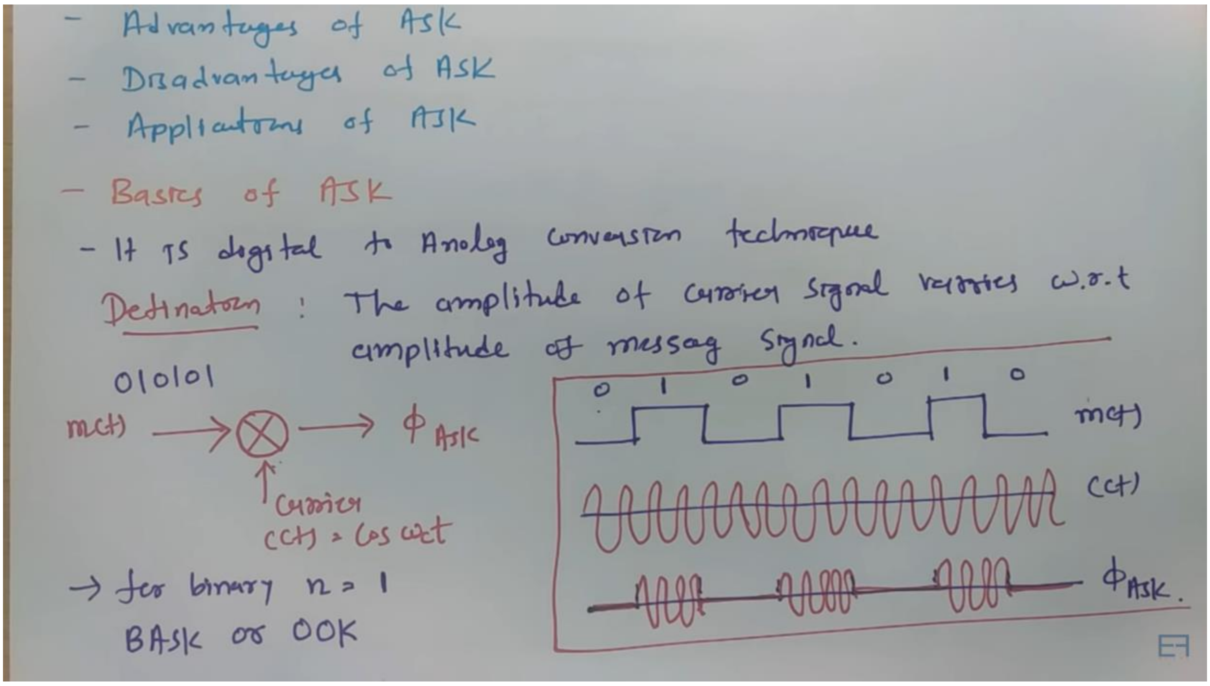
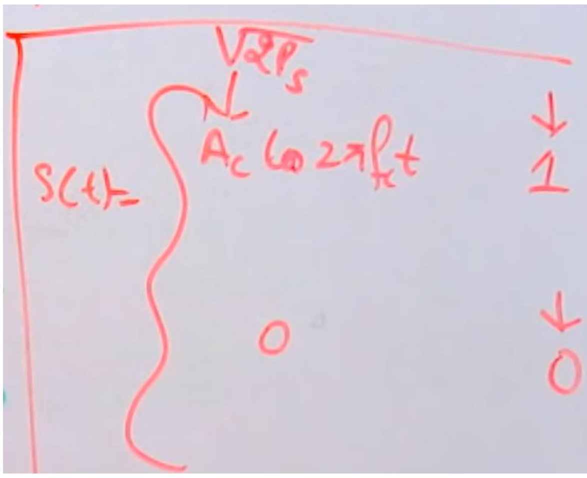
ASK Basics

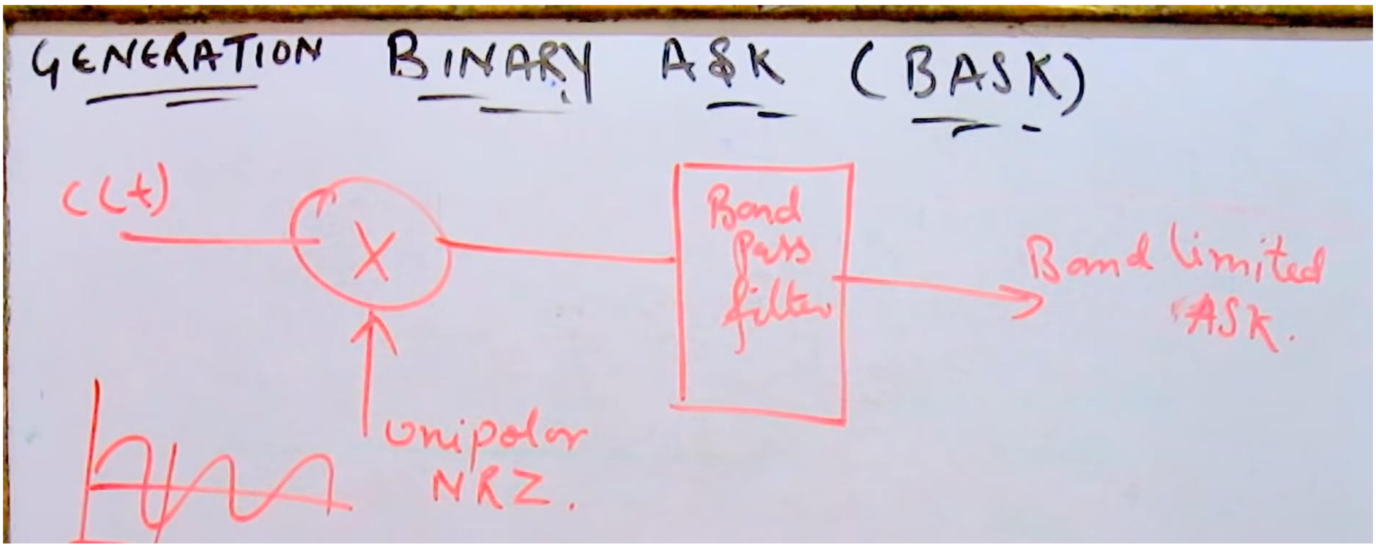


Formula of ASK: -

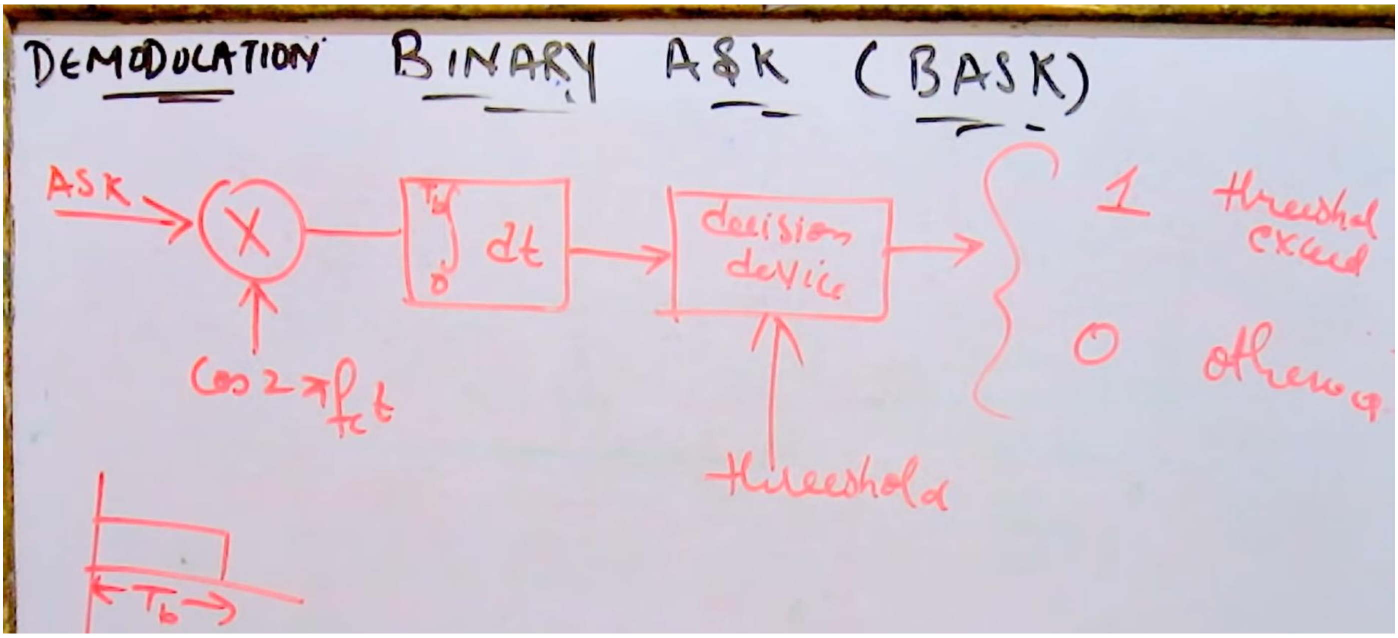
S(t) = A_c Cos(2π f_c t) (by K.S.)



