S.No. : 03 LS1_EC_S+D_150719

Communication Systems

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CLASS TEST 2019-2020

ELECTRONICS ENGINEERING

Date of Test : 15/07/2019

ANSWER KEY ➤ Communication Systems

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

Detailed Explanations

1. (d)

Given 88 MHz < f_c < 108 MHz

Also,

$$f_{LO} - f_c = 10.8 \text{ MHz}$$

or, $$f_{LO} = 10.8 \text{ MHz} + f_c$$

∴ $$f_{LO_1} = 10.8 + 88 = 98.8 \text{ MHz}$$

$$f_{LO_2} = 10.8 + 108 = 118.8 \text{ MHz}$$

∴ $$\text{range} = 98.8 \text{ MHz} - 118.8 \text{ MHz}$$

2. (b)

With equal probability

$$H(X) = \log_2 M = \log_2 27$$

$$= \frac{\log_{10} 27}{\log_{10} 2} = 4.75 \text{ bits/character}$$

4. (d)

In FM, the modulation index (β) = $\frac{\Delta f}{f_m}$

Δf = frequency deviation

f_m = modulating frequency

6. (c)

As X and Y statistically independent,

$$E[XY] = E[X]\,E[Y]$$

$$E[X] = \int_{-\infty}^{\infty} x f_X(x)dx = 1 \quad \because f_X(x) \text{ is symmetric about the point } x = 1$$

$$E[Y] = \int_{-\infty}^{\infty} y f_Y(y)dy = 2 \quad \because f_Y(y) \text{ is symmetric about the point } y = 2$$

so, $$E[XY] = E[X]\,E[Y] = (1)\,(2) = 2$$

7. (b)

Pre-emphasis is used in FM transmitted to boost up the low level signal.

8. (b)

$$\Delta\phi = K_p V_m$$

$$K_p = \frac{\Delta\phi}{V_m} = \frac{68}{4} = 17 \text{ Rad/V}$$

9. (d)
Frequency modulation may be achieved by voltage controlled devices. Such as varactor diode, PIN diode, Miller capacitance or multivibrator etc.

10. (b)

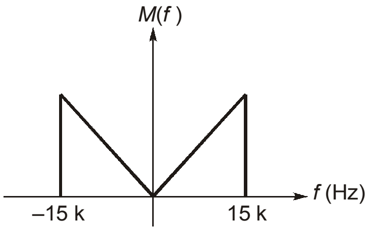
$$x(t) \longleftrightarrow X(\omega)$$

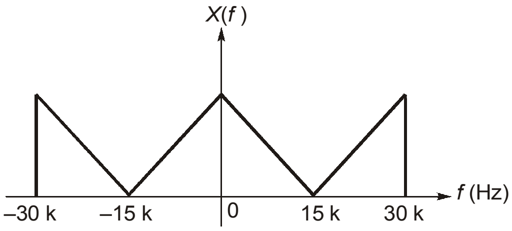
$$\hat{x}(t) \longleftrightarrow \hat{X}(\omega) = -j\text{sgn}(\omega)X(\omega)$$

$$\hat{\hat{x}}(t) \longleftrightarrow \hat{\hat{X}}(\omega) = (-j\text{sgn}(\omega))^2 X(\omega) = -X(\omega)$$

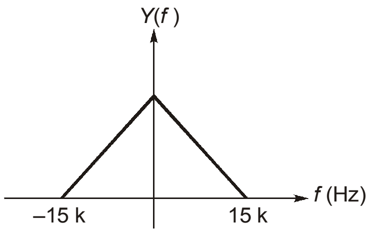
Thus $\hat{\hat{x}}(t)$ is $-x(t)$.

11. (b)





After passing through LPF



12. (d)
For distortionless demodulation

$$\frac{1}{f_c} << RC << \frac{1}{f_m}$$

$$\frac{1}{2\times10^6} << RC << \frac{1}{2\times10^3}$$

$$0.5\ \mu\text{s} << RC << 0.5\ \text{ms} \quad \text{... (i)}$$

For option (a) $\Rightarrow$ $RC = 20$ ms
For option (b) $\Rightarrow$ $RC = 5$ ms
For option (c) $\Rightarrow$ $RC = 10$ ms
For option (d) $\Rightarrow$ $RC = 20\ \mu\text{s} = 0.02$ ms
Only option (d) satisfies the condition given in equation (i).

