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NOTES

CHAPTER 1

PROBABILITY, RANDOM VARIABLE AND RANDOM PROCESS

OBJECTIVE QUESTIONS

1. The variance of a random variable X is σ_x^2. Then the variance of $-$ kx (Where k is an positive constant) is :

(a) σ_x^2 (b) $-k\sigma_x^2$

(c) $k\sigma_x^2$ (d) $k^2\sigma_x^2$

2. Events A and B are mutually exclusive and have nonzero probability. Which of the following statement(s) are true?

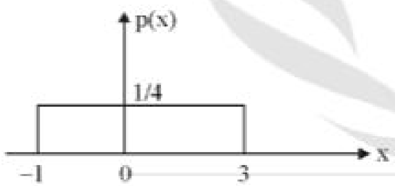
(a) $P(A \cup B) = P(A) + P(B)$

(b) $P(B^C) > P(A)$

(c) $P(A \cap B) = P(A)\,P(B)$

(d) $P(B^C) < P(A)$

3. For a random variable 'X' following the probability density function, p(x), shown in figure, the mean and the variance are, respectively



(a) 1/2 and 2/3 (b) 1 and 4/3

(c) 1 and 2/3 (d) 2 and 4/3

4. The auto-correlation function of an energy signal has :

(a) No symmetry (b) Conjugate symmetry

(c) Odd symmetry (d) Even symmetry

5. The power spectral density of a deterministic signal is given by $[\sin(f)/f]^2$, where 'f' is frequency. The autocorrelation function of this signal in the time domain is :

(a) A rectangular pulse (b) A delta function

(c) A sine pulse (d) A triangular pulse

6. A probability density function is given by $P(x) = K \exp(-x^2/2)$, $-\infty < x < \infty$. The value of K should be :

(a) $\dfrac{1}{\sqrt{2\pi}}$ (b) $\sqrt{\dfrac{2}{\pi}}$

(c) $\dfrac{1}{2}\sqrt{\pi}$ (d) $\dfrac{1}{\pi\sqrt{2}}$

7. The ACF of a rectangular pulse of duration T is :

(a) A rectangular pulse of duration T

(b) A rectangular pulse of duration 2T

(c) A triangular pulse of duration T

(d) A triangular pulse of duration 2T

8. The PSD and the power of a signal g(t) are, respectively $S_g(\omega)$ and P_g. The PSD and the power of the signal ag(t) are respectively.

(a) $a^2S_g(\omega)$ and a^2P_g (b) $a^2S_g(\omega)$ and aP_g

(c) $aS_g(\omega)$ and a^2P_g (d) $aS_g(\omega)$ and aP_g

9. The Probability density function of a continuous random variable is of the form

$$f_x(x) = \frac{1}{2}e^{-|x|} \text{ for } -\infty < x < +\infty$$

The mean of random variables is

(a) 4 (b) 2

(c) 0.5 (d) 0

10. x(t) is random process with mean value 2 and autocorrelation function $R_x(\tau) = 4[2e^{-(0.3)|\tau|} + \sin(\tau)]$. Let x be the gaussian random variable obtained by sampling process at $t = t_1$ and $Q(k) = \int_k^{\infty} \frac{1}{\sqrt{2\pi}} e^{\frac{-t^2}{2}} dt$, the probability that $P[x \le 1]$ is

(a) 1–Q(0.5) (b) Q(0.5)

(c) $Q\left(\dfrac{1}{\sqrt{2\pi}}\right)$ (d) $1-Q\left(\dfrac{1}{\sqrt{2\pi}}\right)$

11. It is desired to generate a random signal x(t) with auto correlation function $R_X(\tau) = 5\eta e^{-5|\tau|}$ by passing white noise n(t) with power spectral density $S_n(f) = \eta/2$ Watt/Hz through a LTI system. An expression for the transfer function H(f) of the LTI system will be

(a) $\frac{50}{25 + 4\pi^2 f^2}$ (b) $\frac{100}{25 + 4\pi^2 f^2}$

(c) $\sqrt{\frac{50}{25 + 4\pi^2 f^2}}$ (c) $\sqrt{\frac{100}{25 + 4\pi^2 f^2}}$

12. Consider a random signal y(t) given by y(t) = k + x(t), where 'K' is constant and x(t) is a zero mean random signal with auto correlation function $R_x(\tau)$. The autocorrelation $R_y(\tau)$ is equal to

(a) $R_x(\tau)$ (b) $K + R_x(\tau)$

(c) $K^2 + R_x(\tau)$ (d) $K^2 + 2K + R_x(\tau)$

13. A random signal x(t) has an auto correlation function of

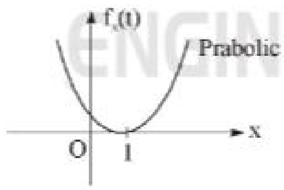
$$R_X(\tau) = \begin{cases} 5 - 3|\tau| & ; |\tau| \le 1 \\ 2 & ; |\tau| > 1 \end{cases}$$

How much the signal average power is embedded in the d.c component

(a) 5 W (b) 3 W

(c) 8 W (d) 2 W

14. For given probability density function for random variable X, find mean for given figure if $0 < x \le 1$



(a) $\frac{1}{3}$ (b) $\frac{1}{6}$

(c) $\frac{1}{9}$ (d) $\frac{1}{12}$

15. Match List-I (Type of Random Process) with List-II (Property of the Random Process) and select the correct answer using the code given below the lists:

List-I	List-II
A. Stationary Process	1. Statistical averages are periodic in time
B. Ergodic Process	2. Statistical averages are independent of time
C. Wide sense stationary	3. Mean and autocorrelation are independent of time
D. Cyclostationary Process	4. Time averages equal corresponding ensemble average

Codes:	A	B	C	D
(a)	3	1	2	4
(b)	2	4	3	1
(c)	3	4	2	1
(d)	2	1	3	4

16. Which one of the followingis not a property of auto correlation function $(R(\tau))$?

(a) $R(0) \le R(\tau)$

(b) $R(z) = R(-\tau)$

(c) R(0) = average of the waveform

(d) Power spectral density is Fourier transform of auto correlation function for a periodic waveform

17. Two random variables U and V are distributed according to

$f_{u,v}(u,v) = (C/3)e^{-u-v}$ (for $u \ge 0, v \ge 0$) and

= 0 otherwise

Where C, a constant, is equal to

(a) 3 (b) 2

(c) 1 (d) 1/2

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ANSWER KEY

1. ***Ans.(d)***

$$Var(-Kx) = E[(-Kx)^2]$$
$$\sigma^2 = E[K^2x^2]$$
$$\sigma^2 = K^2E[x^2]$$
$$\sigma^2 = K^2\sigma_x^2$$

2. ***Ans.(a)***

$$P(A \cup B) = P(A) + (B)$$

For mutually exclusive events A and B

$$\boxed{P(A \cup B) = P(A) + P(B)}$$

3. ***Ans.(b)***

$$\text{Mean} = E[X] = \int_{-\infty}^{\infty} x\rho_x(x)dx$$

$$\mu_x = \int_{-1}^{3} x \frac{1}{4} dx = \frac{1}{4}\left[\frac{x^2}{2}\right]_{-1}^{3}$$

$$\mu_x = \frac{1}{4} \times \frac{1}{2}[9-(-1)^2] = \frac{1}{8} \times 8$$

$$\mu_x = 1$$

$$\text{Variance} = \sigma_x^2 = E[(x-\mu_x)^2] = \int_{-\infty}^{\infty} (x-\mu_x)^2 \rho_x(x)dx$$

$$\sigma_x^2 = \int_{-1}^{3} (x-1)^2 \frac{1}{4} dx = \frac{1}{4}\int_{-1}^{3} (x-1)^2 dx$$

$$\sigma_x^2 = \frac{1}{4}\int_{-2}^{3} (x^2+1-2x)dx$$

$$\sigma_x^2 = \frac{1}{4}\left[\frac{x^3}{3} + x - \frac{2x^2}{2}\right]_{-1}^{3}$$

$$\sigma_x^2 = \frac{1}{4}\left[\left(\frac{27}{3}+3-9\right) - \left(-\frac{1}{3}-1-1\right)\right]$$

$$\sigma_x^2 = \frac{1}{4}\left[3+\frac{1}{3}+2\right] = \frac{1}{4} \times \frac{1}{3}[9+1+6]$$

$$\sigma_x^2 = \frac{4}{3}$$

4. ***Ans.(b) & (d)***

Auto-correlation function of energy signal has conjugatae symmetric

$$\boxed{R_x(\tau) = R_x^*(-\tau)}$$

If the function is real, then the autocorrelation function has even symmetry

$$\boxed{R_x(\tau) = R_x(-\tau)}$$

5. ***Ans.(d)***

Autocorrelation function and power spectral density makes the Fourier transfer pair.

$$\boxed{R_x(\tau) \xleftrightarrow{F.T.} G_x(\omega)}$$

$$R_x(\tau) = F^{-1}\left[\left(\frac{\sin f}{f}\right)^2\right] = F^{-1}\left[\sin c^2\left(\frac{f}{\pi}\right)\right]$$

Inverse Fourier transform of square of sinc function is always a triangular signal in time domain.

6. ***Ans.(a)***

Gaussian probability density of random variable 'x' is given by :

$$\rho_x(x) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left[\frac{-(x-\mu)^2}{2\sigma^2}\right]$$

when $\sigma = 1$ and $\mu = 0$ (zero mean)

$$\rho_x(x) = \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{x^2}{2}\right] \quad \text{...(i)}$$

Given that

$$\rho_x(x) = k \cdot \exp\left[-\frac{x^2}{2}\right] \quad \text{...(ii)}$$

By comparing equation (i) and equation (ii),

we have $K = \frac{1}{\sqrt{2\pi}}$

7. ***Ans.(d)***

$$R_x(\tau) = \int_{-\infty}^{\infty} x(t+\tau)x(t)dt$$

The autocorrelation function (ACF) of a rectangular pulse of duration T is a triangular pulse of duration 2T.

8. ***Ans. (b)***

$$(PSD)S_g = \int_{-\infty}^{\infty} R_x(\tau)e^{-j\omega\tau}d\tau$$

$$R_x(\tau) = \lim_{x\to\infty}\frac{1}{T}\int_{-T/2}^{T/2} g(t)g(t+\tau)dt$$

for $ag(t)$ $\quad s_g' = a^2S_g$

$P_g' = a^2P_g$

9. ***Ans. (d)***

$$\text{Mean } (M_x) = \int_{+\infty}^{+\infty} xf_x(x)dx$$

10. ***Ans. (b)***

$\sigma^2 = R_x(0) - m^2 = 4[2] - 4 = 4; \therefore \sigma = 2$

$$P[X \le 1] = \int_{-\infty}^{1} \frac{1}{\sqrt{8\pi}} e^{\frac{-(x-2)^2}{8}} dx$$

Let $\dfrac{(x-2)^2}{8} = \dfrac{y^2}{2} \therefore x - 2 = 2y; \therefore dx = 2dy$

Also, mean $X = -\infty$, $y = -\infty$

$$\therefore \int_{-\infty}^{0.5} \frac{1}{\sqrt{2\pi}} e^{-y^2/2}dy$$

Let, $y = -z$, $dy = -dz$

$$\therefore P[x \le 1] = \int_{0.5}^{-\infty} \frac{1}{\sqrt{2\pi}} e^{-z^2/2}dx = Q(0.5)$$

11. ***Ans. (d)***

$$X(t) = Ke^{-a|t|}; x(\omega) = \frac{k\cdot 2a}{a^2+\omega^2} = \frac{k\cdot 2a}{a^2+4\pi^2f^2}$$

here, $K = 5$, $a = 5$

then, here $x(\omega) = S_x(\omega)$ (spectral density)

$$S_x(\omega) = |H(\omega)|^2\,\eta/2$$

$$|H(\omega)|^2 = \frac{50\eta}{25+\omega^2} \times \frac{1}{\eta/2} = \frac{100}{25+\omega^2}$$

$$\therefore |H(f)|^2 = \frac{100}{25+4\pi^2f^2}$$

12. ***Ans. (c)***

$$E[y(t)\cdot y(t+\tau)] = E[(k+x(t))\cdot(k+x(t+\tau))]$$

$$= E[K^2] + kE[x(t)+x(t+\tau)+E[x(t)\cdot x(t+\tau)]]$$

$$= k^2 + 0 + R_x(\tau)$$

13. ***Ans. (d)***

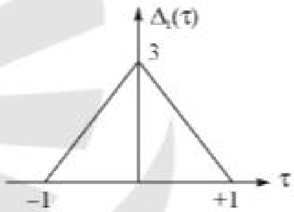
We can write

$$R_x(\tau) = [2+3(1-|\tau|)]$$

where, $\quad |\tau| \le 1$

$$R_x(\tau) = 2; |\tau| > 1$$

$$\therefore R_x(t) = 2 + 3\Delta_f(\tau)$$



$$PSD = FT[R_x(\tau)] = 2\delta(f) + 3\,\text{sinc}^2(f)$$

Area of delta function in PSD is due to the D.C. component.

So, Avg. power in D.C. component = 2W

14. ***Ans. (d)***

$$f_x(x) = (1-x)^2;\ 0 \le x \le 1$$

$$E[x] = m_x = \int_{-\infty}^{\infty} xf_x(x)dx = \int_0^1 x(1-x)^2dx = \frac{1}{12}$$

15. ***Ans. (b)***

16. ***Ans. (a)***

17. ***Ans. (a)***

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CHAPTER 2

AMPLITUDE MODULATION SYSTEM

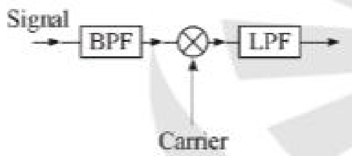
OBJECTIVE QUESTIONS

1. In an AM signal when the modulation index is one, the maximum power P_t, (where P_c is the carrier power) is equal to

(a) P_c (b) $1.5P_c$

(c) $2P_C$ (d) $2.5\ P_c$

2. A DSB suppressed carrier reception is shown in the below figure. If $(SNR)_j$ is the S/N ratio for direct (incoherent) detection and $(SNR)_S$ is that for (coherent) synchronous detection, then



(a) $(SNR)_s = 2(SNR)_i$

(b) $(SNR)_s = (SNR)_i$

(c) $(SNR)_s = 4(SNR)_i$

(d) $(SNR)_s = 1/2(SNR)_i$

3. A 4 GHz carrier is DSB-SC modulated by a lowpass message signal with maximum frequency of 2 MHz. The resultant signal is to be ideally sampled. The minimum frequency of the sampling impulse train should be :

(a) 4 MHz (b) 8 MHz

(c) 8 GHz (d) 8.004 GHz

4. In commercial TV transmission in India, picture and speech signals are modulated respectively as

	(Picture)		(Speech)
(a)	VSB	&	VSB
(b)	VSB	&	SSB
(c)	VSB	&	FM
(d)	FM	&	VSB

5. Which of the following demodulator(s) can be used for demodulating the signal $x(t) = 5(1 + 2\cos 200\pi t)\cos 20000\pi t$:

(a) Envelope demodulator

(b) Square-law demodulator

(c) Synchronous demodulator

(d) None of the above

6. $v(t) = 5[\cos(10^6\pi t) - \sin(10^3\pi t) \times \sin(10^6\pi t)]$ represents :

(a) DSB suppressed carrier signal

(b) AM signal

(c) SSB upper sideband signal

(d) Narrow band FM signal

7. A DSB-SC signal is generated using the carrier $\cos(\omega_c t + \theta)$ and modulating signal x(t). The envelop of the DSB-SC signal is :

(a) x(t)

(b) |x(t)|

(c) Only positive portion of x(t)

(d) x(t) cos θ

8. A modulated signal is given by, $s(t) = m_1(t)\cos(2\pi f_c t) + m_2(t)\sin(2\pi f_c t)$ where the baseband signal $m_1(t)$ and $m_2(t)$ have bandwidths of 10 kHz and 15 kHz, respectively. The bandwidth of the modulated signal, in kHz, is :

(a) 10 (b) 15

(c) 25 (d) 30

9. A modulated signal is given by $s(t) = e^{-at}\cos[(\omega_c + \Delta\omega)t]u(t)$, where a, ω_c and $\Delta\omega$ are positive constants, and $\omega_c >> \Delta\omega$. The complex envelope of s(t) is given by :

(a) $\exp(-at)\exp[j(\omega_c + D\omega)t]u(t)$

(b) $\exp(-at)\exp(j\Delta\omega t)u(t)$

(c) $\exp(j\Delta\omega t)\cdot u(t)$

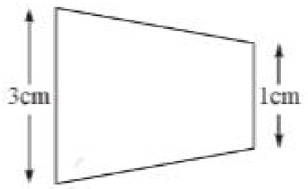
(d) $\exp[(j\omega_c+\Delta\omega)t]$

10. The Hilbert transform of $\cos\omega_1 t + \sin\omega_2 t$ is :

(a) $\sin\omega_1 t - \cos\omega_2 t$ (b) $\sin\omega_1 t + \cos\omega_2 t$

(c) $\cos\omega_1 t - \sin\omega_2 t$ (d) $\sin\omega_1 t + \sin\omega_2 t$

11. Consider the Trapezoidal pattern for AM wave shown below. Modulation index is given by



(a) 33% (b) 50%

(c) 75% (d) 100%

12. Consider vestigial signal sideband modulation system used to modulate a TV signal having bandwidth equal to 4 MHz. If roll-off factor is 1, then the bandwidth required to transmit the signal is given by

(a) 5 MHz (b) 4 MHz

(c) 6 MHz (d) 7 MHz

13. For a message signal m(t) = 10 cos 100t with 60% modulation, the maximum envelope time will be

(a) 10.3 ms (b) 13.3 ms

(c) 33.3 ms (d) 10 ms

14. One of the following methods cannot be used to remove the unwanted sideband in SSB. This is the

(a) filter system (b) phase-shift method

(c) third method (d) balanced modulator

15. In AM voltage signal S(t), with a carrier frequency of 1.15 GHz has a complex envelope $g(t) = A_c[1 + m(t)]$, A_c = 500V, and the Modulation is a 1 KHz sinusoidal test tone described by $m(t) = 0.8 \sin(2\pi \times 10^3 t)$, appears across a 50 W resistive load. What is the actual power dissipated in the load?