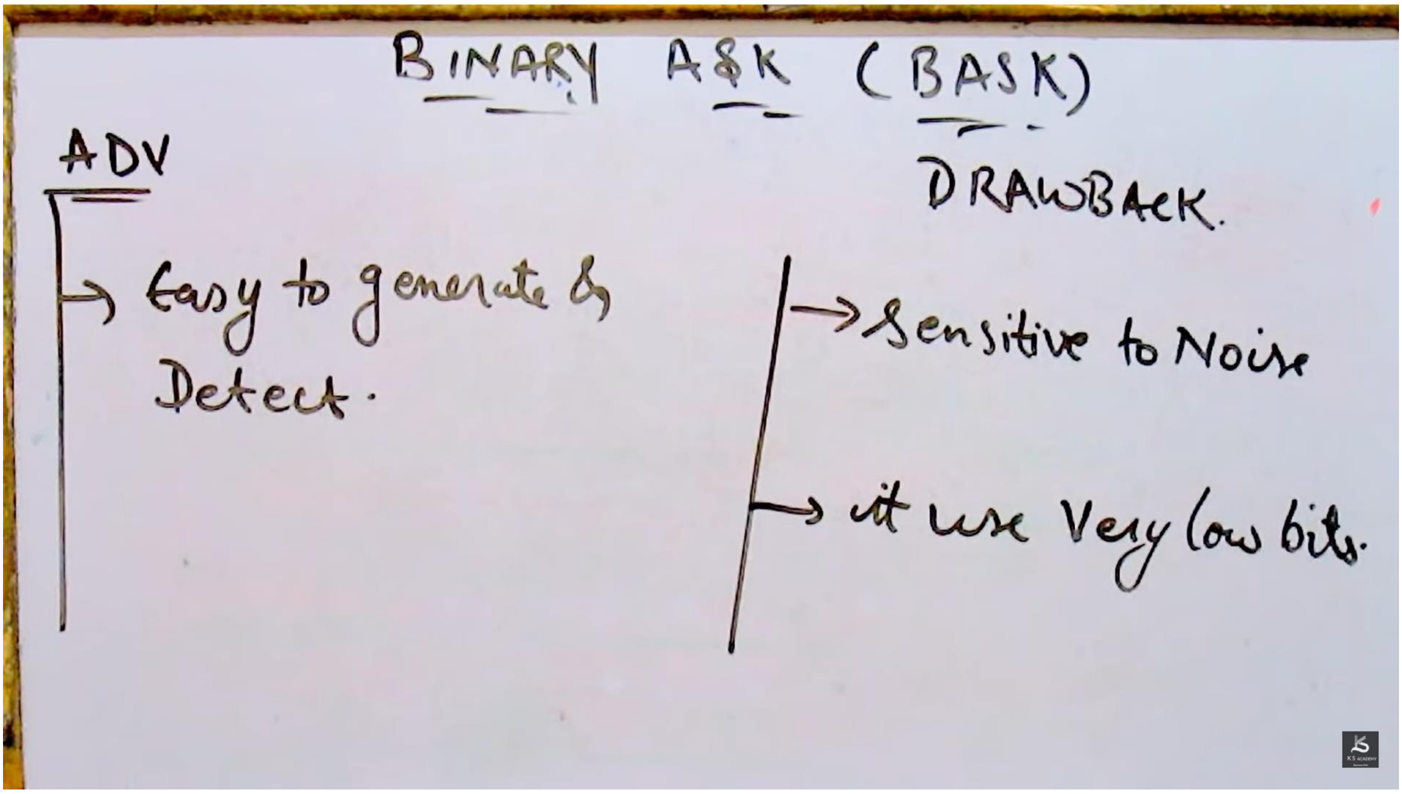
Generation of ASK: -



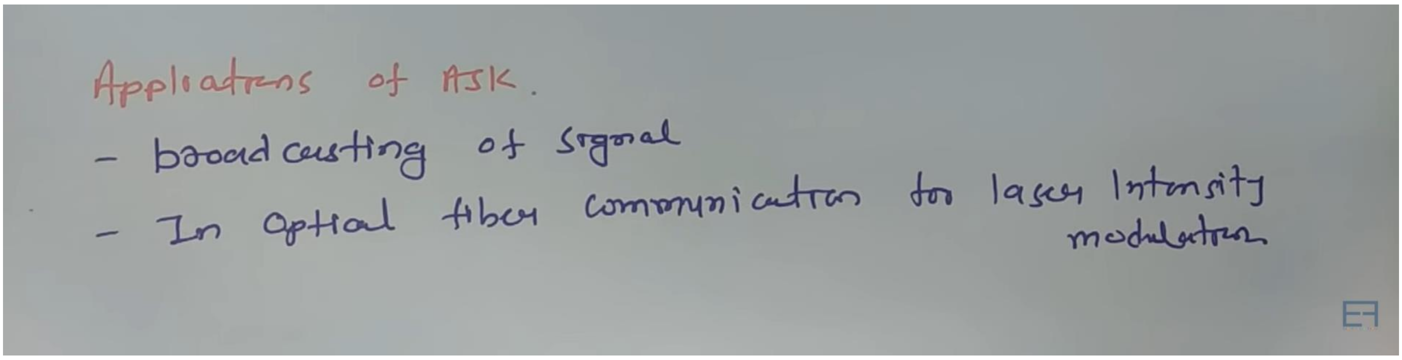
Detection of ASK: -



Advantage of ASK: -



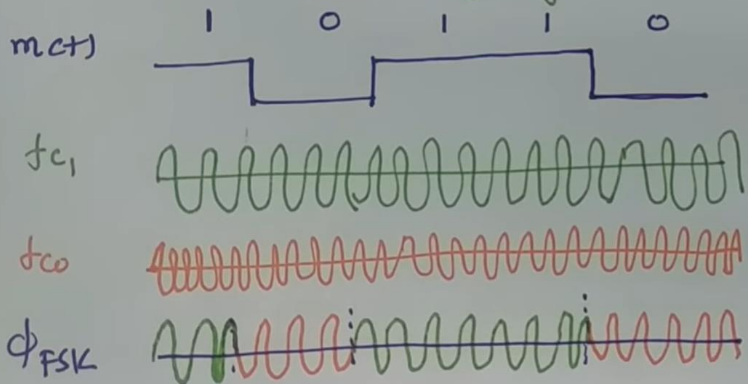
Application: -



FSK Basics: -

- Basics of FSK
- It is used to convert digital data into analog data.

Definition - Freq. of carrier signal varying w.r.t amplitude of message signal.



$$\phi_{FSK} = m_0(t)\cos\omega_{c0}t + m_1(t)\cos\omega_{c1}t$$

$$m(t) = \begin{cases} 1 \rightarrow f_{c1} \\ 0 \rightarrow f_{c0} \end{cases}$$

- Spectrum and BW of FSK

Formula of FSK: -

$$\left[\because P = \frac{V_{rms}^2}{R} = \left(\frac{V_{max}}{\sqrt{2}}\right)^2 = \left(\frac{A}{\sqrt{2}}\right)^2 = \frac{A^2}{2}\right]$$

$$\therefore P = \frac{A^2}{2} \Rightarrow A = \sqrt{2P}$$

eq^n(i) $S_H(t) = \sqrt{2P_s}\cos(2\pi f_c + \Omega)t$; $b(t) =$ '1'

eq^n(ii) $S_L(t) = \sqrt{2P_s}\cos(2\pi f_c - \Omega)t$; $b(t) =$ '0'

[Increment & Decrement in freq by Ω]

