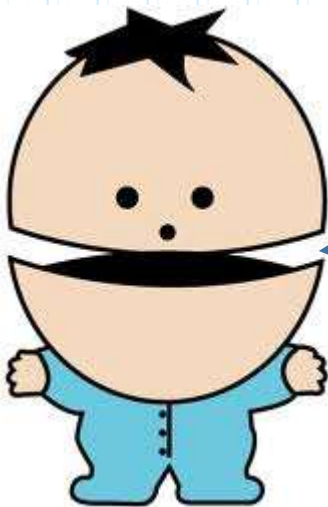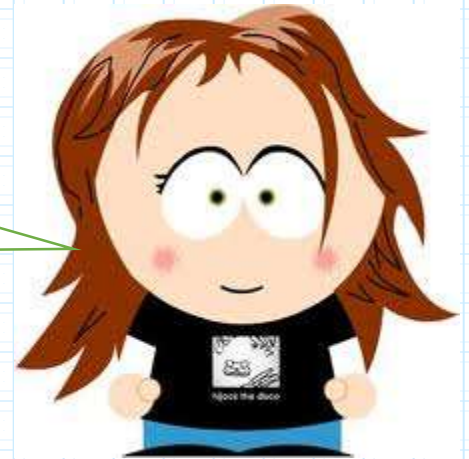# DIGITAL DATA ANALOG SIGNAL

Modulation of binary data or digital-to-analog modulation is the process of changing one of the characteristics of an analog signal based on the information in digital signal (0's and 1's).

But Why we need it

1) When you transmit data from one computer to another across a public access phone line for example, the original data are digital, but because telephone wires carry analog signals; the data must be converted.

2) Permits use of modern digital transmission and switching equipment

And how this process is carried out

There are three methods for modulating digital data into an analog signal.

(ASK) Amplitude shift keying

(FSK) Frequency shift keying

(PSK) Phase shift keying.

There is a fourth mechanism that consists changes in both amplitude and phase is called quadrature amplitude modulation (QAM).

Amplitude shift keying

In amplitude shift keying the strength of the carrier signal is varied to represent binary 1 or 0. Both frequency and phase remain constant while the amplitude changes which voltage represents 1 and which represents 0 are left to the system designers.
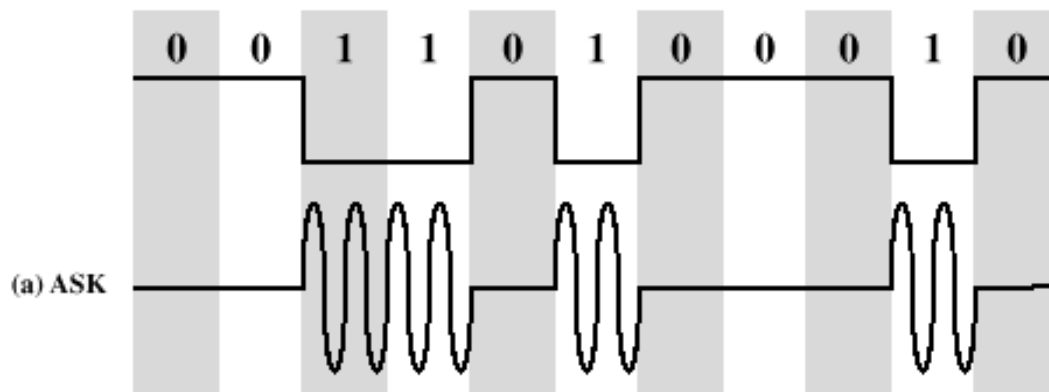
The peak amplitude during each bit duration is constant and its value depends on the bit (0 or 1)

Advantages and Disadvantages of ASK

1. ASK transmission is highly susceptible to noise interference. The terms noise to unintentional voltages introduced on to a line by various phenomena such as heat or electromagnetic induction created by other sources.
2. Used for Voice Channels, used up to 1200 bps
3. Used to transmit digital data over optical fiber

$$s(t) = \begin{cases} A\cos(2\pi f_c t) & \text{binary 1} \\ 0 & \text{binary 0} \end{cases}$$
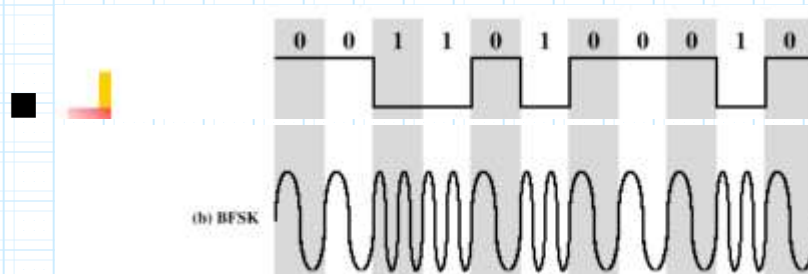
- where the carrier signal is $A\cos(2\pi f_c t)$

(a) ASK

Frequency shift keying (FSK):

In frequency shift keying, the frequency of the carrier signal is varied to represent binary 1 or 0. The frequency of the signal during each bit duration is constant and its value depends on the bit (0 or 1).

