DG

Set-B

Q1
sol

given signal is $p(t) = \begin{cases} \frac{1}{\sqrt{T}} & 0 \leq T \leq T_s \\ 0 & , \text{elsewhere} \end{cases}$

∴ for matched filter the output has a twice time duration as p(t) due its convolution & its peak value is the energy of p(t).

so, time period is $2T_s$
&, peak value is

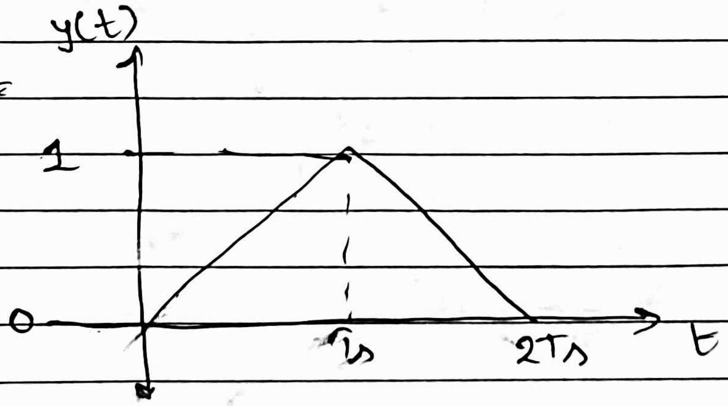
$$E = \int_0^{T_s} \left(\frac{1}{\sqrt{T_s}}\right)^2 dt$$

$$= \frac{1}{T_s} \int_0^{T_s} dt$$

$$= \frac{1}{T_s} \times T_s = 1$$

so, peak value is 1.

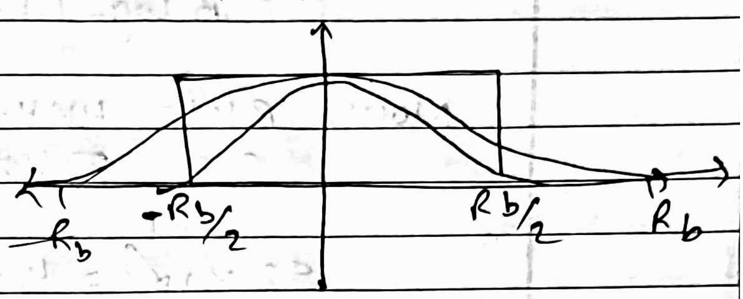
plot =



Q2

Ans For ISI free transmission according to Nyquist Criterion for base band signal is

$$BW \geq \frac{R_b}{2}$$




but for bandpass signal the amplitude s/g spectrum get shifted to some high freq.

$$BW \geq R_b$$

for Mary signaling $BW \geq \frac{R_b}{\log_2 M}$

bitrate $R_b = 128$ kbits/sec.

32-ary signaling is used.

$$BW \geq \frac{128}{\log_2 32}$$

$$BW \geq \frac{128}{5}$$

$$BW \geq 25.6 \text{ KHz}$$

Q3 SNR is the maximised at the output of the filter
sol then the filter is matched.
Filter is matched to the input the energies of both the i/p & matched filters responses $E_s = E_h$ in case the ~~SNR~~ =