By combining eq^{n}s (i) & (ii) we get-

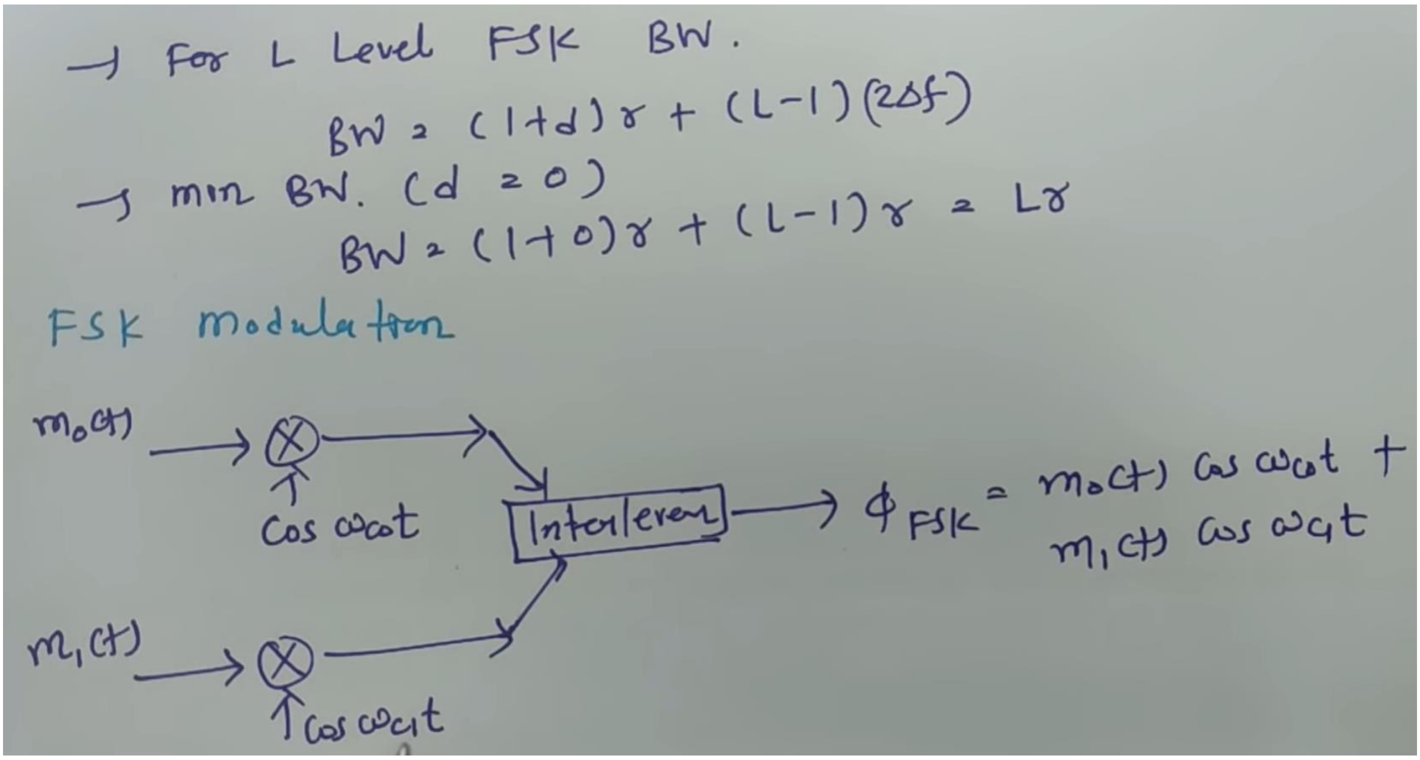
$$\boxed{S(t) = \sqrt{2P_s}\cos\left[(2\pi f_c + d(t)\Omega)t\right]}$$

$(\because \omega = 2\pi f)$

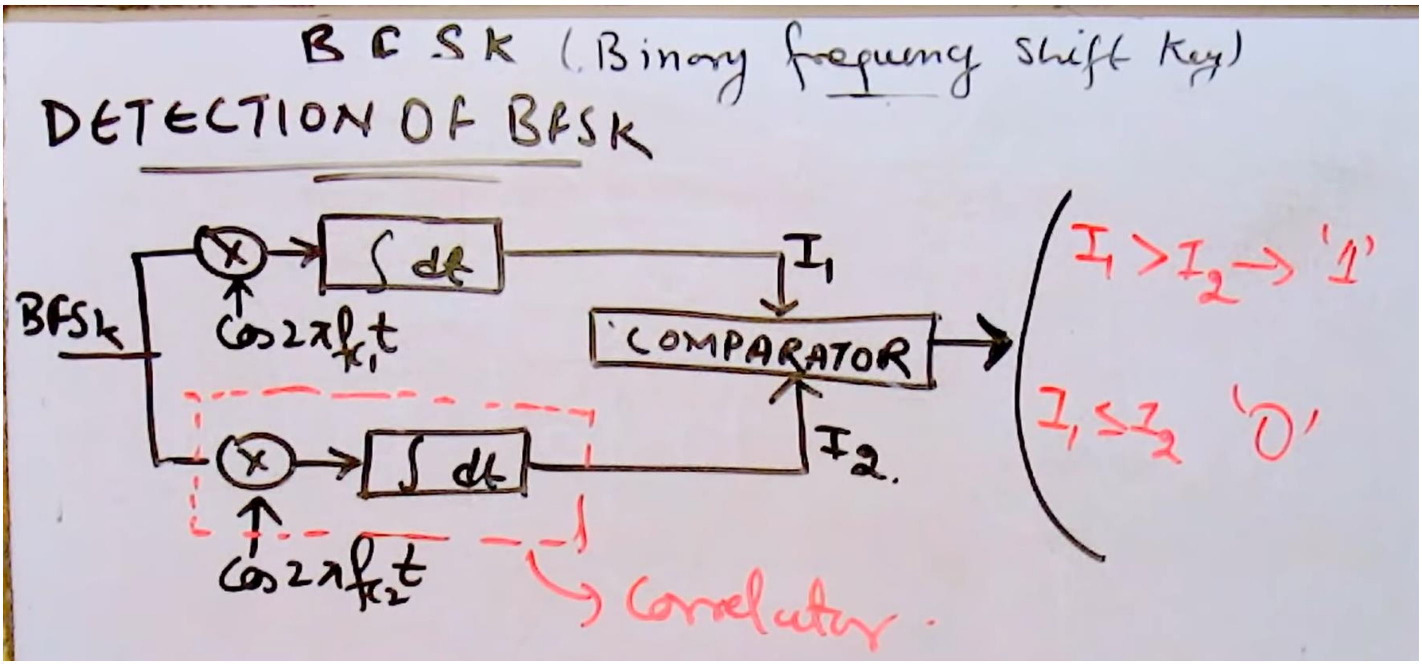
$\therefore f_H \rightarrow f_c + \frac{\Omega}{2\pi}$; For transmitting symbol '1'.

$f_L \rightarrow f_c - \frac{\Omega}{2\pi}$; For transmitting symbol '0'.

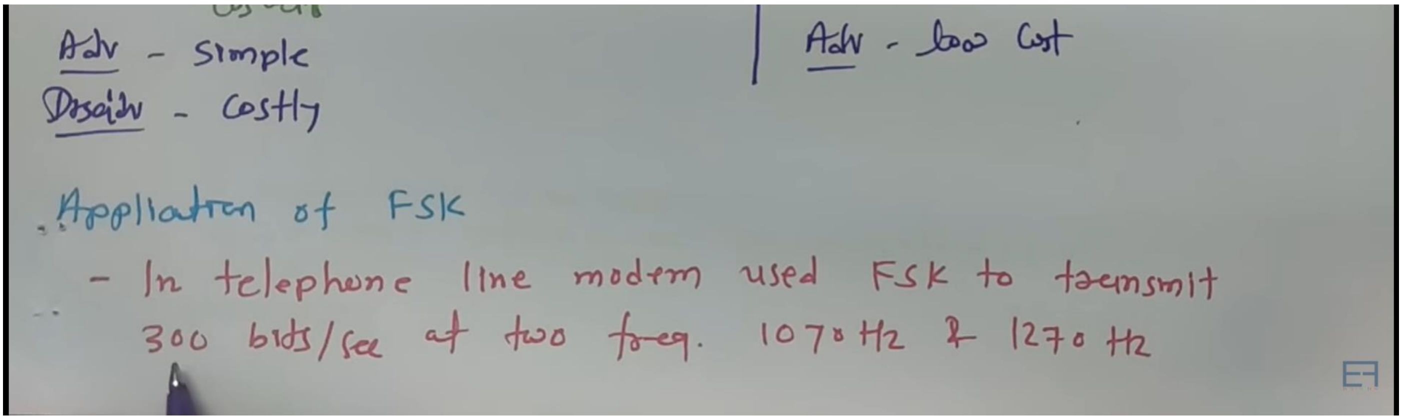
Generation of FSK: -



Detection of FSK: -

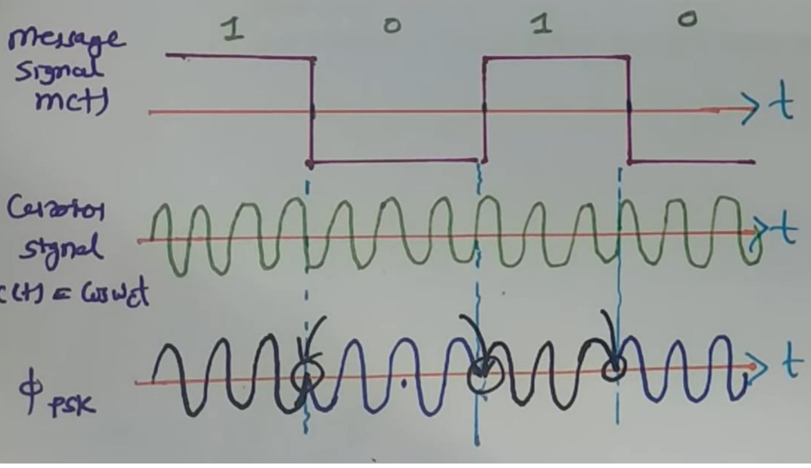


Advantage and Application of FSK: -



PSK Basics: -

- Defination of PSK
  - Carrier phase is varying according to the amplitude of message signal.
- waveforms of PSK



Polar wave NRZ

→ for 1 to 0 phase reversal.

