CLASS TEST

Sl. : 01SK_EC_EFSGHI_060822

MADE EASY

India's Best Institute for IES, GATE & PSUs

Delhi | Bhopal | Hyderabad | Jaipur | Lucknow | Pune | Bhubaneswar | Kolkata | Patna

Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

COMMUNICATIONS

ELECTRONICS ENGINEERING

Date of Test : 06/08/2022

ANSWER KEY

1.	(c)	7.	(b)	13.	(c)	19.	(a)	25.	(c)
2.	(b)	8.	(c)	14.	(c)	20.	(c)	26.	(c)
3.	(c)	9.	(d)	15.	(a)	21.	(d)	27.	(b)
4.	(c)	10.	(a)	16.	(c)	22.	(a)	28.	(b)
5.	(a)	11.	(b)	17.	(c)	23.	(a)	29.	(b)
6.	(c)	12.	(b)	18.	(b)	24.	(d)	30.	(d)

Detailed Explanations

1. (c)

$$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} = \frac{160-40}{160+40} \times 100 = 60\%$$

2. (b)

$$\text{Carrier power} = (A_{rms})^2 = (50)^2 = 2.5\,\text{kW}$$

$$\therefore \quad \text{Total power} = P_c\left(1+\frac{\mu^2}{2}\right) = 2.5\left(1+\frac{(0.6)^2}{2}\right) = 2.95\,\text{kW}$$

3. (c)

$$\theta(t) = 10^8\pi t + 5\sin(4\pi \times 10^6 t)$$

$$\left.\frac{d\theta(t)}{dt}\right|_{t=0} = 10^8\pi + 5 \times 4\pi \times 10^6$$

$$f_i = \frac{1}{2\pi}\frac{d\theta(t)}{dt} = \frac{1}{2\pi}[10^8\pi + 5\times 4\pi \times 10^6]$$

$$f_i = \frac{1}{2\pi}[10^8\pi + 20\pi \times 10^6] = 5\times 10^7 + 1\times 10^7$$

$$= 6 \times 10^7 = 60\text{ MHz}$$

4. (c)

The amplitude of uniformly distributed is equal to $\frac{1}{K}$.

$$\therefore \quad E[X^{K-1}] = \int_{-\infty}^{\infty} X^{K-1} f_x(x)dx$$

$$= \frac{1}{K}\int_0^k x^{K-1}dx = \frac{1}{K}\left|\frac{x^K}{K}\right|_0^K = (K)^{K-2}$$

5. (a)

Since, $Y = 2x$

Thus, $\frac{dx}{dy} = \frac{1}{2}$

$$f_Y(y) = \frac{dx}{dy}f_X(x) = \frac{dx}{dy}f_X\left(\frac{y}{2}\right)$$

$$\therefore \quad K = \frac{1}{2}$$

6. (c)

$$H = P\log_2\frac{1}{P} + (1-P)\log_2\frac{1}{1-P}$$

$$\frac{dH}{dp} = 0$$

Which gives as $P = \frac{1}{2}$

7. (b)

8. (c)

$$T_b = \frac{1}{0.1(10^6)} = 10^{-5}\text{ s}$$

$$f_b = 75\text{ kHz} = 75 \times 10^3\text{ Hz}$$

Now,

$$\alpha = 2f_b T_b - 1 = 1.5 - 1 = 0.5$$

9. (d)

$$(\text{SNR}) \propto (2^n)^2$$

$$\therefore \quad \frac{(\text{SNR})_2}{(\text{SNR})_1} = \frac{(2^{n+1})^2}{(2^n)^2} = 4$$

10. (a)

$$f_s = 10 f_N = 10 \times 20 = 200\text{ kHz}$$

$$\delta f_s \geq \text{Max}\left|\frac{dm(t)}{dt}\right|$$

$$\delta \times 200\text{ kHz} \geq 2\pi f_m A_m$$

$$\delta \geq \frac{2\pi \times (10 \times 10^3) \times \left(\frac{1}{2}\right)}{200\text{ kHz}}$$

$$\delta \geq 0.157\text{ Volts}$$

11. (b)

$$f_I = f_c + 2(IF)$$

$$IF = 10\text{ MHz}$$

$$\left(\frac{C_{max}}{C_{min}}\right) = \left(\frac{f_{Lo_2}}{f_{Lo_1}}\right)^2$$

