Dear ACE students(ECE),

Solutions along with the explanation are given here for typical questions of Communication System booklet which has been issued to you. The student is suggested to try the questions given in the booklet, on his/her own and then refer to the solutions given below.

Good Luck.
ACE Academy.

CHAPTER- 2
Random Signals & Noise

01. From the property of CDF is that $F_x(\infty) = 1$. So, the options 'c' and 'd' can be eliminated since $F_x(\infty)$ is Zero in both of them.

if CDF is a Ramp, the corresponding pdf will be $\frac{d}{dx}$ (Ramp)= Step . But, since the given pdf is not step, the option 'b' also can be eliminated.

Hence, the correct option is 'a'.

02. $H(f) = \frac{1}{1+J2\pi fRC}$ & $f_{3db} = f_c = 1/2\pi RC$

$$\therefore H(f) = \frac{1}{1+J(f/fc)}$$

$$o/p \text{ PSD} = |H(f)|^2. \text{ i/p PSD} = \frac{k}{1+(f/fc)^2}$$

$$o/p \text{ Noise Power} = \int_{-\infty}^{\infty} \frac{k}{1+(f/fc)^2}.df = k\pi fc.$$

Ans: 'c'

03. Auto correlation is maximum at τ=0

i.e. $R(O) \geq |R(\tau)|$

Ans :- 'b'

04. Power spectral density is always non negative

i.e. $S(f) \geq 0$

Ans:- 'b'

05. This corresponds to Binomial distribution. When an experiment is repeated for n times, the probability of getting the success 'm' times, independent of order is

$P(x=m) = n_{c_m} \cdot p^m \cdot (q)^{n-m}$

Where p = Prob. of success & q = 1-p

In the present problem, success is getting an error. The corresponding probability is given as 'p'.

$$\begin{aligned} P(\text{At most one error}) &= P(\text{no errors}) + P(\text{one error}) \\ &= P(X=0) + P(X=1) \\ &= n_{c_0}.(p)^0.(1-p)^n + n_{c_1}.(p)^1\,(1-p)^{n-1} \\ &= (1-p)^n + np(1-p)^{n-1} \end{aligned}$$

Ans:- 'c'

06. The random variable y is taking two values 0 & 1.

$P(y=1) = P(-2.5 < x < 2.5)$

$P(y=0) = P(x \geq 2.5) + P(x \leq -2.5)$

$\therefore P(-2.5 < x < 2.5) = \int_{-2.5}^{2.5} f(x)\,dx = 0.5$

$P(x \geq 2.5) = \int_{2.5}^{5} f(x)dx = 0.25$

$P(x \leq -2.5) = \int_{-5}^{-2.5} f(x)\,dx = 0.25$

$\therefore P(y = 1) = 0.5$; $P(y=0) = 0.25 + 0.25 = 0.5$

$\therefore f(y) = 0.5\,\delta(y) + 0.5\,\delta(y-1)$

Ans :- 'b'

07. Ans: 'b'

08. PSD of i/p process $S_{xx}(\omega) = 1$

PSD of o/p process $S_{yy}(\omega) = \frac{16}{16+\omega^2}$

$|H(\omega)|^2 = \frac{S_{YY}(\omega)}{S_{XX}(\omega)} = \frac{16}{16+\omega^2}$

$|H(\omega)| = \frac{4}{\sqrt{16+\omega^2}} \Rightarrow H(\omega) = \frac{4}{4+J\omega}$

We have H(ω) for a_n RL – Low Pass Filter as $H(\omega) = \frac{R}{R+J\omega L}$

∴ Ans :- (a)

09. R = 4Ω ; L = 4H

Ans :- 'a'

10. o/p Noise Power = (o/p) PSD × B.ω

$H(\omega) = 2 \cdot \exp(-J\omega t_d)$

$|H(\omega)|^2 = 4 \Rightarrow$ o/p Noise PSD = $4N_O$

$\therefore$ o/p Noise Power = $4N_O B$

Ans :- 'b'

11. $P(\bar{r}) = \left(\frac{k}{4}\right)\bar{r}$ for $0 \le k \le 4$

= 0 elsewhere

Since $\int_0^4 P(\bar{r}).d\bar{r} = 1 \Rightarrow k = 1/2$

Mean Square Value is $\int_0^4 \bar{r}^2.P(\bar{r}).d\bar{r} = 8$

Ans :- 'c'

12. $|H(f)|^2 = 1 + (0.1 \times 10^{-3})f$ for -10 KHz $\le f \le 0$

$= 1 - (0.1 \times 10^{-3})f$ for $0 \le f \le 10$ KHz

$(o/p)_{PSD} = |H(f)|^2 \times$ i/p PSD

Power of o/p Process = $\int_{-10\times10^3}^{10\times10^3} (o/p)PSD.df = 1\times10^{-6}\ \omega$

Ans:- 'b'

13. $R(\tau) \xleftrightarrow{FT}$ PSD $[S_{xx}(\omega)]$

Since PSD is sinc – squared function, its inverse Fourier Transform is a Triangular pulse.

Ans:- 'b'

14. $Var[d(n)] = E[d^2(n)] - \{E[d(n)]\}^2$

$E[d(n)] = E[x(n) - x(n-1)]$

$= E[x(n)] - E[x(n-1)] = 0$

$Var[d(n)] = E[d^2(n)] = E[\{x(n) - x(n-1)\}^2]$

$= E[x^2(n)] + E[x^2(n-1)] - 2.E[x(n).x(n-1)]$

$= \sigma_x^2 + \sigma_x^2 - 2.R_{xx}(1)$

$\Rightarrow 2\sigma_x^2 - 2R_{xx}(1) = \frac{1}{10}\sigma_x^2$

$\Rightarrow \frac{R_{xx}(k)}{\sigma_x^2}$ at $k = 1$ = 0.95

Ans: 'a'

15. $P_X(x) = \dfrac{1}{3\sqrt{2\pi}} \exp\left[-\dfrac{(x-4)^2}{18}\right]$

$= \dfrac{1}{\sqrt{2\pi \times 9}} \exp\left[-\dfrac{(x-4)^2}{2 \times 9}\right]$

$P\{X = 4\} = P_X(x)\big|_{x=4} = \dfrac{1}{3\sqrt{2\pi}}$

Ans: b

16. P(at most one bit error)

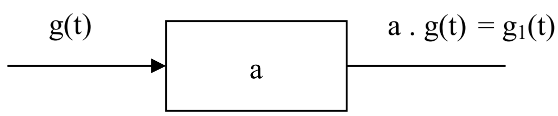
= P(No error) + P(one error)

$= n_{C_0} \cdot (P)^0 (1-P)^{n-0} + n_{C_1} (P)^1 (1-P)^{n-1}$

$= (1-P)^n + n\, P(1-P)^{n-1}$

Ans: d

17.



$\therefore H(\omega) = a \Rightarrow$ PSD of $g_1(t) = a^2 . S_g(\omega)$

$R_{g1}(\tau) = F^{-1}\left[a^2 . S_g(\omega)\right] = a^2 . R_g(\tau)$

$\Rightarrow$ power of $R_{g1}(\tau) = a^2 . R_g(0) = a^2 . P_g$

Ans: a

18. The fourier Transform of a Gaussian Pulse is also Gaussian.

Ans: ‘c’

19. The Auto correlation Function (ACF) of a rectangular Pulse of duration T is a Triangular Pulse of duration 2T

Ans: ‘d’

20. The Prob. density function of the envelope of Narrow band Gaussian noise is Rayleigh

Ans: ‘c’

21. $P(x) = K. \exp(-x^2/2)$, $-\infty < x < \infty$

$$\int_{-\infty}^{\infty} P(x)\, . dx = 1 \Rightarrow \int_{-\infty}^{\infty} k.\exp(-x^2/2)\, dx = 1$$

We have $\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} e^{-x^2/2}$ .dx = 1, since

$\frac{1}{\sqrt{2\pi}}\ e^{-x^2/2}$ is the Normal density

N (m, σ^2) = N (0,1)

$\therefore k = 1/\sqrt{2\pi}$

Ans: ‘a’

22. $F^{-1}[PSD]$ = Auto correlation Function $R(\tau)$

$\therefore\ R(\tau) = F^{-1}\left[\left(\frac{\sin f}{f}\right)^2\right]$, which is a triangular pulse.

Ans: ‘d’

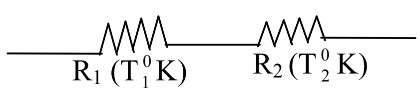
23. $R(\tau)=R(-\tau) \Rightarrow$ Even symmetry

Ans : ‘d’

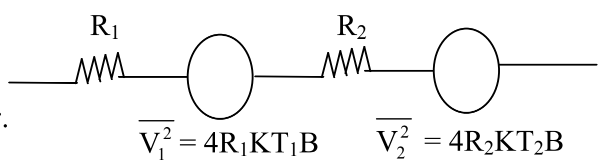
24. Rayleigh

Ans : ‘d’

25.



The Noise equivalent circuit is



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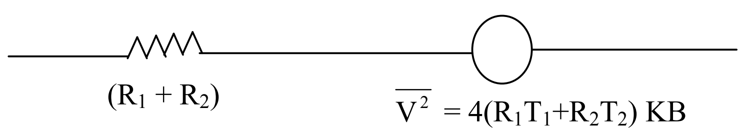

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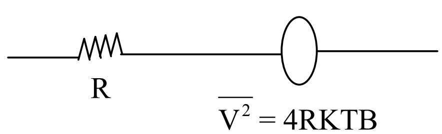


$\therefore\ RT = R_1T_1 + R_2T_2$

$\Rightarrow T = \frac{R_1T_1 + R_2T_2}{R_1 + R_2}$

26. $E(X) = \int_{-1}^{3} x.\, P(x)dx = 1$

$E(X^2) = \int_{-1}^{3} x.\, P(x)dx = 7/3$

$\text{Var}(X) = E(X^2) - [E(X)]^2 = \frac{7}{3} - 1 = \frac{4}{3}$

Ans: 'b'

27. Half wave rectification is Y = X for $x \geq 0$

= 0 elsewhere

$f(y) = \frac{1}{2}\delta(y) + \frac{1}{\sqrt{2\pi N}} e^{-y^2/2N}$

$E(Y) = 0$ & $E(Y^2) = N$

Ans: 'd'

28. P(X = at most one error) = P(X = 0) + P(X = 1)

$= 8_{C_0} . (P)^0 (1\text{-}P)^8 + 8_{C_1} . (P)^1 (1\text{-}P)^{8\text{-}1}$

$= (1-P)^8 + 8P(1-P)^7$

Ans: 'b'