→ 1 → $\phi = 0^\circ$

0 → $\phi = 180^\circ$

Formula of PSK: -

$$s_1(t) = A_c\, cos(2\pi f_c t), \qquad 0 \le t \le T_b \quad \text{for binary 1}$$
$$s_0(t) = A_c\, cos(2\pi f_c t + \pi), \quad 0 \le t \le T_b \quad \text{for binary 0}$$

Now using eq^n^s (i) & (ii)

By combining eq^n^s (i) & (ii) we can define BPSK signal as →

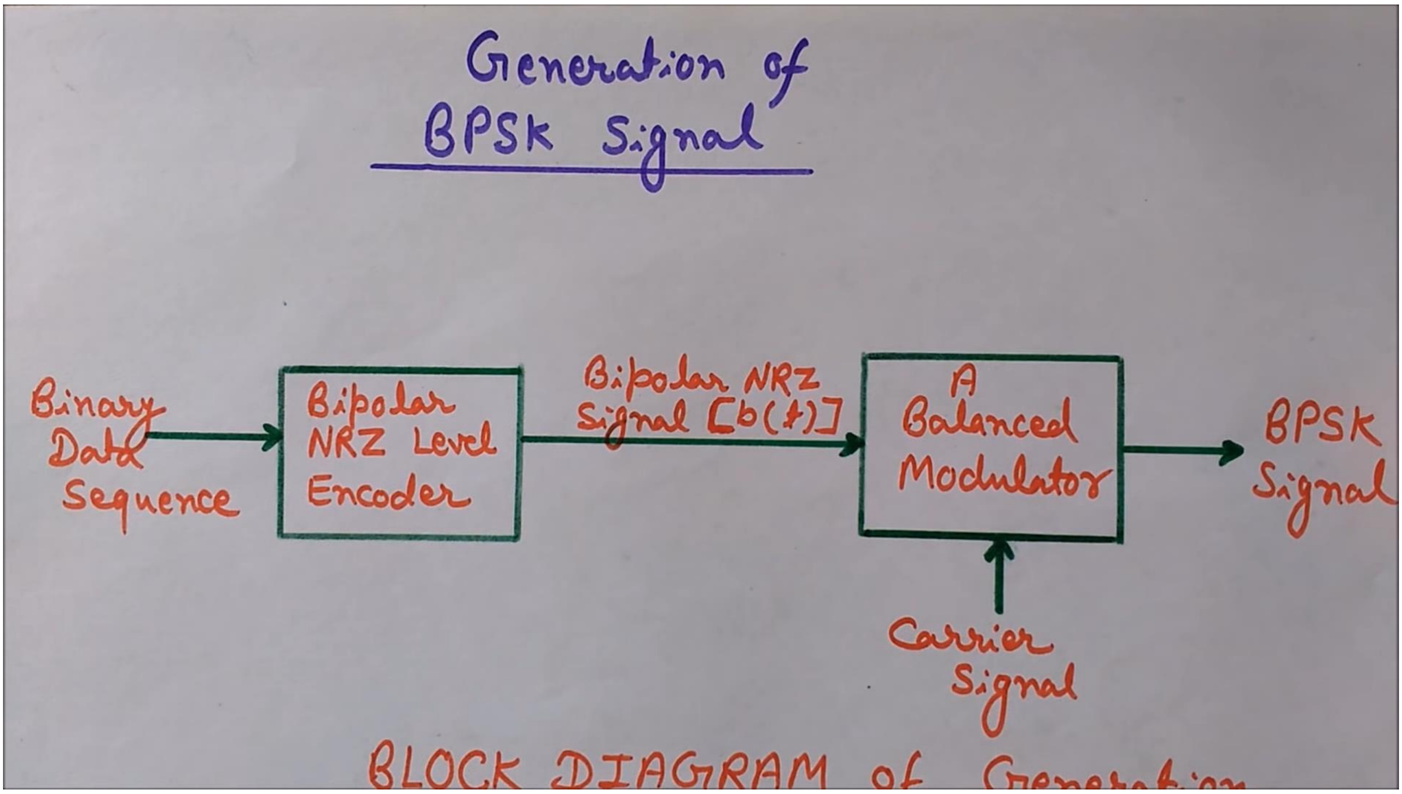
$$\boxed{s(t) = b(t)\sqrt{2P}\cos(2\pi f_c t)}$$

Here

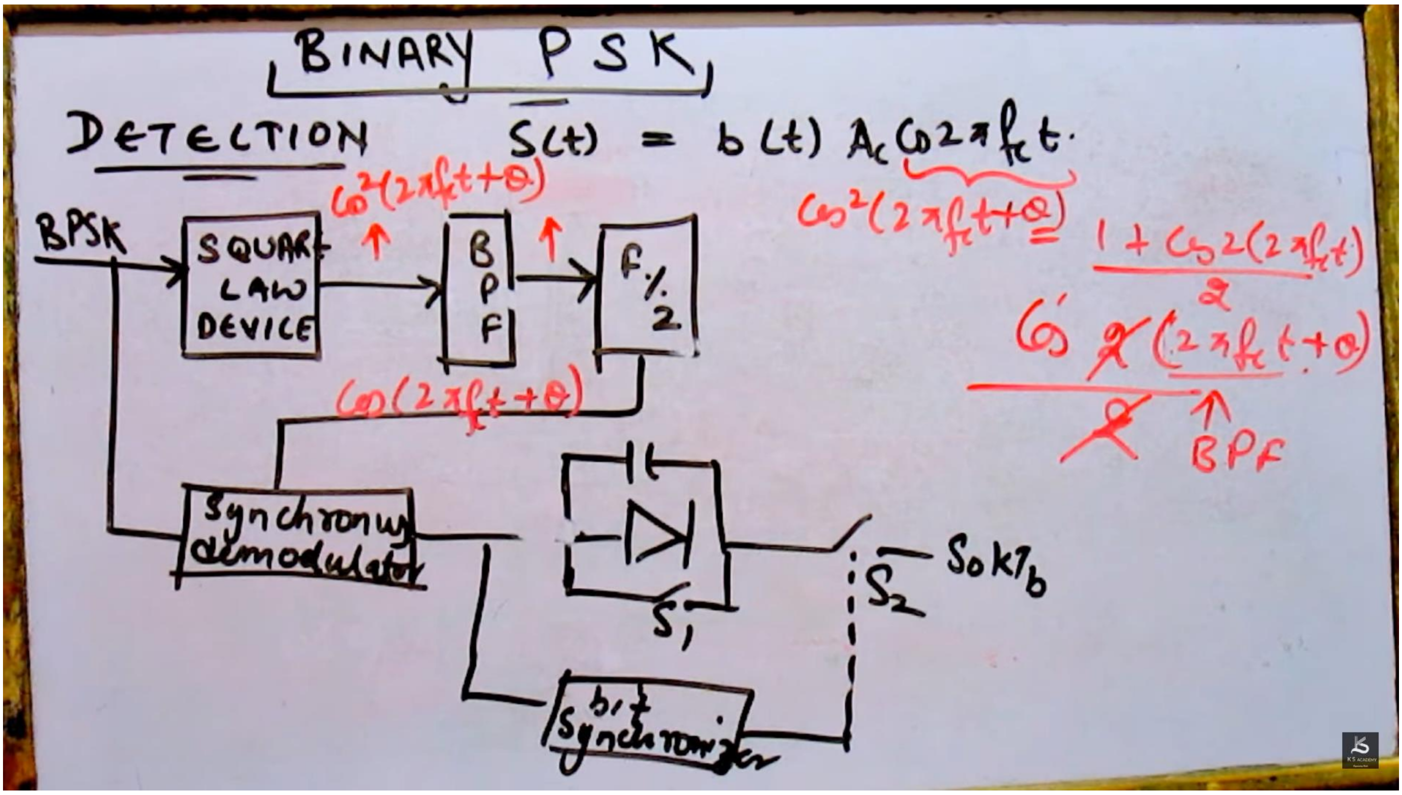
$b(t) = +1$ when transmitting binary '1'

