Module 4

DIGITAL MODULATION TECHNIQUES

INTRODUCTION:

Digital data is transmitted over a band pass channel modulating a carrier wave within the frequency limits allowed by the channel.

The source of digital data may be a digital computer or PCM waves generated by digitizing voice or video links

Various channels are telephone channel, microwave radio link, satellite channel or an optical fibre.

In modulation process, amplitude, frequency or phase of the carrier will be switched according to variations of message data.

There are three basic modulation techniques for the transmission of digital data. Namely,

(i) Amplitude shift keying (ASK)/ON OFF keying (OOK)
(ii) Frequency shift keying (FSK)
(iii) Phase shift keying (PSK)

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Digital Modulation Formats.

Modulation:

defn: It is a process by which some characteristic of carrier signal is varied in accordance with a modulating wave.

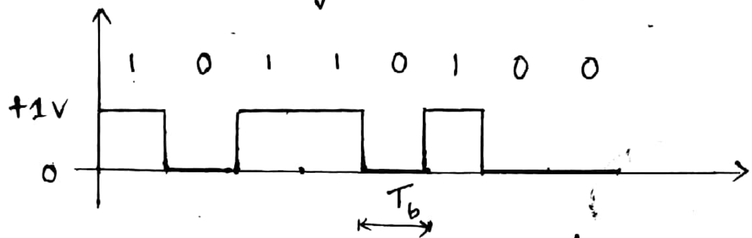
In digital communications the modulating wave can be a binary data or an M-ary encoded version of it. Usually sine wave is used as carrier signal.

Let given digital data be. 10110100

(i) Binary encoded version / Binary signaling

Only two possible voltage levels

Each voltage level represents one bit data.



bit '0' : 0 volt

bit 1 : 1 volt

T_b : bit duration.

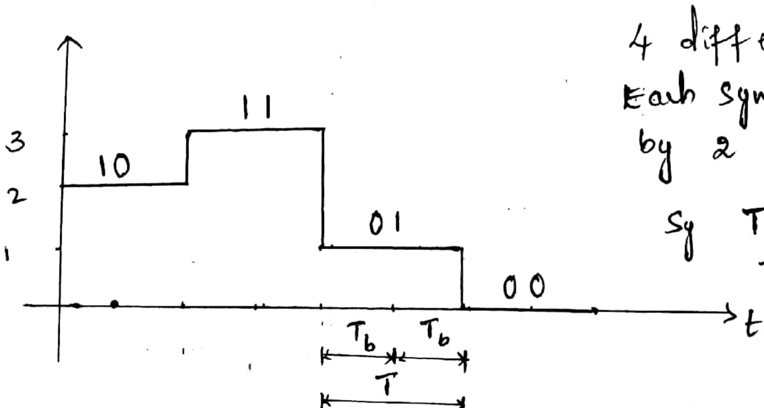
(ii) M-ary encoded version / M-ary signaling

'M' no of different possible voltage levels.

Each voltage level represents 'm' no of bits data.

where $m = \log_2 M$ OR $M = 2^m$

Let $M = 4 \Rightarrow m = 2$



4 different symbols;