$$SNR = \frac{2E_s}{N_0} = \frac{2E_h}{N_0}$$

Q4
Sol →

According to Shannon's Channel theorem

$C = B \log_2(1+SNR)$

Now, $BW = 4KHz$ &
$C =$ ~~64 Kbps~~ $52\ Kbps$

$52 \times 10^3 = 4 \times 10^3 \log(1+SNR)$

$\frac{52}{4} = \log_2(1+SNK)$

$1+SNR = 2^{13}$
$SNR = 8192-1 = \underline{8191}$

$\therefore \frac{S}{N} = 8191$

$S = 8191 \times \frac{\eta}{2} \times 2 \times BW$

$S = 819.1 \times 2\ mJ$

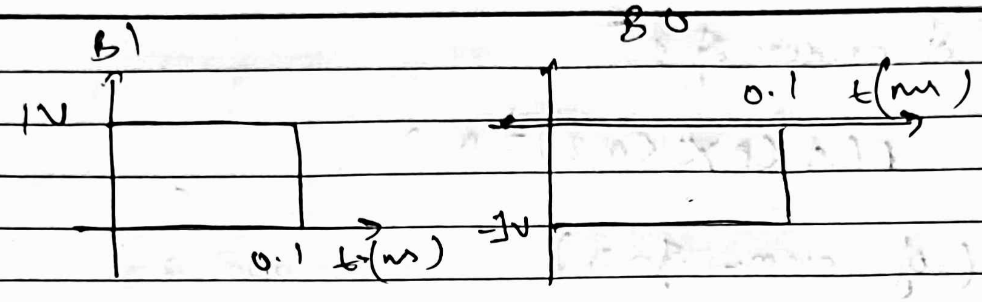
Now $E_b$ = Energy per bit

$E_b = 819.1 \times 2 \times \frac{1}{R_b}\ mJ/bit$

$E_b = 31.5\ mJ/bit.$

Q5

Ans




$R_b = 10$ kbps     BW = 10 KHz     rectangular pulses

$B_1$ & $B_2 = ?$

BPSK     QPSK

the required bandwidth of M-ary PSK is

$$BW = \frac{2R_b}{n}$$

$2^n = M$     $\cancel{M = R = 2^n}$ & $R_b$ is bit rate

for BPSK     $M = 2 = 2^n$ & $n = 1$

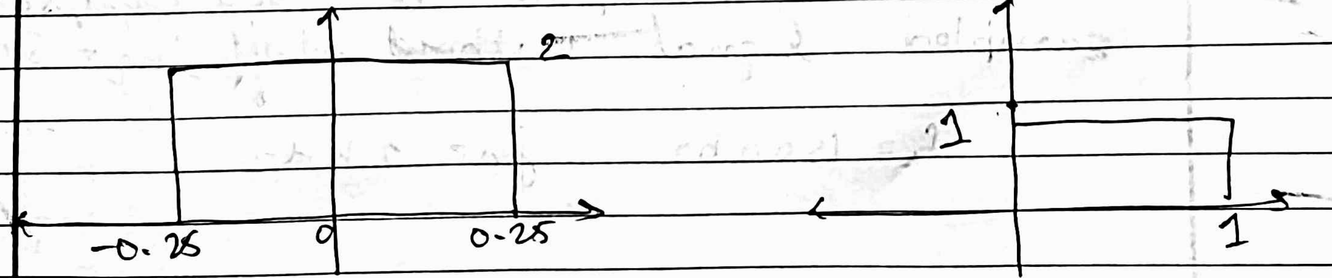
~~there~~ $= B_1 = \frac{2R_b}{1} = 2 \times 10 = 20$ KHz

for QPSK =     $M = 4 = 2^n$ & $n = 2$

$$B_2 = \frac{\cancel{2}R_b}{\cancel{2}} = 10\text{ KHz}$$

Q6     Prob of transmission of 0     prob of transmission of 1

sols



P( of error of 1)

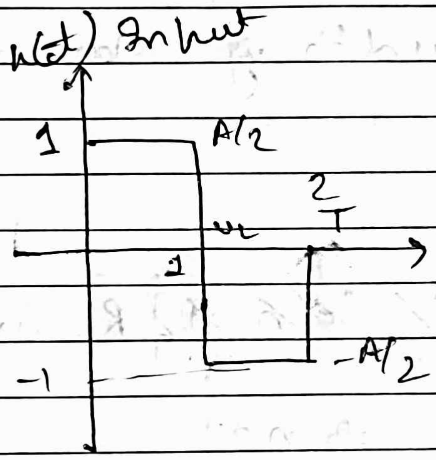
$P(0 < x < 0.2) = 0.2$

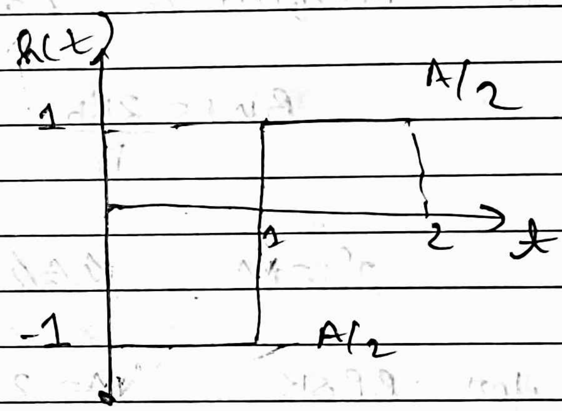
P ( of error of 0)

