☆ Band Pass Data Transmission (OR)

Digital Carrier Modulation:

⇒ The output of the encoder in a Base Band system is binary data which is having significant low freq. So, it is not possible to transmitt binary data directly into the free space. A high freq. Carrier signal is used to transmitt the data into free space.

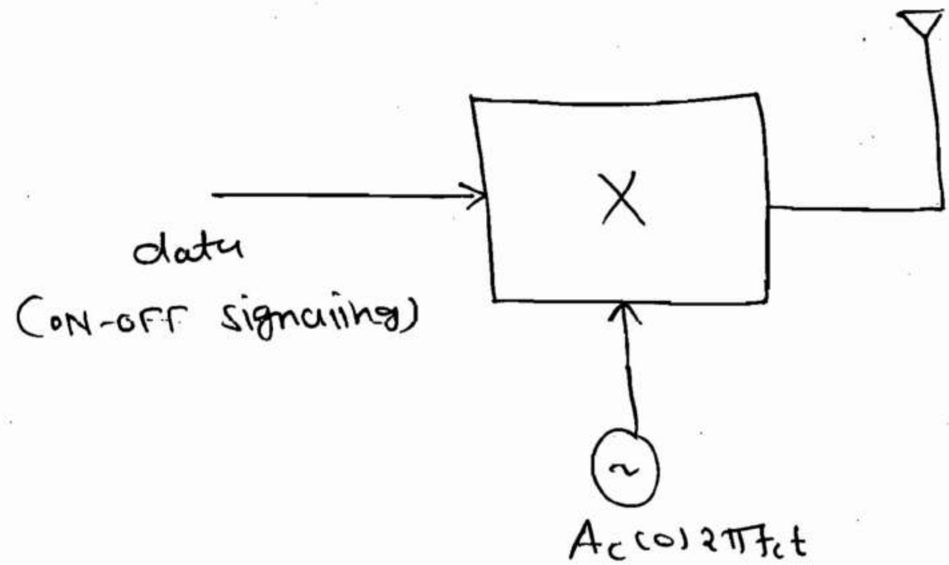
⇒ The three parameters of the carrier which can be varied according to the digital signal are Amplitude, Frequinces & phase. Therefore, the three modulation techniques are,

1. Amplitude shift keying (ASK).
2. Frequency shift keying (FSK).
3. Phase shift keying (PSK).

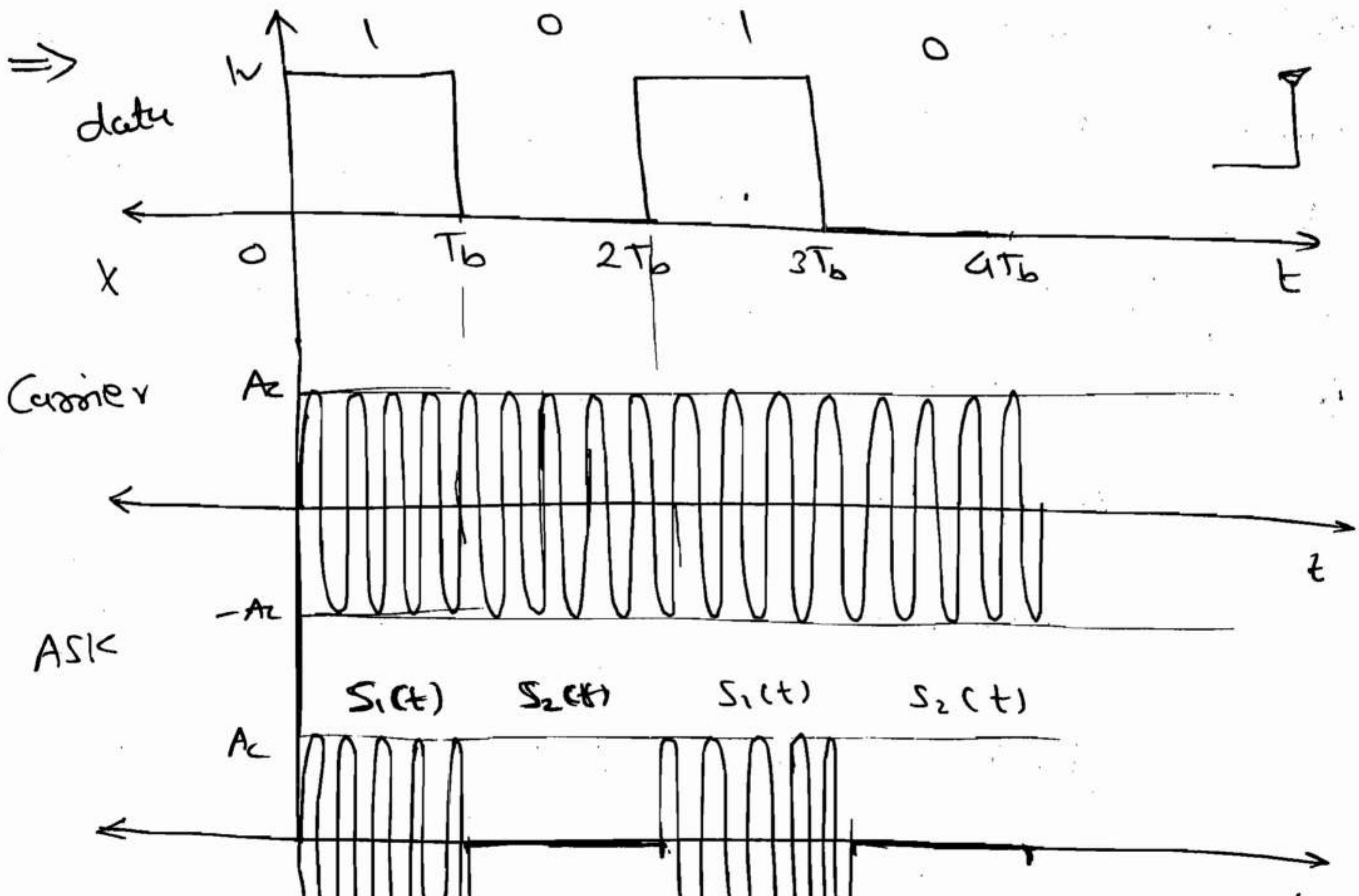
① Amplitude Shift Keying:

⇒ The binary data in ON-OFF signaling is multiplied with the carrier to generate the ASK signal.

⇒



⇒

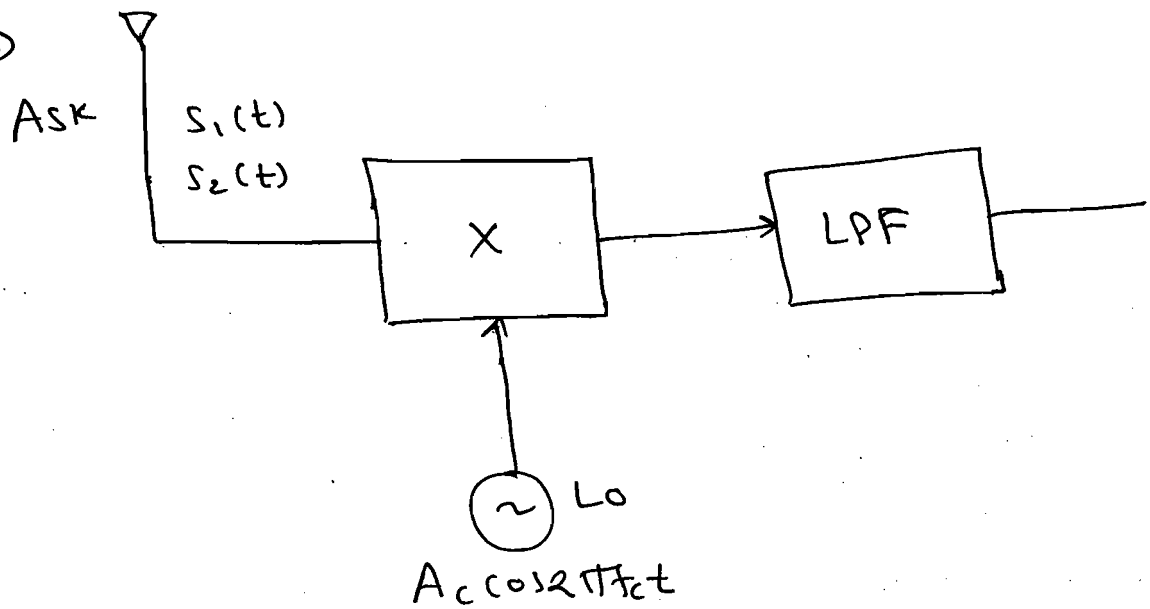


⇒ Mathematical representation of ASK signal is as follow:

$$S_1(t) = A_c \cos 2\pi f_c t \quad '1'.$$
$$= 0 \quad '0'.$$

* **Demodulation of ASK:**

⇒



(Coherent | synchronous detector)