Each symbol represented by 2 bit

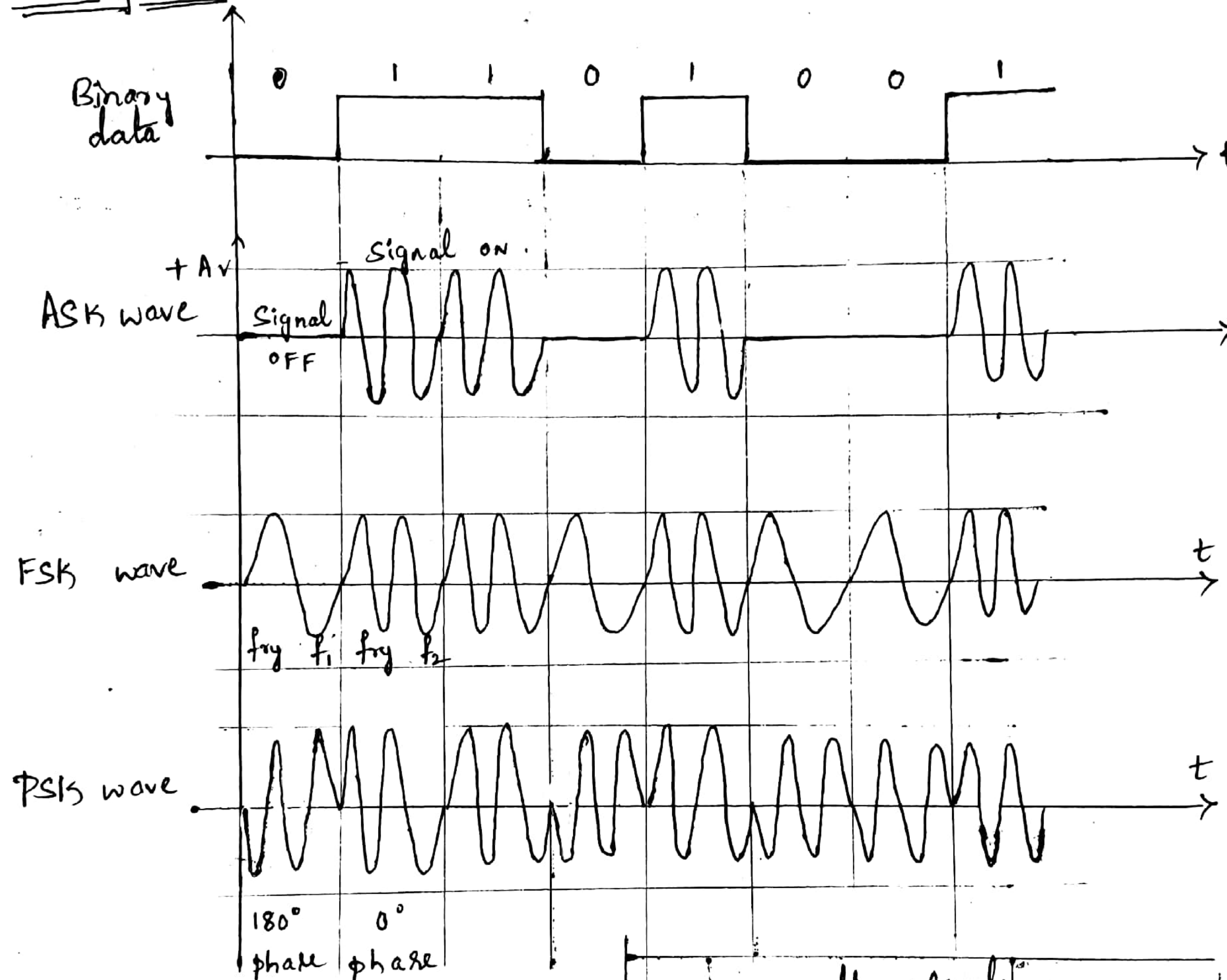
Sy T : symbol duration

$T = 2T_b$

In M ary signaling, modulator produces one of an available set of $M = 2^m$ distinct signals in response to m bits of source data at a time.

Binary signaling is a special case of M-ary signaling with M = 2

Waveforms



ASK	Two voltage levels	bit 0 : 0V bit 1 : +A volt
FSK	Two frequency values	bit 0 : f_1 bit 1 : f_2 $f_2 > f_1$
PSK	Two phase values	bit 0 : 180° bit 1 : 0°

Demodulation

Two types

i) Coherent detection

ii) Non coherent detection

In coherent detection an exact copy of (replica) carrier signal used at the transmitter will be available at the receiver..

Also the receiver will have exact knowledge of the carrier wave's phase reference meaning to say the receiver is PHASE LOCKED to the transmitter

Coherent detection is performed by cross correlating the received signal with each of the replicas and then making a decision based on comparisons with preselected thresholds.

In non-coherent detection, knowledge of the carrier wave phase is not required hence the complexity of the receiver is reduced but at the expense of poor error performance as compared to coherent systems.

The transmitted power per bit & channel B.W are the two important parameters in communication systems.

There will be system trade-offs among the following design goals/specifications.

1) Maximum data rate
2) Minimum probability of symbol error.
3) Minimum transmitted power
4) Minimum channel bandwidth.
5) Maximum resistance to interfering signals.
6) Minimum circuit complexity.

Some of these goals pose conflicting requirements for ex: goal 1 & 2. are in conflict with goal 3 & 4.

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Bit Energy

Carrier signal is given as.

$$s(t) = A \cos 2\pi f_c t \longrightarrow (1).$$

Energy of transmitted carrier signal $s(t)$ over a bit duration 'T_b' is equivalent to bit energy 'E_b' and it is calculated as.

$$E_b = \int_0^{T_b} s^2(t)\, dt$$

$$= \int_0^{T_b} A^2 \cos^2 2\pi f_c t$$

$$= A^2 \int_0^{T_b} \frac{1}{2} (1 + \cos 4\pi f_c t)\, dt$$

$$= \frac{A^2}{2} \int_0^{T_b} dt + \frac{A^2}{2} \int_0^{T_b} \cos 4\pi f_c t\, dt$$

$$E_b = \frac{A^2}{2} [t]_0^{T_b} + \frac{A^2}{2} \left[\frac{\sin 4\pi f_c t}{4\pi f_c}\right]_0^{T_b}$$

$$E_b = \frac{A^2}{2} [T_b - 0] + \frac{A^2}{8\pi f_c} [\sin 4\pi (f_c T_b) - \sin 0]$$

Since f_c & T_b are choosen as $T_b = \frac{n_c}{f_c}$

where n_c is an integer; $f_c T_b = n_c$

$$\therefore \boxed{E_b = \frac{A^2 T_b}{2}} \quad \text{or} \quad \boxed{A = \sqrt{\frac{2E_b}{T_b}}} \longrightarrow (2).$$