In order to avoid image frequency

$$f_{Lo_1} = f_{o_1} + IF = 88 + 10 = 98\text{ MHz}$$

$$f_{Lo_2} = f_{o_2} + IF = 108 + 10 = 118\text{ MHz}$$

$$\therefore \quad \frac{C_{max}}{C_{min}} = \left(\frac{118}{98}\right)^2 = 1.449 : 1$$

12. (b)

$$f_{Lo_1} = f_{c_1} + f_{IF} = 5 + 0.5 = 5.5\text{ MHz}$$

$$f_{Lo_2} = f_{c_2} + f_{IF} = 10 + 0.5 = 10.5\text{ MHz}$$

13. (c)

$$y(t) = 4x(t) + 10x^2(t)$$

$$\therefore \quad y(t) = 4[m(t) + \cos(\omega_c t)] + 10[m(t) + \cos(\omega_c t)]^2$$

$$= 4m(t) + 4\cos(\omega_c t) + 10m^2(t) + \frac{10}{2} + \frac{10}{2}\cos(2\omega_c t) + 20m(t)\cos(\omega_c t)$$

$\therefore$ $$y(t) = 4\cos(\omega_c t) + 20m(t)\cos(\omega_c t) = 4[1+5m(t)]\cos(\omega_c t)$$

Now, $$\max\{|m(t)|\} = A_m$$

$\therefore$ $$\mu = \max\{5|m(t)|\}$$

$$\mu = 5A_m$$
$$0.8 = 5A_m$$
$$A_c = 0.16$$

14. (c)

$$X(t) = 6e^{At}$$
$$R_X(t_1, t_2) = E[X(t_1)X(t_2)] = E[6e^{At_1}\, 6e^{At_2}]$$
$$= 36\left[\frac{1}{2}\int_0^2 e^{A(t_1+t_2)}dA\right] = 18\left[\frac{e^{A(t_1+t_2)}}{t_1+t_2}\right]_0^2 = \frac{18}{t_1+t_2}[e^{2(t_1+t_2)}-1]$$

15. (a)

$$\int_{-\infty}^{\infty} f_X(x)dx = 1$$
$$\int_0^{\infty} Cxe^{-x}dx = 1$$
$$C\left[x\left(\frac{e^{-x}}{-1}\right) - 1\left(\frac{e^{-x}}{1}\right)\right]_0^{\infty} = 1$$
$$C(0+1) = 1$$

$\therefore$ $$C = 1$$

16. (c)

According to MAP criterion

$$\frac{f_X(r|s_1)}{f_X(r|s_o)} \underset{H_1}{\overset{H_0}{\lessgtr}} \frac{P_o}{P_1}$$

Now, $$f_X(r \mid s_1) = \frac{1}{\sqrt{\pi N_o}} \exp -\frac{(x-\mu)^2}{N_o}$$

and $$f_X(r \mid s_1) = \frac{1}{\sqrt{\pi N_o}} \exp -\frac{(x-1)^2}{N_o}$$

$$f_X(r \mid s_0) = \frac{1}{\sqrt{\pi N_o}} \exp -\frac{(x+1)^2}{N_o}$$

$\therefore$ ACC to MAP criterion

$$\frac{\exp -\frac{(t_o-1)^2}{N_o}}{\exp -\frac{(t_o+1)}{2}} = \frac{P_0}{P_1} = 2$$
$$4t_o = 2\ln 2$$
$$t_o = \frac{1}{2}\ln 2 = 0.346$$

17. (c)

$$P_e = 1 - P_c$$

Now, since we are using ML criterion, and the input symbols are equally likely, then we can directly choose the output based on the maximum value of the transmission probabilities.

$$P_c = P(y_1)\ P(y_1 \mid x_1) + P(x_3) \cdot P(y_2 \mid x_3) + P(x_1) \cdot P(y_3 \mid x_1)$$

$$= \frac{1}{3}[0.5+0.5+0.4] = \frac{7}{15}$$

$$\therefore \quad P_e = 1-\frac{7}{15} = \frac{8}{15} = 0.533$$

18. (b)

Probability of error in BPSK system with a phase mismatch of ϕ_e is,

$$P_e = Q\left[\sqrt{\frac{2E_b \cos^2 \phi_e}{N_0}}\right] = Q\left[\sqrt{\frac{2E_b(\cos 30°)^2}{N_0}}\right]$$

$$P_e = Q\left[\sqrt{\frac{3E_b}{2N_0}}\right] = Q\left[\sqrt{\frac{(1.5)E_b}{N_0}}\right]$$