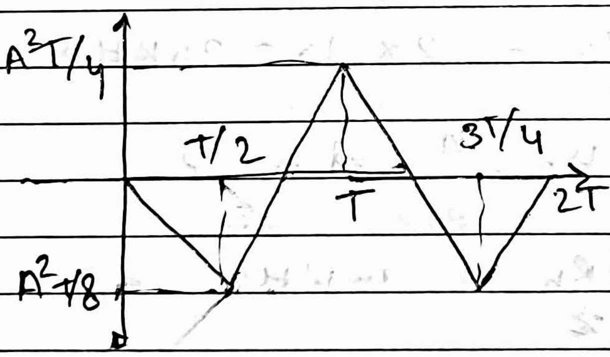
$P(0.2 < x < 0.25) =$
$= 0.05 \times 2 = 0.1$

Average error $= \frac{0.2 + 0.1}{2} = 0.18$

Q8
Sol ->




Q9
Sol ->

1 KHz ideally sampled at 1800 sam/sec
sampled signal without cut-off freq = 800 hz

$f_s = 1500$ hz $\quad f_m = 1$ KHz

Sampled freq. is 2.5 KHz & 0.5 KHz

$\downarrow$ $f_s + f_m$ $\qquad$ $\downarrow$ $f_s + f_m$

$f_c = 800\ hz$ $\quad \therefore$ output $= 0.5\ KHz$

Q10 sol

$$p(t) = \frac{\sin 4\pi W t}{4\pi W t(1-16W^2t^2)}$$

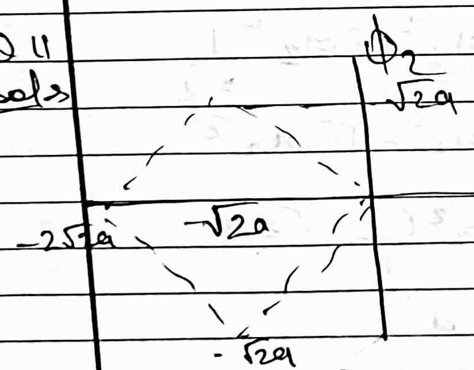
at $t = \frac{1}{4W}$ it is $\frac{0}{0}$ form,
so we'll use L'Hopital's rule.

$$P\left(\frac{1}{4W}\right) = \frac{\cancel{4\pi Wt}\ 4\pi W \cos(4\pi W t)}{4\pi W(1-48W^2t^2)}$$

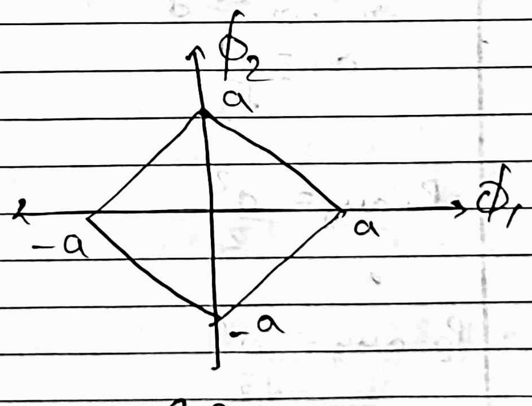
$$= \frac{\cos(4\pi W t)}{1-48W^2t^2} = \frac{\cos\pi}{1-3} = \frac{-1}{-2}$$

$= \underline{0.5}$ Ans

Q11 sols



$C_1$



$C_2$

Average E of C1 is

$$E_1 = \frac{0 + 4a^2 + 4a^2 + 8a^2}{4}$$

$$= 4a^2$$

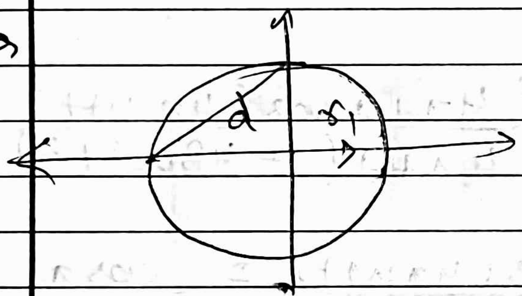
Average E of C2 is

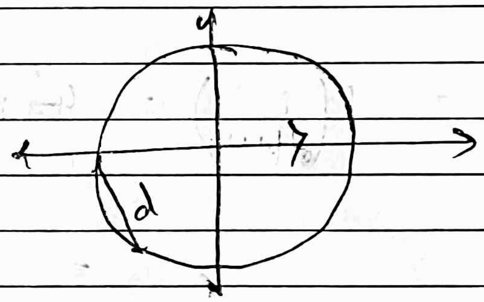
$$E_2 = \frac{a^2 + a^2 + a^2 + a^2}{4} = a^2$$