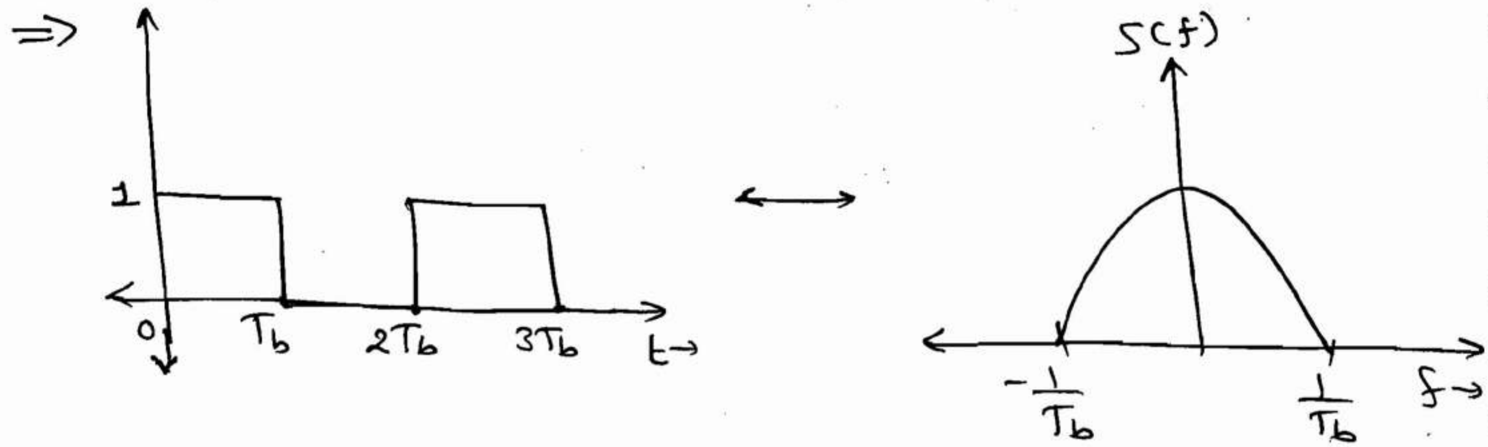
⇒ O/P of the multiplier is

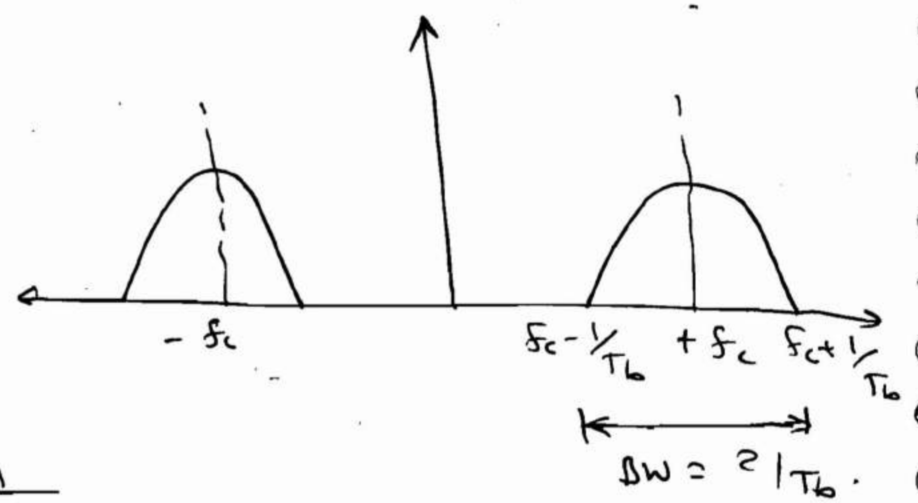
→ $S_1(t) \cdot (LO)_0 = A_c \cos 2\pi f_c t \cdot A_c \cos 2\pi f_c t$

$$= \frac{A_c^2}{2} + \frac{A_c^2}{2} \cos 2\pi f_c t$$

dc AC

∴ O/P of the LPF = $\frac{A_c^2}{2}$.