29. $\text{Var}[(-kx)] = E[(-kx)^2] - \{E(-kx)\}^2$

$= k^2 E(x^2) - [-k.\, E(x)]^2$

$= k^2 E(x^2) - k^2.\, [E(x)]^2$

$= k^2 \left[E(x^2) - \{E(x)\}^2\right]$

$= k^2 . \sigma_x^2$

Ans: 'd'

CHAPTER – 3

Objective Questions Set – A

01. $(B.W)_{AM}$ = 2 (Highest of the Baseband frequency available)

$= 2(20\text{ KHZ}) = 40\text{ KHZ}$

02. Percentage Power saving $= \dfrac{P_T - P_{TX}}{P_T} \times 100\ \%$

$$= \frac{2}{2+m^2} \times 100\ \%$$

For m = 1 , Power saving $= \dfrac{2}{3} \times 100\ \% = 66.66\ \%$

03. $P_T = P_C\left(1 + \dfrac{m^2}{2}\right)$

For m = 0 ; $P_T = P_C$

For m = 1 ; $P_T = 1.5\ P_C$

$\Rightarrow$ TX. Power increased by 50%

04. $m_T = \sqrt{m_1^2 + m_2^2} = \sqrt{(0.3)^2 + (0.4)^2} = 0.5$

06. $m = \dfrac{V_{max} - V_{min}}{V_{max} + V_{min}} = 1/2$

07. The given AM signal is of the form $[A + m(t)] \cos \omega_c t$, which is an AM-DSB-FC signal. It can be better detected by the simplest detector i.e. Diode Detector

08. MW/Broadcast band is 550 KHz – 1650 KHz.

09. Hence the received 1 MHz signal lies outside the MW band.

10. $Q = \dfrac{f_0}{BW} = \dfrac{1\times10^6}{10\times10^3} = 100$

12. $P_T = P_C + P_C\dfrac{m^2}{2} \Rightarrow \dfrac{P_c\,.m^2}{2} = \dfrac{P_c(0.4)^2}{2} = 0.08\ P_c$

$\therefore P_T = 1.08P_c$

$\Rightarrow$ Increase in Power is 8%.

14. $e_m(t) = 10(1+0.4 \cos 10^3 t + 0.3 \cos 10^4 t) \cos(10^6 t)$

This is a multi Tone AM signal with m_1=0.4 and m_2=0.3

$\therefore \; m = \sqrt{m_1^2 + m_2^2} = 0.5$

15. Image freq(f_i) = f_s +2 IF

$\Rightarrow f_s = f_i - 2\text{ IF} = 2100 - 900 = 1200$ KHz.

16. Same as Prob. 2

18. Same as 3

19. $P_{SB} = 75 + 75 = 150 = P_C \frac{m^2}{2}$ and $P_c = P_T - P_{SB} = 600 - 150 = 450$

$\therefore \; P_C \frac{m^2}{2} = \frac{450 \times m^2}{2} = 150 \Rightarrow m = \sqrt{2/3}$

20. $P_c = 450\,\omega$

22. BW of each AM station = 10 KHZ.

No. of stations = $\frac{100 \times 10^3}{10 \times 10^3} = 10$

25. $m = \frac{E_m}{E_c} = \frac{15}{60} \Rightarrow m = 25\%$

26. $(B.W)_{AM} = 2 \times 1500 = 3$ KHz.

27. Message B.W = Band limiting freq. of the baseband signal = 10 KHz.

28. B.W = 2(10 KHz) = 20 KHz.

29. The various freq. in o/p are 1000 KHz, (1000 ± 1) KHz & (1000 ± 10) KHz.

$\therefore$ The freq. which will not be present in the spectrum is 2 MHz.

30. Highest freq. = USB w.r.t highest baseband freq. available =
(1000 + 10) KHz = 1010 KHz

CHAPTER – 3

Objective Questions – SET C

5. A freq. tripler makes the freq. deviation, three times the original.

$\therefore$ New Modulation Index $= 3.\frac{\delta f}{f_m} = 3\ m_f$

6. Mixer will not change the deviation. Thus, deviation at the o/p of the mixer is δ.

20. $B.W_1 = 2(\delta f + 10\text{ KHz})$

$B.W_2 = 2(\delta f + 20\text{ KHz}) \Rightarrow$ B.W increases by 20 KHz.

29. In NBFM, Modulation Index is always less than 1.

CHAPTER – 3

Additional objective questions – SET D

1. Amplitude of each sideband $= \frac{m\,E_c}{2}$

$= \frac{0.3\times 10^3}{2}$

$= 150\text{v}$

Ans: 'b'

2 $E_c = 1\text{ KV} \Rightarrow \frac{m\,E_c}{2} = \frac{1000\times m}{2} = 200$

$\Rightarrow m = 0.4$

Ans: 'c'

3. $P_c = 1\text{ KW};\ P_{SB} = \frac{P_C}{2} = 0.5\text{ KW}$

$\therefore P_T = P_C + P_{SB} = 1.5\text{ KW}.$

Ans: 'b'

4. As per FCC regulations, in AM, $(f_m)_{max} = 5\text{ KHz}$

Ans: 'b'

5. $E_c + E_m = 130 \Rightarrow E_m = 130 - 100 = 30$ V

$$m = \frac{E_m}{E_c} = \frac{30}{100} = 0.3$$

Ans: 'b'

6. $V(t) = A[1 + m \sin \omega_m t] \sin \omega_c t$

By comparing the given with above V(t), the unmodulated carrier peak A = 20

$\Rightarrow$ rms value = $20/\sqrt{2}$

Ans : b'

7. Side band peak = $\frac{mE_c}{2} = \frac{0.5 \times 20}{2} = 5$

Rms value = $5/\sqrt{2}$

Ans: a'

8. $m = 0.5 \Rightarrow$ 50% Modulation

Ans: b'

09. $V = A[1 + m\sin \omega_m t] \sin \omega_c t$

$\Rightarrow \omega_m = 6280$

Ans: c'

10. $\omega_c = 6.28 \times 10^6$

Ans : 'a'

11. m > 1 results in over Modulation, causing distortion .

Ans : 'd'

12. Ans: 'b'

13. $E_C + E_m = 2E_c \Rightarrow E_m = E_c$

$$\Rightarrow m = \frac{E_m}{E_c} = 100\%$$

Ans: 'd'

14. $E_c + E_m = 110$

$E_c - E_m = 90$

$\Rightarrow E_c = 100V; E_m = 10V$

Ans: 'c'

15. Using the above results, $m = \frac{E_m}{E_c} = \frac{10}{100} = 0.1$

Ans: 'a'

16. using the above results, the sideband amplitude is $\frac{mE_c}{2} = \frac{0.1 \times 100}{2} = 5V$

Ans: 'b'

17. $m = \frac{E_m}{E_c} \Rightarrow E_m = m.E_c$

The carrier peak is $(100)\sqrt{2}$

$\therefore E_m = (0.2)(100)\sqrt{2} = 20\sqrt{2}$

$\therefore E_c + E_m = (120)\sqrt{2}$

The corresponding rms value = 120 V

Ans: 'd'

20. $I_t = I_c\sqrt{1 + \frac{m^2}{2}}$

$I_c = 10$ Amp; $I_t = 10.4$ Amp.

$\therefore m = 0.4 \Rightarrow$ Ans: b

21. $m = \sqrt{(0.3)^2 + (0.4)^2} = 0.5$

$\Rightarrow$ Modulation Index = 50%

Ans: 'a'

23. $P_c = P_T - P_{SB} = 1160 - 160 = 1000$ Watts

Ans: 'a'

24. $m = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{6}{20} = 0.3$

$\Rightarrow$ Percent Modulation = 30%

Ans: 'b'

27. To implement Envelope detection,

$T_c < RC < T_m$

$T_c = 1\ \mu sec$; $T_m = 0.5$ msec

$= 500\ \mu sec$

Since $T_c < RC < T_m \Rightarrow RC = 20\ \mu sec$.

Ans: 'b'

28. As per FCC regulations in FM, $(f_m)_{max} = 15$ KHz

Ans: 'c'

29. In FM, $(\delta f) \propto E_m$

$\Rightarrow$ if E_m is doubled, δf also gets doubled

Ans: 'a'

30. If FM, (δf) is independent of Base Band signal frequency. Thus, δf remains unaltered.

Ans: 'd'

31 Ans: 'd'

32. frequency doubler doubles the freq. deviation. Thus at the o/p of the doubler, the modulation index is $2.m_f$

Ans: 'a'

33. Mixer will not change the freq. deviation. Thus freq. deviation at the o/p of Mixer is δ

Ans: 'b'

35. $\delta f = (f_c)_{max} - f_c = 210 - 200 = 10$ KHZ

Ans: 'b'

37. $m_f = \frac{\delta f}{f_m} = \frac{5\ \text{KHz}}{500\ \text{Hz}} = 10$

Ans: 'a'

38. $\delta f \propto E_m \Rightarrow \frac{\delta f_1}{\delta f_2} = \frac{E_{m_1}}{E_{m_2}}$

$$\Rightarrow \delta f_2 = \frac{(\delta f_1)(E_{m_2})}{(E_{m_1})} = \frac{(5\,\text{KHZ})(10\,\text{V})}{(2.5\,\text{V})}$$

$$= 20\,\text{KHz}$$

39. $m = \frac{\delta f_2}{f_m} = \frac{20 \times 10^3}{500} = 40$

40. $\delta f_2 = \frac{(\delta f_1)(E_{m_2})}{E_{m_1}} = \frac{5 \times 20}{2} = 50\,\text{KHz}$

Ans: 'b'

41. Assuming the signal to be an FM signal, the Power of the Modulated signal is same as that of un Modulated carrier.

Ans: 'a'

43. $v_{FM}(t) = A \cos(\omega_c t + m_f \cdot \sin \omega_m t)$

$\Rightarrow \omega_c = 6.28 \times 10^8$

Ans: 'a'

44. $\omega_m = 628$ Hz

Ans: 'a'

45. $m_f = \frac{\delta f}{f_m} \Rightarrow \delta f = 4 f_m = 25/2$ Hz

Ans: 'c'

46. Figure of Merit in FM is $\gamma = \frac{3}{2} m_f^2$, where m_f is the Modulation Index.

$\therefore$ Noise Performance increases with increase in freq. deviation.