19. (a)

$$(0.535 - 0.455) < f_L < (1.605 - 0.455)$$

$$0.08 \text{ MHz} < f_L < 1.15 \text{ MHz}$$

20. (c)

$$s_o(t) = \alpha s_i^2(t) = \alpha A^2 \cos^2(\theta) \qquad \text{where } \theta = \omega_c t + \beta \sin\omega_m t$$

$$= \frac{\alpha A^2}{2}[1+\cos 2\theta] = \frac{\alpha A^2}{2} + \frac{\alpha A^2}{2}\cos 2\theta$$

$\because$ The output $s_o(t)$ is passed through a BPF, thus

$$y(t) = \frac{\alpha A^2}{2}\cos 2\theta$$

$$\therefore \quad y(t) = \frac{\alpha A^2}{2}\cos 2(\omega_c t + \beta \sin \omega_m t)$$

21. (d)

$$Y(t) = X(t) - X(t+\tau)$$

and $$\overline{X^2(t)} = R_X(0)$$

Also, we have to obtain the mean value of the random process $Y(t)$ as

$$E[Y(t)] = 0$$

$$\sigma_x^2 = E[Y^2(t)] - E[Y(t)]^2 = E\left[\{X(t) - X(t+\tau)\}^2\right]$$

$$= E[X^2(t)] - 2E[X(t)\cdot X(t+\tau)] + E[X^2(t+\tau)]$$

$$= R_X(0) - 2R_X(\tau) + R_X(0) = 2R_X(0) - 2R_X(\tau)$$

$$= 2[R_X(0) - R_X(\tau)]$$

22. (a)

$$S_W(f) = \frac{N_o}{2} \text{ and } H(f) = \frac{R}{R + j\omega L} = \frac{R}{R + j2\pi f L}$$

$$\therefore \quad S_v(f) = S_W(f)|H(f)|^2 = \frac{N_o}{2} \frac{1}{1 + \left(\frac{2\pi f L}{R}\right)^2}$$

$$R_v(\tau) = F^{-1}\{S_v(f)\} = \frac{N_o R}{4L} \cdot e^{-\frac{R|\tau|}{L}}$$

23. (a)

$$G = \left[\begin{array}{cc|ccc} 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 \end{array}\right]$$

$$\therefore \quad P = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\therefore \quad H = \left[\begin{array}{cc|ccc} 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 \end{array}\right]$$

Hence option 'A'.

24. (d)

$$\text{Minimum quantization error} = \frac{\Delta}{2}$$

where
$$\Delta = \frac{V_{P-P}}{L}$$

$$\frac{V_{PP}}{2L} \leq \frac{0.1}{100} \times V_{PP}$$

$$\frac{1000}{2} \leq L$$

$$L \geq 500$$

$$2^n \geq 500$$

$$n \geq 8.9$$

$$n_{\min} = 9$$

25. (c)

Let $Y = aX + b$ where 'a' and 'b' are constants.

then
$$x = \frac{y - b}{a}$$

and,
$$\frac{dy}{dx} = a$$

$$\therefore \quad f_Y(y) = \frac{1}{a} f_X\left(\frac{y - b}{a}\right)$$

thus, the differential entropy of Y,

$$H(Y) = -\int_{-\infty}^{\infty} f_y(y) \log_2 f_y(y) dy$$

$$= -\int_{-\infty}^{\infty} \frac{1}{a} f_x\left(\frac{y-b}{a}\right) \log_2\left[\frac{1}{a} f_x\left(\frac{y-b}{a}\right)\right] dy$$

Let, $\frac{y-b}{a} = u \quad \Rightarrow \quad dy = a\,du$

$$H(Y) = -\int_{-\infty}^{\infty} f_X(u) \log_2\left[\frac{1}{a} f_X(u)\right] du$$

$$= -\int_{-\infty}^{\infty} f_X(u) \log_2 f_X(u)\,du + \int_{-\infty}^{\infty} f_X(u) \log_2(a)\,du$$

$$= H(X) + \log_2(a) \int_{-\infty}^{\infty} f_X(x)\,dx$$

$$H(Y) = H(X) + \log_2(a)$$

$\Rightarrow$ $H(Y) = H(X) + \log_2(4)$ $(\because a = 4)$

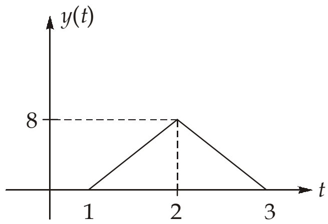
$$H(Y) = H(X) + 2$$

26. (c)