$$\Rightarrow \quad BW = 2 \times \frac{1}{T_b}.$$

$$\boxed{BW = 2 \times R_b.}$$

* Energy Calculation:

$$\Rightarrow \quad E_b = \int_0^{T_b} S_1^2(t)\,dt = P \times T_b.$$

$$\therefore \; E_b = \frac{A_c^2}{2} \times T_b. \qquad '1'.$$

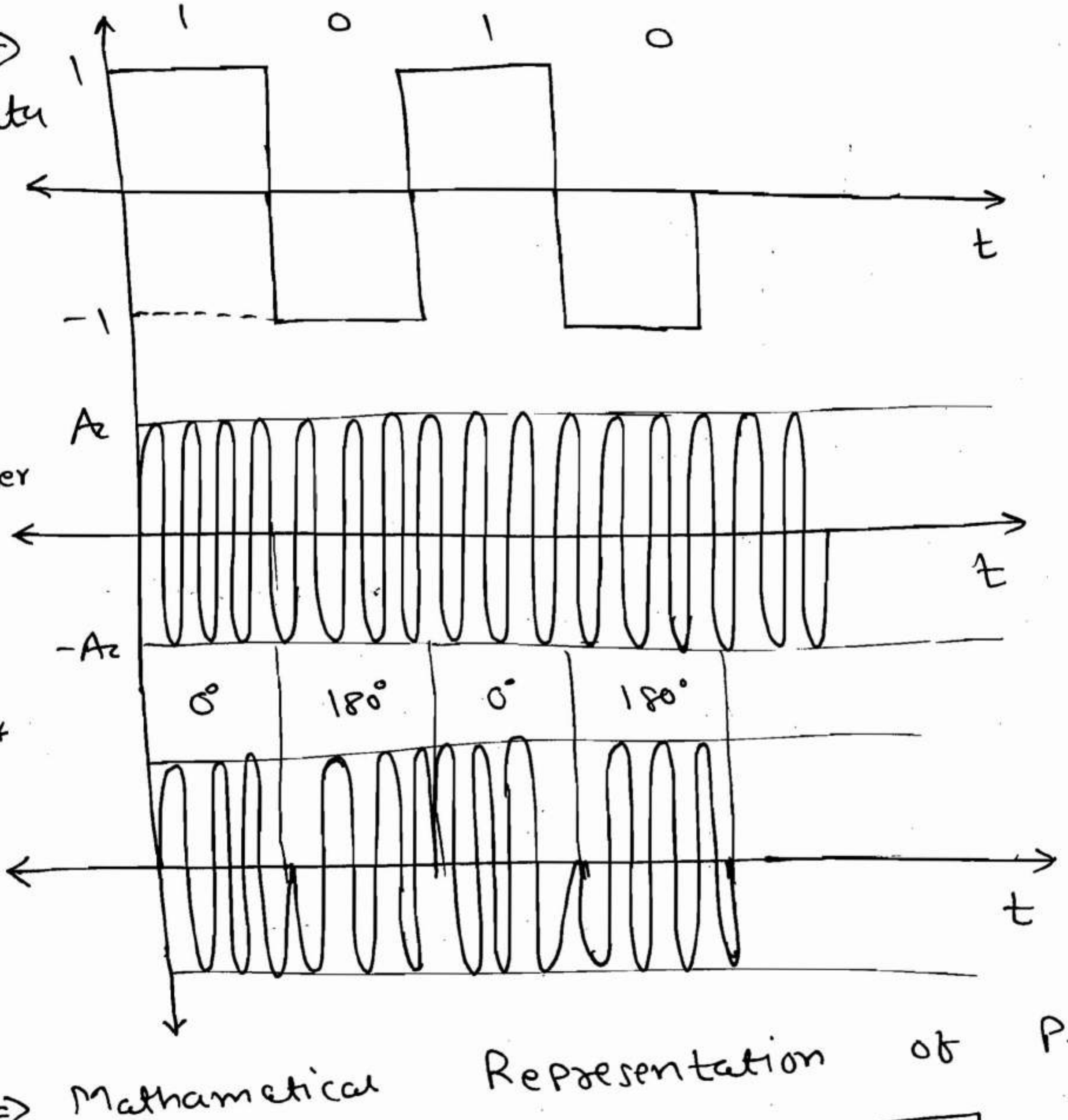
$$= 0 \qquad '0'.$$

$$\Rightarrow \boxed{A_c = \sqrt{\frac{2E_b}{T_b}}} \Rightarrow S_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_c t \quad '1'$$

② PSK (Phase Shift keying):

⇒ Binary data represented in NRZ signalling is multiplied with the Carrier to generate the PSK signal.