Ans: 'a'

47. In FM, Modulation Index $\propto \frac{1}{f_m}$

Ans: 'a'

48. In FM, o/p Power is independent of modulation Index.

Ans: 'd'

52. $B.W = 2(\delta f + f_m) = 2(75 + 15) = 180$ KHz

Ans: 'c'

53. $B W = 2nf_m = 2(8)(15 \text{ KHz}) = 240$ KHz

Ans: 'd'

54. $B.W = 2nf_m$ & $n = m_f + 1 = 8$

$\Rightarrow 2(8)(f_m) = 160 \times 10^3 \Rightarrow f_m = 10$ KHz

$\therefore \delta f (m_f)(f_m) = (7)(10)$ KHz $= 70$ KHz

Ans: 'c'

55. $B.W = 2nf_m$

The modulation Index $m_f = \frac{\delta f}{f_m} = \frac{10^6}{10\times10^3} = 100$

$\therefore n = 100 + 1 = 101$

$\therefore B.W = 2(101)(10 \times 10^3) = 2.02$ MHz

Ans: 'b'

56. If E_m gets doubled, δf also get doubled.

$\therefore m_f = \frac{\delta f}{f_m} = \frac{2\times10^6}{10\times10^3} = 200$

$n = 201$

$B.W = 2(201)(10 \times 10^3) = 4.02$ MHz

Ans: 'd'

58. For WBFM, B.W = $2(\delta f + f_m)$.

Ans: 'd'

59. For NBFM, B.W = $2\ f_m$

Ans: 'b'

60. In WBFM, $\delta f >> f_m \Rightarrow$ B.W $\cong 2\ \delta f$

Ans: 'd'

63. Since (δf) is independent of carrier freq. $\therefore$ the peak deviations are same.

Ans: 'c'

66. At the o/p of the mixer, 'δ' remains the same.

Ans: 'd'

67. $\psi_i(t) = 50t + \sin 5t$

$$\omega_i = \frac{d}{dt}\psi_i(t) = 50 + 5\cos 5t$$

$\therefore$ At t = 0, $\omega_i = 55$ rad /sec

Ans: 'c'

75. IF = 455 KHz; f_s = 1200 KHz.

$\therefore$ Image freq. $= f_s + 2\ IF$

$= 2110$ KHz

76. Ans: Refer Q. No. 26 Set–F

77. $f_i = f_s + 2\ IF = 1000 + 2(455)$

$= 1910$ KHz

Ans: 'd'

78. $f_i = f_s + 2\ IF = 1500 + 2(455)$

$= 2410$ KHz

Ans: 'd'

82. $f_i = f_s + 2\text{ IF} = 500 + 2(465)$

$= 1430$ KHz

Ans; 'b'

Chapter – 3

Additional objective

Questions – Set E

01. By comparing with the general AM – DSB – FC signal $A_c \cdot \cos\omega_c t + m(t)\cdot\cos\omega_c t$, it is found that $m(t) = 2\cos\omega_m t$. To demodulate using Envelope detector,

$A_c \geq m_p$, where m_p is the Peak of the baseband signal, which is 2.

$\therefore (A_c)_{min} = 2$

Ans: 'a'

02. $\nu_{FM}(t) = 10\cos\left[2\pi\times10^5 t + 5\sin(2\pi\times1500t) + 7.5\sin(2\pi\times1000t)\right]$

$\psi_i(t) = \left[2\pi\times10^5 t + 5\sin(2\pi\times1500)t + 7.5\sin(2\pi\times1000)t\right]$

$$\omega_i = \frac{d}{dt}\psi_i(t) = 2\pi\times10^5 + 5(2\pi\times1500)\cos(2\pi\times1500t) + 7.5(2\pi\times1000)\cos(2\pi\times1000t)$$

$\delta\omega = 5(2\pi\times1500) + 7.5(2\pi\times1000)$

$\delta f = 7500 + 7500 = 15000$ Hz

$F_m = 1500$ Hz

` $\therefore$ Modulation Index $= \dfrac{\delta f}{f_m} = 10$

Ans: 'b'

03. $\nu(t) = \cos\omega_c t + 0.5\cos\omega_m t\cdot\sin\omega_c t$

Let $r(t).\cos\theta(t) = 1$

$r(t).\sin\theta(t) = 0.5\cos\omega_m t$

$\nu(t) = r(t).\cos\omega_c t.\cos\theta(t) + r(t).\sin\theta(t).\sin\omega_c t$

$= r(t).\cos[\omega_c t - \theta(t)]$

Where $r(t) = \sqrt{1+(0.5\cos\omega_m t)^2}$

$= [1 + 0.25 \cos^2 \omega_m t]^{1/2}$

$= [1 + \frac{0.25}{2}(1 + \cos 2\omega_m t)]^{1/2}$

$= [1.125 + 0.125 \cos 2\omega_m t]^{1/2}$

$\cong 1.125 + \frac{0.125}{2} \cos 2\omega_m t$

$\therefore\ \nu(t) = [1.125 + 0.0625 \cos 2\omega_m t] \cos[\omega_c t - \theta(t)]$

Hence it is both FM and AM

Ans: 'c'

04. To avoid diagonal clipping, $Rc < \frac{1}{\omega}$

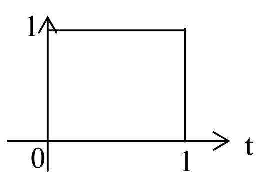
Ans: 'a'

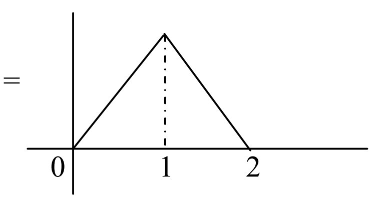
05. The LSB – Modulated signal $f_{c_1} - f_m = 990$ KHZ

Considering this as the Baseband signal, the B.ω of resulting FM signal is

$2(990 \times 10^3) = 1.98$ MHz $\cong 2$ MHz

Ans: 'b'

06. P(t) = 

and g (t) = 

$X_{AM}(t) = 100\,[P(t) + 0.5\,g(t)] \cos\omega_c t$ for $0 \le t \le 1$

By Comparing the above with an AM – DSB – FC signal under arbitrary Modulation

i.e. $A\,[1 + \mu \cdot m(t)] \cos \omega_c t$

$\mu = 0.5$ & $m(t) = g(t)$ is a ramp over $0 \le t \le 1$

$\therefore$ one set of Possible values of modulating signal and Modulation Index would be

t, 0.5

Ans: 'a'

07. $X_{AM}(t) = 10\,[\,1 + 0.5\sin 2\pi f_m t\,]\cos 2\pi f_c t$

The above signal is a Tone Modulated signal.

The AM Side band Power = $\frac{P_c m^2}{2}$

$$= \frac{100}{2} \times \frac{(0.5)^2}{2}$$

$$= 6.25\ \omega$$

Ans: 'c'

08. Mean Noise Power is the area enclosed by noise PSD Curve, and is equal to

$$4\left[\frac{1}{2} \times B \times \frac{N_0}{2}\right] = N_0 B$$

$\therefore$ The ratio of Ave. sideband Power to Mean noise Power = $\frac{6.25}{N_0 B} = \frac{25}{4N_0 B}$

Ans: 'b'

10. $y(t) = x^2(t)$

A squaring circuit acts as a frequency doubler

$\therefore$ New δf = 180 KHZ

$\therefore$ B.W of o/p signal = 2(180 + 5) = 370 KHZ

Ans: 'a'

11. $(\delta\omega)_{PM} = K_f\, E_m\, W_m$, Where $K_f\, E_m$ is the Phase deviation.

Since, it is given that Phase deviation remains unchanged,

$(\delta\,\omega)_{PM} \propto \omega_m$

$$\Rightarrow \frac{\delta\omega_1}{\delta\omega_2} = \frac{\omega m_1}{\omega m_2}$$

$$\Rightarrow \frac{\delta f_1}{\delta f_2} = \frac{f m_1}{f m_2}$$

$$\Rightarrow \frac{10\,\text{KHZ}}{\delta\omega_2} = \frac{1\,\text{KHZ}}{2\,\text{KHZ}} \Rightarrow \delta f_2 = 20\ \text{KHZ}$$

$\therefore$ B.ω = 2 ($\delta f_2 + fm_2$)

$= 2\ (20 + 2\ )\ \text{KHZ} = 44\,\text{KHZ}$

Ans: 'd'

13. Power efficiency $\eta = \frac{P_{SB}}{P_T} \times 100\ \%$

The sidebands are m(t). cos ω_ct

$$= \left[\frac{1}{2}\cos\omega_1 t + \frac{1}{2}\sin\omega_2 t\right]\cos\omega_c t$$

$$= \frac{1}{4}\left[\cos(\omega_c + \omega_1)t + \cos(\omega_c - \omega_1)t\right] + \frac{1}{4}\left[\sin(\omega_c + \omega_2)t - \sin(\omega_c - \omega_2)t\right]$$

$$\therefore P_{SB} = 4\left[\frac{1}{2}(1/4)^2\right] = 1/8$$

$$P_T = P_C + P_{SB} = \frac{1}{2} + \frac{1}{8}$$

$$\therefore\ \eta = \frac{1/8}{5/8} \times 100\% = 20\%$$

Ans: 'c'

14. $C_1 = B\log\left(1 + \frac{S}{N}\right)$ bps

Since $\frac{S}{N} >> 1$

$C_1 = B\log S/N$

$C_2 = B\log(2.\ S/N) = B\log 2 + B\log S/N$

$= B + C_1$

$\therefore\ C_2 = C_1 + B$

Ans: 'b'

15. $T_c < RC < T_m \Rightarrow 1\ \mu\text{ sec} < RC < 500\ \mu\text{ sec}$

$\therefore\ RC = 20\ \mu\text{sec}$

Ans; 'b'

16. $\nu_{AM}(t) = A\cos\omega_c t + 0.1\cos\omega_m t.\cos\omega_c t$

$= A\cos\omega_c t + 0.05\left[\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t\right]$

NBFM is similar to AM signal, except for a Phase reversal of 180^0 for LSB

$\nu_{NBFM}(t) = A\cos\omega_c t + 0.05\,[\cos(\omega_c + \omega_m)t - \cos(\omega_c - \omega_m)t]$

$\therefore\ \nu_{AM}(t) + \nu_{NBFM}(t) = 2A\cos\omega_c t + \cos(\omega_c + \omega_m)t$

This is SSB with carrier.

