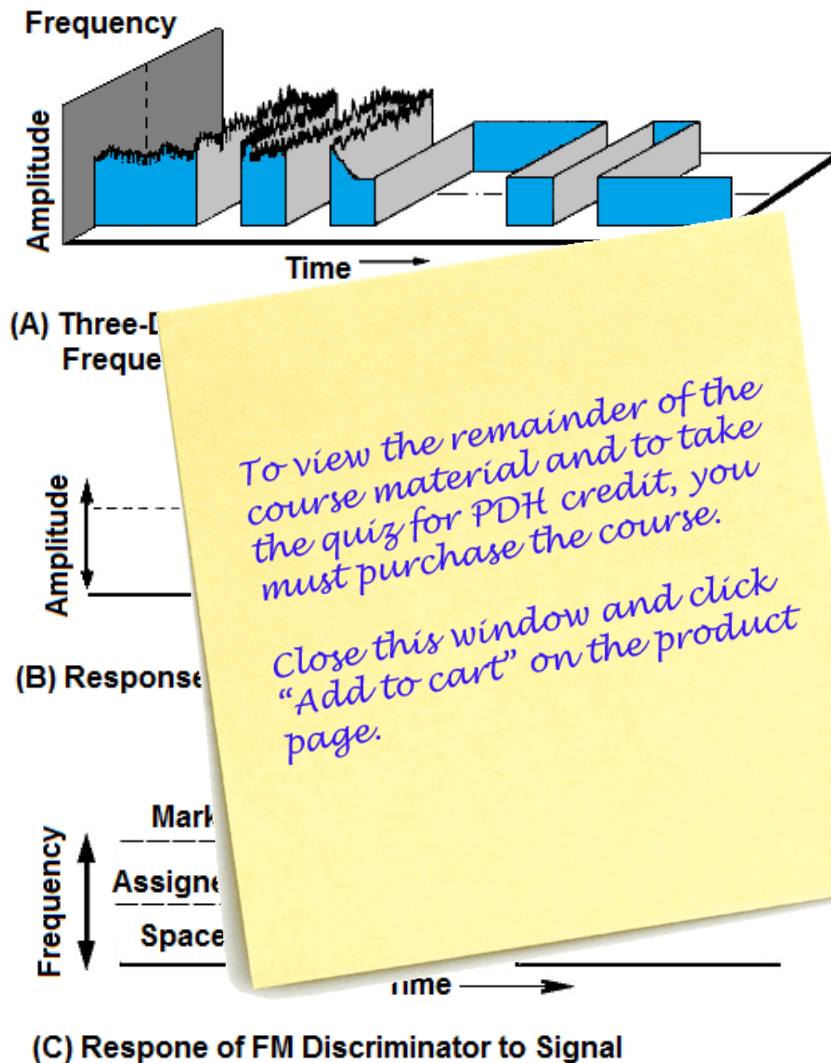


Figure 3

CW Signals

Since CW signals are of essentially constant frequency, there is no variation along the frequency axis in view (A) of Figure 2. The complete intelligence is carried as variations in the amplitude of the signal. To receive the intelligence carried by such a signal, the receiving equipment must be able to scan the signal along the time and amplitude axes, which carry the information. When scanned along the time and amplitude axes, the intelligence appears as large changes in amplitude. If the circuit were perfect, these variations would be from 0 amplitude to some maximum value (established by transmitter power, distance, and so forth) depending on whether the key were open or closed. However, interfering components of energy caused by