(a) 165 KW (b) 82.5 KW

(c) 3.3 KW (d) 6.6 KW

16. A given AM broadcast station transmits an average carrier power output of 40 KW and uses a modulation index of 0.707 for sine wave modulation. What is the maximum (peak) amplitude of output if the antenna is represented by 9.50 Ω resistive load?

(a) 50 KV (b) 50 V

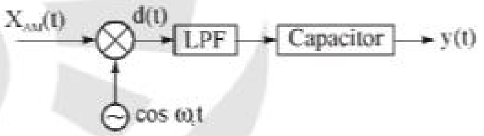
(c) 3.414 KV (d) 28.28KV

17. 15 signal each bandlimited to 15 KHz are to be transmitted over a single channel by frequency division multiplexing. If AM-SSB modulation guardband of 3 KHz is used, the bandwidth of the multiplexed signal will be

(a) 267 KHz (b) 270 KHz

(c) 534 KHz (d) 540 KHz

18. For given synchronous demodulator, modulated AM signal $X_{AM}(t) = [A + m(t)] \cos \omega_c t$. The value of y(t) is



(a) m(t) (b) $\frac{m(t)}{2}$

(c) $\frac{m(t)}{4}$ (d) zero

19. A non-linear device with a transfer characteristic given by $i = (10 + 2v_i + 0.2v_i^2)$ mA is supplied with a carrier of 1 V amplitude and a sinusoidal signal of 0.5 V amplitude in series. If at the output, the frequency component of AM signal is considered, the depth of modulation is

(a) 18% (b) 10%

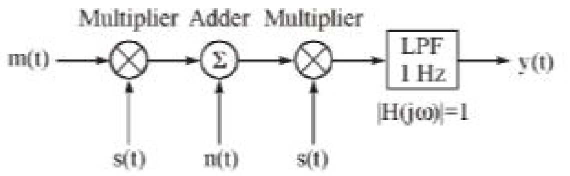
(c) 20% (d) 33.33%

20. An AM modulator has output $x_c(t) = A \cos 400 \pi t + B \cos 380 \pi t + B \cos 420 \pi t$. The carrier power is 100 W and the efficiency is 40%. The value of A and B are

(a) 14.14, 8.16 (b) 50, 10

(c) 22.36, 13.46 (d) None of the above

21. In the given figure $m(t) = \dfrac{2\sin 2\pi t}{t}$, s(t) = cos 200 πt and $n(t) = \dfrac{\sin 199\pi t}{t}$. The output y(t) is



(a) $\dfrac{\sin 2\pi t}{2t}$

(b) $\dfrac{\sin 2\pi t}{2t} + \dfrac{\sin \pi t}{t}\cos 3\pi t$

(c) $\dfrac{\sin 2\pi t}{2t} + \dfrac{\sin 0.5\pi t}{t}\cos 1.5\pi t$

(d) $\dfrac{\sin 2\pi t}{2t} + \dfrac{\sin \pi t}{t}\cos .75\pi t$

22. An arbitrary signal m(t) has zero average value and it is band-limited to 3.2 kHz. It is sampled at the rate of 8 k samples/s. The samples are passed through an ideal band-pass filter with centre frequency of 32 kHz and bandwidth of 6.4 kHz. The output of the band-pass filter is

(a) AM-DSB signal with suppressed carrier

(b) AM-DSB signal with carrier

(c) AM-SSB signal with carrier

(d) a sequence of exponentially decaying sine waves

23. A 4 GHz carrier is DSBSC modulated by a low pass message signal with maximum frequency of 2 MHz. The resultant signal to be ideally sampled. The minimum frequency of the sampling train should be

(a) 4 MHz (b) 8 MHz

(c) 8 GHz (d) 8.004 GHz

24. In an amplitude modulated system, if the total power is 600 W and the power in carrier is 400 W, then the modulation index is

(a) 0.5 (b) 0.75

(c) 0.9 (d) 1

25. The ramp signal m(t) = at is applied to a delta modulator with sampling period T_s and step size 5. Slope overload distortion would occur if

(a) $\delta < a$ (b) $\delta > a$

(c) $\delta < aT_s$ (d) $\delta > aT_s$

26. Which one of the following statements regarding the threshold effect in demodulators is correct?

(a) It is exhibited by all demodulators when the input signal to noise ratio is low

(b) It is the rapid fall in output signal to noise ratio when the input signal to noise ratio falls below a particular value

(c) It is the property exhibited by all AM suppressed carrier coherent demodulators

(d) It is the property exhibited by correlation receivers

27. For an AM wave, the maximum voltage was found to be 10 V and the minimum voltage was found to be 5 V. The modulation index of the wave would be

(a) 0.33 (b) 0.52

(c) 0.40 (d) 0.1

28. If the radiated power of AM transmitter is 10 kW, the power in the carrier for modulation index of 0.6 is nearly

(a) 8.24 kW (b) 8.47 kW

(c) 9.26 kW (d) 9.6 kW

29. In a low-level AM system, the amplifier which follows the modulated stage must be the

(a) linear device (b) harmonic device

(c) class-C amplifier (d) non-linear device

30. In a single-tone amplitude modulated signal at a modulation depth of 100% transmit a total power of 15W, the power in the carrier component is

(a) 5W (b) 10W

(c) 12W (d) 15W

31. Which one of the following is used for the detection of AM-DSB-SC signal ?

(a) Ratio detector

(b) Foster-Seeley discriminator

(c) Product demodulator

(d) Balanced slope detector

32. Consider an amplitude modulated (AM) wave $c_m(t) = (A_c + A_m \cos\omega_m t)\cos\omega_c t$. If P_s denotes the power in any one of the side frequencies and P_T denotes the total powr of the AM signal, $A_c = 2A_m$ for which one of the following is TRUE ?

(a) $P_T = 3P_s$ (b) $P_T = 6P_s$

(c) $P_T = 9P_s$ (d) $P_T = 18P_s$

33. An amplitude modulated signal $s(t) = A_c[1 + km(t)]\cos 2\pi f_c t$ (message signal m(t) has powre P and constant k determines the modulation index) is sent through an AWGN channel and detected using an envelope detector. If the average carier power is large compared to the noise power and any DC component present at the envelope detector output is removed, the figure of the merit of the detector is

(a) $\frac{k^2P}{1+k^2P}$ (b) $\frac{P}{1+k^2P}$

(c) $\frac{2P}{A_c^2 + 2k^2P}$ (d) $\frac{P}{k^2 + P}$

34. Match List I with List II and select the correct answer using the codes given below the lists:

List I

A. Collector modulation

B. Phase shift method

C. Balanced modulator

D. Amplitude limiter

List II

1. FM generation
2. DSB generation
3. AM generation
4. SSB generation

Codes:	A	B	C	D
(a)	3	4	1	2
(b)	4	3	1	2
(c)	3	4	2	1
(d)	4	3	2	1

35. Consider the following applications :

1. Singal adder
2. Signal multiplier
3. AM demodulator
4. Frequency multiplier
5. Pulse modulator

A balanced modulator is useful as

(a) 1, 2, 4 and 5 (b) 1, 3 and 5

(c) 2, 3, 4 and 5 (d) 2, 3 and 4

36. Consider the following statements about SSB (Single Side Band) transmission :

1. It requires less power.
2. Transmitter and receiver needed are simaple.
3. There is no interference.
4. Bandwidth required is less.

Of these statements :

(a) 1, 2 and 3 are correct

(b) 1, 2 and 4 are correct

(c) 1, 2 and 4 are correct

(d) 1 and 4 are correct

37. A 10 MHz carrier of peak value 10V is amplitude modulated by a 10 kHz signal of amplitude 6V. The amplitude of each side-band frequency is

(a) 3V (b) 4V

(c) 5V (d) 6V

38. Assertion (A) : For transmitting audio frequency signals, antennas of several hundred kilometers length would be required.

Reason (R) : For efficient radiation of electromagnetic energy to occur from an antenna, the wavelength of the radiated signal must be comparable with the physical dimensions of the antenna

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not a correct explanation of A

(c) A is true, but R is false

(d) A is false, but R is true

39. Consider an SSB signal where the modulating signal is a speech signal.

Assertion (A) : Its envelope detection will not recover the modulating signal.

Reason (R) : The envelope of an SSB is constant.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not a correct explanation of A

(c) A is true, but R is false

(d) A is false, but R is true

40. A DSB-SC signal is being detected synchronously. The phase error locally generated carrier will

(a) cause phase delay

(b) cause phase distortion only

(c) have the effect of reducing the output and causing phase distortion also

(d) reduce the detected output only

41. The output of a diode detector contains

(a) the modulating signal

(b) the DC voltage

(c) the RF ripple

(d) All of the above

42. An amplitude modulated analog waveform has a maximum amplitude A_{max} and a minimum amplitude A_{min} (a positive value), then the modulation index is given by

(a) $\frac{A_{min}}{A_{max}}$ (b) $\frac{2A_{min}}{A_{max}+A_{min}}$

(c) $\frac{A_{max}-A_{min}}{A_{max}+A_{min}}$ (d) $\frac{A_{max}-A_{min}}{2(A_{max}+A_{min})}$

43. The frequency spectrum of an amplitude modulated signal contains

(a) carrier frequency only

(b) sideband frequencies only

(c) modulated frequencies only

(d) carrier and sideband frequencies

44. A sine wave carrier $v_c = V_c \sin \omega_c t$ is amplitude-modulated by the signal $v_m = V_m \sin \omega_m t$ so that the modulation index is unity : then the normalized total power is carrier and side frequencies is given by

(a) $\frac{3}{4}V_c^2$ (b) V_c^2

(c) $\frac{3}{2}V_c^2$ (d) $3V_c^2$

45. A carrier voltage is simultaneously amplitude modulated by two sine waves causing modulation indices of 0.1 and 0.3. The overall rms value of modulation index is

(a) 0.10 (b) 0.35

(c) 0.50 (d) 0.70

46. An AM transmitter radiates 1 kW with an un-modulated carrier wave and 5 kW when it is amplitude modulated if the same carrier were frequency modulated, then the radiated power will be

(a) 4 kW (b) 5 kW

(c) 4.5 kW (d) 8 kW

47. The maximum transmission power efficiency of DSB-C amplitude modulation is

(a) 25% (b) 33.33%

(c) 50% (d) 100%

48. In an amplitude modulated system if the total power is 600W and the power in the carrier is 400W, the modulation index is

(a) 0.5 (b) 0.75

(c) 0.9 (d) 1

49. A sine wave is applied to a balanced modulator. The peak ouput envelope power is 1000 times the minimum output envelope power. Estimate the carrier suppression in dBc.

(a) 24 dBc (b) 30 dBc

(c) 36 dBc (d) 40 dBc

50. Percentage modulation of an AM wave having a power content of 8 KW at carrier frequency and 2 KW in each of its side bands is

(a) 60% (b) 70%

(c) 100% (d) 80%

51. A 1KW carrier is amplitude modulated to a depth of 60%. The total power in the modulated carrier is

(a) 1 kW
(b) 1.06 kW
(c) 1.6 kW
(d) 1.18 kW

52. De-emphasis circuit is used

(a) To attenuate high frequencies
(b) To attenuate low frequencies
(c) To attenuate midband frequencies
(d) None of the above

53. In Indian TV, video signal bandwidth is

(a) 15 kHz (b) 5 MHz
(c) 5.5 MHz (d) 7 MHz

54. For the modulated carrier

$$s(t)=200\sin(\omega_c+200\pi)t+1000\cos(\omega_c t)$$
$$-200\sin(\omega_c-200\pi)t$$

Where $1000\cos(\omega_c t)$ is unmodulated carrier, the complex envelope is

(a) 1000 + 400 sin (200πt)
(b) 1000 + 200 sin (200πt)
(c) 1000 – 200 sin (200πt)
(d) 400 sin (200πt)

55. Consider the waveform

$V(t)=(1+m\cos\omega_m t)\cos\omega_c t$.

Show that, if the demodulated wave is to follow the envelope of V(t), it is requried that any time t_0.

(a) $RC\le\frac{\omega_n(m\sin\omega_m t_0)}{1+m\cos\omega_m t_0}$

(b) $\frac{1}{RC}\ge\frac{\omega_n(m\sin\omega_m t_0)}{1+m\cos\omega_m t_0}$

(c) $\frac{1}{RC}\le\frac{1}{(m\omega_m)}$

(d) RC is very large

56. An amplitude modulated double sideband suppressed carrier signal is given by $[1+a_m\cos 2\pi f_a t]\cos 2\pi f_m t\cos 2\pi f_c t$. where f_c is the frequency of the carrier signal. The modulating signal is

(a) $a_m\cos 2\pi f_a t$
(b) $a_m\cos 2\pi f_a t\cos 2\pi f_m t$
(c) $[1+a_m\cos 2\pi f_a t]\cos 2\pi f_m t$
(d) $1+a_m\cos 2\pi f_a t$

57. Consider a message signal $m(t)e^{-t}u(t)$ and the carrier is $A_c\cos 2\pi f_c t$. The carrier in modulated by the message signal to generate a DSBSC signal. Which of the following demodulator is used to get back the message.

(a) Envelope detector
(b) Synchronous detector
(c) Both of the above
(d) None

58. In an AM signal when the modulation index is one, the maximum power P_t (where P_c is the carrier power) is equal to

(a) P_c (b) $1.5P_c$
(c) $2P_c$ (d) $2.5P_c$

59. An AM signal is band limited to 3.2 KHz. It is sampled at the rate of 8000 samples/sec. samples are passed through an ideal BPF with pass band from 32 KHz to 35.2 KHz, the output of the BPF is

(a) AM (b) DSB
(c) SSB (d) FM

60. The smallest value of modulation index in frequency modulation such that all the modulated power is contained in the side bands is

(a) 0.4 (b) 1.4
(c) 2.4 (d) 8.6

61. The AM signal,

$$S(t) = A_c[1+5\cos 2\pi 10^3 t]\cos 2\pi f_c t$$

can be demodulated by using

(a) Square law demodulation

(b) Envelope detector

(c) Synchronous detector

(d) All

62. A 1000 KHz carrier is simultaneously modulated with 300 Hz and 2 KHz audio signals. Which of the following frequencies will not be present in the output ?