Ans: 'b'

17. Noise Power $= 10^{-20} \times 100 \times 10^{6}$
$= 10^{-12}\ \omega$
Loss = 40 dB
$\Rightarrow$ loss $= 10^{4}$
Signal Power at the receiver $= \dfrac{10^{-3}}{10^{4}} = 10^{-7}\ \omega$

$\therefore\ 10\log\dfrac{S}{N} = 10\log\dfrac{10^{-7}}{10^{-12}} = 10\log 10^{-5}$

= 50 db
Ans: 'a'

18. Carrier $= \cos 2\pi(101 \times 10^{6})t$
Modulating signal $= \cos 2\pi(10^{6})t$
o/p of BM $= 0.5\,[\cos 2\pi(101 \times 10^{6})t + \cos 2\pi(99 \times 10^{6})t]$
o/p of HPF
$= 0.5\cos 2\pi(101 \times 10^{6})t$
o/p of Adder is
$= 0.5\cos 2\pi(101 \times 10^{6})t + \sin 2\pi(100 \times 10^{6})t$
$= 0.5\cos 2\pi\,[(100 + 1) \times 10^{6}]t + \sin 2\pi(100 \times 10^{6})t$

$= 0.5\,[\cos 2\pi(100 \times 10^{6})t.\ \cos 2\pi \times 10^{6}t$

$- \sin 2\pi(100 \times 10^{6})t.\sin 2\pi\times 10^{6}t] + \sin 2\pi(100 \times 10^{6})t$

$= 0.5\cos 2\pi(100 \times 10^{6})t.\ \cos 2\pi \times 10^{6}t$

$- \sin 2\pi(100 \times 10^{6})t\,[1 - 0.5\sin(2\pi\times 10^{6})t]$

Let. $0.5\cos(2\pi \times 10^{6})t = R(t).\ \sin\theta(t)$

$1 - 0.5\sin(2\pi \times 10^{6})t = R(t).\cos\theta(t)$

The envelope $R(t) = \left\{[0.5\cos(2\pi\times 10^{6})t]^{2} + [1 - 0.5\sin(2\pi\times 10^{6})t]^{2}\right\}^{1/2}$

$= [1.25 - \sin(2\pi \times 10^{6})t]^{1/2}$

$= \left[\dfrac{5}{4} - \sin(2\pi\times 10^{6})t\right]^{1/2}$

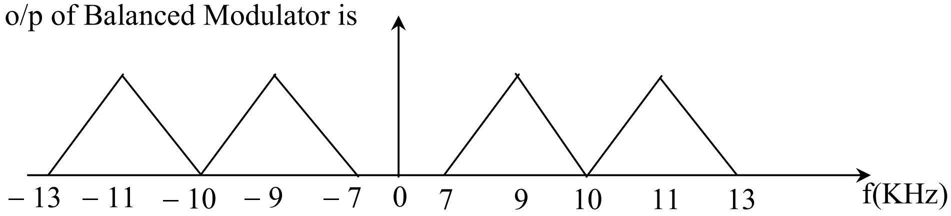
Ans: 'b'

19. A frequency detector produces a d.c voltage (constant) depending on the difference of the two i/p frequencies.

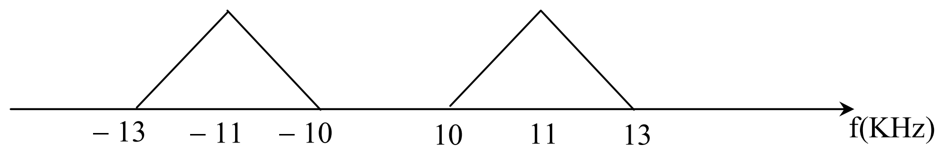
Ans: 'd'

20. Ans: 'c'

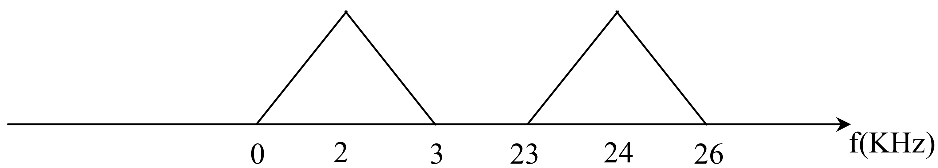
21. o/p of Balanced Modulator is



o/p of HPF is



The freq. at the o/p of 2^{nd} BM are



$\therefore$ The +ve frequencies where Y(f) has spectral peaks are 2 KHZ & 24 KHZ

Ans: 'b'

22. $V_0 = a_0\,[A_c{}^1.\cos(2\pi f_c{}^1 t) + m(t)] + a_1\,[A_c{}^1\cos(2\pi f_c{}^1 t) + m(t)]^3$

$= a_0\,[A_c{}^1\cos(2\pi f_c{}^1 t) + m(t)] + a_1[(A_c{}^1)^3\cos^3(2\pi f_c{}^1 t) + m^3(t)$

$+ 3\,(A_c{}^1)^2\cos^2(2\pi f_c{}^1 t).\,m(t)$

$+ 3\,(A_c{}^1).\,\mathrm{Cos}\,(2\pi f_c{}^1 t).\,m^2(t)]$

The DSB – Sc Components are

$2\,f_c{}^1 \pm f_m$

These should be equal to $f_c \pm f_m$

$\Rightarrow 2f_c{}^1 = f_c \Rightarrow f_c{}^1 = f_c/2 = 0.5$ MHZ

Ans: 'c'

23. $$\frac{\text{Total side band Power}}{\text{carrier power}} = \frac{P_c\, m^2/2}{P_c}$$

$$= \frac{m^2}{2} = 1/8$$

Ans: 'd'

24. $f_m = 2KHZ$; $f_c = 10^6$ HZ

$\delta f = 3(2f_m) = 12$ KHZ

Modulation index $\beta = \dfrac{\delta f}{f_m} = 6$

$$\nu_{FM}(t) = \sum_{n=-\infty}^{\infty} A.J_n(\beta)\cos(\omega_c + n\omega_m)\,t$$

$$= \sum_{n=-\infty}^{\infty} 5.\ J_n\,(6)\cos\left\{2\pi\,[\{1000 + n(2)\}10^3]\,t\right\}$$

$\therefore$ the coefficient of $\cos 2\pi\,(1008 \times 10^3)t$ is $5.\ J_4\,(6)$

Ans: 'd'

25. P – 6 ; Q – 3; R – 2; S – 4

Ans: 'a'

26. $f_0 = f_s + IF$

$(f_0)_{max} = (f_s)_{max} + IF = 1650 + 450 = 2100$

$(f_0)_{min} = (f_s)_{min} + IF = 1650 - 450 = 1200$

$$(f_0)_{max} = \frac{1}{2\pi\sqrt{Lc_{min}}} = 2100$$

$$(f_0)_{min} = \frac{1}{2\pi\sqrt{Lc_{max}}} = 1200$$

$$\therefore \sqrt{\frac{c_{max}}{c_{min}}} = \frac{2100}{1200} = 7/4$$

$$\Rightarrow \frac{c_{max}}{c_{min}} = 3$$

Image freq. = $f_s + 2$ IF = 700 + 2 (450) = 1600 KHZ

Ans: 'c'

27. Let the i/p signal be

$\cos\omega_c t.\ \cos\omega_m t + n(t)$

$= \cos\omega_c t.\ \cos\omega_m t + n_c(t)\cos\omega_c t - n_s(t).\ \sin\omega_c t$

$= [n_c(t) + \cos\omega_m t]\cos\omega_c t - n_s(t).\ \sin\omega_c t$

When this is multiplied with local carrier, the o/p of the multiplier is

$$[n_c(t) + \cos\omega_m t]\cos^2\omega_c t - \frac{n_s(t)}{2}.\ \sin 2\omega_c t$$

$$= [n_c(t) + \cos\omega_m t]\left[\frac{1+\cos 2\omega_c t}{2}\right] - \frac{n_s(t)}{2}\sin 2\omega_c t$$

The o/p of Base band filter is

$$\frac{1}{2}[n_c(t) + \cos\omega_m t]$$

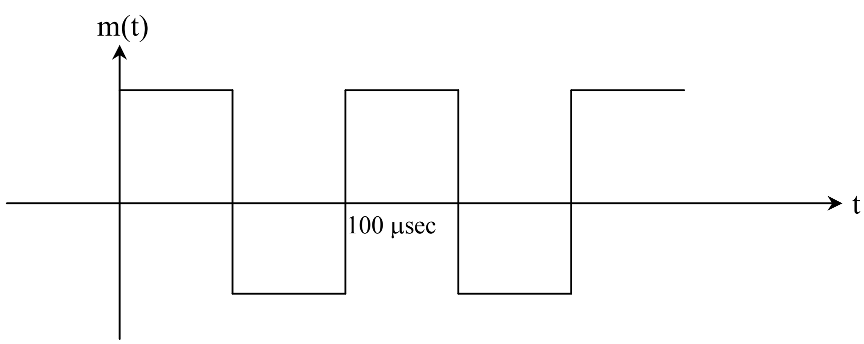
Thus, the noise at the detector o/p is $n_c(t)$ which is the inphase component.

Ans: 'a'

28. The o/p noise in an Fm detector varies parabolically with frequency.

29. Ans: 'a'

30.



$$f_m = \frac{1}{100 \times 10^6} = 10\,\text{KHZ}$$

Its Fourier series representation is

$$\frac{4}{\pi}\left[\cos 2\pi(10 \times 10^3)t - \frac{1}{3}\cos 2\pi(30 \times 10^3)t + \frac{1}{5}\cos 2\pi(50 \times 10^3)t + \text{-----}\right]$$

The frequency components present in the o/p are $f_c \pm 10KHZ = (1000 \pm 10)$ KHZ

$f_c \pm 30$ KHZ $= (1000 \pm 30)$ KHZ -------

i.e. 970 KHZ , 990KHZ, 1010KHZ, 1030 KHZ -----etc.

Hence, among the frequencies given, the frequency that is not present in the modulated signal is 1020 KHZ

Ans: 'c'

31. $S(t) = \cos 2\pi (2 \times 10^6 t + 30 \sin 150 t + 40 \cos 150t)$

$\psi_i (t) = 2\pi (2 \times 10^6 t + 30 \sin 150t + 40 \cos 150t)$
$\therefore$ Phase change $= 2\pi [30 \sin 150t + 40 \cos 150t]$
Let $r \cos\theta = 30$; $r \sin\theta = 40$
$\therefore$ Phase Change $= 2\pi r \cos (150t - \theta)$
Where $r = \sqrt{(30)^2 + (40)^2} = 50$
$\therefore$ Phase change $= 100\pi .\cos (150t - \theta)$.
$\therefore$ Max Phase deviation $= 100\pi$

$$\omega_i = \frac{d}{dt} \psi_i (t) = 2\pi \left[2 \times 10^6 + (30)(150) \cos(150t) - (40)(150) \sin 150t\right]$$

Frequency change $= 2\pi [(30)(150)\cos 150t - (40)(150)\sin 150t]$

This can be written as

$(2\pi)(150)\, r. \cos(150 t + \theta)$, Where $r = 50$

Frequency change $= (2\pi)(150)(50) \cos(150t + \theta)$

Max frequency deviation $\delta\omega = 2\pi (150)(50)$

$\Rightarrow \delta f = (150)(50) = 7.5$ KHz

Ans: 'd'

32. LPF can be used as reconstruction filter.

Ans: 'd'

33. The envelope of an AM is the baseband signal. Thus, the o/p of the envelope detector is the base band signal

Ans: 'a'

34. $2(\delta f + f_m) = 10^6$ HZ

$\Rightarrow \delta f = 495$ KHZ

For y(t), $\delta f = 3(495 \text{ KHZ}) = 1485\text{KHZ}$

and $f_c = 300$ MHZ

$\therefore$ B.ω of y(t) = 2 (1485 + 5) KHZ

= 2980 KHZ = 2.9 MHZ ≅ 3 MHZ

adjacent frequency components in FM signal will be separated by $f_m = 5$ KHz.