$ = -1$ when binary '0' is to be transmitted

Generation of PSK: -



Detection of PSK: -



Advantage and Application of PSK: -

Advantages of PSK

- Better than ASK, FSK
- BW is better than FSK
- Noise Immunity - Datarate better than FSK

Drawbacks of PSK

- No Non Coherent detection
- Costly

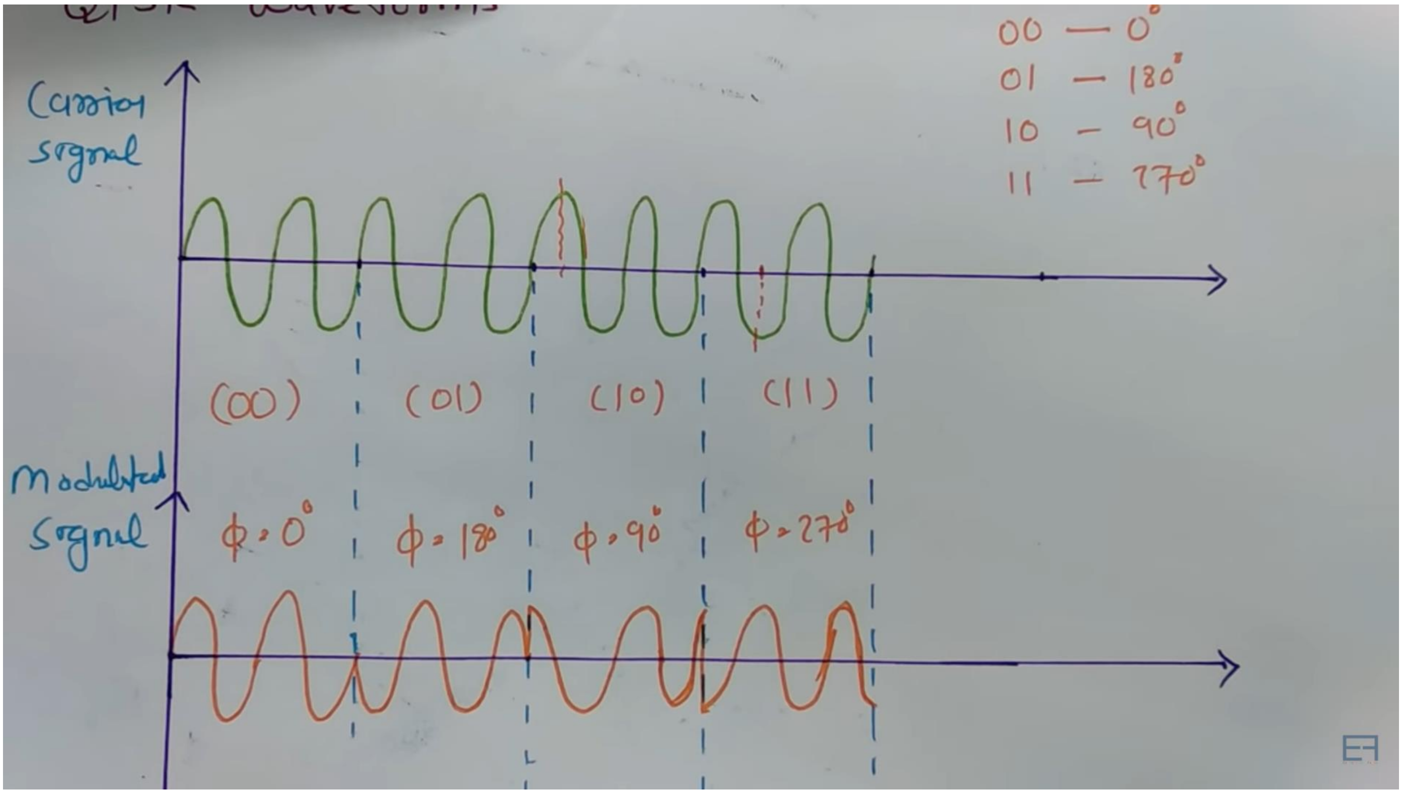
Applications of PSK

- In digital communication
- It was also used in earliest telephone modems with data rate [2400 and 4800 bits/sec]

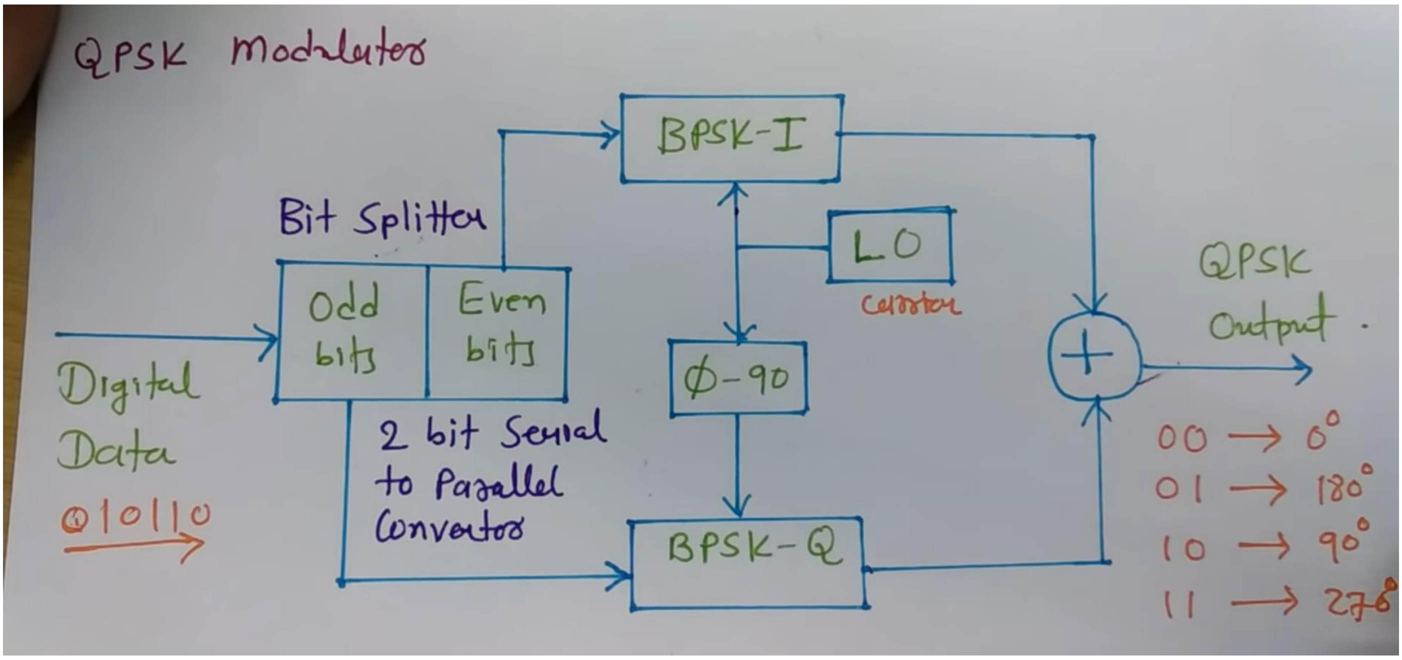
QPSK Basics: -

- Quadrature phase shift keying (QPSK) is a form of PSK (Phase shift keying), in which two bits are modulated at once.
- It selects one of four possible carrier phase shifts [0°, 90°, 180°, 270°]
- QPSK allows the signal to carry twice as much information as ordinary PSK using the same BW.
- QPSK is used for satellite transmission of MPEG2, cable modem, cellular phone system etc.