(a) 998 KHz (b) 999.7 KHz

(c) 1000.3 KHz (d) 700 KHz

63. A linear diode detector just starts giving diagonally dipped out when the input is are amplitude modulated signal. This of the following can remove this distortion.

1. Reduction of carrier frequency
2. Reductin of modulation index
3. Reduction of modulation frequency
4. Reduction of filter time constant

(a) 1, 2, 3 (b) 1, 3 and 4

(c) 2, 3 and 4 (d) 1, 2 and 4

64. Consider the following statements :

1. The band width of the AM signal depends on the message frequency.
2. The band width of the AM signal depends on the modulation index.
3. The band width of the FM signal depends on the amplitude of the message signal.
4. The spacing between the spectral components of FM signal depends on the maximum frequency deviation

Of these statements

(a) 1 and 2 are correct

(b) 1 and 3 are correct

(c) 1, 3 and 4 are correct

(d) 1, 2 and 4 are correct

65. The peak amplitude of an AM signal varies from 5V to 10V. The amplitude of the carrier which must be added to attain a modulation index of 0.1 is

(a) 26.5

(b) 29.5

(c) 12.5

(d) 17.5

66. A tone signal $\cos 2\pi f_m t$ is used to DSB and SSB modulators respectively having same carrier frequency $f_c = 200$ KHz and carrier amplitude A_d and A_s respectively. In order for the modulated signals to have equal average powers, the ratio of the carrier amplitudes A_d/A_s is

(a) 2

(b) 0.707

(c) 1

(d) 1.404

67. A sinusoidal signal is applied toa transmitter that radiates an AM signal with 10 KW power. The modulation index is 0.6, the percentage of the carrier power in the total power is

(a) 84.7%

(b) 25.3%

(c) 8.47%

(d) 2.53%

68. Consider an AM signal $A_c = 1V$ and $\mu = 0.5$, the upper side band is attenuated by a factor of two. The inphase component of the resultant signal is

(a) $\cos 2\pi f_m t$

(b) $3/8\cos 2\pi f_m t$

(c) $(1+3/8)\cos 2\pi f_m t$

(d) None of these

69. A linear diode detector just starts giving diagonally clipped output when the input is an amplitude modulated signal modulated by a single frequency modulating signal. Which of the following can remove this distortion ?

1. Reduction of carrier frequency
2. Reduction of modulation frequency
3. Reduction of modulation index
4. Reduction of filter time constant

Select the correct answer using the codes given below :

(a) 1, 2 and 3 (b) 1, 3 and 4

(c) 2, 3 and 4 (d) 1, 2 and 4

❍❍❍

Answer Key

1. ***Ans. (b)***

$$p_t = p_c\left(1+\frac{m_a^2}{2}\right)$$

$$m_a = 1$$

$$p_t = p_c\left(1+\frac{1}{2}\right) = 1.5p_c$$

2. ***Ans. (b)***

In case of direct (incoherent) and coherent detection SNR remains same but in case of Non coherent detection SNR decreases compare to incoherent and coherent.

3. ***Ans.(b)***

$$f_c = 4\text{ GHz} = 4000\text{ MHz}$$

$$f_m = 2\text{ MHz}$$

$$f_H = f_c + f_m = 4000 + 2 = 4002\text{ MHz}$$

$$f_L = f_c - f_m = 4000 - 2 = 3998\text{ MHz}$$

$$\text{B.W.} = f_H - f_L = 4002 - 3998 = 4\text{ MHz}$$

$$\frac{f_H}{\text{B.W.}} = \frac{4002}{4}$$

So, $f_H >> \text{B.W.}$

$$f_{s(min)} \cong 2\text{B.W.}$$

$$f_{s(min)} = 2 \times 4 = 8\text{ MHz}$$

4. ***Ans. (c)***

In commercial TV transmission in India, picture signal is modulated using VSB modulation and speech or audio signal is modulated using FM modulation.

5. ***Ans. (c)***

Given that

$$x(t) = 5(1 + 2\cos 200\pi t)\cos 20000\pi t \quad \ldots(i)$$

The standard equation for AM signal is

$$\boxed{X_{AM}(t) = A_c(1 + m\cos\omega_m t)\cos\omega_c t}$$

By comparing the equation (i) and equation (ii), we have m = 2

Since the modulation index is more than 1 here, so it is the case of over modulation. When the modulation index of AM wave is more than 1 (over modulation) then the detection is possible only with synchronous modulator only. Such signals can not be detected with envelope detector.

6. ***Ans. (d)***

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

So, carrier and upper side-band are in phase and lower side band is out of phase with carrier and upper side-band.

So, the given signal is narrow band FM signal.

7. ***Ans. (b)***

8. ***Ans. (d)***

$$\text{B.W.} = 2f_m = 2 \times 15\text{ kHz} = 30\text{ kHz}$$

9. ***Ans.(b)***

Complex envelope

$$\tilde{g}(t) = g_+(t)e^{-j\omega_c t}$$

Where $g_+(t)$ is preenvelope given as

$$g_+(t) = g(t) + j\hat{g}(t)$$

and $\hat{g}(t) = e^{-at}\sin[(\omega_c + \Delta\omega)t]$

$\therefore$ $g_+(t) = e^{-at}e^{+j(\omega_c+\Delta\omega)t}$

Hence $\tilde{g}(t) = e^{-at}e^{-j\omega_c t}u(t)$

$$= e^{-at}e^{+j(\omega_c+\Delta\omega)t}e^{-j\omega_c t}$$

$$\tilde{g}(t) = e^{-at}e^{j\Delta\omega t}u(t)$$

10. *Ans.(a)*

$$\cos\omega_1 t \xleftrightarrow{\text{H.T.}} \sin\omega_1 t$$

$$\sin\omega_2 t \xleftrightarrow{\text{H.T.}} -\cos\omega_2 t$$

11. *Ans. (b)*

12. *Ans. (c)*

$$(\text{B.W.})_{\text{VSSB}} = \left(1+\frac{r}{2}\right)\cdot f_m \text{ and } r = 1 \text{ (given)}$$

$$\text{B.W.} = \left(1+\frac{1}{2}\right)\cdot 4 = 6\,\text{MHz}$$

13. *Ans. (b)*

$$RC \le \frac{1}{\omega_m}\frac{\sqrt{1-\mu^2}}{\mu}$$

Max envelope time ;

$$t_{env} = RC = \frac{1}{\omega_m}\frac{\sqrt{1-\mu^2}}{\mu}$$

$$= \frac{1}{100}\frac{\sqrt{1-(0.6)^2}}{0.6} = 13.3\,\text{ms}$$

14. *Ans. (d)*

15. *Ans. (c)*

Average power dissipated inthe load (50Ω)

$$= \frac{V^2}{R} = \frac{(500)^2}{2\times 50} + \frac{(400)^2}{4\times 500} = 3.3\,\text{KW}$$

16. *Ans. (c)*

$$P_C = \frac{A_C^2}{2\times 50} = 40\times 1000 \Rightarrow A_C^2 = 2\text{KV}$$

$$A_m = \mu A_C = (0.707)\times 2 = 1.414\,\text{KV}$$

∴ peak amplitude of the output

$= A_C + A_m = 3.414$ KV

17. *Ans. (a)*

15 × 15 KHz = 225 KHz

For Guard Band (15 – 1) 3 KHz = 42 KHz

Total Bandwidth = 267 KHz

18. *Ans. (b)*

$$X_{AM}(t)\cos\omega_c t = [A+m(t)]\cos^2\omega_c t$$

$$= \frac{1}{2}[A+m(t)] + \frac{1}{2}[A+m(t)]\cos^2\omega_c t$$

After, LPF signal is $\frac{1}{2}m(t) + \frac{1}{2}A$

By passing through blocking capacitor

Then, $y(t) = \frac{m(t)}{2}$

19. *Ans. (b)*

$$v_i(t) = \cos\omega_c t + 0.5\cos\omega_m t$$

$$i = 10 + 2(\cos\omega_c t + 0.5\cos\omega_{mt})$$

$$+0.2(\cos\omega_c t + 0.5\cos\omega_m t)^2$$

The AM signal

$$= 2\cos\omega_c t + 0.2\cos\omega_c t\cos\omega_m t$$

$$= (2 + 0.2\cos\omega_m t)\cos\omega_c t$$

$$b = \frac{0.2}{2} = \frac{1}{10} = 10\%$$

20. *Ans. (a)*

Carrier power $P_c = \frac{A^2}{2} = 100\text{W},\ A = 14.14$

$$E_{eff} = \frac{P_{sb}}{P_c + P_{sb}} = \frac{40}{100} \Rightarrow \frac{P_{sb}}{100+P_{sb}} = 0.4$$

$$P_{sb} = 66.67\text{W}$$

$$P_{sb} = \frac{1}{2}B^2 + \frac{1}{2}B^2 = 66.67 \Rightarrow B = 8.161$$

21. *Ans. (c)*

$$m(t)s(t) = y_1(t) = \frac{2\sin(2\pi t)\cos(200\pi t)}{t}$$

$$= \frac{2\sin(202\pi t) - \sin(198\pi t)}{t}$$

$$y_1(t) + n(t) = y_2(t)$$

$$= \frac{\sin 202\pi t - \sin 198\pi t}{t} + \frac{\sin 198\pi t}{t}$$

$$y_2(t)s(t) = y(t)$$

$$= \frac{[\sin 202\pi t - \sin 198\pi t + \sin 199\pi t]\cos 200\pi t}{t}$$

$$= \frac{1}{2t}[\sin(402\pi t) + \sin(2\pi t)$$

$$-\{\sin(398\pi t) - \sin(2\pi t)\} + \sin(399\pi t) - \sin(\pi t)]$$

After filtering

$$y(t) = \frac{\sin(2\pi t) + 2\sin(2\pi t) - \sin(\pi t)}{2t}$$

$$= \frac{\sin(2\pi t) + 2\sin(0.5t)\cos(1.5\pi t)}{2t}$$

$$= \frac{\sin 2\pi t}{2t} + \frac{\sin 0.5\pi t}{t}\cos 1.5\pi t$$

22. ***Ans.(a)***

Signal has zero average value

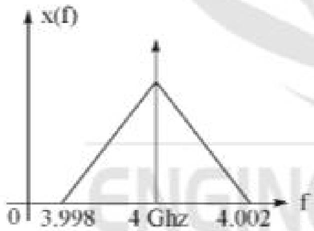
$\Rightarrow$ carrier is supressed

23. ***Ans. (d)***

4 GHz carrier DSB-SC modulated by a message signal 2 MHz.

Total bandwidth = 4.002 GHz

Nyquist rate = $2f_{max}$ = 8.004 GHz



24. ***Ans.(d)***

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

$$600 = 400\left(1+\frac{m^2}{2}\right)$$

$$\Rightarrow \quad \frac{m^2}{2} = \frac{6}{4} - 1 = \frac{1}{2}$$

$$\Rightarrow \quad m = 1$$

25. ***Ans.(c)***

Slope overload distortion would occur is

$$a > \frac{\delta}{T_s} \Rightarrow \delta < aT_s$$

26. ***Ans.(b)***

The loss of a message in an envelope detector that operates at a low carrier-to-noise ratio is referred to as the threshold effect. By threshold we mean a value of carrier-to-noise ratio below which the noise performance of a detector deteriorates much more rapidly than proportionately to the CNR.

27. ***Ans.(a)***

Modulation index,

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

$$= \frac{10-5}{10+5}$$

$$= \frac{5}{15} = 0.33$$

28. ***Ans.(b)***

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

$$10 = P_C\left(1+\frac{0.6^2}{2}\right)$$

$$\Rightarrow \quad P_C = 8.47 \text{ kW}$$

29. ***Ans.(a)***

In a low-level AM system, the amplifier must be linear device.

30. ***Ans. (b)***

31. ***Ans. (c)***

32. ***Ans. (d)***

33. ***Ans. (a)***

34. ***Ans. (c)***

35. ***Ans. (a)***

36. ***Ans. (c)***

37. ***Ans. (a)***

38. *Ans. (a)*
39. *Ans. (b)*
40. *Ans. (d)*
41. *Ans. (d)*
42. *Ans. (c)*
43. *Ans. (d)*
44. *Ans. (a)*
45. *Ans. (b)*
46. *Ans. (a)*
47. *Ans. (b)*
48. *Ans. (d)*
49. *Ans. (b)*
50. *Ans. (c)*
51. *Ans. (d)*
52. *Ans. (a)*
53. *Ans. (d)*
54. *Ans. (a)*
55. *Ans. (b)*
56. *Ans. (c)*
57. *Ans. (b)*
58. *Ans. (b)*
59. *Ans. (c)*
60. *Ans. (c)*
61. *Ans. (c)*
62. *Ans. (d)*
63. *Ans. (c)*
64. *Ans. (b)*
65. *Ans. (d)*
66. *Ans. (b)*
67. *Ans. (a)*
68. *Ans. (c)*
69. *Ans. (c)*

❍❍❍

CHAPTER 3

ANGLE MODULATION

OBJECTIVE QUESTIONS

1. In the frequency modulation if f_m is modulating frequency, Δf is maximum frequency deviation and B is bandwidth, then
   (a) $B = \Delta f + f_m$ (b) $B = \Delta f - f_m$
   (c) $B = 2(\Delta f + f_m)$ (d) $B = 2(\Delta f - f_m)$

2. The waveform A cos $(\omega_1 t + k \cos \omega_2 t)$ is
   (a) amplitude modulated
   (b) frequency modulated
   (c) phase modulated
   (d) frequency as well as phase modulated

3. Let $x(t) = 5 \cos (50t + \sin 5t)$. Its instantaneous frequency (in rad/s) at t = 0 has the value
   (a) 5 (b) 50
   (c) 55 (d) 250

4. An FM wave uses a 2-5 v, 500 Hz modulating frequency and has a modulation index of 50. The deviation is
   (a) 500 Hz
   (b) 100 Hz
   (c) 1250 Hz
   (d) 25000 Hz

5. A carrier $A_C \cos \omega_c t$ is frequency modulated by a signal $E_m \cos \omega_m t$. The modulation index is m_f. The expression for the resulting FM signal is :
   (a) $A_C \cos [\omega_m t + m_f \sin \omega_m t]$
   (b) $A_C \cos [\omega_m t + m_f \cos \omega_m t]$
   (c) $A_C \cos [\omega_m t + 2\pi\, m_f \sin \omega_m t]$
   (d) $A_C \cos\left[\omega_c t + \frac{2\pi m_f E_m}{\omega_m} \cos \omega_m t\right]$

6. Which of the following schemes suffer(s) from the threshold effect?
   (a) AM detection using envelope detection
   (b) AM detection using synchronous detection
   (c) FM detection using a discriminator
   (d) SSB detection with synchronous detection

7. A signal $x(t) = 1 \cos (\pi.10^4)$ volts is applied to an FM modulator with the sensitivity constant of 10 kHz/volt. Then the modulation index of the FM wave is :
   (a) 4 (b) 2
   (c) $4/\pi$ (d) $2/\pi$

8. A 10MHz carrier is frequency modulated by a sinusoidal signal of 500 Hz. the maximum frequency deviation being 50 kHz. The bandwidth required, as given by the Carsons' rule is .....