13. (c)

$$S(t) = 10\cos(2\pi f_c t + 5\sin 2\pi f_m t)$$
$$\beta = K_p A_m = 5 \text{ rad}$$

When amplitude of message signal (A_m) is doubled and f_m is halved,

$$\beta_{new} = 2\beta_{old} = 10 \text{ rad} \qquad \because \beta \propto A_m$$
$$BW = (1 + \beta_{new})\, 2 f_{m\,(new)}$$
$$= (1+10)\left(2 \times \frac{1}{2}\right) \text{ kHz} \qquad \because f_{m\,(old)} = 1 \text{ kHz}$$
$$BW = 11 \text{ kHz}$$

14. (d)

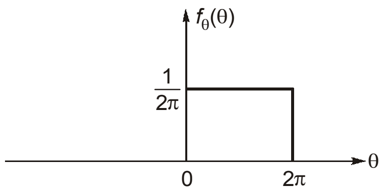
$$G_1 = G_2 = G_3 = 10 \text{ dB} \Rightarrow 10^1 = 10$$
$$F_1 = F_2 = F_3 = 6 \text{ dB}$$

or

$$F_1 = F_2 = F_3 = 10^{0.6} = 3.98 \approx 4$$
$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2}$$
$$= 4 + \frac{4-1}{10} + \frac{4-1}{100} = 4.33$$

15. (c)

$$Y(t) = X(t)\cos(\omega_0 t + \theta)$$



ACF of $Y(t)$,

$$R_Y(\tau) = E[Y(t)\, Y(t+\tau)]$$
$$= E[X(t)\cos(\omega_0 t + \theta)\, X(t+\tau)\cos(\omega_0 t + \theta + \omega_0 \tau)]$$
$$= E[X(t)\, X(t+\tau)]\, E[\cos(\omega_0 t + \theta)\cos(\omega_0 t + \theta + \omega_0 \tau)]$$
$$= R_X(\tau)\left[\frac{1}{2}\cos\omega_0\tau + \frac{1}{2}E\left[\cos(2\omega_0 t + 2\theta + \omega_0\tau)\right]\right]$$

$$E[\cos(2\omega_0 t + \omega_0\tau + 2\theta)] = E[\cos(\alpha + 2\theta)] = \int_{-\infty}^{\infty} \cos(\alpha + 2\theta) f_\theta(\theta)\, d\theta$$
$$= \int_0^{2\pi} \cos(\alpha + 2\theta)\frac{1}{2\pi}\, d\theta = 0$$

So,

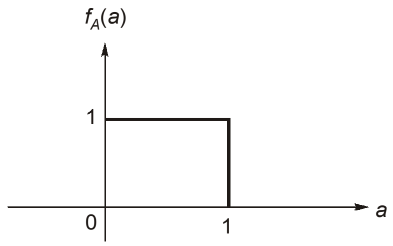
$$R_Y(\tau) = \frac{1}{2}R_X(\tau)\cos(\omega_0\tau)$$

Average power of $Y(t)$,

$$P_Y = R_Y(0) = \frac{1}{2}R_X(0) = \frac{K}{2} \text{ Watts} \qquad (\because \text{ given } R_X(0) = K \text{ Watts})$$

16. (a)

$$E[X(t)] = \int_{-\infty}^{\infty} X(t) f_A(a)\,da$$



$$E[X(t)] = \int_0^1 (a\cos(\omega t + \theta))\,(1)da$$

$$= \cos(\omega t + \theta)\int_0^1 a\,da$$

$$= \cos(\omega t + \theta)\left(\frac{a^2}{2}\right)_0^1$$

$$= \frac{1}{2}\cos(\omega t + \theta)$$

17. (c)

$$f_X(x) = \begin{cases} \frac{k}{4}(x+1)\,; & -1 \le x < 3 \\ 0 \quad ; & \text{otherwise} \end{cases}$$

$$E[X^2] = \int_{-1}^{3} x^2 \cdot f_X(x)\,dx = \int_{-1}^{3} x^2 \frac{k}{4}(x+1)\,dx$$

$$= \frac{k}{4}\int_{-1}^{3}(x^3 + x^2)\,dx = \frac{k}{4}\left[\frac{x^4}{4} + \frac{x^3}{3}\right]_{-1}^{3}$$

$$= \frac{k}{4}\left(\frac{1}{4}(81-1) + \frac{1}{3}(27+1)\right) = \frac{k}{4}\left(\frac{1}{4}\times 80 + \frac{1}{3}\times 28\right)$$

$$= \frac{k}{4}\left(\frac{28}{3} + 20\right) = k\left(\frac{22}{3}\right)$$

$$\int_{-\infty}^{\infty} f_X(x) = 1 = \frac{1}{2}(4)(k) = 1$$

$$k = \frac{1}{2}$$

So, $$E[X^2] = k\left(\frac{22}{3}\right) = \frac{11}{3} = 3.67$$

18. (b)

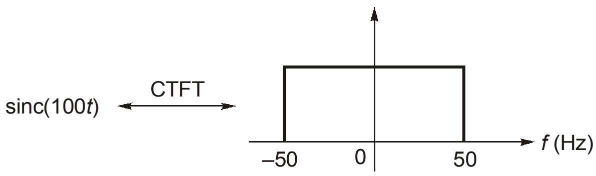
$$f_{XY}(y/x) = \frac{f_{XY}(x, y)}{f_X(x)}$$

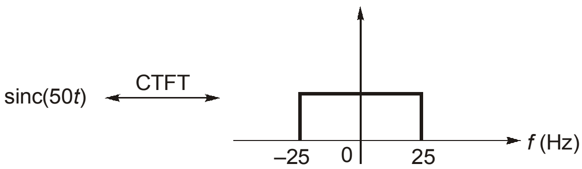
$$f_{XY}(x, y) = xye^{-\frac{(x^2+y^2)}{2}}u(x)u(y)$$