Ans: 'a'

35. o/p of multiplier = $m(t) \cos\omega_0 t . \cos(\omega_0 t + \theta)$

$= \frac{m(t)}{2}\left[\cos(2\omega_0 t + \theta) + \cos\theta\right]$

o/p of LPF = $\frac{m(t)}{2}.\cos\theta$

Power of o/p $= \frac{\overline{m^2(t)}}{4}.\cos^2\theta$

Since, $\overline{m^2(t)} = P_m$, the Power of output signal is $\frac{P_m.\cos^2\theta}{4}$.

Ans: 'd'

36. 'a'

37. 'a'

38. The frequency components available in S(t) are $(f_c - 15)$ KHZ, $(f_c - 10)$ KHZ, $(f_c + 10)$ KHZ, $(f_c + 15)$ KHZ.

$\therefore$ B.ω = $(f_c + 15)$ KHZ – $(f_c - 15)$ KHZ

= 30 KHZ.

Ans: 'd'

39. Complex envelope or pre envelope is S(t) + J . $S_h(t)$, Where S(t) is the Hilbert Transform of S(t).

Let $S(t) = e^{-at} . \cos(\omega_c + \Delta\omega)t$.

$\Rightarrow S_h(t) = e^{-at} . \sin(\omega_c + \Delta\omega)t$

$\therefore$ pre envelope = $e^{-at}. [\cos(\omega_c + \Delta\omega)t + J \sin(\omega_c + \Delta\omega)t]$

$= e^{-at} . \exp[J(\omega_c + \Delta\omega)t]$

Ans: 'a'

40. To Provide better Image frequency rejection for a superheterodyne receiver, image frequency should be prevented from reaching the mixer, by providing more tuning circuits in between Antenna and the mixer, and increasing their selectivity against image frequency. There circuits are preselector and RF amplifier.

Ans: ‘d’

41. Ans: ‘a’

42. Ans: ‘b

43. New deviation is 3 times the signal. So, Modulation Index of the output signal is 3(9) = 27

Ans: ‘d’

44. Ans: ‘b’

45. Ans: ‘c’

46. a – 2 ; b – 1 ; c – 5

47. a – 2 ; b – 1 ; c – 5

48. $\nu(t) = 5\,[\cos(10^6\pi t) - \sin(10^3\pi t)\sin 10^6\pi t]$

$= 5\cos 10^6(\pi t) - \frac{5}{2}[2\sin 10^3\pi t.\ \sin 10^6\pi t\,]$

$= 5\cos 10^6\pi t - \frac{5}{2}\,[\cos(10^6 - 10^3)\pi t - \cos(10^6 + 10^3)\pi t$

$= 5.\cos 10^6\pi t + \frac{5}{2}\cos(10^6 + 10^3)\pi t - \frac{5}{2}\cos(10^6 - 10^3)\pi t.$

It is a narrow band FM signal, where the phase of LSB is 180^0 out of phase with that of AM.

Ans: d

49. B.ω = 2 (50 + 0.5) KHZ = 101 KHZ

50. a – 3 ; b – 1 ; c – 2

51. The given signal is AM – DSB – FC, which will be demodulated by envelope detector.

Ans: ‘a’

52. Image frequency = $f_s + 2$ IF

= 1200 KHZ + 2(455) = 2110 KHZ

53. Power efficiency = $\frac{P_{useful}}{P_T} \times 100\ \%$

$$= \frac{m^2}{2+m^2} \times 100\%$$

For m = 1, the Power efficiency is max. and is 33.3 %

54. Picture $\rightarrow$ AM – VSB

Speech $\rightarrow$ FM

Ans: 'c'

55. For the generated DSB – Sc signal,

Lower frequency Limit f_L = (4000 – 2) MHZ

= 3998 MHZ

and Upper frequency Limit f_H = (4000 + 2) MHZ

= 4002 MHZ.

$(f_s)_{min} = 2\ f_H = 8.004$ GHZ

Ans: 'd'

56. Ans: 'a'

57. $m_f = \frac{\delta f}{f_m}$ where $\delta f = \frac{K_f\ E_m}{2\pi}$

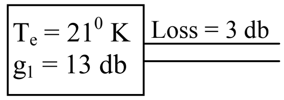
$$\therefore\ \delta f = \frac{10\times10^3\times2}{2\pi} = \frac{10\times10^3}{\pi}$$

$$\omega_m = 10^4 \times \pi \rightarrow f_m = \frac{10^4}{2}$$

$$\therefore\ m_f = 2/\pi$$

Ans: 'd'

58.



$T_0 = 300^0$ K

Noise fig. of amp. $F_1 = 1 + \frac{T_e}{T_0}$

$= 1 + \frac{21}{300}$

$= 1.07$

For a Lossy Network, Boise Figure is same as its loss. $\therefore$ $f_2 = 3$ db $\Rightarrow f_2 = 1.995$

$\therefore$ Overall Noise figure $f = f_1 + \frac{f_2 - 1}{g_1}$

$g_1 = 13\text{db} \Rightarrow g_1 = 19.95$

$\therefore\ f = 1.07 + \frac{1.995 - 1}{19.95} = 1.1198$

$\Rightarrow f = 0.49$ db

T_e of cable $= (f - 1)\ T_0$

$= (1.995 - 1)\ 300 = 298.5^0$ K

Overall $T_e = T_{e_1} + \frac{T_{e_2}}{g_1}$

$= 21 + \frac{298.5}{19.95}$

$= 35.96^0$ K

Ans: ‘c’

60. A preamplifier is of very large gain. This will improve the noise figure (i.e. reduces its numerical value) of the receiver, if placed on the antenna side

Ans: ‘a’

61. Ans: ‘a’

Chapter – 4

01. A source transmitting 'n' messages will have its maximum entropy, if all the messages are equiprobable and the maximum entropy is logn bits/message.
Thus, Entropy increases as logn.
Ans: 'a'

02. This corresponds to Binomial distribution. Let the success be that the transmitted bit will be received in error.
P(X = error) = P(getting zero no. of ones) + P(getting one of ones)
$= P(X = 0) + P(X = 1)$
$= 3_{c_0}(1-p)^0 p^3 + 3_{c_1}(1-p)p^2$
$= p^3 + 3p^2(1 - p)$
Ans: 'a'

03. Most efficient source encoding is Huffman encoding.

0.5	0	0.5	0
0.25	10	0.5	1
0.25	11		

$\overline{L} = 1 \times 0.5 + 2 \times 0.25 + 2 \times 0.25$
$= 1.5$ bits/symbol
Ave. bit rate $= 1.5 \times 3000 = 4500$ bits/sec
Ans: 'b'

04. Considering all the intensity levels are equiprobable, entropy of each pixel $= \log_2 64$
$= 6$ bits/pixel

There are $625 \times 400 \times 400 = 100 \times 10^6$ pixels/sec

$\therefore$ Data rate $= 6 \times 100 \times 10^6$ bps

$= 600$ Mbps

Ans: 'c'

05. Source coding is a way of transmitting information with less number of bits without information loss. This results in conservation of transmitted power.

Ans. 'c'

06. Entropy of the given source is
$H(x) = - 0.8 \log 0.8 – 0.2 \log 0.2$
$= 0.722$ bits/symbol
4^{th} order extension of the source will have an entropy of $4.H(x) = 2.888$ bits/4 symbol
As per shanon's Theoram,
$H(x) \le L \le H(x) + 1$
i.e., $2.888 \le L \le 3.888$ bits/4 messges

07. $12 \times 512 \times \log_2^8 = 18432$ bits

08. Code efficiency $= \eta = \frac{L_{min}}{\overline{L}} \times 100\% = \frac{H}{\overline{L}} \times 100\%$

$\overline{L} = 2$ bits/symbol and the entropy of the source is

$$H = -\frac{1}{2}\log\frac{1}{2} - \frac{1}{4}\log\frac{1}{4} - \frac{2}{8}\log\frac{1}{8}$$

$$= \frac{14}{8} \text{ bits/symbol}$$

$$\therefore \eta = \frac{14}{16} \times 100\% = 87.5\%$$

Ans : 'b'

09. $H(X) = -\frac{1}{2}\log\frac{1}{2} - \frac{1}{4}\log\frac{1}{4} - \frac{2}{8}\log\frac{1}{8}$

$= 1.75$ bits/symbol

10. Channel Capacity $C = B\log_2\left(1 + \frac{S}{\eta B}\right)$

$\frac{S}{\eta B} = 30 \text{ db} \rightarrow \frac{S}{\eta B} = 1000$

$\therefore C = 3 \times 10^3 \log_2 (1 + 1000) = 29904.6$ bits/sec

For errorless transmission, information rate of source R < C. Since, 32 symbols are there the number of bits required for encoding each $= \log_2 32$

$= 5$ bits

$\rightarrow$ 29904.6 bits/sec constitute 5980 symbols/sec. So, Maximum amount of information should be transmitted through the channel, satisfying the constraint R < C

$\rightarrow$ R = 5000 symbols/sec

Ans: 'c'

11. Not included in the syllabus

12. $H(x) = \log_2 16 = 4$ bits

Ans: 'd'

13. $P(0/1) = 0.5 \rightarrow P(0/0) = 0.5$

$P(1/0) = 0.5 \rightarrow P(1/1) = 0.5$

$$P(Y/X) = \begin{bmatrix} 1/2 & 1/2 \\ 1/2 & 1/2 \end{bmatrix}$$

A channel with such noise matrix is called the channel with independent input and o/p. Such a channel conveys no information.

$\therefore$ its capacity = 0

Ans: 'd'

14. A ternary source will have a maximum entropy of $\log_2 3 = 1.58$ bits/message. The entropy is maximum if all the messages are equiprobable i.e. 1/3

Ans: 'a'

15. Ans: 'b'

16. Entropy coding – McMillan's rule
Channel capacity – Shanon's Law
Minimum length code – Shanon Fano
Equivocation – Redundancy

Ans: 'c'

17. Since $\frac{S}{N} << 1$

$C \approx B \log 1 \approx 0$

$\therefore$ C is nearly o bps

Ans: 'd'

18. Ans: 'b'

19. Ave. information = $\log_2 26 = 4.7$ bits/symbol

Ans: 'd'

20. Ans: 'd'

21. Ans: 'b'

22. Ans: 'b'

23. $H_1 = \log_2 4 = 2$ bits/symbol

$H_2 = \log_2 6 = 2.5$ bits/symbol

$H_1 < H_2$ Ans: 'a'

24. The maximum entropy of binary source is 1 bit/message.
The maximum entropy of a quaternary source is 2 bits/message.
The maximum entropy of an octal source is 3 bits/message.
Since the existing entropy is 2.7 b/symbol the given source can be an octal source
Ans: 'c'

Chapter – 5A **Set A**

01. $(f_s)_{min}$ = 4 KHz

$\rightarrow (T_s)_{max} = \frac{1}{(f_s)_{min}} = \frac{1}{4\,KHz} = 250\,\mu sec$

Ans: 'c'

Set B

05. In PCM, $(B.W)_{min} = \frac{\gamma\ f_s}{2}$ Hz

If Q = 4 $\Rightarrow \gamma = 2$

$\therefore$ $(B.W)_{min} = f_s$ Hz.