$$\frac{E_1}{E_2} = \frac{4\cancel{a^2}}{\cancel{a^2}} = 4$$

Q12

Sol →




8 phase

Pythogoreous theorem

$r_1^2 + r_1^2 = d^2$

$r_1 = \frac{d}{\sqrt{2}}$

$d^2 = r_2^2 + r_2^2 - 2r_2^2 \cos 45^\circ$

$d^2 = 2r_2^2 - 2r_2^2 \frac{1}{\sqrt{2}}$

$d^2 = 2r_2^2 - \sqrt{2} r_2^2$

$d^2 = r_2^2(2 - \sqrt{2})$

$P_4 \text{ avg} = \frac{d^2}{2}$

$P_8 \text{ avg} = \frac{d^2}{2 - \sqrt{2}}$

$r_2^2 = \frac{d^2}{2 - \sqrt{2}}$

$r_2 = \sqrt{\frac{d^2}{2 - \sqrt{2}}} = \frac{d}{\sqrt{2 - \sqrt{2}}}$

Addition transmitted

Power needed by 8-PSK $= P = 10 \log_{10} \frac{2d^2}{(2-\sqrt{2})d^2}$

$$P = 10 \log_{10} \frac{r_2^2}{r_1^2}$$

$$P = 10 \log_{10} \frac{2}{2-\sqrt{2}}$$

$$P = 5.3328 \text{ dB}$$

If we use

Prob of Error $P_m = 2Q\left[2\gamma_s \sin\frac{\pi}{m}\right]$

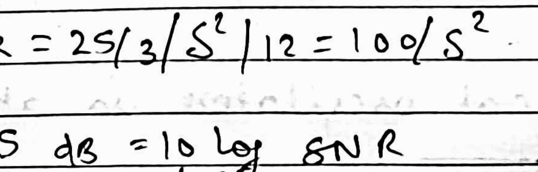
$$\gamma_s = SNR$$

For 4 phase $\gamma_{4,s} \sin^2\frac{\pi}{4} = \gamma_{8,s} \sin \pi/8$

$$10 \log_{10} \frac{\gamma_{8,s}}{\gamma_{4,s}} = 20 \log_{10} \frac{\sin \pi/4}{\sin \pi/8}$$

Q14

sol →




$SNR = E[X^2]/E[X_{QB}^2]$

$E[X^2] = 5^2/3 = 25/3$

$E[X_{QB}^2] = \delta^2/12$

$$SNR = 25/3/\delta^2/12 = 100/\delta^2$$

$43.5 \text{ dB} = 10 \log SNR$

$SNR = 10^{4.35} = \frac{100}{\delta^2}$ ; $\delta = 0.0667$

Q15

sol → for a raised cosine spectrum transmition bandwidth is given as

$$BT = RW(1+\alpha) \quad \alpha = \text{Roll of factor}$$

$$BT = R_b/2\,(1+a) \quad R_b = \text{max. signaling rate}$$

$$3500 = \frac{R_b}{2}(1+0.75)$$

$$R_b = \frac{7000}{1.75}$$

$$R_b = 4000$$

Q16

sol → In a coherent binary PSK system the pair of signals $S_1(t)$ & $S_2(t)$ used to represent binary system 1 & 0 resp.

$$S_1(t) = \sqrt{\frac{2E_1}{T}}\sin w_c t \quad , \text{when } 0 \le t \le T$$

$$S_2(t) = -\sqrt{\frac{2E_1}{T}}\sin w_c t \quad , 0$$

E is the transmitted energy per bit

∴ General function of local oscillator

$$\phi_1(t) = \sqrt{\frac{2}{T}}\sin(w_c t) \quad , 0 \le t \le T$$

But here local oscillator is ahead wi 45° so,

$$\phi_1(t) = \sqrt{\frac{2}{T}}\sin(w_c t + 45^\circ)$$

the coordinate of message point are

$$S_{11} = \int_0^T s_1(t)\,\phi_1(t)\,dt$$

$$= \int_0^T \sqrt{\frac{2E}{T}}\, \sin(w_c t) \times \sqrt{\frac{2}{T}}\, \sin(w_c t + 45^\circ)\, dt$$

$$\Rightarrow \sqrt{\frac{2E}{T}}\sqrt{\frac{2}{T}} \int_0^T \sin(w_c t)\sin(w_c t + 45^\circ)\, dt$$