9. A PLL can be used to demodulate :
   (a) PAM signals
   (b) PCM signals
   (c) FM signals
   (d) DSB - SC signals

10. In a FM system, a carrier of 100 MHz is modulated by a sinusoidal signal of 5 kHz. The bandwidth by Carson's approximation is 1 MHz. If y(t) = (modulated waveform)^3, then by using Carson's approximation, the bandwidth of y(t) around 300 MHz and the spacing of spectral components are, respectively.
    (a) 3 MHz, 5 kHz (b) 1 MHz, 15 kHz
    (c) 3 MHz, 15 kHz (d) 1 MHz, 5 kHz

11. An angle modulated signal with carrier frequency $\omega_C = 2 \times 10^6$ rad/sec is given by $s(t) = \cos 2\pi (2 \times 10^6 t + 30 \sin 150 t + 40 \cos 150t)$. The maximum frequency deviation is

(a) $15 \times 10^3\pi$ (b) $30 \times 10^3\pi$
(c) $10^3\pi$ (d) $60 \times 10^3\pi$

12. In an FM system the deviation is 4 KHz where the modulating voltage is 3V and modulating frequency is 400 Hz. If the modulating frequency increases to 1000 Hz and its amplitude to 5V, then the modulating index will

(a) remain the same (b) increase
(c) decrease (d) be indeterminate

13. The instantaneous frequency in Hz for the signal $y(t) = \cos(200\pi t)\cos(5 \sin 2\pi t) + \sin(200\pi t)\sin(5 \sin 2\pi t)$ at $t = 0$ sec

(a) 90 Hz (b) 95 Hz
(c) 105 Hz (d) 120 Hz

14. The maximum frequency deviation for the signal $x_{FM}(t) = 10 \cos[(10^{10})\pi t + 10\sin 2\pi(10^4)t]$

(a) 75kHz (b) 10kHz
(c) 60kHz (d) 100kHz

15. For angle modulated signal FM is $x_{FM}(t) = 10 \cos[2\pi(10^6)t + 0.1 \sin(10^3)\pi t]$ and $k_f = 10\pi$. The maximum amplitude of message signal is

(a) 0.01 (b) 0.1
(c) 1.0 (d) 10

16. A carrier is frequency modulated with a sinusoidal signal of 8 KHz, resulting in a maximum frequency deviation of 20 KHz. If amplitude of modulating sinusoid is increased by a factor 3 and its frequency is lowered to 1 KHz. The Bandwidth of New modulated signal is

(a) 128KHz (b) 64 KHz
(c) 32KHz (d) 16KHz

17. In the spectrum of a frequency-modulated wave

(a) the carrier frequency disappears when the modulation index is-large

(b) the amplitude of any sideband depends on the modulation index

(c) the total number of sidebands depends on the modulation index

(d) the carrier frequency cannot disappear

18. The difference between phase and frequency modulation

(a) is purely theoretical because they are the same in practice

(b) is too great to make the two systems compatible

(c) lies in the poorer audio response of phase modulation

(d) lies in the different definitions of the modulation index

19. A pre-emphasis circuit provides extra noise immunity by

(a) boosting the bass frequencies

(b) amplifying the higher audio frequencies

(c) pre-amplifying the whole audio band

(d) converting the phase modulation to FM

20. A 50.004 MHz Carrier is to be frequency modulated by a 3 KHz audio tone resulting in a narrow band FM signal. Determine the bandwidth of the FM Signal

(a) 2 KHz (b) 4 KHz
(c) 6 KHz (d) 4 MHz

21. Signal $m(t) = 10 \cos(4\pi\ 100t)$ frequency modulates a carrier. The resulting FM signal is $20 \cos[(27\pi \times 10^6 t) + 7 \sin(4\pi \times 100t)]$. The approximate bandwidth of the FM would be

(a) 1.6KHz (b) 3200KHz
(c) 3.2KHz (d) 100KHz

22. Let $m(t) = \cos[(4\pi \times 10^3)t]$ (message signal)

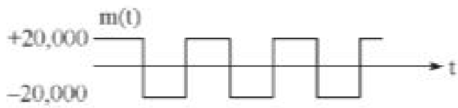
$c(t) = 5 \cos[(2\pi \times 10^6)t]$ (carrier signal)

above signals are used to generate an FM signal if the peak frequency deviation of the generated FM signal is three times the transmission band width (BW) of the AM signal, then the coefficient of the term $\cos[2\pi (1006 \times 10^3 t)]$ in the FM signal (in terms of the bessel coefficient) is

(a) $5\ J_4(3)$ (b) $\frac{2}{5}J_3(6)$

(c) $5\ J_3(6)$ (d) $\frac{2}{5}J_4(6)$

23. Given a modulating signal such that m(t) is given as



and constants k_f and k_p are $2\pi \times 10^5$ and 10π respectively and the carrier frequency is f_c(100 MHz). Assume the essential bandwidth of m(t) as frequency of third harmonic. Assume maximum amplitude of m(t) is '1'. The bandwidth of PM signal for the above modulating signal is

(a) ∞ (b) 99.1 KHz
(c) 1.30 KHz (d) 230 KHz

24. An Angle modulated signal with carrier frequency $\omega_c = 2\pi \times 10^5$ is described by the equation $\phi(t) = 10\cos(\omega_c t + 5\sin 3000\,t + 10\sin 2000\,\pi t)$. The phase deviation $\Delta\phi$ is

(a) 15 rad (b) $2\pi \times 10^5$ rad
(c) 35000 rad (d) $15000 + 20000\pi$ rad

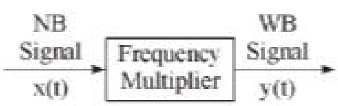
25. Consider a FM wave with carrier frequency 5000 Hz, $K_f = 10$ Hz/V and modulating signal $x(t) = 100\cos 2000\,\pi t$. The approximate band of frequency occupied by the wave is equal to

(a) 4000 to 6000 Hz (b) 4500 to 5500 Hz
(c) 3500 to 6500 Hz (d) 3000 to 7000 Hz

26. $X_{FM}(t) = \cos[200\,\pi t + 0.4\sin 10\,\pi t]$. If signal is regarded as phase modulated signal with $K_p = 10\,\pi$ rad/unit, the maximum frequency deviation is equal to

(a) 2 Hz (b) 3 Hz
(c) 4 Hz (d) 5 Hz

27. For a given fig. NBFM signal $X_{NBFM}(t) = A\cos(\omega_c t + \beta\sin\omega_m t)$ with $\beta < 0.5$ and $f_c = 200$ KHz, f_m range 50 Hz to 15 KHz maximum frequency deviation output 75 KHz. Find the maximum allowed frequency deviation at input



(a) 10 Hz (b) 20 Hz
(c) 25 Hz (d) 50 Hz

28. A carrier wave of 1 GHz and amplitude 3 V is frequency modulated by a sinusoidal modulating signal frequency of 500 Hz and of peak amplitude of 1 V. The frequency deviation is 1 KHz. The peak level of the modulating wave form is changed to 5 V and the modulating frequency is changed to 2 KHz. The expression tor the new modulated wave form is

(a) $\cos[2\pi \times 10^6 t + 2.5\cos(4\pi \times 10^3 t)]$
(b) $\cos[2\pi \times 10^6 t + 5\cos(4\pi \times 10^3 t)]$
(c) $3\cos[2\pi \times 10^6 t + 2.5\cos(4\pi \times 10^3 t)]$
(d) $3\cos[2\pi \times 10^6 t + 5\cos(4\pi \times 10^3 t)]$

29. An FM modulator has $f_c = 1$ KHz and frequency sensitivity constant of the modulator $k_f = 12.5$ Hz/V. The modulator has input $m(t) = 4\cos(2\pi\,10t)$. The modulation index would be

(a) 0.5 (b) 5
(c) 1.25 (d) 0.8

30. An FM signal with a frequency deviation of 10 KHz at a modulation frequency of 5 KHz is applied to two multipliers connected in cascade. The first multiplier doubles the frequency and the second multiplier triples the frequency. The modulation index of the FM signal obtained at the second multiplier output is

(a) 2 (b) 12
(c) 1.4 (d) 2.4

31. In phase modulation, the frequency deviation is

(a) independent of the modulating signal frequency
(b) inversely proportional to the modulating signal frequency
(c) directly proportional to the modulating signal frequency
(d) inversely proportional to the square root of the modulating frequency

32. The correct sequence of subsystems in an FM receiver is

(a) mixer, RF amplifier, limiter, IF amplifier, discriminator, audio amplifier
(b) RF amplifier, mixer, IF amplifier, limiter, discriminator audio amplifier
(c) RF amplifier, mixer, limiter, discriminator, IF amplifier, audio amplifier
(d) mixer, IF amplifier, limiter, audio amplifier, discriminator

33 A signal $m(t) = 5 \cos 2\pi\ 100\ t$ frequency modulates a carrier. The resulting FM signal is $10 \cos \{(2\pi\ 10^5 t) + 15 \sin (2\pi 100t)\}$.

The approximate bandwidth of the FM signal would be

(a) 0.1 kHz (b) 1 kHz

(c) 3.2kHz (d) 100kHz

34. Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I

A. AM Broadcast

B. FM Broadcast

C. TV Broadcast

D. Point-to-point

List-II

1. Tropospheric waves
2. 535 kHz-1600 kHz
3. Repeater tower
4. VSB modulation communication
5. Multipath phenomenon

Codes:	A	B	C	D
(a)	1	2	3	4
(b)	2	3	4	5
(c)	3	4	5	1
(d)	2	1	4	3

35. The essential blocks of a phase lock loop (PLL) are phase detector, amplifier.

(a) high-pass filter and crystal controlled oscillator

(b) low-pass filter and crystal controlled oscillator

(c) high-pass filter and voltage controlled oscillator

(d) low-pass filter and voltage controlled oscillator

36. An angle-modulated signal is expressed by $f_a(t) = \cos(2 \times 10^8\ \pi t + 75 \sin 2 \times 10^3\ \pi t)$. The peak frequency deviation of the carrier is then

(a) 1 kHz (b) 7.5 kHz

(c) 75kHz (d) 100MHz

37. In frequency modulation, the instantaneous

(a) amplitude of the carrier signal is varied with the instantaneous amplitude of the message signal

(b) amplitude of the carrier signal is varied with the instantaneous frequency of the message signal

(c) frequency of the carrier signal is varied with the instantaneous amplitude of the message signal

(d) frequency of the carrier signal is varied with the instantaneous frequency of the messsage signal

38. Which one of the following statement is NOT true?

(a) A frequency modulated signal is produced when a modulating signal m(t) is integrated and applied to a phase modulator.

(b) For a sinusoidally modulated FM carrier, it is possible that for particular values of the modulation index β, all the power lies in the side frequencies and no power in the carrier

(c) When carrier to noise ratio is high, an increase in the transmission bandwidth decrease the figure of merit of an FM system

(d) A phase modulated signal is produced when a modulating signal m(t) is differentiated and applied to a frequency modulator.

39. A particular FM radio station is having frequency deviation equals to 75 kHz, taking the maximum audio frequency as 15 KHz, the transmission bandwidth is approximately equal to

(a) 90 kHz (b) 180 kHz

(c) 270 kHz (d) 360 kHz

40. The frequency deviation of an FM signal is increased from 25 kHz to 50 kHz, for the same sinusoidal modulating signal of 10 kHz, the improvement in the demodulated signal to noise power ratio will be

(a) 2.0 (b) 2.5

(c) 4.0 (d) 5.0

41. A frequency modulation wave is passed through

1. harmonic generator
2. frequency translator

The modulation index is

(a) not changed in either case

(b) changed only in 1

(c) changed only in 2

(d) changed in both 1 and 2

42. In the narrow band FM system, the bandwidth is (f_m is the modulating frequency)

(a) f_m

(b) $2f_m$

(c) $3f_m$

(d) Of the same value as that for the wide band FM system

43. In India, the maximum frequency deviation in commercial FM broadcasting signal is about

(a) 5 kHz (b) 15 kHz

(c) 75 kHz (d) 200 kHz

44. A frequency-modulated voltage wave is given as $V = 10\sin(2\pi\times10^8 t + \sin 400\pi t)$. The carrier frequency and maximum deviation of the signal are respectively

(a) 10 MHz and 10 kHz

(b) 100 MHz and 1 kHz

(c) 10 MHz and 1 kHz

(d) 100 MHz and 10 kHz

45. Bandwidth of a frequency modulated signal is

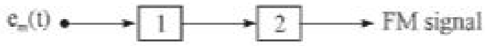
(a) zero

(b) the frequency of the modulating signal

(c) twice the frequency of modulating signal

(d) infinity

46. To produce frequency modulation through phase modulation, themodulating signal $e_m(t)$ is passed. Through block 1 and block 2 a shown in figure.



These two blocks are respectively

(a) Phase modulator and differentiators

(b) Phase modulator and integrator

(c) Integrator and phase modulator

(d) Differentiators and phase modulator

47. The frequency deviation produced in a VHF carrier by a signal of 100 Hz is 50 kHz. The frequency modulation index is

(a) 100 radians (b) 250 radians

(c) 500 radians (d) 750 radians

48. In an FM system, the deviation is 1 kHz when the modulating voltage is 3V and the modulating frequency is 100 Hz if the modulating frequency increases to 1000 Hz and its amplitude to 5V, then the modulation index will

(a) remain the same (b) increase

(c) decrease (d) be indeterminate

49. A particular FM radio station is having frequency deviation equal to 75 kHz. Taking the maximum audio frequency as 15 kHz, the transmission bandwidth is approximately equal to

(a) 90 kHz (b) 180 kHz

(c) 270 kHz (d) 360 kHz

50. ***Assertion (A) :*** Frequency modulation systems are more widely used than amplitude modulation systems.

Reason (R) : Frequency modulation systems have less noise than amplitude modulation systems.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true and R is not a correct explanation of A

(c) A is true, but R is false

(d) A is false, but R is true

51. In phase modulated signal, the frequency deviation is proportional to

(a) Frequency only

(b) Amplitude only

(c) Both of the above

(d) None of the above

52. In case of which of the following, an increase in the modulation index leads to increase in bandwidth

(a) PM (b) FM

(c) AM (d) Both PM and FM

53. An angle modulated signal with carrier frequency $\omega_c = 2\pi \times 10^5$ is described the equation

$s(t) = 10\cos(\omega_c t + 5\sin(3000\pi t) + 10\sin(2000\pi t))$

What is the frequency deviation Δf ?

(a) 12387.32 Hz (b) 17500 Hz

(c) 20000 Hz (d) 15000 Hz

54. An audio frequency of 15 kHz is frequency modulated with a deviation of 75 kHz. The resulting bandwidth is

(a) 180 kHz (b) 150 kHz

(c) 210 kHz (d) 240 kHz

55. As the modulation index of an FM signal with sinusoidal modulation is increased from zero to two,the power in the carrier component will

(a) Decrease continuously

(b) Increase continuously

(c) First increase, becomes zero and then decreases

(d) First decrease, becomes zero and then increase

56. In which modulation system, when modulating frequency is doubled, the modulation index also becomes double

(a) AM (b) FM

(c) PM (d) None of the above

57. Two carriers of 2 GHz and 4 GHz respectively are frequency modulated by a signal of 10 kHz, such that bandwidth of the FM signal in the two cases are same. The peak deviation in the two cases are in the ratio of

(a) 1 : 8 (b) 1 : 2

(c) 2 : 1 (d) 1 : 1

58. When a carrier is phase modulated, with an integrated modulating signal, the resultant is

(a) Phase modulated signal

(b) Frequency modulated signal

(c) Amplitude modulated signal

(d) QPSK modulated signal

59. The modulated carrier average power in an FM system is equal to the

(a) modulating signal power

(b) sum of the modulated signal power and the unmodulated carrier power

(c) difference between the modulating signal power and the munmodulated carrier power

(d) unmodulated carrier power

60. Carson's bandwidth for an angle modulated carier

$s(t) = A\cos[2\pi \times 10^6 t + 0.5\sin(1000\pi t)]$

is given by

(a) 2 MHz (b) 500 Hz

(c) 1000 Hz (d) 1500 Hz

61. Which one of the following expression represents a frequency modulated signal ?

(a) $A_c \cos 2\pi[f_c t + m(t)]$

(b) $\left[1 + \int_0^t m(\tau)d\tau\right]\cos 2\pi f_c t$

(c) $A_c m(t)\cos 2\pi f_c t$

(d) $A_c \cos 2\pi\left[f_c t + \int_0^t m(\tau)d\tau\right]$

Linked Answer Question : 62 & 63

62. The message signal $m(t) = 10\sin[400\pi t]$ frequency modulates the carrier, $c(t) = 100\cos 2\pi f_c t$. The modulation index is '6'.

