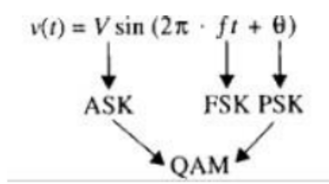
DIGITAL MODULATION TECHNIQUES

Digital Modulation provides more information capacity, high data security, quicker system availability with great quality communication. Hence, digital modulation techniques have a greater demand, for their capacity to convey larger amounts of data than analog ones.

There are many types of digital modulation techniques and we can even use a combination of these techniques as well. In this chapter, we will be discussing the most prominent digital modulation techniques.

if the information signal is digital and the amplitude (IV of the carrier is varied proportional to the information signal, a digitally modulated signal called amplitude shift keying (ASK) is produced.

If the frequency (f) is varied proportional to the information signal, frequency shift keying (FSK) is produced, and if the phase of the carrier (0) is varied proportional to the information signal, phase shift keying (PSK) is produced. If both the amplitude and the phase are varied proportional to the information signal, quadrature amplitude modulation (QAM) results. ASK, FSK, PSK, and QAM are all forms of digital modulation:



Amplitude Shift Keying

The amplitude of the resultant output depends upon the input data whether it should be a zero level or a variation of positive and negative, depending upon the carrier frequency.

Amplitude Shift Keying (ASK) is a type of Amplitude Modulation which represents the binary data in the form of variations in the amplitude of a signal.

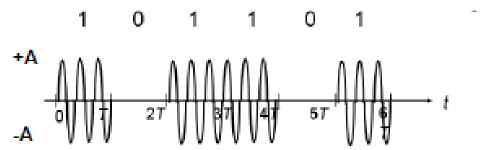
Following is the diagram for ASK modulated waveform along with its input.

ASK – strength of carrier signal is varied to represent binary 1 or 0

- both frequency & phase remain constant while amplitude changes
- commonly, one of the amplitudes is zero

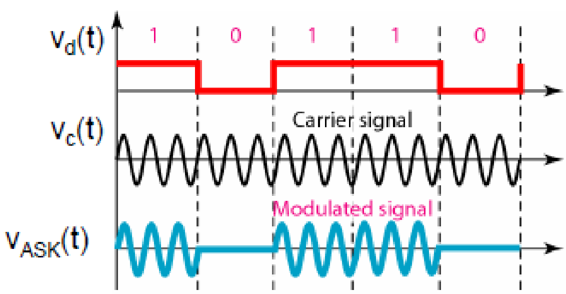
$$s(t) = \begin{cases} A_0 \cos(2\pi f_c t), & \text{binary } 0 \\ A_1 \cos(2\pi f_c t), & \text{binary } 1 \end{cases}$$

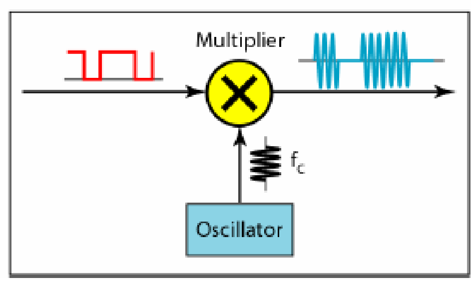
Is this picture, from the textbook, entirely correct?! →



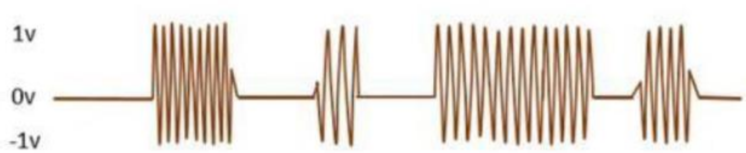
- **demodulation**: only the presence or absence of a sinusoid in a given time interval needs to be determined
- **advantage**: simplicity
- **disadvantage**: ASK is very susceptible to noise interference – noise usually (only) affects the amplitude, therefore ASK is the modulation technique most affected by noise
- **application**: ASK is used to transmit digital data over optical fiber

Example [ASK]