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


(b) BFSK

- ■ <u>Advantages and Disadvantages of ASK</u>
- ■ Less susceptible to error than ASK
- ■ On voice-grade lines, used up to 1200bps
- ■ Used for high-frequency (3 to 30 MHz) radio transmission
- ■ Can be used at higher frequencies on LANs that use coaxial cable

Phase shift keying (PSK)

In phase shift keying, the phase of the carrier is varied to represent binary 1 or 0. Both peak amplitude and frequency remain constant as the phase changes. If we start phase of 0° to represent binary 0, then we can change the phase to 180° to send binary 1. The phase of the signal during each bit duration is constant and its value depends on the bit (0 or 1).
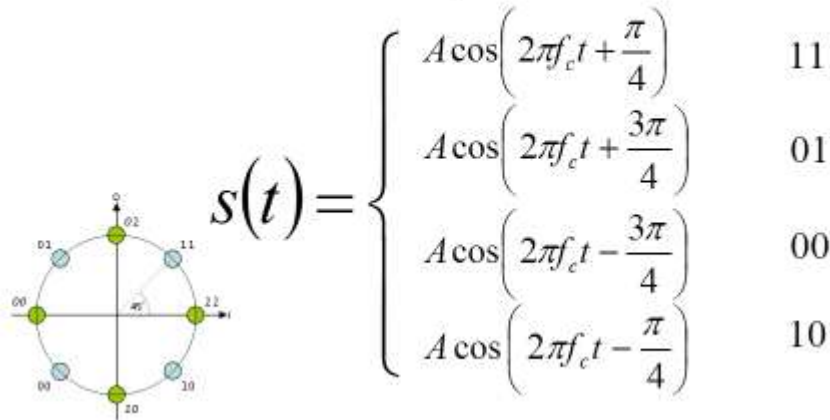
$$s(t) = \begin{cases} A\cos(2\pi f_c t) & \text{binary 1} \\ A\cos(2\pi f_c t + \pi) & \text{binary 0} \end{cases}$$

(c) BPSK
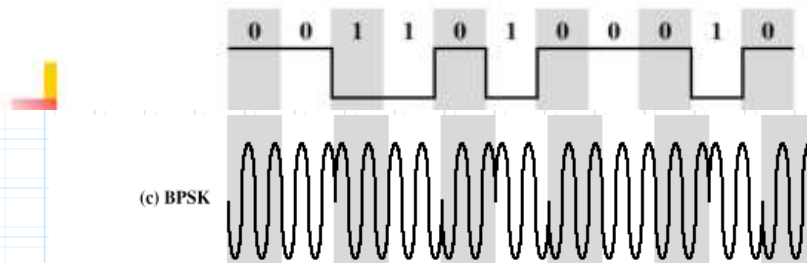
Similar we can use more than two phase to represent multiple signal level

- Four-level PSK (QPSK)
  - Each element represents more than one bit

$$s(t) = \begin{cases} A\cos\left(2\pi f_c t + \dfrac{\pi}{4}\right) & 11 \\[2mm] A\cos\left(2\pi f_c t + \dfrac{3\pi}{4}\right) & 01 \\[2mm] A\cos\left(2\pi f_c t - \dfrac{3\pi}{4}\right) & 00 \\[2mm] A\cos\left(2\pi f_c t - \dfrac{\pi}{4}\right) & 10 \end{cases}$$

- Multilevel PSK
  - Using multiple phase angles with each angle having more than one amplitude, multiple signals elements can be achieved

$$D = \frac{R}{L} = \frac{R}{\log_2 M}$$

- D = modulation rate, baud
- R = data rate, bps
- M = number of different signal elements = 2^L
- L = number of bits per signal element

- **■ <u>Advantages and Disadvantages of PSK</u>**
- ■ Phase-Shift Keying technology is what is utilized by most high speed modern modems
- ■ PSK is very resistant to external interference

COMPARISON TABLES

Parameter	BPSK (PSK)	QPSK
1. Variable characteristic of the carrier	Phase	Phase
2. Type of modulation	Two level (binary)	Four level
3. Type of representation	A binary bit is represented by one phase state	A group of two binary bits is represented by one phase state
4. Bit rate/ Baud rate	Coherent	Coherent
5. Detection method	Coherent	Coherent
6. Complexity	Complex	Very complex
7. Applications	Suitable for applications that need high bit rate	Suitable for applications needing very high bit rates.

Parameter	ASK	FSK	PSK
. Variable Characteristics	Amplitude	Frequency	Phase
. Noise Immunity	Low	High	High
. Error Probability	High	Low	Low
Performance in presence of noise	poor	Better than ASK	Better than FSK
Complexity	Simple	Moderately complex	Very Complex
Bit rate	Suitable upto 100 bit/sec	Suitable upto about 1200 bit/sec.	Suitable for high bit rates.
Detection method	Envelope	Envelope	Coherent

Hey Dude …What about the Questions that Appeared in Islamia University Papers

Q1: Write down the performance of ASK FSK AND PSK

Answer- Comparison Table + Performance in term of BW

- Bandwidth of modulated signal (B_T)
  - ASK, PSK $\quad B_T=(1+r)R$
  - FSK $\qquad\qquad B_T=2DF+(1+r)R$

    - R = bit rate
    - $0 < r < 1$; related to how signal is filtered
    - $DF = f_2 - f_c = f_c - f_1$

Q2: What is QAM , Draw its Schematic Diagram and represent it Mathematically

Ans: Quadrature Amplitude Modulation (QAM): Quadrature amplitude modulation is a combination of ASK and PSK. In this Method the number of amplitude shifts is fewer than the number of the phase shifts. Because amplitude changes are susceptible to noise and require greater shift difference than do phase changes, the number of phase changes used by QAM system is always large the number of amplitude shifts.

$$s(t) = d_1(t)\cos 2\pi f_c t + d_2(t)\sin 2\pi f_c t$$