⇒



⇒ Mathematical Representation of PSK are as follow:

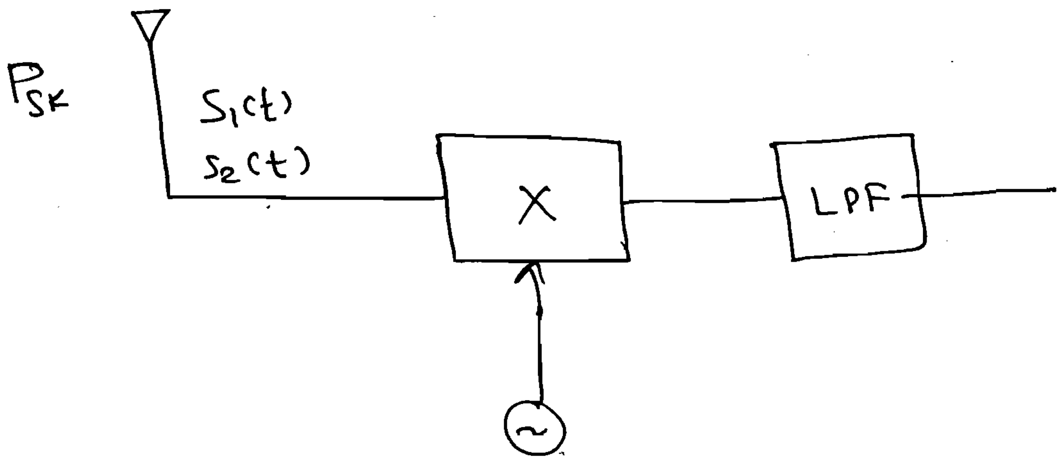
$$S_1(t) = A_c \cos 2\pi f_c t \quad '1'$$
$$S_2(t) = -A_c \cos 2\pi f_c t \quad '0'$$

$$S_1(t) = A_c \cos [2\pi f_c t + 0°]$$

* Demodulation of PSK:

$$s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cdot \cos 2\pi f_c t$$

$$s_2(t) = -\sqrt{\frac{2E_b}{T_b}} \cdot \cos 2\pi f_c t.$$



⇒ O/P of the multiplier,

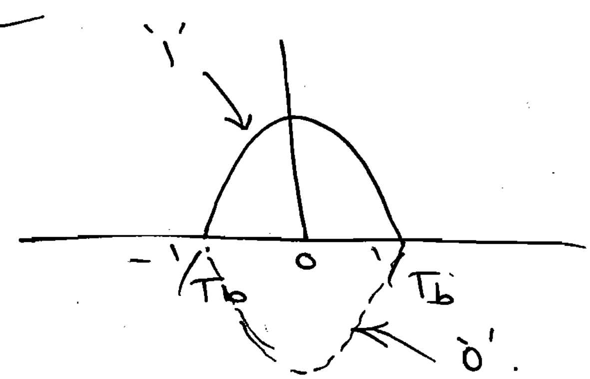
$$s_1(t) \cdot (LO)_0 = A_c \cos 2\pi f_c t \cdot A_c \cos 2\pi f_c t$$

$$= \frac{A_c^2}{2} + \frac{A_c^2}{2} \cdot \cos 2\pi (2f_c t).$$

$$s_2(t) \cdot (LO)_0 = -A_c^2 \cos 2\pi f_c t \cdot \cos 2\pi f_c t$$

$$= -\frac{A_c^2}{2} - \frac{A_c^2}{2} \cos 2\pi (2f_c) t.$$

* Energy:



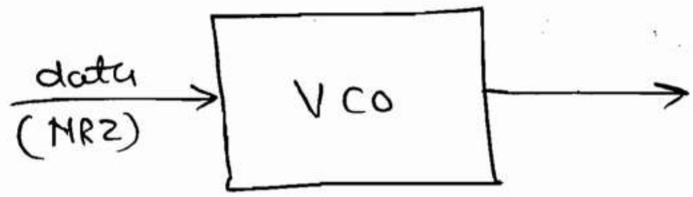
$$\Rightarrow \quad E_b = \int_0^{T_b} s^2(t)\,dt = P \times T_b.$$

$$\therefore \quad E_b = \frac{A_c^2}{2} \cdot T_b. \quad \text{'1'} \qquad A_c = \sqrt{\frac{2E_b}{T_b}}.$$

$$E_b = \frac{A_c^2}{2} \cdot T_b \quad \text{'0'}.$$

③ Frequency Shift Keying:

$\Rightarrow$



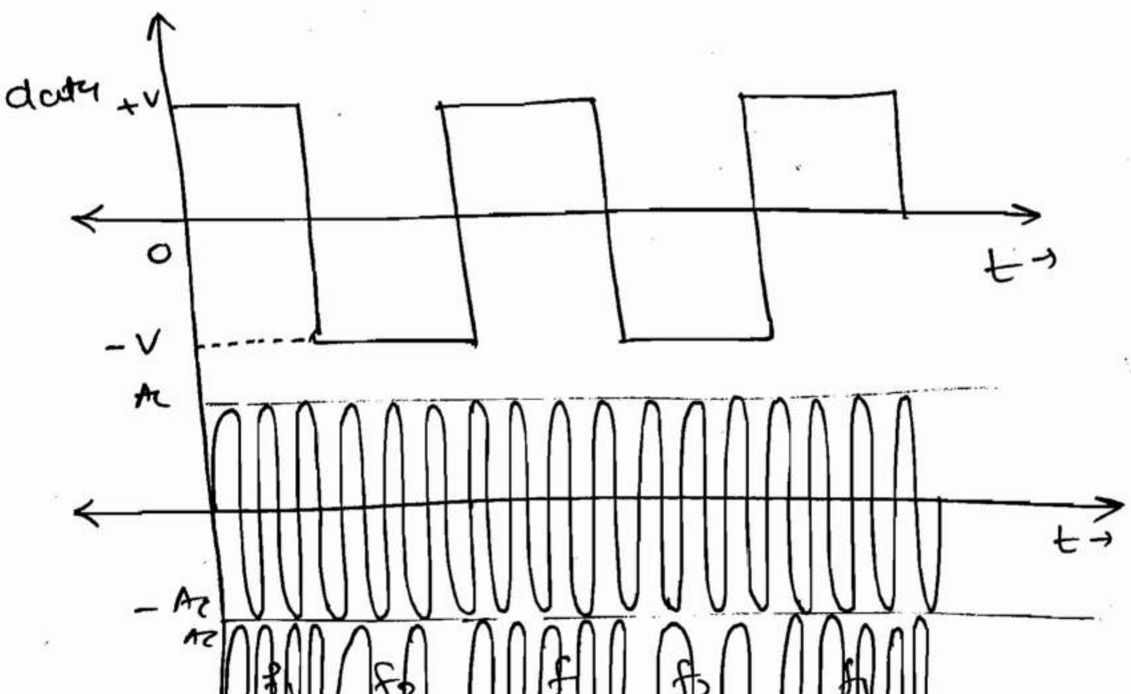
$1 \rightarrow +V \qquad f_1$

$0 \rightarrow -V \qquad f_2$

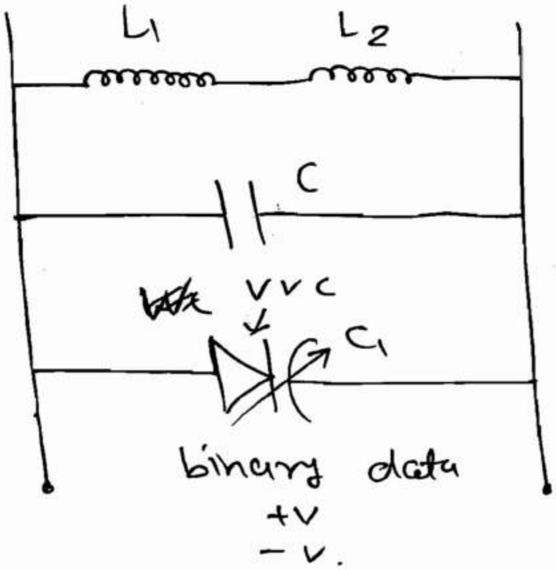
$$f_i = f_c + k_f m(t).$$

$$\therefore \quad f_1 = f_c + k_f \cdot V = \text{Mark freq.}$$