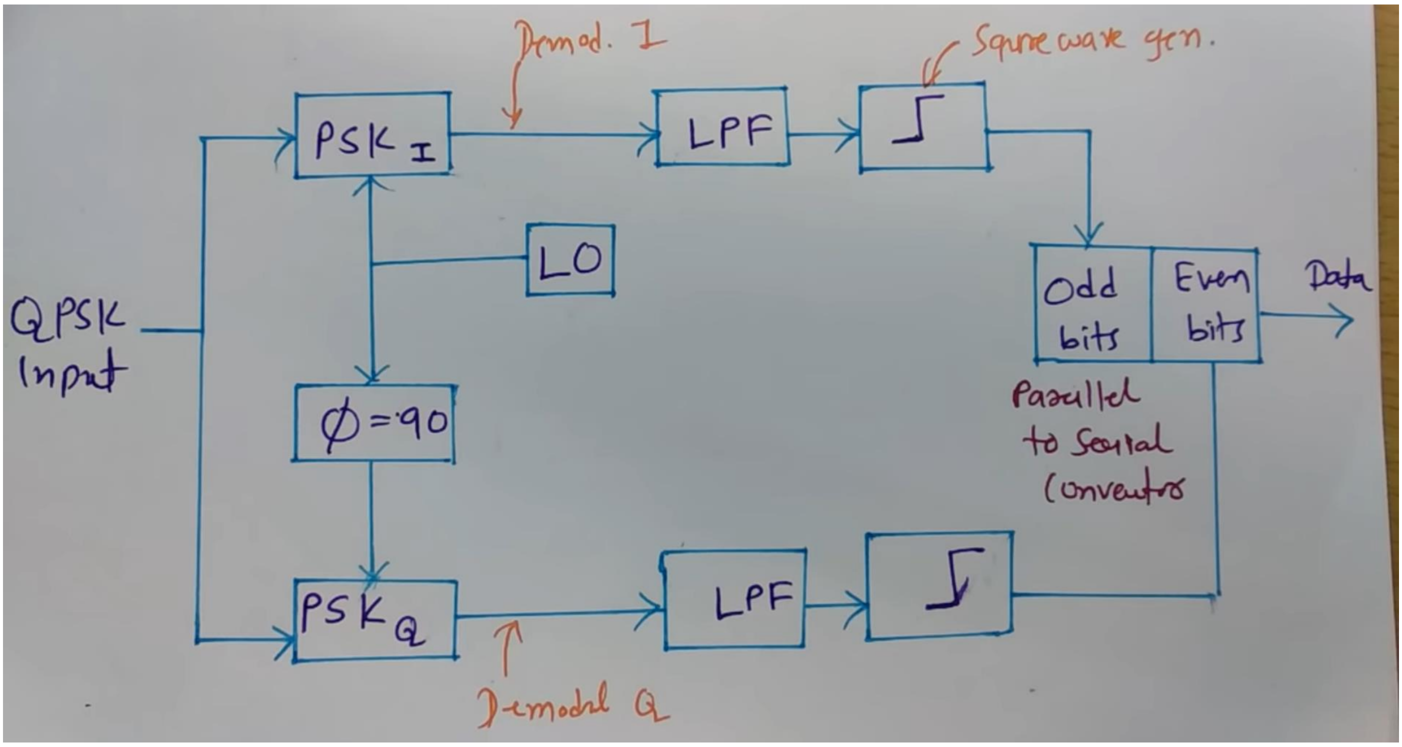
Waveform: -



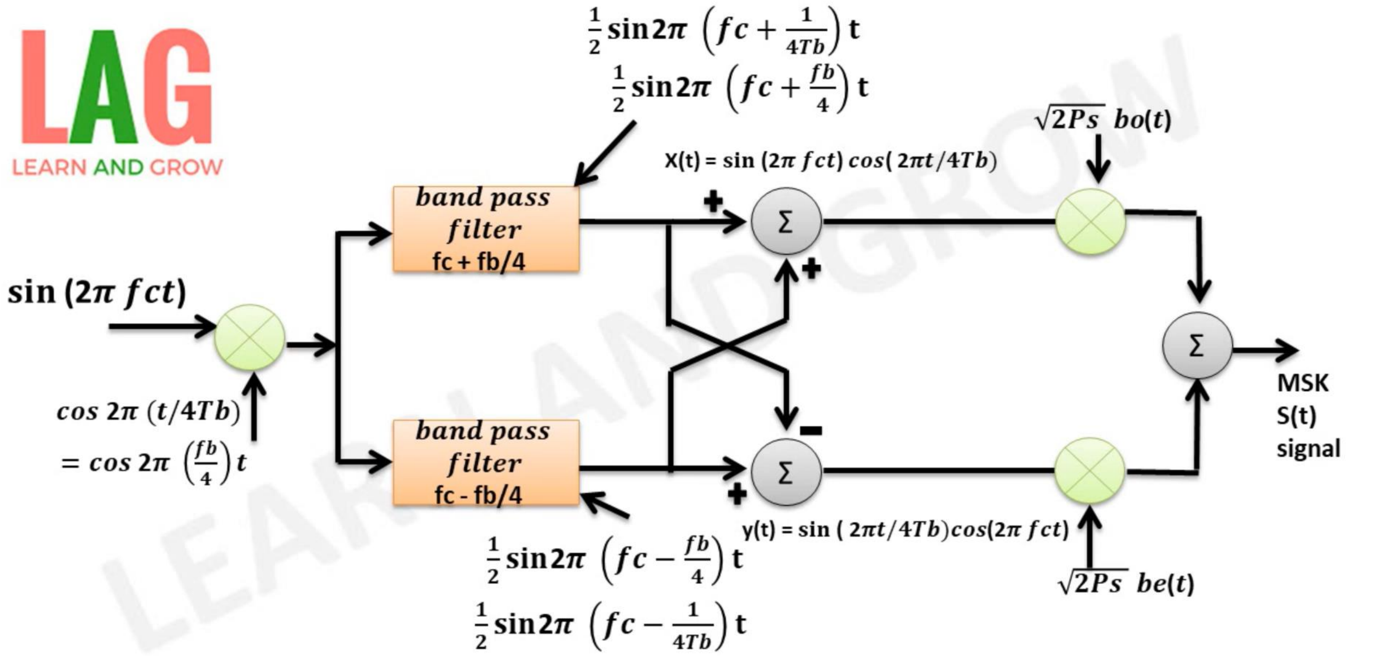
Modulation: -



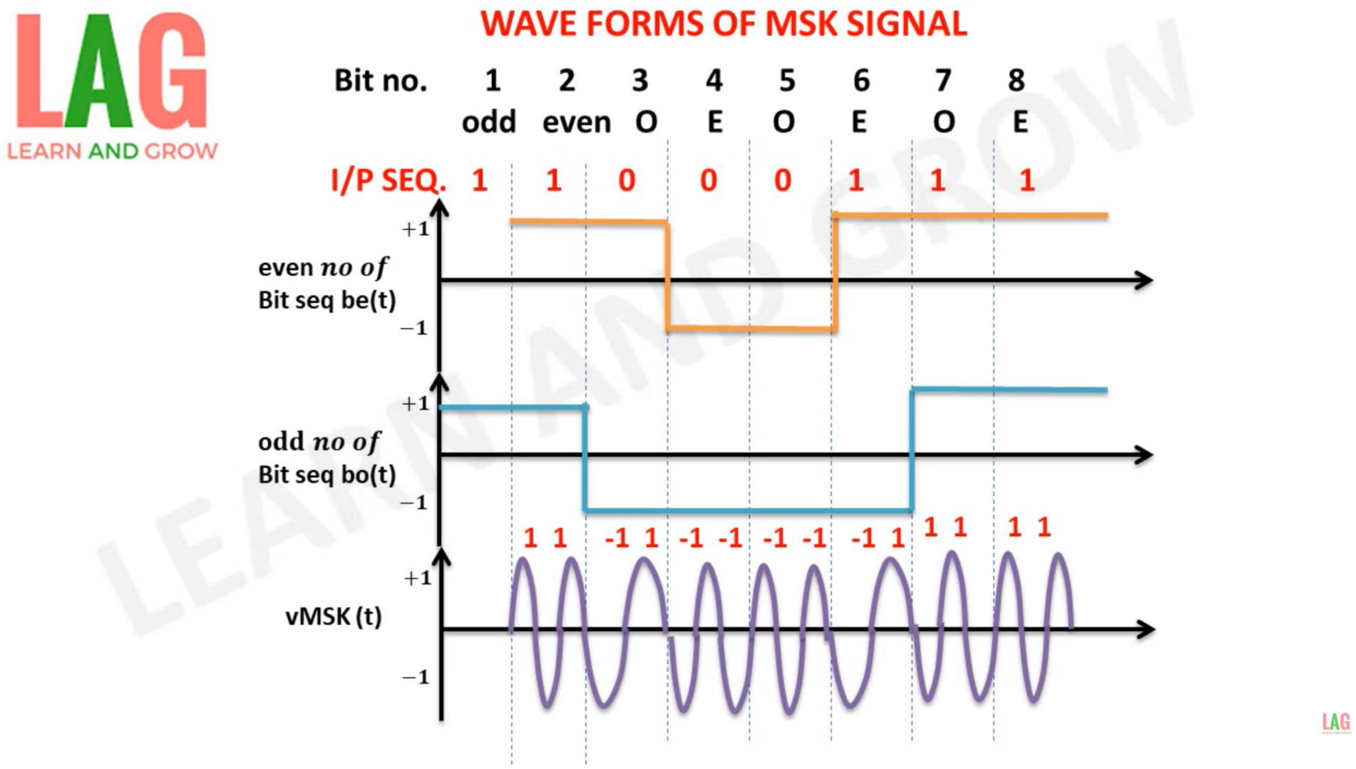
Demodulation: -



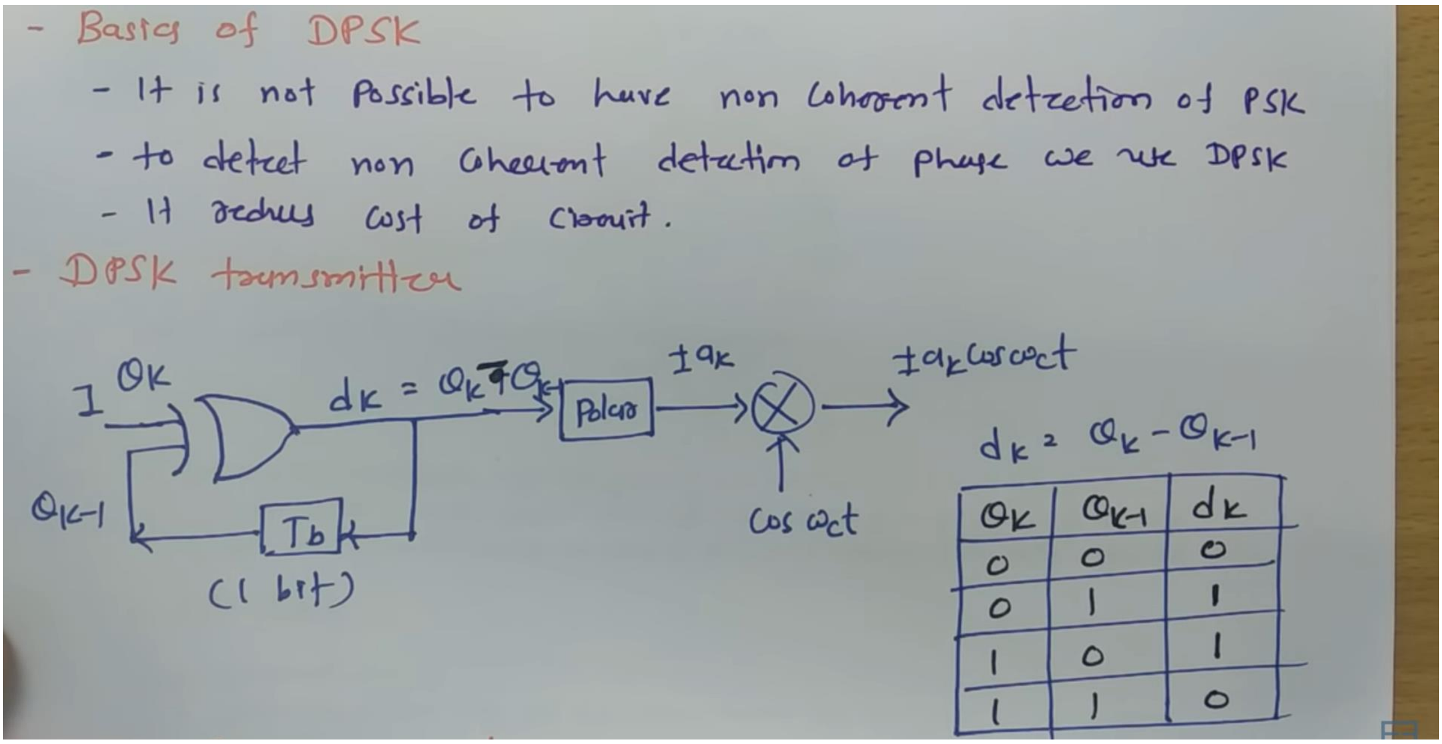
MSK: -



$$S(t) = \sqrt{2Ps}\ [be(t)\sin(2\pi t/4Tb)]\cos(2\pi fct) + \sqrt{2Ps}\ [bo(t)\cos(2\pi t/4Tb)]\sin(2\pi fct)$$

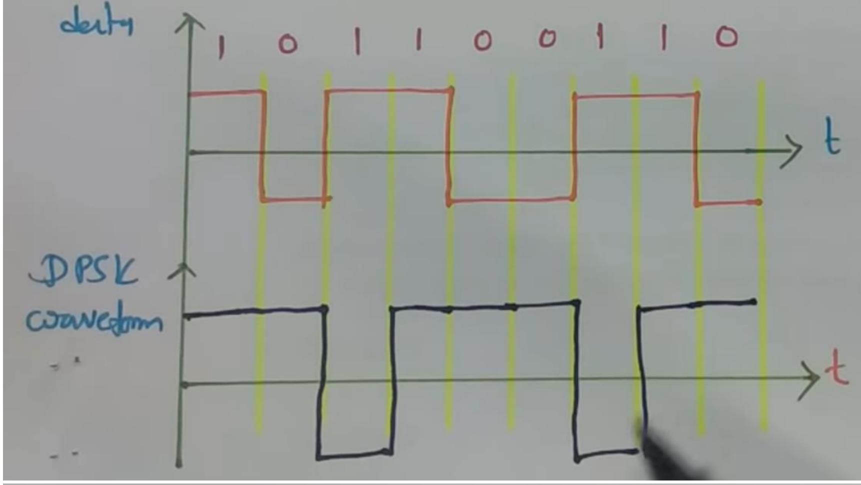

LAG
LEARN AND GROW
WAVE FORMS OF MSK SIGNAL
Bit no. 1 2 3 4 5 6 7 8
odd even O E O E O E
I/P SEQ. 1 1 0 0 0 1 1 1
+1
even no of
Bit seq be(t)
−1
+1
odd no of
Bit seq bo(t)
−1
1 1 -1 1 -1 -1 -1 -1 -1 1 1 1 1 1
+1
vMSK (t)
−1

DPSK: -

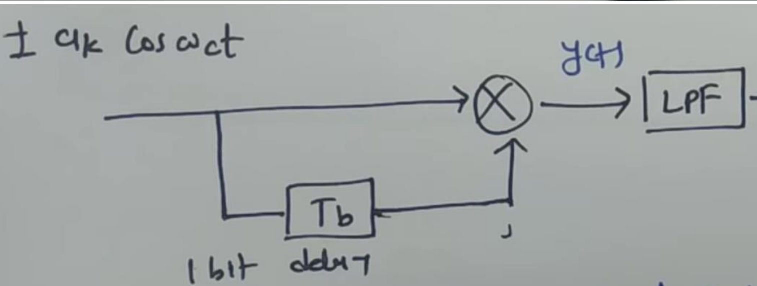

- Basics of DPSK
- It is not possible to have non coherent detection of PSK
- to detect non Coherent detection of phase we use DPSK
- It reduces cost of Circuit.