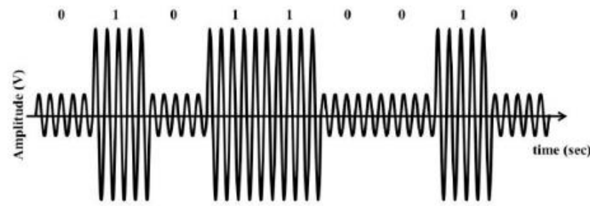




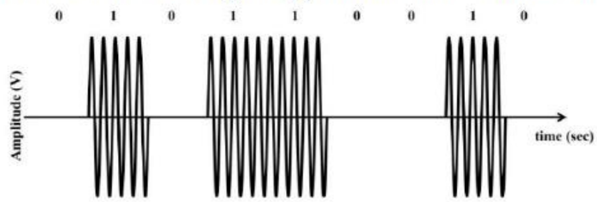
Input binary sequence



ASK Modulated output wave



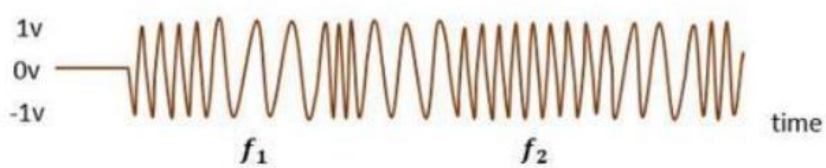
The simplest digital modulation scheme is a form of ASK called *On-Off keying* (OOK). This is analogous to flashing light communication. In OOK, a carrier is transmitted for a 1-bit and nothing is transmitted for a 0-bit; this is the same as saying that the smaller ASK amplitude is 0. Note that OOK is just a type of ASK and not its own scheme.



Frequency Shift Keying (FSK) is the digital modulation technique in which the frequency of the carrier signal varies according to the discrete digital changes. FSK is a scheme of frequency modulation.

Following is the diagram for FSK modulated waveform along with its input.

Input binary sequence

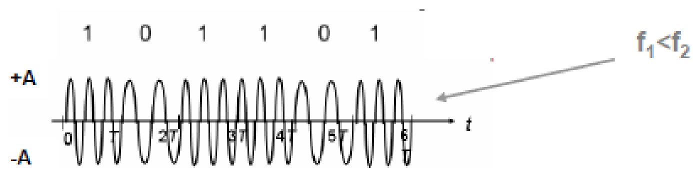


FSK Modulated output wave

FSK – frequency of carrier signal is varied to represent binary 1 or 0

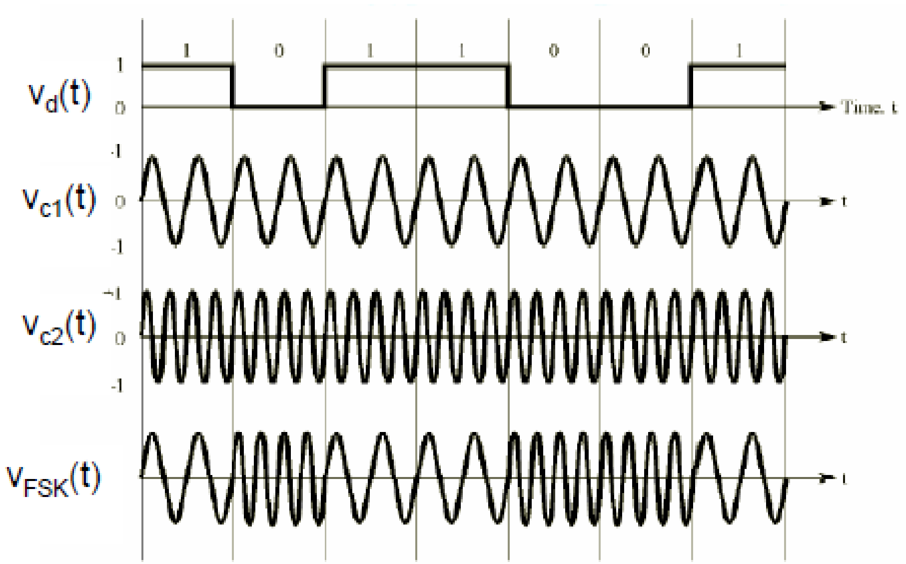
- peak amplitude & phase remain constant during each bit interval

$$s(t)=\begin{cases}A\cos(2\pi f_1 t), & \text{binary } 0\\ A\cos(2\pi f_2 t), & \text{binary } 1\end{cases}$$