The frequency sensitivity of the modulator in Hz/volt is

(a) 6 (b) 100

(c) 120 (d) 165

63. The modulated signal in time domain is

(a) $100\cos\left[2\pi f_c t + 2400\pi\int \sin c\, 400t\right]$

(b) $100\cos\left[2\pi f_c t + 1200\pi\int \sin c\, 400t\right]$

(c) $100\cos\left[2\pi f_c t + 2000\pi\int \sin c\, 400t\right]$

(d) $100\cos\left[2\pi f_c t + 3300\pi\int \sin c\, 400t\right]$

❍❍❍

ANSWER KEY

1. ***Ans. (c)***

Modulating frequency = f_m

maximum frequency deviation = Δf

we know that modulation index in case of FM

$$\beta = \frac{\Delta f}{f_m}$$

According to Carso's rule,

$$B.W. = 2(\beta + 1) f_m$$

$$= 2\left(\frac{\Delta f}{f_m}+1\right)f_m$$

$$B.W. = 2(\Delta f + f_m)$$

2. ***Ans. (d)***

By looking at an angle-modulated carrier, there is no way of telling whether it is FM or PM. In fact, it is mean-ing less to ask an angle-modulated wave whether it is FM or PM.

3. ***Ans. (c)***

Phase $\phi(t) = 50t + \sin 5t$

Instantaneous frequency

$$\omega_1 = \frac{d\phi(t)}{dt} = 50 + 5\cos 5t$$

at $t = 0 \; \omega_1 = 50 + 5 = 55$ rad/sec.

4. ***Ans. (d)***

Modulation index

$$\beta = \frac{\Delta f}{B} \Rightarrow \Delta f = 50 \times 500 \times 25000 \text{ Hz}$$

5. ***Ans. (a)***

$$X_{Fm}(t) = A_c \cos\left[\omega_c t + k_f \int m(t)dt\right]$$

$$X_{Fm}(t) = A_c \cos\left[\omega_c t + k_f \int E_m \cos\omega_m t dt\right]$$

$$X_{Fm}(t) = A_c \cos\left[\omega_c t + \frac{k_f E_m}{\omega_m}\sin\omega_m t\right]$$

Modulation index

$$m_f = \frac{k_f E_m}{\omega_m}$$

$$\boxed{X_{FM}(t) = [A_c \cos[\omega_c t + m_f \sin\omega_m t]]}$$

6. ***Ans. (c)***

FM detection using a discriminator suffers from the threshold effect.

7. ***Ans. (a)***

$$\boxed{\text{Modulation index} = M_f = \frac{k_f A_m}{\omega_m} = \frac{\Delta\omega}{\omega_m}}$$

$$M_f = \frac{(2\pi \times 10 \times 10^3) \times (2)}{\pi \times 10^4} = 4$$

8. ***Solution***

By Carson's rule

$$BW = 2(\Delta f + f_m)$$

$$BW = 2(50 + 0.5)$$

$$BW = 101 \text{ kHz}$$

9. ***Ans. (c)***

PLL (Phase Locked Loop) is used to demodulate the FM signals.

10. ***Ans. (a)***

$$x(t) = A_c\cos[\omega_c t + \beta\sin\omega_m t]$$

$$y(t) = K\cos[3\omega_c t + 3\beta\sin\omega_m t]$$

[After passing from $y(t) = [x(t)]^3$]

$\therefore \quad \beta^1 = 3\beta$

i.e. $\quad \Delta f^1 = 3 \times \Delta f = \Delta f >> f_m$

$$BW = 2\Delta f^1 \times 3 = 3 \text{ MHz}$$

f_m remains same

$\therefore \quad f_m = 5$ kHz

11. ***Ans. (a)***

Instantaneous frequency is given by

$$\omega_i = \frac{d\theta(t)}{dt} = 2\pi \times 10^6 t + 60\pi \times 150$$

cos 150t − 80π × 150 sin 150t

$$\Delta\omega = \omega_i - \omega_c = 15000\pi \cos(150t + \alpha)$$

$$\Delta\omega_{max} = 15 \times 10^3 \pi$$

12. ***Ans. (d)***

13. ***Ans. (b)***

By solving message signal y(t)

$$y(t) = \cos(200\pi t - 5\sin 2\pi t)$$

$$\theta(t) = 200\pi t - 5\sin 2\pi t$$

$$\omega_i = \frac{d\theta(t)}{dt} = 2\pi(100 - 5\cos 2\pi t)$$

at, t = 0

ω_i = 95 Hz

14. ***Ans. (d)***

$$\phi(t) = 10\sin 2\pi(10^4)t$$

$$\phi'(t) = 10.10^4\left[\cos 2\pi(10^4)t\right]\cdot 2\pi$$

$$\Delta\omega = |\phi'(t)|_{max} = 10.10^4.2\pi$$

Then, $\Delta f = 100\,\text{KHz}$

15. ***Ans. (d)***

$$X_{FM}(t) = A\cos\left[\omega_c t + k_f \int_{-\infty}^{t} m(\lambda)\,d\lambda\right]$$

$$= 10\cos\left[2\pi(10^6)t + 0.1\sin(10^3)\pi t\right]$$

Let, $m(t) = a_m \cos(10^3)\pi t$

Then,

$$10\pi\int_{-\infty}^{t} m(\lambda)\,d\lambda = 10\pi a_m \int_{\infty}^{t} \cos(10^3)\pi\lambda\,d\lambda$$

$$= \frac{a_m}{100}\sin(10^3)\pi t = 0.1\sin(10^3)\pi t$$

So, $a_m = 10$

16. ***Ans. (c)***

$$\beta_1 = \frac{k_f 3A_m}{\frac{1}{2}\omega_m} = 6\frac{K_f A_m}{\omega_m} = 6\beta = 15$$

$$f_b = 2(\beta_1 + 1)f_{m_1} = 2(15+1)\cdot(1) = 32\text{KHz}$$

17. ***Ans. (b)***

18. ***Ans. (d)***

19. ***Ans. (b)***

20. ***Ans. (c)***

Since, It is NBFM it is similar to AM

$$\therefore B\omega = 2f_m = 2 \times 3 = 6\,\text{KHz}$$

21. ***Ans. (c)***

$$\text{B.W.} = 2(\Delta f + f_m) = 2f_m\left(1 + \frac{\Delta f}{f_m}\right) = 2f_m(1 + m_f)$$

$m_f = 7$, and $f_m = 200\,\text{Hz}$

Standard FM signal = $A\cos(\omega_c t + m_f \sin\omega_m t)$

∴ BW = 2 × 200 (1 + 7) = 3200 Hz.

22. ***Ans. (c)***

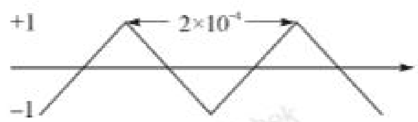
23. ***Ans. (d)***

For PM, we take m(t) only and

$$\Delta f = \frac{K_p}{2\pi}\ \text{(max. amplitude)}$$

$$= \frac{1}{2\pi} \times 10\pi \times 20000 = 100\,\text{KHz}$$

and so m(t) ⇒



$$\therefore \text{essential bandwidth} = \frac{3\times10^4}{2} = 15\,\text{KHz}$$

$$\therefore (BW)_{PM} = 2(100 + 15) = 230\ \text{KHz}$$

24. ***Ans. (a)***

Phase deviation $(\Delta\phi) = 5 + 10 = 15$ rad

25. ***Ans. (d)***

Bandwidth of FM wave $\cong 2(AK_1 + f_m)$

$= 2[100 \times 10 + 1000] = 4000$ Hz

So, Band of frequency occupied is

$5000 \pm 2000\,\text{Hz} = 3000 \text{ to } 7000\,\text{Hz}$

26. ***Ans. (a)***

27. ***Ans. (c)***

$$\beta_{min} = \frac{75(10^3)}{15(10^3)} = 5;\ \beta_{max} = \frac{75(10^3)}{50} = 1500$$

if, β_1 0.5, where β_1 is the input β.

$$\eta = \frac{\beta_{max}}{\beta_1} = \frac{1500}{0.5} = 3000$$

Maximum allowed frequency deviation

$$\Delta f_1 = \frac{\Delta f}{n} = \frac{75(10)^3}{3000} = 25\,\text{Hz}$$

28. ***Ans. (c)***

Frequency sensitivity constant

$$k_f = \frac{\Delta f}{f_m} = \frac{1\times10^3}{1} = 1\,\text{KHz}$$

Now for the second case $A_m = 5V$ and $f_m = 2$ KHz

Frequency deviation $\Delta f = k_f \times A_m\ 5\,\text{KHz}$

Modulation index $= \frac{\Delta f}{f_m} = \frac{5k}{2k} = 2.5$

The FM signal is

$$= 3\cos\left[2\pi 10^6 t + 2.5\sin\left(4\pi\times10^3 t\right)\right]$$

29. ***Ans. (b)***

The peak deviation

$12.5 \times 4 = 50$, $f_m = 10$

Thus modulation index $= \frac{50}{10} = 5$

30. ***Ans. (b)***

The overall frequency multiplication

$n = 2 \times 3 = 6$

The frequency deviation of this FM wave is

$n\Delta f = 6 \times 10.60$ KHz

Modulation index is $\frac{n\Delta f}{f_m} = \frac{60}{5} = 12$

31. ***Ans. (c)***

Let modulating signal, $m(t) = v_m \sin \omega_m t$

In PM, $\theta_i = \omega_c t\ .\ k_p m(t)$

$$\Rightarrow \quad w_i = \frac{d\theta_i}{dt} = \omega_c + k_p m(t)$$

$$\Rightarrow \quad \omega_i = \omega_c + k_p \omega_m v_m \cos\omega_m t$$

This frequency deviation is $k_p v_m \omega_m \cos \omega_m t$ which is directly proportional to ω_m.

32. ***Ans.(b)***

FM Receiver Block Diagram

33. ***Ans.(c)***

$f_m = 100$Hz

$m_f = 15$

$BW = 2(m_f + 1)f_m$

$= 2(15 + 1) \times 100$

$= 3.2$ kHz

34. ***Ans.(b)***

35. ***Ans.(d)***

The block diagram of a PLL cousists of law pass filter and VCO.

36. ***Ans.(c)***

$f_m = 10^3$Hz

$= 1$ kHz

$m_f = 75$

Peak frequency deviation,

$\delta = m_f f_m$

$= 75$ kHz

37. *Ans. (c)*

38. *Ans. (c)*

39. *Ans. (b)*

40. *Ans. (a)*

41. *Ans. (b)*

42. *Ans. (b)*

43. *Ans. (b)*

44. *Ans. (d)*

45. *Ans. (d)*

46. *Ans. (c)*

47. *Ans. (c)*

48. *Ans. (a)*

49. *Ans. (b)*

50. *Ans. (c)*

51. *Ans. (c)*

52. *Ans. (d)*

53. *Ans. (b)*

54. *Ans. (a)*

55. *Ans. (a)*

56. *Ans. (d)*

57. *Ans. (d)*

58. *Ans. (b)*

59. *Ans. (d)*

60. *Ans. (d)*

61. *Ans. (d)*

62. *Ans. (c)*

63. *Ans. (a)*

❍❍❍

NOISE

CHAPTER 4

OBJECTIVE QUESTIONS

1. The transmission bandwidth is doubled in FM. The SNR is
   (a) also doubled
   (b) improved four fold
   (c) decreased by one fourth
   (d) unaffected

2. A superheterodyne receiver is to operate in the frequency range of 550 KHz - 1650 KHz, with the intermediate frequency of 450 KHz. The receiver is tuned to 700 KHz. The capacitance ratio $R = C_{max}/C_{min}$ of the local oscillator would be
   (a) 4.41 (b) 2.1
   (c) 3 (d) 9

3. 13 dBm is equivalent to
   (a) 2 mW (b) 20 W
   (c) 20 mW (d) 2 MW

4. Consider the following statements comparing delta modulation with PCM systems: DM requires
   1. a lower sampling rate
   2. a higher sampling rate
   3. a large bandwidth
   4. simpler hardware

   Which of these statements are correct?
   (a) 1,2 and 4 (b) 1, 2, and 3
   (c) 1,3 and 4 (d) 2, 3, and 4

5 The ratio $\frac{(S/N)_{WBFM}}{(S/N)_{AM}}$ for 100% amplitude AM modulation with identical total transmitted power (m_f is modulation index of FM) is
   (a) $9/2\ m_f^2$ (b) $3/2\ m_f^2$
   (c) $3/2\ m_f^3$ (d) $9/2\ m_f^3$

6. One the basis of equal carrier powers, the ratio of 'signal-noise ratio of FM and signal-noise ratio of AM' can be expressed, as (assume that detector / discriminator losses are zero).
   (a) $\frac{S_0/N_0\,(FM)}{S_0/N_0\,(AM)} = 3m_f$
   (b) $\frac{S_0/N_0\,(FM)}{S_0/N_0\,(AM)} = 3m_f^2$
   (c) $\frac{S_0/N_0\,(FM)}{S_0/N_0\,(AM)} = 4.5m_f^3$
   (d) $\frac{S_0/N_0\,(FM)}{S_0/N_0\,(AM)} = \sqrt{3}\,m_f^3$

7. Noise figure is defined as
   (a) $F = \frac{S_i/N_i}{S_o/N_o}$ (b) $F = \frac{S_o/N_o}{S_i/N_i}$
   (c) $F = \frac{S_o/N_o}{\sqrt{S_i/N_i}}$ (d) $F = \frac{S_i/N_i}{\sqrt{S_o/N_o}}$

ANSWER KEY

1. ***Ans. (b)***

SNR $\propto$ $(R.w)^2$

2. ***Ans. (a)***

f_{max} = 1650 + 450 = 2100 KHz

f_{min} = 550 + 450 = 100 KHz

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Whenfrequency is minimum, capacitance will be maximum

$$R = \frac{C_{max}}{C_{min}} = \frac{t_{max}^2}{t_{min}^2} = (2.1)^2 \Rightarrow R = 4.41$$

3. ***Ans.(c)***

$$13 = 10\log\left(\frac{P}{10^{-3}}\right)$$

$$\Rightarrow \quad \frac{P}{10^{-3}} = (10)^{1.3} = 20$$

$$\Rightarrow \quad P = 20 \text{ mW}$$

4. ***Ans.(d)***

Answer (d) is correct only when option (3) is "Least B.W. required".

5. ***Ans.(c)***

$(S/N)_{WBFM}$ at m = 100% modulation is

$$= \frac{3}{2}B^2 = \frac{3}{2}m_f^2$$

(m_f = modulation index of FM) and $(S/N)_{AM}$ at 100% modulation = η = 1/3

$$\therefore \quad \frac{(S/N)_{WBFM}}{(S/N)_{AM}} = \frac{3}{2}m_f^2 = \frac{9}{2}m_f^2$$

6. ***Ans. (a)***

7. ***Ans. (a)***

❍❍❍

RECEIVERS

5

OBJECTIVE QUESTIONS

1. Match List-I (Modulation/reception techniques) with List-II (Disadvantages) and select the correct answer:

List-I		List-II
A. Superheterodyne receiver	1.	Threshold effect
B. FM	2.	Granular noise
C. PCM	3.	Image frequency interference
D. Delta modulation	4.	Quantization noise

Codes:

	A	B	C	D
(a)	1	3	4	2
(b)	3	1	4	2
(c)	1	3	2	4
(d)	3	1	2	4

2. A receiver has poor IF selectivity. It will therefore also have poor

(a) blocking (b) double-spotting
(c) diversity reception (d) sensitivity

3. A 10 KHz communication channel has an SNR of 40 dB. If the channel bandwidth is four times increase, keeping the signal power constant the SNR for the modified channel will be

(a) 27 dB (b) 33 dB
(c) 34 dB (d) 60 dB

4. A system has a receiver noise resistance of 50Ω. It is connected to an antenna with an input resistance of 50Ω. The noise figure of the system is

(a) 1 (b) 2
(c) 50 (d) 101

5. In a superhetrodyne receiver, if the intermediate frequency is 10.7 MHz and the carrier frequency is 89.6 MHz, the image frequency is

(a) 78.9 MHz (b) 100.3 MHz
(c) 111 MHz (d) 121 MHz

6. When signal frequency is 2000 KHz and IF is 455 KHz, the image frequency could be

(a) 2910 KHz (b) 1645 KHz
(c) 2455 KHz (d) 2090 KHz

7. Without any filtering, a broadcasting station at 1600 KHz is heard together with another station at 2500 KHz on a super heterodyne receiver. The IF used is

(a) 000 KHz (b) 450 KHz
(c) 300 KHz (d) 225 KHz

8. A superheterodyne receiver is to operate in the frequency range 550 KHz - 1650 KHz, with the local intermediate frequency of 450 KHz. Let $R = C_{max}/C_{min}$ deonote the required capacitance ratio of the local oscillator and I denote the image frequency (in KHz) of the incoming signal. If the receiver is tuned to 700 KHz, then

(a) R = 4.41, I = 1600
(b) R = 2.10, I = 1150
(c) R = 3.0, I = 1600
(d) R = 9.0, I = 1150

❍❍❍

Answer Key

1. *Ans. (b)*

Super heterodyne receiver → There is problem of image frequency ($f_c + 2I_f$) if we want to receive a message signal at carrier frequency f_c. To avoided this B.W. of RF amplifier should be B.C. $< B_{RF} < 2I_f$.

where B.C. is modulated signal B.W.