$$\Rightarrow \frac{\cancel{2}}{T} \times \frac{1}{\cancel{2}} \sqrt{E} \int_0^T \left(\sin 45^\circ + \sin(2w_c t + 45^\circ)\right) dt$$

$$\Rightarrow \frac{\sqrt{E}}{T} \int_0^T \frac{\cancel{\sqrt{2}}}{\cancel{2}} + \sin(2w_c t + 45^\circ)$$

$$\Rightarrow \frac{\sqrt{E}}{T} \int_0^T \frac{1}{\sqrt{2}}\, dt + \underbrace{\frac{\sqrt{E}}{T} \int_0^T \sin(2w_c t + 45^\circ)\, dt}_{0}$$

$$\downarrow$$

$$\frac{\sqrt{E}}{\cancel{T}} \left[\frac{\cancel{T} - 0}{\sqrt{2}}\right] = \sqrt{\frac{E}{2}}$$

similarly we can find $S_{31} = -\sqrt{\frac{E}{2}}$

$$-\sqrt{E/2} \qquad\qquad 0 \qquad\qquad \sqrt{E/2}$$

Now, distance between vectors

$$d = 2\sqrt{\frac{E}{2}}$$

Page No:
Date:

Now, distance between vectors

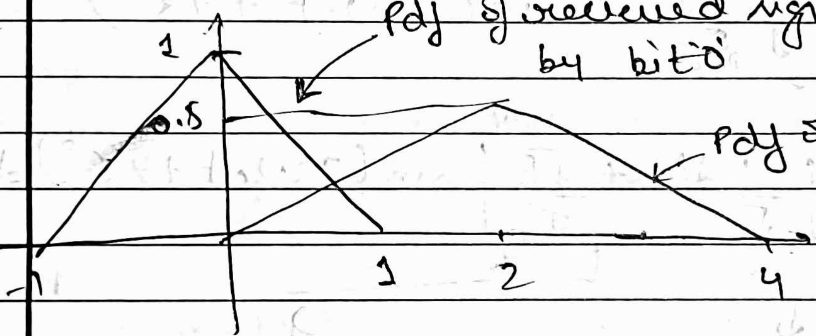
$$d = 2\sqrt{\frac{E}{2}}$$

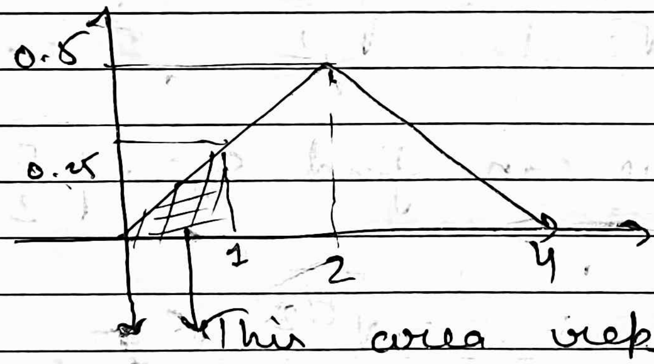
Now using the relation b/w $P_e = Q\sqrt{\frac{d^2}{2N_0}}$

$$P_e = Q\left(\sqrt{\frac{4^2 \times E/2}{2N_0}}\right)$$

$$P_e = Q\left(\sqrt{\frac{E}{N_0}}\right)$$ ans

Q17
sol




This area represents the errors

there is no error in representation of 0

$P_e = P(0)P\left(\frac{1}{0}\right) + P(1)P\left(\frac{0}{1}\right)$

$P_e = \frac{1}{2}(0) + \frac{1}{2} \times \frac{1}{2} \times 1 \times 0.25$

$P_e = \frac{1}{16}$ ans

Q18

sol→ Bit error rate for BPSK $= Q\left[\sqrt{\frac{2E}{N_0}}\right] \times Q\left[\sqrt{\frac{E}{N_0/2}}\right]$