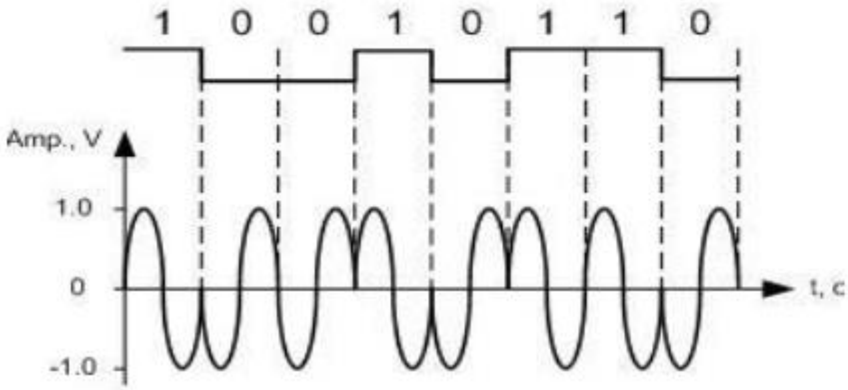


- **demodulation**: demodulator must be able to determine which of two possible frequencies is present at a given time
- **advantage**: FSK is less susceptible to errors than ASK – receiver looks for specific frequency changes over a number of intervals, so voltage (noise) spikes can be ignored
- **disadvantage**: FSK spectrum is 2 x ASK spectrum
- **application**: over voice lines, in high-freq. radio transmission, etc.

Example [FSK]



Phase Shift Keying (PSK) is the digital modulation technique in which the phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications.



Phase shift keying (PSK)

PSK – phase of carrier signal is varied to represent binary 1 or 0

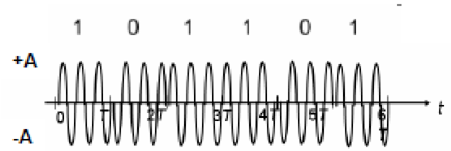
- **peak amplitude & freq. remain constant during each bit interval**
- **<u>example</u>: binary 1 = 0° phase, binary 0 = 180° (πrad) phase**

  ⇒ PSK is equivalent to multiplying carrier signal by +1 when the information is 1, and by -1 when the information is 0

2-PSK, or **Binary PSK**, since only 2 different phases are used.

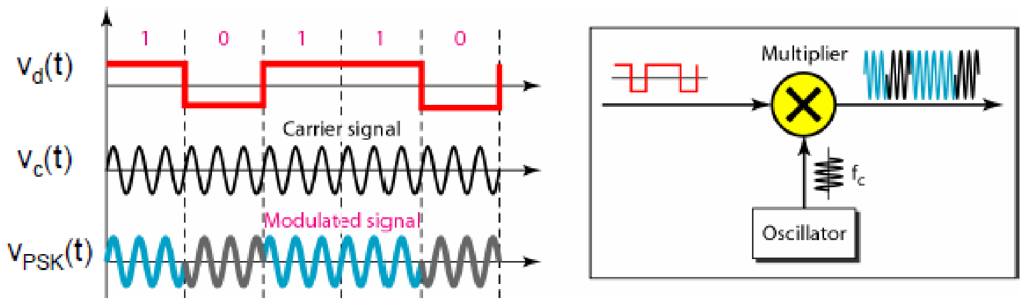
$$s(t) = \begin{cases} A\cos(2\pi f_c t), & \text{binary 1} \\ A\cos(2\pi f_c t + \pi), & \text{binary 0} \end{cases}$$

$$s(t) = \begin{cases} A\cos(2\pi f_c t), & \text{binary 1} \\ -A\cos(2\pi f_c t), & \text{binary 0} \end{cases}$$



- **demodulation: demodulator must determine the phase of received sinusoid with respect to some reference phase**
- **advantage:**
  - **PSK is less susceptible to errors than ASK, while it requires/occupies the same bandwidth as ASK**
  - **more efficient use of bandwidth (higher data-rate) are possible, compared to FSK !!!**
- **disadvantage: more complex signal detection / recovery process, than in ASK and FSK**

Example [PSK]



HW

Compare between ASK, FSK and PSK