I_f = 455 KHz (Intermediate frequency)

FM → Threshold effect

PCM → Problem of quantization noise due to quantization error

DM → Problem of granular noise when signal becomes constant.

2. *Ans. (b)*

3. *Ans. (c)*

Bandwidth four times, then noise also four time S/N ratio will decrease four times S/N = 10000 after bandwidth four times,

$$\frac{S}{N} = 2500$$

$$\left(\frac{S}{N}\right)_{dB} = 10\log_{10} 2500 = 34\,dB$$

4. *Ans. (b)*

R_{eq} → Receiver noise resistance

R_a → Resistance of antenna

$$F = 1 + \frac{R_{eq}}{R_a}$$

$$= 1 + \frac{50}{50}$$

$$= 1 + 1 = 2$$

5. *Ans. (c)*

6. *Ans. (a)*

7. *Ans. (b)*

8. *Ans. (a)*

❍❍❍

INTRODUCTION TO DIGITAL COMMUNICATION & PCM

CHAPTER 6

OBJECTIVE QUESTIONS

1. A 4 GHz carrier is DSB-SC modulated by a low pass message signal with maximum frequency of 2 MHz. The resultant signal is to be ideally sampled. The minimum frequency of the sampling impulse train should be

(a) 4 MHz (b) 8 MHz

(c) 8 GHz (d) 8.004 GHz

2. A signal has frequency components from 300 Hz to 1.8kHz. The minimum possible rate at which the signal has to be sampled is

3. A 1.0 kHz signal is flat top sampled at the rate of 1800 samples/sec and the samples are applied to an ideal rectangular LPF with cut-off frequency of 1100 Hz, then the output of the filter contains

(a) only 800 Hz component

(b) 800 Hz and 900 Hz components

(c) 800 Hz and 1000 Hz components

(d) 800 Hz, 900 Hz and 100 Hz components

4. The signal to quantization noise ratio in an n-bit PCM system

(a) depends upon the sampling frequency employed

(b) is independent of the value of 'n'

(c) increasing with increasing value of 'n'

(d) decreases with the increasing value of 'n'

5. The number of bits in a binary PCM system is increased from n to n + 1. As a result, the signal to quantization noise ratio will improve by a factor

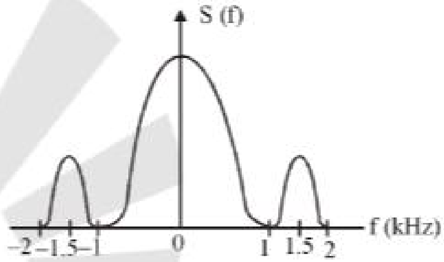
(a) $(n + 1)/n$

(b) $2^{(n+1)/n}$

(c) $2^{2(n+1)/n}$

(d) which is independent of n

6. A deterministic signal has the power spectrum given in figure. The minimum sampling rate needed to completely represent signal is



(a) 1 kHz (c) 3 kHz

(b) 2 kHz d) none of these

7. In a PCM system with uniform quantization, increasing the number of bits from 8 to 9 will reduce the quantization noise power by a factor of

(a) 9 (c) 4

(b) 8 (d) 2

8. The Nyquist sampling frequency (in Hz) of a signal given by $6 \times 10^4 \sin C^3 (400t) * 10^6 \sin C^3 (100t)$ is

(a) 200 (b) 300

(c) 1500 (d) 1000

9. A 4 GHz carrier is amplitude-modulated by a low-pass signal of maximum cut off frequency 1 MHz. If this signal is to be ideally sampled, the minimum sampling frequency should be nearly

(a) 4 MHz (b) 4 GHz

(c) 8 MHz (d) 8 GHz

10. The maximum number of quantized amplitude levels, in a 3-digit ternary PCM system can be used to represent is

(a) 8 (b) 9

(c) 27 (d) 81

11. The performance of the DPCM-Coder improves as the

(a) input probability density becomes more and more Gaussian

(b) input power spectral density tends to be white

(c) input dynamic range increases

(d) sample-to-sample correlation of the input increases

12. ***Assertion (A):*** Slope overload is a problem in D.P.C.M.

Reason (R): D.P.C.M. makes use of adjacent sample correlations.

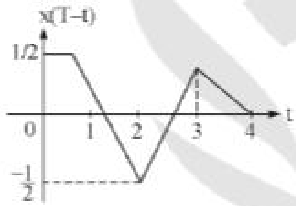
(a) Both A and R are true and R is the correct explanation of A

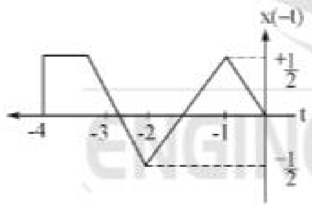
(b) Both A and R are true but R is not a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

13. x(t) is as shown below. h(t) is the impulse response of the matched filter to x(t), $h(t) \neq 0$, $0 < t < 4$ sec. The slope of h(t) in the interval $3 < t < 4$ sec is





(a) $-\frac{1}{2}\sec^{-1}$ (b) $-1\sec^{-1}$

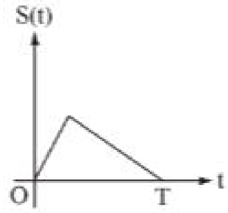
(c) $+\frac{1}{2}\sec^{-1}$ (d) $+1\sec^{-1}$

14. Consider an Audio signal comprising three individuals terms, x(t) = 3 cos 500 + 3 cos 700 t + 2 cos 1000 t this is quantized using 10 bit PCM and the nyquist sampling rate is used. The SNR is equal to

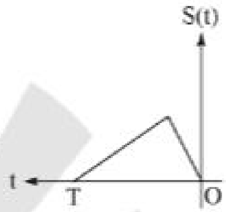
(a) 46.8dB (b) 52.4 dB

(c) 38.6dB (d) 41.7dB

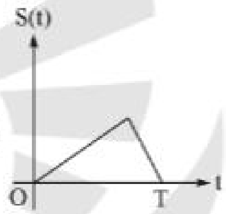
15. For a given signal S(t), the impulse response is given by the figure



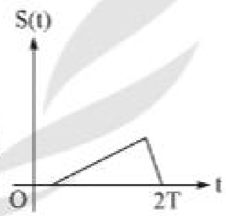
(a)



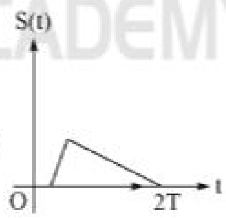
(b)



(c)



(d)



16. Quantizing noise occurs in

(a) time-division multiplex

(b) frequency-division multiplex

(c) pulse-code modulation

(d) pulse-width modulation

17. Companding is used

(a) to overcome quantizing noise in PCM

(b) in PCM transmitters, to allow amplitude limiting in the receivers

(c) to protect small signals in PCM from quantizing distortion

(d) in PCM receivers, to overcome impulse noise

18. The biggest disadvantage of PCM is

(a) its inability to handle analoc

(b) the high error rate which its quantizing noise introduces

(c) its incompatibility with TDM

(d) the large bandwidths that are required for it

19. Time-division multiplex

(a) can be used with PCM only

(b) combines five groups into a supergroup

(c) stacks 24 channels in adjacent frequency slots

(d) interleaves pulses belonging to different transmissions

20. A 1.0 kHz signal is flat-top sampled at the rale of 1800 samples per sec and the samples are applied to an ideal rectangular LPF with cut off frequency of 1100 Hz. The output of the filter contains

(a) only 800 Hz component

(b) 800 Hz and 900 Hz components

(c) 800 Hz and 1000 Hz components

(d) 800 Hz, 900 and 1000 Hz components

21. A 6 MHz channel is used by a digital signalling system utilizing four-level signals. The maximum possible transmission rate is

(a) 6 M bauds/s (b) 12 M bauds/s

(c) 6 M bits/s (d) 12 M bits/s

22. The bandwidth of a 'N' bit binary coded PCM signal for modulating a signal having bandwidth of T Hz is

(a) $\frac{f}{N}$ Hz (b) $\frac{f}{N^2}$ Hz

(c) Nf Hz (d) H^2f Hz

23. Time division multiplexing requires

(a) constant data transmission

(b) transmission of data samples

(c) transmission of data at random

(d) transmission of data of only one measurand

24. In a PCM system each quantisation level is encoded into 8 bits. The signal to quantisation noise ratio is equal to

(a) 24 dB (b) 48 dB

(c) 64 dB (d) 256 dB

25. Four signals each band-limited to 5 kHz are sampled at twice the Nyquist rate. The resulting PAM samples are transmitted over a single channel after time division multiplexing. The theoretical minimum transmission bandwidth of the channel should be equal to

(a) 5 kHz (b) 20 kHz

(c) 40 kHz (d) 80 kHz

26. A signal $x(t) = 6 \cos 10 \pi t$ is sampled at the rate of 14 Hz. To recover the original signal, the cut-off frequency f_c of the ideal low-pass filter should be

(a) $5 \text{ Hz} < f_c < 9 \text{ Hz}$

(b) 9Hz

(c) 10 Hz

(d) 14 Hz

27. For 10-bit PCM system, the signal to quantisation noise ratio is 62dB. If the number of bits is increased by 2, then the signal to quantisation noise ratio will

(a) increase by 6 dB (b) increase by 12dB

(c) decrease by 6 dB (d) decrease by 12 dB

28. Bandwidth of the input to PCM is restricted to 4 KHz. The input varies from –3.8V to 3.8V and has average power of 30 mW, the required signal to quantisation notice ratio is 20 dB. The modulator produce binary output. Assume uniform quantisation. Calculate the number of bits required per sample.

(a) 10 (b) 5

(c) 8 (d) 7

29. Compute the matched filter output over (0, T) to the pulse wave form

$$S(t) = \begin{cases} e^{-t} & ; 0 \le t \le T \\ 0 & ; \text{otherwise} \end{cases}$$

(a) e^{T} cos ht (b) e^{-T} sin ht

(c) e^{-T} cos ht (d) e^{-T} tan ht

30. A telephone signal with cut off frequency of 4 KHz is digitized into 8-bit samples at the rate $f_s = 2 f_m$. If raised cosine filtering with roll-off factor of unity is assumed, the baseband transmission bandwidth and the quantisation to noise ratio are respectively

(a) 32 KHz, 24 (b) 64 KHz. 48

(c) 128 KHz 48 (d) 64 KHz, 24

31. The pulse rate in delta modulation (DM) system is 50,000 per sec. The input signal is 5 cos(5000t) + 10 cos(2000 t). The minimum value of step size to avoid slope-overload distortion

(a) 0.4 (b) 0.5

(c) 0.9 (d) ≥0.5

32. A delta modulator system is designed to operate at five times the nyquist rate for a signal with 3 KHz bandwidth. The maximum amplitude of 2 KHz input sinusoid for which the delta modulator does not have slope overload quantising step size of 250 mV, is

(a) 0.2 V (b) 0.4 V

(c) 0.6 V (d) 0.8 V

33. A sinusoidal signal with peak to peak amplitude of 1.536 V is quantized into 256 levels using a midrise uniform quantiser. The quantisation noise power is

(a) 0.768 V^2 (b) 3×10^{-6} V^2

(c) 12×10^{-6} V^2 (d) 0.006 V^2

34. Eight base band analog signals each of 100 Hz bandwidth are to be transmitted by a signal binary PCM system in such a way that the quantization error for each signal does not exceed 0.1 % of the peak amplitude of the signal. The sampling rate for each signal is to be 50% higher than its nyquist rate. The bit transmission rate is

(a) 6 K bits/sec (b) 12 K bits/sec

(c) 18 K bits/sec (d) 24 K bits/sec

35. Consider a finite time integrator with impulse response given by

$$h(t) = \begin{cases} \dfrac{1}{T} & ; 0 < t < T \\ 0 & ; \text{elsewhere} \end{cases}$$

Its input is a zero mean white noise with $S(\omega) = S_0$. How large should T be if it is desired to have an output power of $10S_0$.

(a) $T = \frac{1}{10}$ (b) $T = \frac{1}{20}$

(c) $T = \frac{1}{2}$ (d) $T = \frac{1}{5}$

36. A communication channel of bandwidth 75 KHz is required to transmit binary data at a rate of 0.1 Mb/s using raised cosine pulses. The roll-off factor α is

(a) 0.4 (b) 0.5

(c) 0.8 (d) zero

37. 25 telephone channels, each band limited to 3.4 KHz, are to be time division multiplexed by using PCM. Calculate the bandwidth of the PCM system for 128 quantisation levels and 5 KHz sampling frequency.

(a) 800KHz (b) 1005KHz

(c) 1240KHz (d) 2010KHz

38. A television signal is sampled at a rate of 20% above the Nyquist rate. The signal has a bandwidth of 6 MHz. The samples are quantized into 1024 levels. The minimum bandwidth required to transmit this signal would be

(a) 72 M bits/sec (b) 144 M bits/sec

(c) 72 K bits/sec (d) 144 K bits/sec

39. A binary channel with capacity 36 K bits/sec is available for PCM voice transmission. If signal is band limited to 3.2 KHz, then the appropriate values of quantizing level L and the sampling frequency will be

(a) 32, 3.6 KHz (b) 63, 7.2 KHz

(c) 64, 3.6 KHz (d) 32, 7.2 KHz

40. A PCM system uses a uniform quantizer followed by a 8-bit encoder. The bit rate of the system is equal to 10^8 bits/s. The maximum message bandwidth for which the system operates satisfactorily is

(a) 25MHz (b) 6.25 MHz

(c) 12.5MHz (d) 50MHz

41. A linear delta modulator is designed to operate on speech signals limited to 3.4 KHz. The sampling rate is 10 time the Nyquist rate of the speech signal. The step size 8 is 100 mV. The modulator is tested with a 1 KHz sinusoidal signal. The maximum amplitude of this test signal required to avoid slope overload is

(a) 2.04V (b) 1.08V

(c) 4.08V (d) 2.16V

42. A speech signal has a total duration of 20 sec. It is sampled at the rate of 8 KHz and then PCM encoded. The signal-to-quantization noise ratio is required to be 40 dB. The minimum storage capacity needed to accommodate this signal is

(a) 1.12MBytes (b) 140MBytes

(c) 168GBytes (d) None of the above

43. A sinusoidal signal with peak-to-peak amplitude of 1.536 V quantised into 128 levels using a mid-rise uniform quantizer. The quantisation noise power is

(a) 0.768V (b) 48×10^{-6} V^2

(c) 12×10^{-6} V^2 (d) 3.072 V

44. Three analog signals, having bandwidths 1200 Hz, 600 Hz and 600 Hz are sampled at their respective Nyquist rates, encoded with 12 bit words, and time division multiplexed, The bit rate for the multiplexed signal is

(a) 115.2kbps (b) 28.2 kbps

(c) 57.6 kbps (d) 38.4 kbps

45. A signal m(t), band-limited to a maximum frequency of 20 kHz is sampled at a frequency f_s kHz to generate s(t). An ideal low pass filter having cut-off frequency 37 kHz is used to reconstruct m(t) from s(t). The minimum of f_s required to reconstruct m(t) without distortion is

(a) 20 kHz (b) 40 kHz

(c) 57 kHz (d) 77 kHz

46. The number bits per sample of a PCM system depends upon the

(a) sample type

(b) quantizer type

(c) number of the levels of the quantizer

(d) sampling rate

47. A PCM system uses a uniform quantizer which a has a range –V and +V and it is followed by a 7 bit binary encoder. A zero mean signal applied to the quantizer extends over its entire range and ha uniform probability density. The ratio of the signal power to the quantization noise power at the output of the quantizer is

(Take $\log_{10} 2 \approx 0.3$)

(a) 14dB (b) 28dB

(c) 42dB (d) 56dB

48. ***Assertion (A) :*** Commercial PCM generally use a 6-bit code.