The value of the matched filter, $h(t) = s_2(T - t) = s_2(t)$

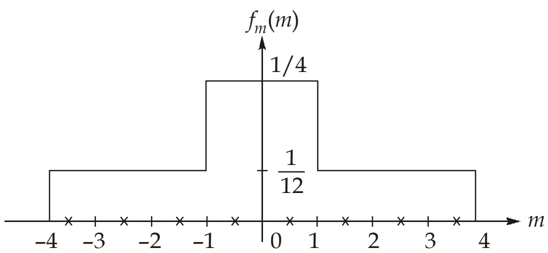
thus, the output $y(t) = s_1(t) * s_2(t)$

$$y(t) = 2[u(t-1) - u(t-2)] * 4[u(t) - u(t-1)]$$
$$= 8[r(t-1) - r(t-2) - r(t-2) + r(t-3)]$$
$$= 8[r(t-1) - 2r(t-2) + r(t-3)]$$



27. (b)

3-bit quantizer means 8-levels.



The eight levels can be chosen as the midpoint of the amplitude level for optimum quantization.
Now, the signal power is equal to

$$\sigma_m^2 = \int_{-4}^{4} m^2 f_m(m)\,dm = 2\int_{0}^{4} m^2 f_m(m)\,dm$$

$$= 2\left[\left(\frac{m^3}{12}\right)_0^1 + \left(\frac{m^3}{36}\right)_1^4\right] = \frac{11}{3}\text{W}$$

Now, the quantization noise is equal to

$$\sigma_q^2 = 2\left[\frac{1}{4}\int_0^1\left(m-\frac{1}{2}\right)^2 dm+\frac{1}{12}\int_1^2\left(m-\frac{3}{2}\right)^2 dm+\frac{1}{12}\int_2^3\left(m-\frac{5}{2}\right)^2 dm+\frac{1}{12}\int_3^4\left(m-\frac{7}{2}\right)^2 dm\right]$$

$$\sigma_q^2 = \frac{2}{3}\left[\frac{1}{4}\left(m-\frac{1}{2}\right)^3\Bigg|_0^1+\frac{1}{12}\left(m-\frac{3}{2}\right)^3\Bigg|_1^2+\frac{1}{12}\left(m-\frac{5}{2}\right)^3\Bigg|_2^3+\frac{1}{12}\left(m-\frac{7}{2}\right)^3\Bigg|_3^4\right]$$

$$\sigma_q^2 = \frac{1}{12}\text{W}$$

$$\therefore \quad (\text{SNR})_q = \frac{\sigma_m^2}{\sigma_q^2} = \frac{11/3}{1/12} = 44$$

$$\therefore \quad (\text{SNR}_q)_{\text{dB}} = 16.43 \text{ dB}$$

28. (b)

$$\therefore \quad (\text{BW})_{\text{QPSK}} = \frac{R_b}{\log_2(4)}$$

$$\Rightarrow \quad (\text{BW})_{\text{QPSK}} = 50 \text{ kHz}$$

29. (b)

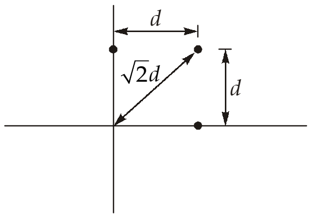
Average energy of constellation 1,

$$E_1 = \sum_{i=1}^{8} E_{Si}P_i$$

$$= R^2$$

Average energy of constellation 2,

$$E_2 = \sum_{i=1}^{8} E_{Si}P_i$$



$$E_2 = d^2\left(\frac{1}{8}\right)\times 4+2d^2\left(\frac{1}{8}\right)\times 4$$

$$E_2 = \frac{3d^2}{2}$$

Since, $E_1 = E_2 \Rightarrow R^2 = \frac{3d^2}{2}$

$\Rightarrow \quad R = 1.22d$

30. (d)

$$n = 6;\ A_m = 10$$

$$\text{Signal Power} = \frac{A_m^2}{2} = 50$$

$$\text{Quantization Noise Power} = \frac{\Delta^2}{12} = \left(\frac{2A_m}{2^n}\right)^2 \times \frac{1}{12}$$

$$= \frac{4(100)}{2^{12}} \times \frac{1}{12}$$

$$\frac{S}{NQ} = \frac{50}{400} \times 2^{12} \times 12 = 6144$$

$$\frac{S}{NQ}(dB) = 10 \log_{10}(6144) = 37.8 \text{ dB}$$

■■■■