If Q = 64 $\rightarrow \gamma = 6$

$\therefore (B.W)_{min} = 3f_s$

Ans: 'a'

18. $(f_s)_{min}$ = 8 KHz; $\gamma = \log_2 128 = 7$

$B.W = \frac{\gamma f_s}{2} = 28\,KHz$

Ans: 'd'

Set – C

01. Maximum slope = S f_s = $\frac{75\times10^{-3}}{1.5\times10^{-3}}$ = 50 V/sec

Ans: 'a'

02. $\frac{d}{dt}m(t) = \frac{d}{dt}(at) = a$

Rate of rise of the modulator = $\delta . f_s = \delta / T_s$

Slope over loading will occur if $\delta\ f_s < a \Rightarrow \frac{\delta}{T_s} < a \Rightarrow \delta < a\ T_s$

Ans: 'c'

03. Ans: 'c'

04. Since with increasing 'n' (increased number of Q levels), N_q reduces, S/N_q increases.
For every 1 bit increase in 'n'. N_q
S/N_q improves by a factor of 4.

Ans: 'd'

05. o/p bit rate = $\gamma\ f_s$, where $\gamma = \log_2 258 = 8$

$\therefore\ \gamma\ f_s$ = 64 kbps

Ans: 'c'

06.

07. Ans: 'c'

08. $(Q.E)_{max} = S/2 = \frac{V_H - V_L}{2Q}$

$= \frac{1}{264}$ of the total peak to peak range

Ans: 'c'

09. Ans: 'b'

10. For every one bit increase in the data word length, S/N_q improves by a 6 db.
$\therefore$ The total increase is 21 db
Ans: 'b'

11. Number of samples from the multiplexing system $= 4 \times 2 \times 4$ KHz
$= 32$ KHz
Each sample is encoded into $\log_2 256 = 8$ bits
So, the bit transmission rate
$= 32 \times 8$ kbps $= 256$ kbps
Ans: 'c'

12. $f_s = 10$ KHz; $\gamma = \log_2 64 = 6$
Transmission Rate = 60 kbps
Ans: 'a'

13. $V_{P\text{-}P} = 2$ V; $\gamma = 8 \Rightarrow Q = 256$
$S/N_q = (1.76 + 20 \log_{10}^{Q})$ db
$= 49.9$ db
Ans: 'b'

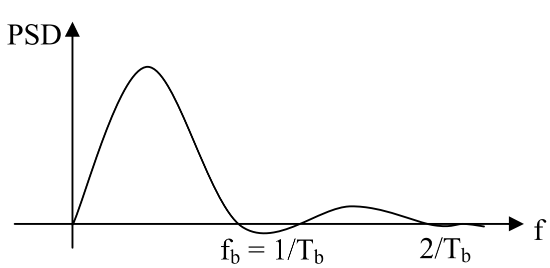
14. $(f_s)_{\text{Multiplexed system}} = 200 + 400 + 800 + 200$
$= 1600$ Hz
Ans: 'a'

15. Each sample is represented by 7 + 1 = 8 bits.
Total bit rate $= 8 \times 20 \times 8000$
$= 1280$ kbps
Ans: 'b'

16. 'a' (Question number 5 in set B)

Set – D

01. The power spectrum of Bipolar pulses is



$(B.W)_{min}$ required = f_b

Here $\gamma = 8$; $f_s = 8$ KHz

$\therefore$ Bit rate = 64 kbps

$\therefore$ $(B.W)_{min} = 64$ KHz

Ans: 'a'

02. Signal power = $\int_{-5}^{5} x^2 f(x).dx$

$f(x) = \frac{1}{10}$ $-5 \le x \le 5$

= 0 elsewhere

$\therefore$ Signal Power = 25/3 watts.

Quantization Noise Power $N_q = \frac{s^2}{12}$

Step size = $\frac{V_{P-P}}{Q} = \frac{10}{2^8} = \frac{10}{256} = 0.039\,V$

$\therefore N_q = \frac{(\text{Step size})^2}{12} = 0.126$ mW

$10 \log \frac{S}{N_q} = 48$ db

Ans: 'c'

03. For every one bit increase in the data word length, N_q reduces by a factor of H.

Given $\gamma = 8 \Rightarrow$ Required $\gamma = 9$

$\Rightarrow$ Number of Q – levels = $2^9 = 512$

Ans: 'b'

04. Ans: 'd'

05. Since, entropy of the o/p of the quantizer is to be maximized, it implies that all the decision boundaries are equiprobable.

$\therefore \int_{-5}^{-1} f(x).dx = 1/3$

$\Rightarrow \int_{-5}^{-1} b.dx = 1/3 \Rightarrow b = 1/12$

Similarly $\int_{-1}^{1} a.dx = 1/3 \Rightarrow a = 1/6$

Ans: 'a'

06. Reconstruction levels are – 3V, 0V and 3V.

Step size = 3V $\Rightarrow N_q = \frac{9}{12} = 3/4$

Signal Power $= 2.\int_{-5}^{-1} x^2\left(\frac{1}{12}\right)dx + \int_{-1}^{1} x^2\left(\frac{1}{6}\right)dx$

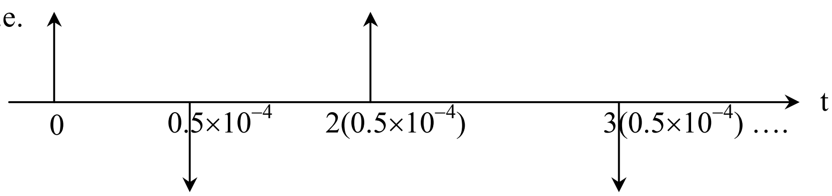
$$= \frac{1}{6}\left[\left[\frac{x^3}{3}\right]_{-5}^{-1} + \left[\frac{x^3}{3}\right]_{-1}^{1}\right]$$

$$= \frac{1}{6}\left[\frac{124}{3} + \frac{2}{3}\right] = \frac{126}{18} = \frac{21}{3}$$

$$\therefore S/N_q = \frac{21}{3} \times \frac{4}{3} = \frac{28}{9}$$

07. g(t) is Periodic with period of 10^{-4} sec

i.e.



In its Fourier series representation, $a_0 = 0$.

The remaining frequency components will be f_s = 10 KHZ; $2f_s$ = 20 KHZ;

$3f_s$ = 30 KHz ….etc.

∴ The frequency components in the sampled signal are 10 KHz ± 500 Hz; 20 KHz ± 500 Hz ….etc.

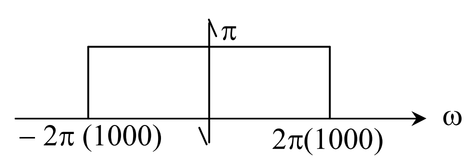
When the sampled signal is passed through an ideal LPF with Band width of 1 KHz, The o/p of the LPF will be zero.

Ans: 'c'

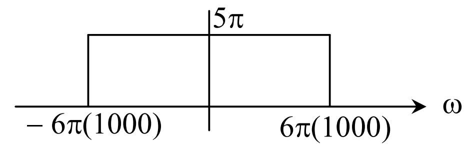
08. $x(t) = x_1(t) + x_2(t)$

Since $\frac{\sin at}{\pi t} \xleftrightarrow{F.T} \pi.G_{2a}(\omega)$

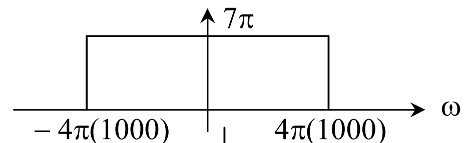
$\frac{\sin 2\pi 1000t}{\pi t} \xleftrightarrow{F.T}$



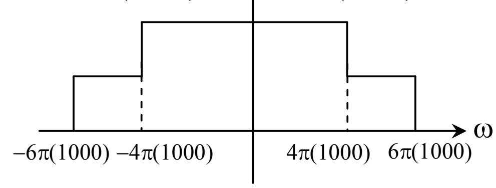
$$\Rightarrow x_1(t) = 5\left(\frac{\sin 2\pi\ 1000t}{\pi t}\right)^3 \quad \xleftrightarrow{F.T}$$



$$x_2(t) = 7\left(\frac{\sin\ 2\pi\ 1000t}{\pi t}\right)^2 \quad \xleftrightarrow{F.T}$$



Thus, $x_1(t) + x_2(t) \quad \xleftrightarrow{F.T}$

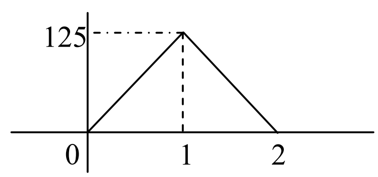


$\therefore\ \omega_m = 6\pi(1000) \Rightarrow f_m = 3$ KHz

$\therefore\ (f_s)_{min} = 6$ KHz

Ans: 'c'

09. x(t) =



To Track the signal, rate of rise of Delta Modulator and of the signal should be same,

i.e. $Sf_s = 125$

$$\Rightarrow \quad S = \frac{125}{32\times10^3} = 0.0039\,V$$

$$= 2^{-8}\ V$$

Ans: 'b'

10. In the process of Quantization, the quantizer is able to avoid the effect of all channel noise Magnitudes less than or equal to $S/2$.
If the channel noise Magnitude exceeds $S/2$, there may be an error in the output of the quantizer.
On the given Problem for $y_1(t) + c$ to be different from $y_2(t)$, the minimum value of c to be added is half of the step size, i.e. $\frac{\Delta}{2}$

Ans: 'b'

11. $\int_{-a}^{+a} P(x)\,dx = \frac{1}{3} \Rightarrow \int_{-a}^{a} \frac{1}{4}.dx = \frac{1}{3}$

$\Rightarrow a = \frac{2}{3}$ Ans: 'b'

12. $\int_{-a}^{a} x^2 f(x).dx = \frac{1}{4}\left[\frac{x^3}{3}\right]^{2/3}$

$$= \frac{1}{12}\left[\frac{2\times 8}{27}\right]^{-2/3} = \frac{4}{81}$$

Ans: 'a'

13. signal Power $= \int_{-5}^{5} x^2.f(x)\,dx$

$f(x) = \frac{1}{10}$ for $-5 \leq x \leq +5$

$= 0$ elsewhere

$\therefore$ signal power $= \frac{25}{3}$ volts^2

$\frac{S}{N_q} = 43.5\text{db} \Rightarrow \frac{S}{N_q} = 22387.2$

$\Rightarrow N_q = 3.722 \times 10^{-4} = \frac{(\text{stepsize})^2}{12}$

$\Rightarrow$ step size = 0.0668 V

Ans: 'c'

14. Total $N_q = \frac{(0.05)^2}{12} + \frac{(0.1)^2}{12} = 1.041\times 10^{-3}$

$\therefore \frac{S}{N_q} = 40\text{db}$

Ans: 'd'

15. for every one bit increase in data word length, S/N_q improves by a factor of 4.Hence, for two bits increase, the improvement factor is 16.