Reason (R) : This a compromise between quantisation noise and channel bandwidth requirements.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not a correct explanation of A

(c) A is true, but R is false

(d) A is false, but R is true

49. Consider the following statements regarding digital communication systems:

1. Pulse code modulation (PCM) is used.
2. Quantization noise occurs in PCM
3. In PCM, companding is used to protect small signals from quantization distortion.
4. The Shannon-Hartley law describes signalling rates.

Of these statements are correct :

(a) 2, 3 and 4 (b) 1, 3 and 4

(c) 1, 2 and 4 (d) 1, 2 and 3

50. Which one of the following is the correct statement ?

In a DM system, the chances of slope overload, increased when the

(a) modulating signal changes rapidly

(b) modulating signal remains constant

(c) pulse amplitude is increased

(d) pulse rate is increased

51. Consider the following statements in connection with PCM system.

1. PCM is much better for noise immunity as it depends only on the presence or absence of the pulses at any given time.
2. PCM requires a small bnadwidth compared to analog systems.
3. PCM requires very complex encoding and quantizing circuitry.
4. PCM has all advantages of frequency modulation when it comes to noise performance.

Which of the statements given above are correct?

(a) 1, 2 and 4 (b) 1, 3 and 4

(c) 2, 3 and 4 (d) 1, 2 and 3

52. In a DM system, the granular noise occurs when the modulating signal

(a) increases linearly

(b) increases exponentially

(c) remains constant

(d) decreases rapidly

53. Good voice reproduction via PCM requires 728 quantization levels. If the bandiwdth of voice channel is 4 KHz the data rate is

(a) 256 kbps (b) 128 kbps

(c) 56 kbps (d) 28 kbps

54. The bandwidth of a 'N' bit binary coded PCM signal for modulating a signal having bandwidth of 'f' Hz is

(a) f/N Hz (b) f

(c) Nf (d) N

55. Four voice signals, each limited to 4 kHz and sampled at Nyquist rate, are converted into binary PCM signal using 256 quantisation levels. The bit transmission rate for the time division multiplexing signal will be

(a) 8 kbps (b) 64 kbps

(c) 256 kbps (d) 5126 kbps

56. In a binary PCM system, the maximum tolerable error in a sample amplitude is 0.25% of the peak input signal is amplitude. The input signal bandwidth is 5MHz. The minimum rate of transmission of the PCM coded bits is

(a) 70 Mbits/sec (b) 80 Mbits/sec

(c) 90 Mbits/sec (d) 100 Mbits/sec

57. The signalling information in a 30-channel PCM system has a bit rate of

(a) 2.048 Mbps (b) 64 kbps

(c) 80 kbps (d) 2 ibps

58. The input to a linear delta modulator is a sinusoidal signal having a peak amplitude of 1 volt. The maximum input signal frequency is 1000 Hz, the input signal is sampled at 8 times the Nyquist rate. The step size for a 800 Hz input, assuming no slope overload, is

(a) $\pi/40$ volts (b) $\pi/8$ volts

(c) $\pi/10$ volts (d) $\pi/4$ volts

59. In a binary PCM system, the maximum tolerable error is sample amplitude is 0.5% of the peak input signal amplitude. The input signal bandwidth is 5 MHz. The minimum rate of the transmission of the PCM coded bits is

(a) 70 Mbits/sec (b) 80 Mbits/sec

(c) 90 Mbits/sec (d) 100 Mbits/sec

60. If the minimum sampling frequency required to reconstruct a band limited analog signal from its samples is 8 kHz, the maximum frequency present in the signal is

(a) 16 kHz (b) $\geq$ 16 kHz

(c) 4 kHz (d) > 4kHz

❍❍❍

Answer Key

1. ***Ans.(b)***

Given that

$f_c = 4$ GHz

$f_m = 2$ MHz

$\boxed{f_H = f_c + f_m} = 4000 + 2 = 4002$ MHz

$\boxed{f_L = f_c - f_m} = 4000 - 2 = 3998$ MHz

B.W. $= f_H - f_L = 4002 - 3998$

B.W. = 4 MHz

$$\boxed{(f_s)_{min} = 2(\text{B.W.})}$$

$(f_s)_{min} = 2 \times 4 = 8$ MHz

2. ***Solution:***

3600 samples/sec

Given that

$f_H = 1800$ Hz

$f_L = 300$ Hz

So, $\boxed{\text{B.W.} = f_H - f_L}$

B.W. = 1800 – 300 = 1500 Hz

$$\boxed{K = \frac{f_H}{\text{B.W.}}}$$

$$K = \frac{1800}{1500}$$

So, $K = 1$

$$\boxed{(f_s)_{min} = \frac{2f_H}{K}}$$

$$(f_s)_{min} = \frac{2 \times 1800}{1} = 3600 \text{ samples/sec}$$

3. ***Ans.(c)***

Given that

$f_m = 1$ kHz

$f_s = 1.8$k samples/s

The frequency components in the sampled signal are

$n = 0 \Rightarrow f_m$=1 kHz =1000 Hz

$n = 1 \Rightarrow 1.8 \pm 1 = 800$ Hz and 2800 Hz

$n = 2 \Rightarrow 3.6 \pm 1$=2600 Hz and 4600 Hz

Cut-off frequency of LPF1100 Hz.

So, 800 Hz and 1000 Hz components.

4. ***Ans.(c)***

The signal to quantization noise ratio in an n-bit PCM sysetm is given by

$$\boxed{\begin{aligned}(\text{SQNR})_{dB} &= 1.76 + 6n \\ \text{SQNR} &= \frac{3}{2}2^{2n}\end{aligned}}$$

From teh above equation it is clear that SQNR increases with increase in value of 'n'.

5. ***Ans.(d)***

$$\text{SQNR} = \frac{3}{2}2^{2n}$$

Given that $n_1 = n$

$n_2 = n + 1$

$$(\text{SQNR})_1 = \frac{3}{2}2^{2n}$$

$$(\text{SQNR})_1 = \frac{3}{2}2^{2(n+1)} = \frac{3}{2}2^{2n+2}$$

$$= \frac{3}{2}\left[2^{2n}0 2^2\right]$$

So, $$\frac{(\text{SQNR})_2}{(\text{SQNR})_1} = \frac{2^2}{1} = 4$$

$$(\text{SQNR})_2 = 4(\text{SQNR})_1$$

Signal to quantization noise ratio increases by a factor of 4. So, this improvement in SQNR is independent of 'n'.

6. ***Ans.(b)***

Given that

$f_m = 1$ kHz

Practically, 90% of the total signal strength lies in the major lobe.

So, minimum sampling rate required,

$$\boxed{(f_s)_{min} = 2f_m}$$

$$(f_s)_{min} = 2 \times (1) = 2 \text{ kHz}$$

7. ***Ans.(c)***

QNP of power signal is given by

$$QNP = \frac{\Delta^2}{12}$$

$$\text{Stepm size} = \Delta = \frac{V_{P-P}}{2^2}$$

$$QNP = \frac{V_{P-P}^2}{12 \times 2^{2n}};\ QNP = \propto \frac{1}{2^2} = \frac{1}{4}$$

$$\frac{(QNP)_2}{(QNP)_1} = \frac{2^{2n_2}}{2^{2n_1}} = \frac{2^{2\times 8}}{2^{2\times 9}} = \frac{2^{16}}{2^{18}} = \frac{1}{2^2} = \frac{1}{4}$$

$$(QNP)_2 = \frac{(QNP)_1}{4}$$

So, the QNP reduces by a factor of 4.

8. ***Ans.(c)***

$\{6 \times 10^4 \text{ sinc}^3 (400t)\} \times \{10^6 \text{ sinc}^3(100t)\}$

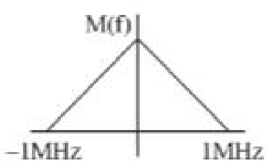
$f_s = 3f_{m_1} + 3f_{m_2}$

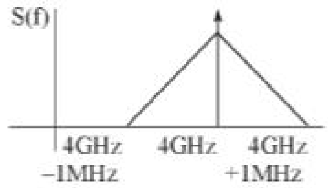
$= 3 \times 400 + 3 \times 100 = 1500$ Hz

9. ***Ans. (a)***

Highest frequency component of low pass signal = 1 MHz

When this signal modulates the carrier of frequency 4 GHz (AM) then modulated signal will become as





So B.W. of modulated signal = 2 MHz

therefore according to Nyquist rule minimum sampling frequency

$f_s = 2 \times$ B.W. (for band pass signals)

$= 2f_m$ (for low pass signals)

$f_s = 2 \times 2$MHz

$f_s = 4$ MHz

10. ***Ans. (a)***

No. of quantization level in n-bit PCM

$= 2^n = 2^3$ (for n = 3) = 8

11. ***Ans. (d)***

In DPCM, we make a good guess about a sample value from a knowledge of the past sample values. The sample values are not independent and generally there is a great deal of redundancy in the Nyquist samples. Proper exploitation of this redundancy leads to encoding a signal with a lesser number of bits.

12. ***Ans. (d)***

Slope overload is a problem in DM not in DPCM.

13. ***Ans. (b)***

14. ***Ans. (d)***

15. ***Ans. (c)***

$$s(t) \xrightarrow[\text{Response}]{\text{Impulse}} s(T-t)$$

16. ***Ans. (c)***

17. ***Ans. (c)***

18. ***Ans. (d)***

19. ***Ans. (d)***

20. ***Ans. (b)***

Since the sampling rate is 1800 samples/sec, the highest frequency that can be recovered is 900 Hz (sampling freq./2) frequencies higher than 900 Hz will be recollected as low frequencies due to well known aliasing effect.

21. *Ans.(b)*

$f_m = 6$ MHz and $f_s = 2f_m$

$= 12$M samples/sec

also, $H_{(x)max} = \log_2 M = \log_2 4 = 2$

$\therefore$ $(R_b)_{max}$ = maximum possible transmission rate

$= f_s \cdot H_{(x)max}$

$= 24$H bits/second

$= \frac{24}{2}$ M bauds/sec

$(R_b)_{max} = 12$ M bauds/sec

$\therefore$ bitrate $\rightarrow$ baudrate

when symbol $\rightarrow$ bit (bcz symbol = 2bit)

22. *Ans.(c)*

BW = Nf

23. *Ans.(b)*

TDM requires transmission of data samples.

24. *Ans.(b)*

$$\frac{S}{N_q}(\text{dB}) = 6n$$

where n $\rightarrow$ number of bits

$$\frac{S}{N_q}(\text{dB}) = 6 \times 8$$

$= 48$ dB

25. *Ans.(c)*

$$\text{Transmission bandwidth} = BW = \frac{nmf_s}{2}$$

where n $\rightarrow$ number of bits in a signal

m $\rightarrow$ number of signals

$f_s \rightarrow$ sampling frequency

$m = 4$, $f_s = 2f_{smin} = 4f_m$

(Assuming n = 1)

$$BW = \frac{4 \times 4 \times 5\text{kHz}}{2}$$

$\Rightarrow$ BW = 40kHz

26. *Ans.(a)*

$$f_m = \frac{10\pi}{2\pi} = 5\text{Hz}$$

f_c of LPF should be $5 < f_c < 9$ Hz

27. *Ans.(b)*

$$\frac{S}{N_q} \cong 6\,n$$

In the number of bits is increased by 2, then the S/N_q will be increased by $6 \times 2 = 12$ dB.

28. *Ans. (d)*

Quantizer step size, $\Delta = \frac{2A}{2}$

$L = 2^n$, n $\rightarrow$ no. of binary digit

$$N_q = \frac{\Delta^2}{12} = \frac{A^2}{3L^2}$$

$$\frac{S}{N_q} = 100 = \frac{30 \times 10^{-3}}{A^2/3L^2}$$

$L = 126.67$

So, n = 7 bit.

29. *Ans. (c)*

$$h(t) = s(T-t) = e^{-(T-t)}$$

$$z(t) = s(t) \times h(t) = \int_{-\infty}^{\infty} e^{-\tau} e^{-(T-t+\tau)} \cdot d\tau$$

30. *Ans. (b)*

31. *Ans. (b)*

$|mt|_{max} = 25000$ and 20000

Step size $\geq \frac{25000}{50000}$ or $\geq \frac{20,000}{50,000}$

≥ 0.5 or ≥ 0.4

32. *Ans. (c)*

To above slope overload

$$AM \leq \frac{0.25}{2\pi \times 2 \times 10^3 \times \frac{1}{30 \times 10^3}}$$

$\therefore AM \leq 0.6$ volts

5 times nyquist rate $= 5 \times 2 \times 3 \times 10^3$ Hz

$= 30 \times 10^3$ Hz

33. ***Ans. (b)***

$3 \times 10^{-6}\ V^2$

$$\text{noise power} = \frac{\left(\frac{1.536}{256}\right)^2}{12} = 3\times10^{-6}\ V^2$$

34. ***Ans. (b)***

$$\frac{S}{N_q} = \frac{1\,\text{sec}}{0.001\,\text{sec}} = 1000$$

in dB, it is '30'

$$\therefore \eta = \frac{30 - 1.76}{6.02} = 5\,\text{bits.}$$

$$f_s = 1.5 \times 200 = 300\,\text{Hz}$$

for 8 base band analog signal $8 \times 300 = 2400$ Hz bit transmission rate $= \eta f_s = 5 \times 2400 = 12$ Kbits/sec.

35. ***Ans. (a)***

$$\text{Since, } P = R(0) = \frac{S_0}{T^2}[T - 0] = \frac{S_0}{T} = 10S_0$$

$$\text{So, } T = \frac{1}{10}$$

36. ***Ans. (b)***

$$T_b = \frac{1}{0.1\times10^6} = 10^{-5}\,s$$

$$1+\alpha = 2\times f_b T_b = 2\times75\times10^3\times10^{-5} = 1.5$$

$$\Rightarrow \alpha = 0.5$$

37. ***Ans. (b)***

n = 25

M = 128

$\therefore$ N = $\log_2$ 128 = 7

So, BW = [n [N + 1] + 1] $2f_m$.Hz

$$= [25(7+1)+1]5000 = 1005\,\text{KHz}$$

38. ***Ans.* (b)**

Nyquist rate = 2 × 6 MHz = MHz

The actual sampling rate

= 12 × 12 = 14.4 MHz

1024 = 2^{10}, So, that 10 bits or binary pulses are needed to encode each sample.

Minimum bandwidth = 14.4 M × 10 = 144 M bits/sec.

39. ***Ans. (d)***

$F_2 > 2f_m = 2f_m = 6400$ Hz, $nf_x \le 3600$

$$n \le \frac{3600}{6400} = 5.63$$

$$n = 5,\ L = 2^n = 32,\ f_2 = \frac{36000}{5} = 7.2\,\text{KHz}$$

40. ***Ans. (b)***

Message bandwidth = W

Nyquist rate = 2W

Bandwidth = 2W × 8 = 16 W bit/s

$$16W = 10^8,\ W = \frac{10^8}{16} = 6.25\,\text{MHz}$$

41. ***Ans. (b)***

$$A_{max} = \frac{\delta f_s}{\omega_m} = \frac{0.1\times68k}{2\pi\times10^2} = 1.08\,\text{V}$$

42. ***Ans. (b)***

$(SNR)_q$ = 1.76 + 6.02(n) = 40 dB, n = 6.35

We take the n = 7.

Capacity = 20 × 8k × 7 = 1.12 Mbits = 140 kbytes

43. ***Ans. (c)***

44. ***Ans. (c)***

Sampling rate is given by,

f_s = 2(1200 + 600 + 600) = 4800 b/s

therefore, bit rate is

Bit rate = Nf_s = 12 × 4800 = 57.6 kbps.