- DPSK transmitter
I Qk
dk = Qk ⊕ Qk-1
Polar
±ak
±ak cos ωct
cos ωct
Qk-1
Tb
(1 bit)
dk = Qk - Qk-1
Qk Qk-1 dk
0 0 0
0 1 1
1 0 1
1 1 0

- DPSK ~~Receiver~~ waveforms

  - If next data is 1, then change polarity of o/p.
  - If next data is 0, then do not change polarity of o/p.



$\pm a_k \cos \omega_c t$



$z(t) = \frac{a_k^2}{2} \rightarrow$ bit 1

$= -\frac{a_k^2}{2} \rightarrow$ bit 0

- Case-I [same polarity of Input & delayed signal]
  - $y(t) = (a_k \cos \omega_c t)(a_k \cos \omega_c t) = a_k^2 \cos^2 \omega_c t$

    $= \frac{a_k^2}{2}[1 + \cos 2\omega_c t] = \frac{a_k^2}{2} + \frac{a_k^2}{2}\cos 2\omega_c t \xrightarrow{LPF} = \frac{a_k^2}{2}$
- Case-II [opposite polarity of Input & delayed signal]
  - $y(t) = (a_k \cos \omega_c t)(-a_k \cos \omega_c t) = -\frac{a_k^2}{2} - \frac{a_k^2}{2}\cos 2\omega_c t$