$$\boxed{\gamma = \frac{2E}{N_0}}$$

function of bit energy & noise PSD $\left(\frac{N_0}{2}\right)$

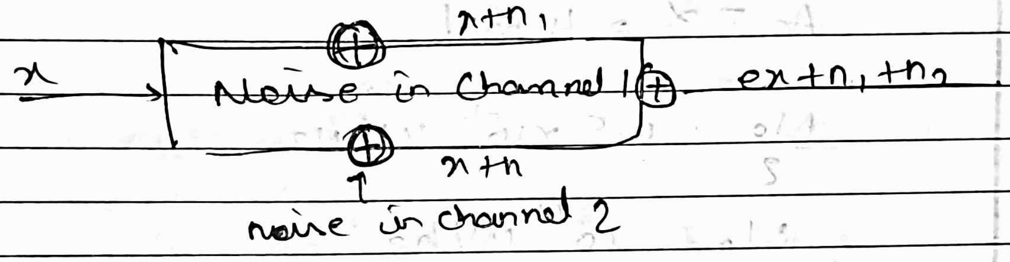



fig. Counterllation diagram of BPSK

Channel is A which implies noise sample as independent

Let $2x + n_1 + n_2 = x' + n'$ $(\because x' = 2x)$ & $(n' = n_1 + n_2)$

Now Bit error rate (BER) $= Q\sqrt{\frac{2E'}{N_0'}}$

$$\left\{\begin{array}{l} \text{where } E' \text{ is energy in } x_1 \text{ \&} \\ N_0' \text{ is PSD of } n_1 \end{array}\right\}$$

$E_1 = 4E$ (as amplitude is getting doubled)
$N_0' = N_0$ (Independent & Identical channel)

$\therefore$ Bit error rate (BER) $= Q\left(\sqrt{\frac{4E}{N_0}}\right)$

$$= Q\sqrt{2}\sqrt{\frac{2E}{N_0}}$$

$$= \sqrt{2}$$

$$\simeq 1.414.$$

Q19
sol →

Bit error probability $= Q\sqrt{\frac{E}{N_0}}$

$E \rightarrow$ Energy per bit [no. of symbols = No of bits]

$$BEP = Q\sqrt{\frac{A_c^2 T_b}{2N_0}}$$

$$A_c = \alpha = 4\ mV$$

$$\frac{N_0}{2} = 0.5 \times 10^{-12}\ W/Hz$$

$$N_0 = 10^{-12}\ W/Hz$$

$$T_b = \frac{1}{R_b} = \frac{1}{500 \times 10^3} = 0.2 \times 10^{-5}$$

$$T_b = 2 \times 10^{-6}$$

Now $BEP = Q\left[\sqrt{\frac{A_c^2 T_b}{2N_0}}\right]$

$$= Q\left[\sqrt{\frac{(4 \times 10^{-3})^2 \times 2 \times 10^{-6}}{2 \times 10^{-12}}}\right]$$

$$= Q\left[\sqrt{\frac{16 \times \cancel{10^{-6}} \times \cancel{2} \times 10^{-6}}{\cancel{2} \times 10^{-12}}}\right]$$

$$= Q\sqrt{16}$$

$$\boxed{BER = 4Q}$$

Q20
sol →

for M-PSK bandwidth of signal is given by

$$B = \frac{R_b(1+\alpha)}{\log_2 M}$$

Bit rate = 200 kbps, Excess Bandwidth = 100 KHz

$$\cancel{100}\ KHz = \frac{2\cancel{00} \times 10^{\cancel{3}} \times 2}{\log_2 M}$$

$$\log_2 M = 4$$

$$\boxed{M = 16}$$

Q21
sol →

$R_b = 4800$ bits/s

$BW = 2000 - 500 = 1500$ Hz

BW req. for 16 QAM

$$\frac{R_b(1+\alpha)}{\log_2 M} = 1500$$

$$(1+\alpha) = \frac{15\cancel{00} \times \log_2 16}{48\cancel{00}}$$

$$= \frac{15 \times 4}{48\ 12}$$

$$1+\alpha = \frac{3}{12}$$

$$\boxed{\alpha = 0.25}$$

Q22
sol → (i) Calculate the Nyquist Rate for each Analog signal

$NR_1 = 2 \times 1200$ hz $= 2400$ sam/sec

$NR_2 = 2 \times 600$ hz $= 1200$ sam/sec

$NR_3 = 2 \times 600$ hz $= 1200$ sample/sec.

(ii) Total no. of sample/second $= NR_1 + NR_2 + NR_3$
$= 4800$ samp/sec.

(iii) Bit Rate = (Total no. of sample/sec) × (No of bits/samp

$= 4800 \times 12$
$= 57600$ bit/sec
$= 57.6$ Kbps

Q23
sol → If a signal symbol is represented by a code of 8 chip, the chip rate will be 8 × symbol rate

$$SF = \frac{8 \times \text{symbol rate}}{\text{symbol rate}} = 8$$