45. ***Ans. (c)***

46. *Ans.* *(c)*
47. *Ans.* *(c)*
48. *Ans.* *(a)*
49. *Ans.* *(d)*
50. *Ans.* *(a)*
51. *Ans.* *(b)*
52. *Ans.* *(b)*
53. *Ans.* *(c)*
54. *Ans.* *(c)*
55. *Ans.* *(c)*
56. *Ans.* *(c)*
57. *Ans.* *(b)*
58. *Ans.* *(c)*
59. *Ans.* *(b)*
60. *Ans.* *(c)*

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CHAPTER 7

BANDPASS MODULATION TECHNIQUES

OBJECTIVE QUESTIONS

1. In a BPSK signal detector, the local oscillator has a fixed phase error of 20°. This phase error deteriorates the SNR at the output by a factor of
   (a) (c)os 20°
   (c) (c)os 70°
   (b) (c)os^2 20°
   (d) (c)os^2 70°

2. ***Assertion (A):*** Coherent FSK system is preferred over non-coherent FSK.
   Reason (R): Coherent FSK requires less power than non-coherent FSK.
   (a) Both A and R are true and R is the correct explanation of A
   (b) Both A and R are true but R is not a correct explanation of A
   (c) A is true but R is false
   (d) A is false but R is true

3. "Slope overload" occurs in delta modulation when the
   (a) frequency of the clock pulses is too low
   (b) rate of change of analog waveform is too large
   (c) step size is too small
   (d) analog signal varies very slowly with time

4. If in a digital communication the bit rate is f_b bits/sec, the BW for QPSK and BPSK signals are
   (a) f_b and $2f_b$ respectively
   (b) $2f_b$ and f_b respectively
   (c) $2f_b$ and $4f_b$ respectively
   (d) $4f_b$ and $2f_b$ respectively

5. For a given data rate, the bandwidth B_p of a BPSK signal and the bandwidth B_0 of the OOK signal are related as
   (a) $B_p = \frac{B_0}{4}$ (b) $B_p = \frac{B_0}{2}$
   (c) $B_p = B_0$ (d) $B_p = 2B_0$

6. A telephone channel has bandwidth B of 3 kHz and SNR (S/ηB) of 30 dB. It is connected to a teletype machine having 32 different symbols. The symbol rate required for errorless transmission is nearly
   (a) 1800symbols/s (b) 3000 symbols/s
   (c) 5000 symbols/s (d) 6000 symbols/s

7. A band-pass signal has significant frequency components in the range of 1.5 MHz to 2 MHz. If the signal is to be reconstructed from its samples, the minimum sampling frequency will be
   (a) 1 MHz (b) 2 MHz
   (c) 3.5 MHz (d) 4 MHz

8. In a single error correcting Hamming code, the number of message bits in a block is 26. The number of check bits in the block would be
   (a) 3 (b) 4
   (c) 5 (d) 7

9. If binary PSK modulation is used for transmission, the required minimum bandwidth is 9600 Hz. To reduce the transmission bandwidth to 2400 Hz, the modulation scheme to be adopted should be
   (a) quadrature phase-shift keying
   (b) minimum shift keying
   (c) 16-ary quadrature amplitude modulation
   (d) 8-ary PSK

10. Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I	List-II
A. BPSK	1. f_b
B. DPSK	2. $2f_b$
C. QPSK	3. $4f_b$
D. M-ary PSK	4. $3f_b/N$

Codes:	A	B	C	D
(a)	2	1	3	2
(b)	1	2	3	4
(c)	2	1	1	4
(d)	4	1	2	3

11. A direct sequence BPSK system is used to transmit a voice signal. The voice signal is sampled at 8 KHz and each samples is converted to 8 bits using PCM format. Suppose that the carrier frequency is at 1.90 GHz and that a band width of 40 MHz is available. The achievable processing gain and maximum chip rate is equal to

(a) 312.5, 128 KHz (b) 312.5, 20 MHz

(c) 125.64 KHz (d) 62.5, 40 MHz

12. Bits of duration T_b are to be transmitted using a BPSK modulation with a carrier of frequency f_c Hz. The power spectral density of the transmitted signal has the first null at the normalized frequency.

(a) $|f-f_c|T_b = 0$ (b) $|f-f_c|T_b = 1$

(c) $|f-f_c|T_b = 2$ (d) $|f-f_c|T_b = 4$

13. The probability of bit error of a BFSK modulation scheme, with transmitted signal energy per bit E_b, in an additive white Gaussian noise channel having one-side power spectral density N_0, is

(a) $\frac{1}{2}\text{erfc}\left(\frac{E_b}{2N_0}\right)$ (b) $\frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{2N_0}}\right)$

(c) $\frac{1}{2}\text{erfc}\left(\frac{E_b}{N_0}\right)$ (d) $\frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$

14. The advantage of differential PSK (DPSK) over coherent PSK is

(a) DPSK requires less bandwidth compared coherent PSK

(b) DPSK receiver design is simple compared to coherent PSK

(c) DPSK bit error rate is lower than coherent PSK

(d) For same bandwidth, DPSK bit rate is higher compared to coherent PSK

15. In a band limited channel higher bit rate can be transmitted with

(a) BPSK (b) QPSK

(c) FM (d) FSK

16. The following demodulator scheme requires least $\frac{E_b}{N_0}$

(a) BPSK (b) FSK

(c) ASK (d) QAM

17. The bandwidth required for QPSK modulated channel is

(a) Twice the BW or BPSK

(b) Equal to BPSK

(c) Equal to FSK

(d) Half of the BW of BPSK

18. In a QPSK digital signalling scheme

(a) 4 data bits are transmitted per channel symbol

(b) 4 different carrier frequency are used

(c) the signals are either orthogonal or antipodal

(d) abrupt phase discontinuities between consecutive symbols are avoided

19. In frequency shift keying

(a) The signing system is antipodal

(b) the bandwidth requirement is independent of the number of symbols used

(c) The transmitted power is independent of the symbol transmitted

(d) The signaling is non-orthogonal

20. QPSK system is superior to BPSK system because

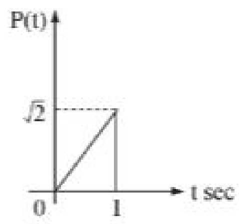
(a) Its bandwidth is higher that of a BPSK system

(b) Inter channel interference in QPSK system is less then that in BPSK system

(c) Bandwidth of QPSK system is half of the bandwidth of BPSK system

(d) In QPSK system inter-symbol interferences is in proved

21. In a digital communication system, the transmitted pulse is shown in figure. The matched filter output at the sampling instant (i.e., t = 1 sec) is



(a) $\frac{\sqrt{3}}{2}$ (b) $\frac{2}{3}$

(c) $\frac{1}{2}$ (d) $\frac{1}{6}$

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Answer Key

1. ***Ans.(b)***

In BPSK if detector has a fixed phase error ϕ then the output power would change by a factor $\cos^2\phi$.

2. ***Ans. (c)***

Non-coherent FSK is widely used (preferred) compare to coherent FSK because of it's simplicity therefore no coherent detector is required so receiver circuit become simple although probability of error increases compare to coherent FSK. So a is false.

R is true. Always coherent schemes requires low power compare to non coherent schemes.

3. ***Ans. (b)***

Slop overload occur in delta modulation if

$$\underbrace{\left|\frac{dm(t)}{dt}\right|}_{\text{Rate of change of message signal}} \geq \underbrace{\left(\frac{\Delta}{T_s}\right)}_{\text{Slope at the o/p of delta modulator}}$$

So if message is varying very fast then slope overload will occur.

4. ***Ans. (a)***

Bandwidth for APSK = f_b and

Bandwidth for BPSK = $2f_b$

where f_b = bit rate in bits/second

5. ***Ans. (c)***

Bandwidth of BPSK signal is :

$$B_P = 2f_b$$

and bandwidth of On-Off Keying is :

$$B_0 = 2f_b$$

then, $B_P = B_0$

6. ***Ans.(d)***

The symbol rate required for errorfree transmission, i.e., Nyquist sampling rate is

$$f_s = 2f_m$$

$$\Rightarrow \quad f_s = 2 \times 3000$$

$$= 6000 \text{ symbols/s}$$

7. ***Ans.(a)***

Minimum sampling frequency,

$$f_{s_{min}} = \frac{2f_H}{k}$$

where $$k = \left\lfloor \frac{f_H}{f_H - f_L} \right\rfloor$$

where $\lfloor x \rfloor$ means the greatest integer lower than x

$$k = \left\lfloor \frac{2}{2-1.5} \right\rfloor$$

$$= \left\lfloor \frac{2}{0.5} \right\rfloor = 4$$

$$f_{s_{min}} = \frac{2\times 2}{4} = 1\text{MHz}$$

8. ***Ans.(c)***

In a Hamming code, for k check bits and n message bits,

$$2^k - 1 - k \geq n$$

$$\Rightarrow \quad 2^k - 1 - k \geq 26$$

$$\Rightarrow \quad k = 5$$

9. ***Ans.(c)***

$$BW|_{BPSK} = 2f_b$$

$$BW|_{QPSK} = f_b$$

$$BW|_{QASK} = f_b/2$$

$$BW|_{BFSK} = 4f_b$$

Thus, BW of 16-ary QASK modulation is one-fourth of the BW required for BPSK.

10. ***Ans. (c)***

11. ***Ans. (b)***

Data rate is $8 \times 8000 = 64$ kbps

So, $T = \frac{5.75}{20}$

for, 40 MHz band width

$$PG = \frac{20M}{64K} = 312.5$$

Also, the chip rate is half of the band width

Wo, chip rate = 20 MHz.

12. ***Ans. (c)***

13. ***Ans. (d)***

14. ***Ans. (a)***

15. ***Ans. (b)***

16. ***Ans. (a)***

17. ***Ans. (d)***

18. ***Ans. (d)***

19. ***Ans. (d)***

20. ***Ans. (c)***

21. ***Ans. (b)***

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CHAPTER 8

INFORMATION THEORY

OBJECTIVE QUESTIONS

1. A source produces 4 symbols with probability $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}$ and $\frac{1}{8}$. For this source, a practical coding scheme has an average codeword length of 2 bits/symbols. The efficiency of the code is

   (a) 1 (b) $\frac{7}{8}$

   (c) $\frac{1}{2}$ (d) $\frac{1}{4}$

2. An image uses 512 × 512 picture elements. Each of the picture element can take any of the 8 distinguishable intensity levels. the maximum entropy in the above image will be

   (a) 2097152 bits (b) 786432 bits

   (c) 648 bits (d) 144 bits

3. An analog signal having 5 KHz bandwidth is sampled at double times the nyquist rate, and each sample is quantised into one of 256 equally likely levels. The information rate of this source is

   (a) 80kb/s (b) 160kb/s

   (c) 240 kb/s (d) 320 kb/s

4. A source deliver symbols X_1, X_2, X_3 and X_4 with probabilities 1/2, 1/4, 1/8 and 1/8 respectively. The entropy of the system is

   (a) 1.75 bits per second

   (b) 1.75 bits per symbol

   (c) 1.75 symbols per second

   (d) 1.75 symbols per bit

5. To permit the selection of 1 out of 16 e'qui-probable events, the number of bits required is

   (a) 2 (b) $\log_{10}16$

   (c) 8 (d) 4

6. For four symbols, probabilities are $P(x_1) = 0\ 0.4$, $P(x_2) = 0.3$, $P(x_3) = 0.2$ and $P(x_4) = 0.1$. The entropy is

   (a) 1.1 b/symbol

   (b) 1.85 b/symbol

   (c) 2.12 b/symbol

   (d) 3.2 b/symbol

7. A channel has a signal to noise ratio of 63 and bandwidth of 1200 Hz. The maximumdata rate that can be sent through the channel with arbitrary low probability of error is

   (a) 600 bps

   (b) 1200 bps

   (c) 4800 bps

   (d) 7200 bps

8. A source generates one of the five symbols s_1, s_2, s_3, s_4 and s_5 once is every $\frac{1}{60}$ second. The symbols are assumed to be independent and occur with probabilities $\frac{1}{4}, \frac{1}{4}, \frac{1}{4}, \frac{1}{8}$ and $\frac{1}{8}$. The average information rate of the source in bits/second is

   (a) 100 (b) 125

   (c) 135 (d) 150

9. A source has 256 symbols which are equiprobability and their successive transmission are independent. If an AWGN channel having a bandwidth of 4 KHz and SNR of 31 is used for transmission of symbols, the maximum rate (in symbols/s) at which the transmission can be made with an arbitrary low probability of error is

(a) 1000 (b) 1500

(c) 2000 (d) 2500

10. The capacity of the channel is the

(a) number of digits used in coding

(b) bandwidth required for information

(c) volume of information it can take

(d) maximum rate of instruction transmission

11. If all the messages of a source have same probability P, then source entropy H(m) is given by

(a) $-\log P$ (b) $+\log P$

(c) $\frac{P}{1-P}$ (d) $\frac{1-P}{P}$

12. A binary source generates two messages with probabilities P_0 and $P_1\left(P_1 = 1 - P_0\right)$. The entropy of this source is

(a) 1-bit/symbol irrespective of the value of P_1

(b) Maximum when $P_0 = 0$

(c) Maximum when $P_1 = P_0$

(d) Minimum when $P_1 = P_0$

13. An analog signal is band limited to β Hz, sampled at the nyquist rate and the sample are quantized into 4 levels. The quantization levels Q_1, Q_2, Q_3 and Q_4 (messages) are assumed independent. If they occur with the probability rates $P_1 = P_4 = \frac{1}{8}$ and $P_2 = P_3 = \frac{3}{8}$, then the information rate of the source is

(a) 10 β bits/s (b) 5 β bits/s

(c) 3.6 β bits/s (d) 2 β bits/s

14. An ideal power limited communication channel with additive white Gaussian noise is having 4 KHz band width and signal to noise ratio of 255. The channel capacity is :

(a) 8 kilo bits/sec (b) 9.63 kilo bits/sec

(c) 16 kilo bits/sec (d) 32 kilo bits/sec

15. The channel capacity under the Gaussian noise environment for a discrete memory less channel with a bandwidth of 4 MHz and SNR of 31 is

(a) 20 Mbps (b) 4 Mbps

(c) 8 kbps (d) 4 kbps

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Answer Key

1. *Ans. (b)*

$$\text{Entropy} = 4 = -\sum_{i=1}^{4} P_i \log_2(P_i)$$

$$H = \left[\frac{1}{2}\log_2\left(\frac{1}{2}\right)+\frac{1}{4}\log_2\left(\frac{1}{4}\right)+\frac{1}{8}\log_2\left(\frac{1}{8}\right)+\frac{1}{8}\log_2\left(\frac{1}{8}\right)\right]$$

$$H = \frac{1}{2}+\frac{1}{4}\times 2+\frac{1}{8}\times 3+\frac{1}{8}\times 3$$

$$H = 1+\frac{3}{4}=\frac{7}{4}$$

2. *Ans. (b)*

$n = \log_2 L$

$n = \log_2 8 = 3$

Maximum entropy

$= 512 \times 512 \times n$

$= 512 \times 512 \times 3$

$= 786432$

3. *Ans. (b)*

nyquist rate $= 2f_m = 10 \times 10^3$ samples/s

$r = 10 \times 10^3 \times 2 = 2 \times 10^4$ samples/s

$H(x) = \log_2 256 =$ .8b/sample

So, $R = r.H(x) = 2 \times 10^4 \times 8 = 160$ kb/s

4. *Ans.(b)*

$$H(x) = \sum_{i=1}^{4} P(i)\log_2\frac{1}{(i)}$$

$$= \frac{1}{2}\log_2 2+\frac{1}{4}\log_2 4+\frac{1}{8}\log_2 8+\frac{1}{8}\log_2 8$$

= 1.75 bits per symbol

5. *Ans.(d)*

Number of bits required,

6. *Ans. (b)*

$$I_t = I_c\left(1+\frac{\beta^2}{2}\right)^{\frac{1}{2}}$$

$$\Rightarrow 5.9 = 5\left(1+\frac{\beta^2}{2}\right)^{\frac{1}{2}}$$

$\Rightarrow \beta = 0.886$, depth = 88.6%

7. *Ans. (d)*

8. *Ans. (c)*

9. *Ans. (d)*

10. *Ans. (d)*

11. *Ans. (b)*

12. *Ans. (c)*

13. *Ans. (a)*

14. *Ans. (d)*

15. *Ans. (a)*

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