    $\xrightarrow{LPF} = -\frac{a_k^2}{2}$

Advantages of DPSK

Advantage and Disadvantage: -

Advantages of DPSK

$\xrightarrow{LPF} \; -\frac{q_k^2}{2}$

- Non Coherent detection is possible
- Cost is less
- Circuit Complexity is less

Drawbacks of DPSK

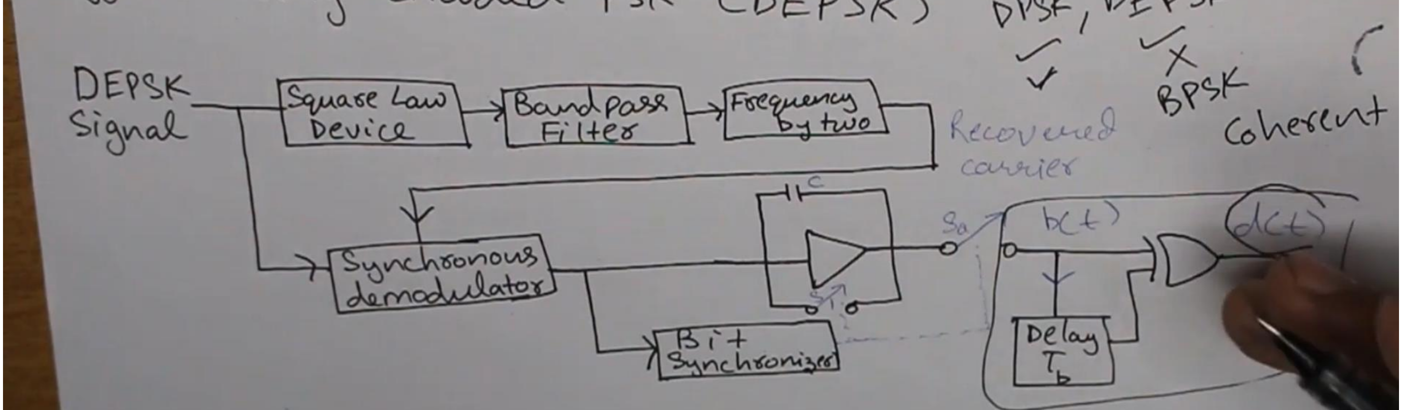
- Noisy

DEPSK: -

Generation of DEPSK is same as DPSK

Detection: -

Differentially encoded PSK (DEPSK)



$d(t) = 0$ if $b(t) = b(t - T_b)$ ✓

$d(t) = 1$ if $b(t) = \overline{b(t - T_b)}$ ✓

Advantages: Uses coherent type of detection unlike DPSK. Therefore POE is less.

Drawbacks: Complex receiver

Calculation of average probability of error for different modulation schemes

1) Nature of signal

2) SNR, $\gamma_{max}^2 = \frac{2}{\eta}\int_0^T |P(t)|^2\,dt$

3) $P_e = \frac{1}{2}\,\text{erfc}\left[\frac{1}{8}\gamma_{max}^2\right]^{1/2}$

Prob. of Error of ASK:

1) $1 \rightarrow A\cos wt$, $0 \rightarrow 0$ } unipolar

$\int_0^T \cos^2 wt\,dt = \frac{T}{2} + \frac{\sin 2wT}{4w}$

$\int_0^T \left(\frac{1+\cos 2wt}{2}\right)dt$

2) $\gamma_{max}^2 = \frac{2}{\eta}\int_0^T |P(t)|^2\,dt = \frac{2}{\eta}\int_0^T (A\cos wt - 0)^2\,dt$

$= \frac{2A^2}{\eta}\int_0^T \cos^2 wt\,dt$

$= \frac{2}{\eta}A^2\left[\frac{T}{2} + \frac{\sin 2wT}{4w}\right]$ → 1, $\frac{1}{\text{large}} \rightarrow 0$, $w >>$

$= \frac{A^2 T}{\eta}$

$E_s = \frac{A^2}{2}T$

3) $P_e = \frac{1}{2}\,\text{erfc}\left[\frac{1}{8}\gamma_{max}^2\right]^{1/2} = Q\left[\sqrt{\frac{E_s}{\eta}}\right]$ where $E_s = \frac{A^2}{2}T$

$= \frac{1}{2}\,\text{erfc}\left[\frac{1}{8}\times\frac{A^2T}{\eta}\right] = \frac{1}{2}\,\text{erfc}\left[\frac{E_s}{4\eta}\right]$

Prob. of Error of BPSK:

1) $1 \rightarrow A\cos wt$, $0 \rightarrow -A\cos wt$ $\frac{360^\circ}{2} = 180^\circ$

$P(t) = A\cos wt - (-A\cos wt) = 2A\cos wt$

2) $\gamma_{max}^2 = \frac{2}{\eta}\int_0^T |2A\cos wt|^2\,dt = \frac{2\times 4A^2}{\eta}\int_0^T \cos^2 wt\,dt$

$= \frac{2}{\eta}\times 4A^2\left[\frac{T}{2} + \frac{\sin 2wT}{4w}\right]$

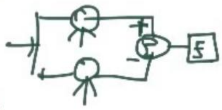
$= \frac{2}{\eta}\times 4A^2\frac{T}{2} = \frac{4A^2T}{\eta}$

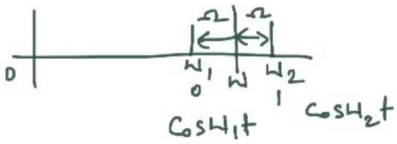
3) $P_e = \frac{1}{2}\,\text{erfc}\left[\frac{1}{8}\gamma_{max}^2\right]^{1/2}$

$= \frac{1}{2}\,\text{erfc}\left[\frac{1}{8}\times\frac{4A^2T}{\eta}\right]^{1/2} = \frac{1}{2}\,\text{erfc}\left[\frac{E_s}{\eta}\right]^{1/2}$ where $E_s = \frac{A^2}{2}T$

Prob. of Error of BFSK:

1) $0 \rightarrow A\cos(\omega-\Omega)t$





$1 \rightarrow A\cos(\omega+\Omega)t$

$P(t) = A\cos(\omega+\Omega)t - A\cos(\omega-\Omega)t$

2) $\gamma^2_{max} = \frac{2}{\eta}\int_0^T |P(t)|^2 dt = \frac{2A^2}{\eta}\int_0^T [\cos(\omega+\Omega)t - \cos(\omega-\Omega)t]^2 dt$

$= \frac{2A^2}{\eta}\int_0^T \left[\cos^2(\omega+\Omega)t + \cos^2(\omega-\Omega)t - 2\cdot\cos(\omega+\Omega)t\cdot\cos(\omega-\Omega)t\right] dt$

$\int_0^T \cos at\cdot\cos bt\, dt = \frac{\sin(a-b)T}{2(a-b)} + \frac{\sin(a+b)T}{2(a+b)}$

$= \frac{2A^2}{\eta}\left[\frac{T}{2} + \frac{\sin 2(\omega+\Omega)T}{4(\omega+\Omega)} + \frac{T}{2} + \frac{\sin 2(\omega-\Omega)T}{4(\omega-\Omega)} - \frac{\sin 2\Omega T}{2\Omega} - \frac{\sin 2\omega T}{2\omega}\right]$

$= \frac{2A^2T}{\eta}\left[1 + \frac{\sin 2(\omega+\Omega)T}{4(\omega+\Omega)T} + \frac{\sin 2(\omega-\Omega)T}{4(\omega-\Omega)T} - \frac{\sin 2\Omega T}{2\Omega T} - \frac{\sin 2\omega T}{2\omega T}\right]$

$\rightarrow \omega \gg \Omega, \; \omega T \gg 1$

$\gamma^2_{max} = \frac{2A^2T}{\eta}\left[1 - \frac{\sin 2\Omega T}{2\Omega T}\right] = \frac{2.42\, A^2 T}{\eta}$

$2\Omega T = \frac{3\pi}{2}$

3) $P_e = \frac{1}{2}\,\text{erfc}\left[\frac{1}{8}\times 2.42\frac{A^2T}{\eta}\right] = \frac{1}{2}\,\text{erfc}\left[0.3\frac{A^2T}{\eta}\right]$

$= \frac{1}{2}\,\text{erfc}\left[0.6\frac{E_s}{\eta}\right]$

where $E_s = \frac{A^2}{2}\cdot T$

Prob. of Error of DPSK:

$P_e = \frac{1}{2}e^{-\frac{E_s}{\eta}}$ where E_s = Energy of [illegible]
η = Gaussian noise constant

ASK < FSK < PSK

$P_{ASK} > P_{FSK} > P_{PSK}$

Comparison b/w ASK, FSK, PSK

ASK

[1] $s_1(t) = A_c \cos 2\pi f_c t$

[0] $s_2(t) = 0$

$$A_c = \sqrt{\frac{2E}{t_b}}$$

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

PSK

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

$s_2(t) = -A_c \cos 2\pi f_c t$

$$BW = 2R_b$$

FSK

$s_1(t) = A_c \cos 2\pi f_1 t$

$s_2(t) = A_c \cos 2\pi f_2 t$

$$BW = [f_1 - f_2] + 2R_b$$