Ans: 'c'

16. Between two adjacent sampling instances, if the base band signal changes by an amount less than the step size, i.e. if the variations are very less magnitude, the o/p of the Delta Modulator consists of a sequence of alternate +ve and –ve Pulses.

Ans: 'a'

17. $f(x) = 1$ for $0 \leq x \leq 1$

$= 0$ elsewhere

M.S. value of Quantization Noise

$= \int_0^{0.3} x^2 . f(x).dx + \int_{0.3}^{1} (x-0.7)^2 f(x) dx$

$= 0.039$ volts^2

$\therefore$ rms value = 0.198 Volts

18. FM – Capture effect
DM – Slope overload
PSK – Matched filter
PCM – μ–Law
Ans: 'c'

19. Step size = $\frac{V_{P-P}}{\text{no.of Q levels}} = \frac{1.536}{128} = 0.012$ V

$N_q = \frac{S^2}{12} = 12 \times 10^{-6}$ Volts^2

Ans: 'c'

20. slope overload occurs if $S f_s < 2\pi f_m . E_m$
$S f_s = 25120 < 2\pi (4 \times 10^3) (1.5) = 37699.11$

Ans: 'b'

21. $R = \gamma f_s = 8 \times 8$ KHz = 64 Kbps
$\frac{S}{N_q} = 1.76 + 20 \log Q$ (db) = 49.8 db

Ans: 'b'

22. Let $S(t) = 5 \times 10^{-6} \sum_n \delta(t - nT_s) \& T_S = 100 \mu\sec = 10^{-4}$ sec

The Fourier series representation of S(t) is

$\therefore S(t) = 5 \times 10^{-6} [\frac{1}{T_s} + \frac{2}{T_s} \sum_{n=-\infty}^{\infty} \cos 2\pi n f_s t]$

$= 5 \times 10^{-2} + 10^{-1} \sum_{n=-\infty}^{\infty} [\cos 2\pi (n \times 10 \times 10^3) t]$

$\therefore y(t) = S(t). x(t)$

$= S(t). 10 \cos 2\pi (4 \times 10^3)t$

$= 5 \times 10^{-1} \cos 2\pi (4 \times 10^3)t + \sum_{n=-\infty}^{\infty} \cos 2\pi(n \times 10^4)t.\cos 2\pi(4 \times 10^3)t$

$\therefore$ The o/p of ideal LPF = $5 \times 10^{-1} \cos (8\pi \times 10^3)t$

Ans: 'c'

23. $x(t) = 100 \cos 2\pi (12 \times 10^3)t$

$T_s = 50\ \mu sec \Rightarrow f_s = 20$ KHz
The frequency components available in the sampled signal are
12 KHZ, (20 ± 12) KHZ, (40 ± 12) KHZ …..etc.
The o/p of the ideal LPF are 8 KHZ and 12 KHZ.
Ans: ‘d’

24. $x(t) = \text{sinc}\ (700t) + \text{sinc}\ (500t)$

$$= \frac{\sin(700t)}{700t} + \frac{\sin(500t)}{500t}$$

$$= \frac{\pi}{700}\left[\frac{\sin\ (700t)}{\pi t}\right] + \frac{\pi}{500}\left[\frac{\sin\ (500t)}{\pi t}\right]$$

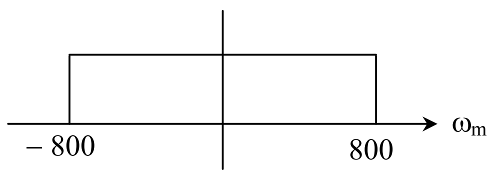
The band limiting frequency of above x(t) is $\omega_m = 700 \Rightarrow f_m = 350/\pi$

$$\Rightarrow (f_s)_{min} = \frac{700}{\pi}\text{Hz}$$

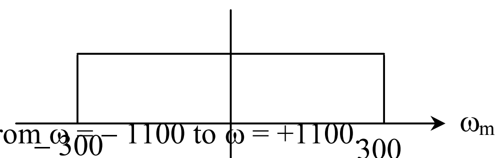
$$\therefore (T_s)_{max} = \pi/700\ \text{sec}$$

25. $x(t) = 6 \times 10^{-4}\ \text{sinc}^2\ (400t) + 10^6\ \text{sinc}^3(100t)$

$\text{Sinc}^2\ (400t) \xleftrightarrow{F.T}$



$\text{Sinc}^3\ (100t) \xleftrightarrow{F.T}$



The convolution extends from ω = – 1100 to ω = +1100.

$$\therefore \omega_m = 1100 \Rightarrow f_m = \frac{1100}{2\pi} = 175\ \text{Hz}$$

$(f_s)_{min} = 350$ Hz

26. step size $= \frac{2}{28} = 0.0078$ Volts

$$N_q = \frac{S^2}{12} = 5.08\ \mu\ \text{volts}^2$$

$$\text{Signal Power} = \frac{(0.5)^2}{2} = 0.125\ \text{Volts}^2$$

$$10\log\frac{S}{N_q} = 44\text{db}$$

27. For every one bit increase in the data word length, quantization noise power reduces by a factor of 4.

Ans: ‘c’

28. Flat Top sampling is observing be baseband signal through a finite time aperture. This results in Aperture effect distortion.
Ans: 'a'

29. In compression the baseband signal is subjected to a non linear Transformation, whose slope reduces at higher amplitude levels of the baseband signal.

Ans: 'a'

30. Most of the signal strength will be available in the Major lobe. Hence,
$(f_s)_{min} = 2(1\ KHZ) = 2\ KHZ$

Ans: 'b'

31. Irrespective of the value of η, for every one bit increase in Data word length, S/N_q improves by a factor of 4.

Ans: 'd'

32. $10 \log 4 = 6$ db

Ans: 'b'

33. The frequency components available in the sampled signal are 1 KHz, (1.8 ± 1) KHz, (3.6 ± 1) KHz etc.
The o/p of the filter are 800 Hz and 1000 Hz.

Ans: 'c'

34. Ans: 'c'

35. Ans: a – 2, b – 1, c – 5.

36. Ans: a – 2, b – 1, c – 4.

37. If pulse width increases, the spectrum of the sampled signal becomes zero even before f_m.
Ans: 'a'

38. $(B.\omega)_{min} = \frac{\gamma f_s}{2}$

$Q = 4 \Rightarrow \gamma = 2$

$Q = 64 \Rightarrow \gamma = 6$

$\Rightarrow$ B.ω increases by a factor of 3.

39. $(B.\omega)_{min} = (3\omega + \omega + 2\omega + 3\omega + 2\omega)$ Hz

$= 11\ \omega$ Hz

40. The given signal is a band pass signal. $(f_s)_{min} = \frac{2\ f_H}{N}$, where $N = \frac{f_H}{3}$

$$N = \frac{1.8 \times 10^3}{1500} = \frac{1800}{1500} = 1.2$$

$\Rightarrow N = 1$

$\therefore (f_s)_{min} = 2\ f_H = 3600$ Hz

41. LSB = (4000 – 2) MHz = 3998 MHz
USB = (4000 + 2) MHZ = 4002 MHz

$N = \frac{f_H}{B} = \frac{4002}{4} = 1000.5$

$\Rightarrow N = 1000$

$(f_s)_{min} = \frac{2 f_H}{N} = \frac{2 \times 4002}{1000}$ MHz = 8.004 MHz

42. $P_e = \frac{1}{2}\ \text{erfc}\left[\frac{Es}{\eta}.\ \cos^2\ \phi\right]^{1/2}$

$\therefore$ The factor is $\cos^2 20$

Ans: ‘b’

43. N_q depends on step size, which inturn depends on No. of Q-levels.

Ans: ‘c’

44. $(f_s)_{min}$ to reconstruct 3 KHz part = 6 KHz
$(f_s)_{min}$ to reconstruct 6 KHz part = 12 KHz
The frequencies available in sampled signal are 3 KHz, 6 KHz, (8 ± 3) KHz, (8 ± 6) KHz, (16 ± 3) KHz, (16 ± 6) KHz etc.
The o/p of LPF are 3 KHZ, 6 KHz, 5 KHz and 2 KHz.
Ans: ‘d’

45. Ans: ‘c’

Chapter – 5 B & C

01. Required Probability

= P (No bit is 1 i.e. zero No. of 1’s) + P (one bit is 1)

$= 3_{C_0}\ .\ (P)^3\ .\ (1 - P)^{3-3} + 3_{C_1}\ .\ P^2\ (1 - P)^{3-2}$

$= P^3 + 3P^2\ (1 - P)$

Ans: ‘a’

02. The given raised cosine pulse will be defined only for $0 \leq |\ f\ | \leq 2\omega$. Thus, at $t = 1/4\omega$, i.e. $f = 4\omega$, $P(t) = 0$.
Ans: b

03. Required probability = P(X = 0) + P(X = 1)

$$= n_{C_0}(P)^0(1-P)^{n-0} + n_{C_1}P(1-P)^{n-1}$$

$$= (1-P)^n + nP(1-P)^{n-1}$$

Ans: c

04. Constellation – 1:

$S_1(t) = 0$; $S_2(t) = -\sqrt{2}\,a\,\phi_1 + \sqrt{2}\,a.\phi_2$

$S_3(t) = -2\sqrt{2}a.\phi_1$; $S_4(t) = -\sqrt{2}\,a\,\phi_1 - \sqrt{2}\,a\,\phi_2$

Energy of $S_1(t) = E_1 = 0$

Energy of $S_2(t) = E_2 = 4a^2$

Energy of $S_3(t) = E_3 = 8a^2$

Energy of $S_4(t) = E_4 = 4a^2$

Avg. Energy of Constellation 1

$$E_{C_1} = \frac{E_1+E_2+E_3+E_4}{4} = 4a^2$$

Constellation – 2:

$S_1(t) = a\,\phi_1 \Rightarrow E_1 = a^2$

$S_2(t) = a\,\phi_2 \Rightarrow E_2 = a^2$

$S_3(t) = -a\,\phi_1 \Rightarrow E_3 = a^2$

$S_4(t) = -a\,\phi_2 \Rightarrow E_4 = a^2$

$$E_{C_2} = a^2$$

$$\frac{E_{C_1}}{E_{C_2}} = 4$$

Ans: b

05. Constellation – 1

Distance $d_{S_1S_2} = 2a$; $d_{S_1S_3} = 2\sqrt{2}\,a$; $d_{S_1S_4} = 2a$; $d_{S_2S_3} = 2a$; $d_{S_2S_4} = 2\sqrt{2}\,a$; $d_{S_3S_4} = 2a$

$$\therefore (d_{min})_{C_1} = 2a$$

Constellation – 2

$d_{S_1S_2} = \sqrt{2}\,a$; $d_{S_1S_3} = 2a$; $d_{S_1S_4} = \sqrt{2}a$; $d_{S_2S_3} = \sqrt{2}a$; $d_{S_2S_4} = 2a$; $d_{S_3S_4} = \sqrt{2}a$;

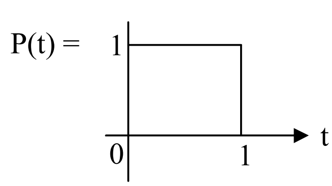
$$(d_{min})_{C_2} = \sqrt{2}\,a$$

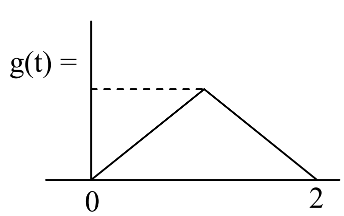
Since $(d_{min})_{C_2} = (d_{min})_{C_1}$,

Probability of symbol error in Constellation – 2 (C_2) is more than that of constellation – 1 (C_1).

Ans: a

06.



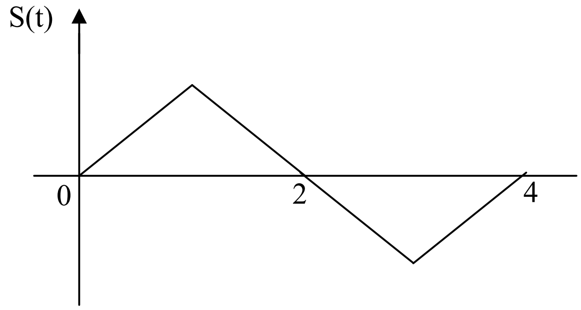


$S(t) = g(t) - \delta(t-2) * g(t)$

We have $\delta(t-2) * g(t) = g(t-2)$

$S(t) = g(t) - g(t-2)$

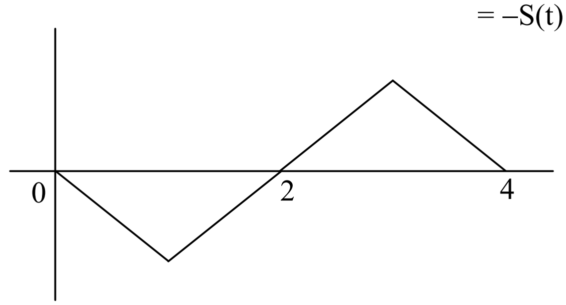
=



The impulse response of corresponding Matched filter is $h(t) = S(-t+4)$

$= -S(t)$

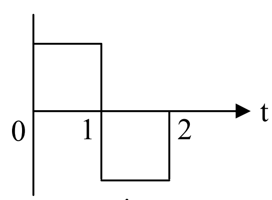
=



Ans: c

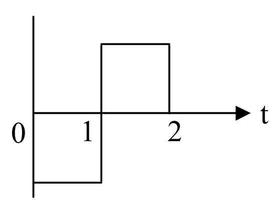
07. Since $P(t) = 1$ for $0 \le t \le 1$, and $g(t) = t$ for $0 \le t \le 1$, the given
$x_{AM}(t) = 100[1 + 0.5t] \cos\omega_c t$
Ans: a

08. Output of the matched filter is the convolution of its impulse response and its input.
The given input S(t) =



The corresponding impulse response is

h(t) =

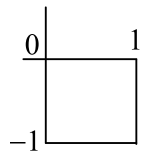


The response should extend from t = 0 to t = 4.

$$\text{Response} = \int_{-\infty}^{\infty} s(\tau)\, h(t-\tau)\, d\tau$$

Let t = 1

$S(\tau)\, h(-\tau + 1) =$



$\therefore$ The response at t = 1 is −1

Ans: 'c'

09. Let z be the received signal.

$$P(z/0) = \frac{1}{0.5} \quad \text{for } -0.25 \le z \le 0.25$$
$$= 0 \quad \text{elsewhere}$$

$$P(1/0) = \int_{0.2}^{0.25} \left(\frac{1}{0.5}\right) dz$$
$$= 0.1$$

$$P(z/1) = 1 \text{ for } 0 \le z \le 1$$
$$= 0 \text{ elsewhere}$$

$$P(0/1) = \int_{0}^{0.2} dz = 0.2$$

$$\text{Ave. bit error prob.} = \frac{0.1 + 0.2}{2} = 0.15$$

Ans: 'a'

10. Ans: 'c'

11. $(B.W)_{BPSK} = 2f_b = 20$ KHz

$(B.W)_{QPSK} = f_b = 10$ KHz

Ans: 'c'

12. $$\frac{S_0}{N_0} = \frac{2E_b}{N_0} = \frac{2 \times 10^6}{10^5} = 20$$

$10 \log 20 = 13$ db

Ans: 'd'

13. $$\text{B.W efficiency} = \frac{\text{data rate}}{(B.W)_{min}}$$

For BPSK, $(B.W)_{min}$ required is same as data rate.

$\therefore$ B.W efficiency for BPSK = 1

Since, coherent detection is used for BPSK, Carrier synchronization is required.

Ans: 'b'

14. $$(P_e)_{PSK} = \frac{1}{2}\,\text{erfc}\left[\frac{A^2 T}{2\eta}\right]^{1/2}$$

$(P_e)_{FSK} = \frac{1}{2} \text{erfc}\left[0.6 \frac{A^2 T}{2\eta}\right]^{1/2}$

10 log 0.6 = -2.2 db = -2 db

Ans: 'c'

15. $f_H = nf_b$ & $f_L = mf_b$, where n and m are integers such that n>m.
    Ans: 'd'

16. Ans: 'd'

17. f_H = 25 KHz & f_L = 10 KHz

$\Rightarrow f_c + \frac{\Omega}{2\pi} = 25 \text{ KHz}$

$f_c - \frac{\Omega}{2\pi} = 10 \text{ KHz}$

$\Rightarrow \frac{\Omega}{\pi} = 15 \text{ KHz}$

$\Rightarrow \Omega = 15\ \pi(10^3)$

For FSK signals to be orthogonal,

$2\Omega T_b = n\pi \Rightarrow 2(15 \times \pi \times 10^3)\ T_b = n\pi$

$\rightarrow 30 \times 10^3 \times T_b$ should be an integer. This is satisfied for $T_b = 280\ \mu\text{sec}$

Ans: 'd'

18. Ans: 'c'

19. In PSK, the signaling format is NRZ and in ASK, it is ON-OFF signaling. Both representations are having same PSD plot.

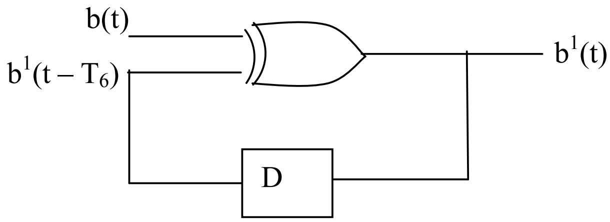
    Ans: 'c'

20. Ans: 'd'

21. Ans: 'b'

22. Ans: a – 3; b – 1; c – 2

23.



b(t)		0	1	0	0	1
$b^1(t)$	1	1	0	0	0	1
Phase		0	π	π	π	0

Ans: 'c'

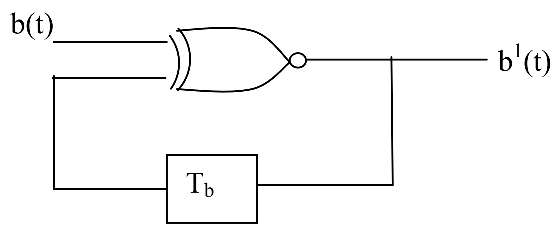
24. a

25. c

26. QPSK

27. a

28.



b(t)		1	1	0	0	1	1
$b^1(t)$	1	1	1	0	1	1	1

since the phase of the first two message bits is π, π, the received is

0)	0	1	0	1	1	1	
	0	0	1	0	1	1	(1
	0	0	0	0	1	1	
	π	π	π	π	0	0	

Ans : d

29. P(at most one error)

$= P(X=0) + P(X=1)$

$= 8_{C_0}.(1-P)^8 . P^0 + 8_{C_1}. (1-P)^7 P = (1-P)^8 + 8P(1-P)^7$

Ans: b

Chapter – 6 (Objective Questions)

01. $(B.W)_{min} = w+w+2w+3w = 7w$

Ans: 'd'

02. The total No.of channels in 5 MHz B.W is

$$\frac{5\times10^6}{2\times10^5} \times 8 = 200$$

With a five cell repeat pattern, the no. of simultaneous channels is $\frac{200}{5} = 40$

Ans : B

03. $R_C = 1.2288 \times 10^6$

$$G_P = \frac{R_c}{R_b} \geq 100$$

$$\Rightarrow \frac{R_c}{100} \geq R_b$$

$$\Rightarrow 1.2288 \times 10^4 \geq R_b$$

$$\Rightarrow R_b \leq 12.288 \times 10^3 \text{ bps}$$

Ans: a

04. Bit rate = 12 (2400 + 1200+1200)

= 57.6 kbps

Ans: c

05. Sample rate = 200+ 200 + 400 +800

= 1600 Hz

Ans : a

06. d

07. 12×5 KHz + 1 KHz = 61 KHz

08. b

09. d

10 . Theoritical $(B.W)_{min} = \frac{1}{2}$ (data rate)

$= \frac{1}{2} (4 \times 2 \times 5 \text{ KHz})$

= 20 KHz

11. c

12. a

13. The path loss is due to
    a) Reflection : Due to surface of earth, buildings and walls
    b) Diffraction : This is due to the surfaces between Tx. and Rx. that has sharp irregularities (edges)
    c) Scatterings: Due to foliage, street signs, lamp posts, i.e. scattering is due to rough surfaces, small objects or by other irregularities in a mobile communication systems.

14. 1333 Hz.

15. Min. Tx. Bit rate = $(2 \times 4000 + 2\times 8000 + 2\times 8000 + 2\times 4000)8$
    = 384 kbps
    Ans: 'd'

16. 12×8 KHz
    Ans : c

17. a

18. c

19. b

20. c

21. b

All the Best.

ACE Academy