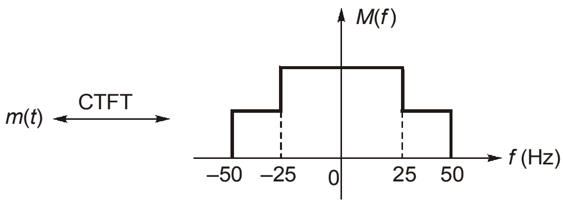
$$f_X(x) = \int_{y=-\infty}^{\infty} f_{XY}(x,y)\,dy = \int_0^{\infty} xye^{\frac{-(x^2+y^2)}{2}}u(x)\,dy = xe^{\frac{-x^2}{2}}u(x)$$

$$f_{XY}\left(\frac{y}{x}\right) = \frac{f_{XY}(x,y)}{f_X(x)} = \frac{xye^{-\frac{(x^2+y^2)}{2}}u(x)\,u(y)}{xe^{-\frac{x^2}{2}}u(x)} = ye^{-\frac{y^2}{2}}u(y)$$

19. (b)







$$f_{max} = 50 \text{ Hz}$$

$$\text{Nyquist interval} = \frac{1}{2f_{max}} = \frac{1}{100}\text{ s} = 10 \text{ ms}$$

20. (d)

$$H(m) = -0.8\log_2 0.8 + 0.2\log_2 0.2$$
$$= 0.722 \text{ bits/symbol}$$

$$\bar{L} = 0.8 \times 1 + 0.2 \times 1 = 1 \text{ bits/symbol}$$

∵ two symbols are there, each symbol can be represented with one bit.

$$\eta = \frac{H(x)}{\bar{L}} = 0.722 \Rightarrow 72.2\%$$

21. (a)

$$\text{Bandwidth} = 2(\Delta f + f_m)$$

Here, Bandwidth as well as f_m is constant.

∴ Deviation also remains the same.

22. (b)

Hilbert transformation of $x_H(t)$ is $-x(t)$.

23. (b)

Entropy $$H = \frac{1}{2}\log_2 2 + \frac{1}{4}\log_2 4 + \frac{1}{8}\log_2 8 + \frac{1}{8}\log_2 8 = 1.75 \text{ bits/symbol.}$$

24. (b)

$$P_{YY} = \frac{1}{2\pi}\int_{-\infty}^{\infty} P_{XX}\cdot|H(\omega)|^2\, d\omega = \frac{1}{2\pi}\int_{-B}^{B} 2.6\times10^{-6}\times 1\, d\omega$$

$$16 = \frac{1}{\pi}\left(2.6\times10^{-6}\right)\times B$$

or, $$B = 6.15\,\pi\times10^{6} \text{ rad/sec}$$

25. (c)

$|A_C[1 + K_a m(t)]|$

26. (b)

Nyquist Interval, $$f_{s(\min)} = 2f_{s(\max)} = 8 \text{ kHz}$$

$$T_{s(\max)} = \frac{1}{f_{s(\max)}} = \frac{1}{8}\text{ msec} = 125\ \mu\text{sec}$$

27. (a)

Bandwidth for QPSK = f_b and

Bandwidth for BPSK = $2f_b$

where f_b = bit rate in bits/second

28. (d)

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

$$0.85 = \frac{x - 0.5}{x + 0.5}$$

$$0.85(x + 0.5) = x - 0.5$$

$$x = 6.17 \text{ cm}$$

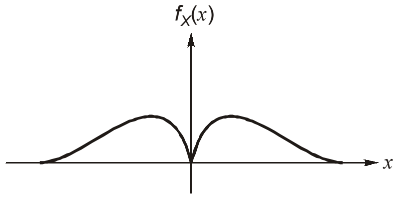
29. (a)

$$6(2f_m) = 90,000$$

$$f_m = \frac{90000}{12} = 7500 \text{ Hz}$$

30. (b)

$$f_X(x) = \frac{1}{2}|x|e^{-|x|} = \begin{cases} \frac{1}{2}xe^{-x}; \ x \geq 0 \\ -\frac{1}{2}xe^{x}; \ x < 0 \end{cases}$$



$f_X(x)$ is symmetric about $x = 0$, so, $E[X] = \bar{X} = 0$

$$\sigma_X^2 = E\left[\left(X - \bar{X}\right)^2\right] = E[X^2] = \int_{-\infty}^{\infty} x^2 f_X(x)dx = \frac{1}{2}\int_{-\infty}^{\infty} x^2 |x| e^{-|x|}dx$$

$$= \int_0^{\infty} x^3 e^{-x} dx \qquad \because x^2|x|e^{-|x|} \text{ is an even function of } `x\text{'}$$

$$= \left[e^{-x}(-x^3 - 3x^2 - 6x - 6)\right]_0^{\infty} = 6$$

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