$$f_2 = f_c - k_f \cdot V = \text{Space freq.}$$



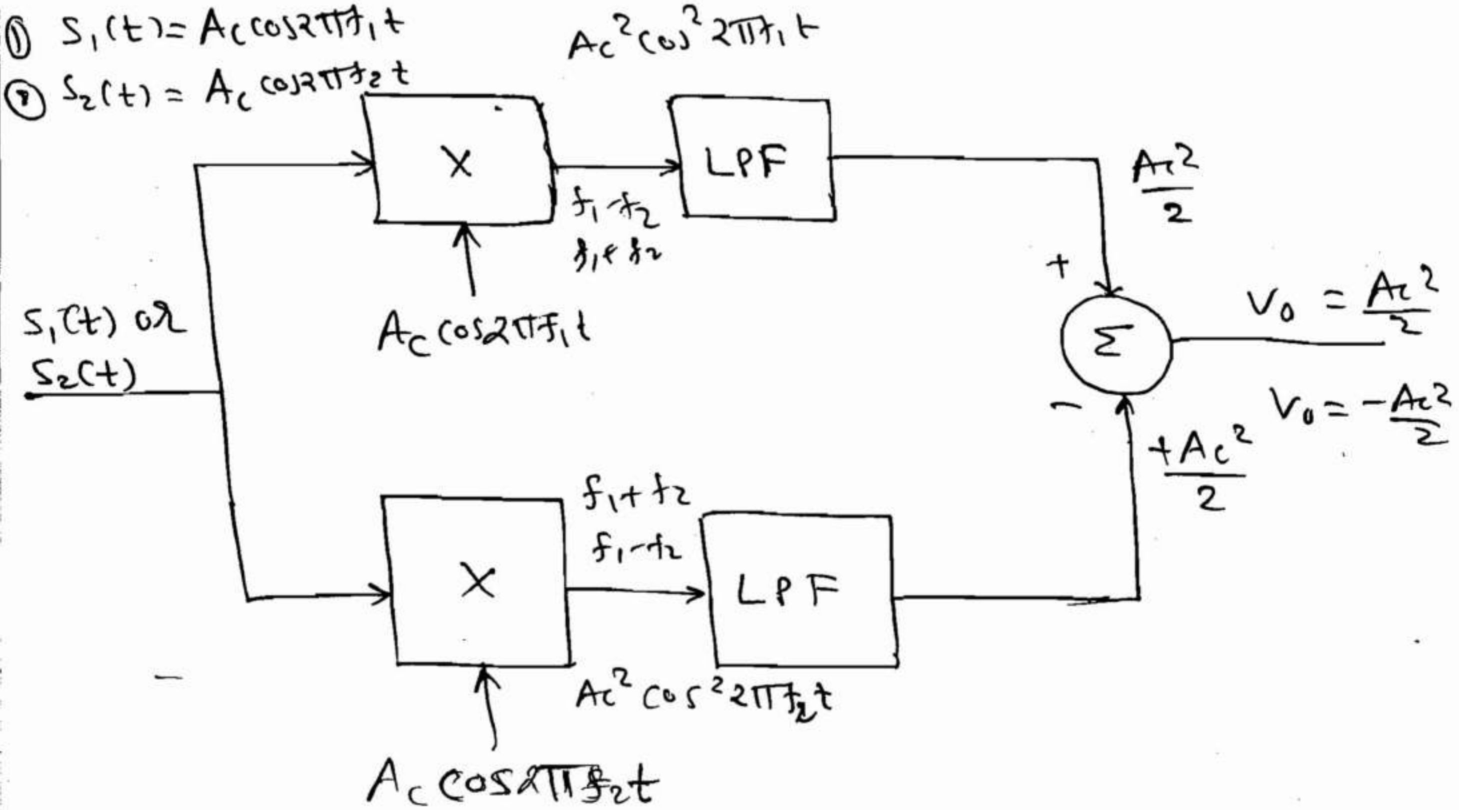
$\Rightarrow$



$$\Rightarrow \quad S_1(t) = A_c \cos 2\pi f_1 t.$$

$$S_2(t) = A_c \cos 2\pi f_2 t.$$

* Demodulation OF FSK:



$$\Rightarrow \quad E_b = \frac{A_c^2}{2} \cdot T_b. \quad \text{'1'}$$

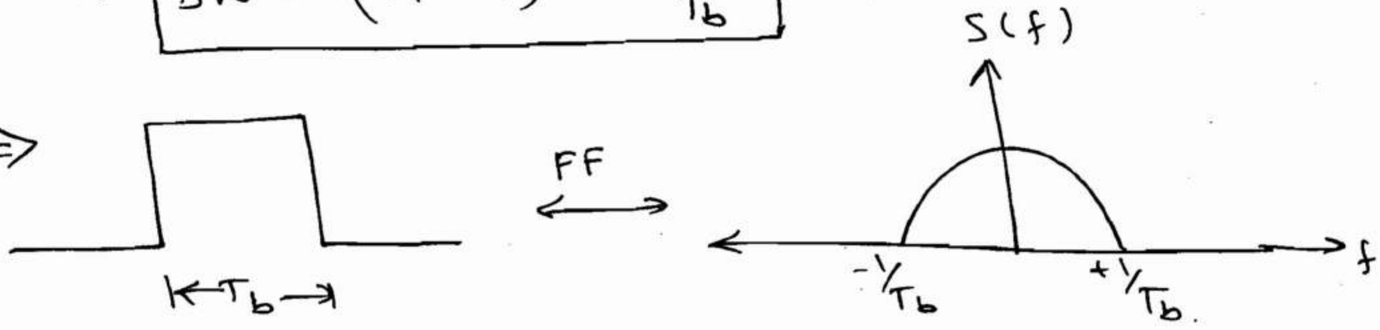
$$E_b = \frac{A_c^2}{2} \cdot T_b \quad \text{'0'}.$$

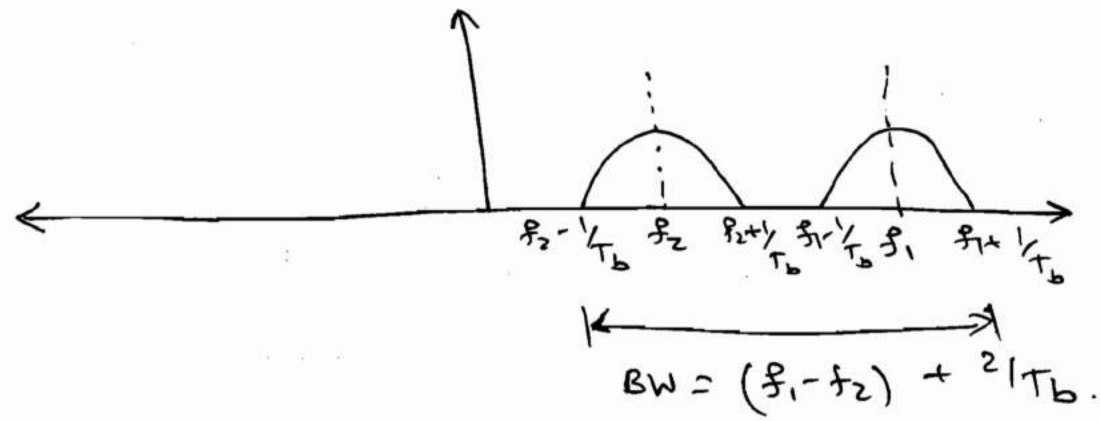
$\Rightarrow \quad BW = 2\Delta f + 2f_m$

$BW = (f_{max} - f_{min}) + 2f_m.$

$\therefore \boxed{BW = (f_1 - f_2) + \frac{2}{T_b}}.$

$\Rightarrow$





Q A Voice signal is sampled at the rate of 8000 samples/sec and each sample is encoded into 8-bits using PCM. The binary data is transmitted into free space after modulation. Determine the BW of the modulated signal when the modulation used is

① ASK ② PSK ③ FSK. ($f_1 = 10\,MHz$, $f_2 = 8\,MHz$).

Sol^n:

Samping rate = 8000 samples / sec.

$n = 8.$

$\therefore \quad R_b = \frac{1}{T_n} \times n.$

① **ASK:** $BW = 2R_b$

$= 2 \times (64 \text{ kbps})$

$$\boxed{BW = 128 \text{ kHz}}$$

② **PSK:** $BW = 2R_b$.

$BW = 2 \times (64 \text{ kbps})$

$$\boxed{BW = 128 \text{ kHz}}$$

③ **FSK:**

$BW = (f_1 - f_2) + 2R_b$.

$= (10-8)\text{m} + 0.128\text{m}$.

$$\boxed{BW = 2.128 \text{ MHz}}$$

⇒ In FSK BW is very high and in ASK Probability of error is very high.
So, optimum techniane is PSK.