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COMMUNICATIONS

ELECTRONICS ENGINEERING

Date of Test : 24/09/2026

ANSWER KEY ➤

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

Detailed Explanations

1. (b)

Power saving in SSB modulated signal as compared to AM

$$\begin{aligned} &= \frac{P_c + \frac{P_c \mu^2}{4}}{P_c + \frac{P_c \mu^2}{2}} = \frac{4 + \mu^2}{4 + 2\mu^2} \\ \frac{4 + \mu^2}{4 + 2\mu^2} &= \frac{90}{100} \\ 400 + 100 \mu^2 &= 360 + 180 \mu^2 \\ 80 \mu^2 &= 40 \\ \mu &= \frac{1}{\sqrt{2}} = 70.71\% \end{aligned}$$

2. (b)

Total sideband power = 100 watt i.e.,

$$\frac{P_c \mu^2}{2} = 100$$

We have,

$$P_c = \frac{A_c^2}{2} = \frac{(60)^2}{2}$$

$$P_c = 1800 \text{ Watt}$$

∴

$$\frac{1800 \mu^2}{2} = 100$$

$$\mu^2 = \frac{100 \times 2}{1800}$$

$$\mu = \frac{1}{3} = 0.33$$

$$\mu = \frac{A_m}{A_c} = \frac{1}{3}$$

$$A_m = \frac{A_c}{3} = \frac{60}{3} = 20 \text{ volt}$$

3. (a)

$$\mu = 100\%, \quad I_t = 12\sqrt{6} \text{ A}$$

$$\mu = 1$$

$$I_t = I_c \sqrt{1 + \frac{\mu^2}{2}} = I_c \sqrt{\frac{2 + (1)^2}{2}}$$

$$12\sqrt{6} = I_c \sqrt{\frac{3}{2}}$$

$$I_c = 12\sqrt{6} \times \sqrt{\frac{2}{3}} = 24 \text{ A}$$

4. (a)

$$(BW)_{PM} = (BW)_{FM}$$

$$\left(\frac{\Delta f_{PM}}{f_m} + 1 \right) 2f_m = \left(\frac{\Delta f_{FM}}{f_m} + 1 \right) 2f_m$$

Hence,

$$\Delta f_{PM} = \Delta f_{FM}$$

$$K_p A_m f_m = K_f A_m$$

$$K_f = 3000 K_p$$

5. (c)

Given; $f_m = 3$ kHz; Nyquist Rate = $2f_m = 6000$ Hz

It is sampled at a rate $33\frac{1}{3}\%$ higher than the Nyquist rate.

$$\therefore f_s = 6000 \left(1 + \frac{1}{3} \right) = 8000 \text{ Hz}$$

$$\text{Max. Quantization Error} = \pm \frac{\Delta}{2} = \frac{0.5}{100} \times m_p$$

(For the quantization step Δ , the maximum quantization error is $\pm \frac{\Delta}{2}$)

$$\frac{2m_p}{2L} = \frac{0.5m_p}{100}$$

$$\therefore L = 200 \leq 2^n, \text{ where } n \text{ is the number of bits per sample}$$

We get,

$$n = 8$$

$$R_b = nf_s$$

$$R_b = 8 \times 8K = 64 \text{ kHz}$$

Now, the minimum bandwidth of the channel required is $\frac{R_b}{2}$.

$$\therefore BW = \frac{64}{2} = 32 \text{ kHz}$$

6. (d)

Given,

$$\mu = 1,$$

$$\text{Peak envelope power} = A_C^2 (1 + \mu)^2 = 32 \text{ kW}$$

$$A_C^2 (1 + 1)^2 = 32 \times 10^3$$

$$A_C^2 = 8 \times 10^3$$

$$\text{Now transmitted power, } P_T = \frac{A_C^2}{2} \left(1 + \frac{\mu^2}{2} \right)$$

$$= \frac{8 \times 10^3}{2} \left(1 + \frac{1}{2} \right)$$

$$P_T = 6 \text{ kW}$$

7. (a)

The angle of the modulated signal $s(t)$ is given as,

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

Instantaneous frequency of the modulated signal can be written as,

$$f_i = \frac{1}{2\pi} \cdot \frac{d}{dt} \theta(t)$$

$$f_{i \max} = \frac{\omega_c}{2\pi} + \left[\frac{5}{2\pi} \times 3000 \cos 3000t + \frac{10}{2\pi} \times 2000\pi \cos 2000\pi t \right]_{\max}$$

$$f_{i \max} = \frac{\omega_c}{2\pi} + \left[\frac{5}{2\pi} \times 3000 + \frac{10}{2\pi} \times 2000\pi \right]_{\max}$$

$$f_{i \max} = f_c + 12387.32$$

$$f_{i \max} = 112.387 \text{ kHz}$$

8. (b)

As the received signal frequency $f_s > f_l$

$$\therefore \text{Image frequency, } f_{si} = f_s - 2IF$$

$$f_{si} = 1000 - 2 \times 50$$

$$= 1000 - 100$$

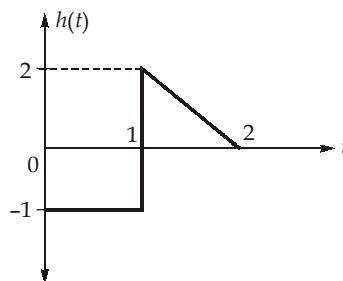
$$f_{si} = 900 \text{ kHz}$$

9. (b)

Impulse response of matched filter is given as,

$$h(t) = S(T - t)$$

$\therefore$ By doing shifting and reversing we get,



10. (c)

We have; $f_m = 5 \text{ kHz}, n = 10$

$\Rightarrow$ ON-OFF signalling is also known as BASK signalling.

Now, sampling frequency $(f_s) \geq 2f_m$

$$(f_s)_{\min} = 10 \text{ kHz}$$

$$\text{Bit Rate } (R_b) = n(f_s)_{\min}$$

$$= 10 \times 10$$

$$= 100 \text{ kbps}$$

For BASK, $(BW)_{\min} = R_b = 100 \text{ kHz}$

11. (c)

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

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

Which gives as

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

12. (a)

$$P = E[X^2(t)] = \frac{1}{2\pi} \int_{-\infty}^{\infty} S_X(\omega) d\omega = \frac{1}{2\pi} [5 + 1.5 + 1.5] = \frac{8}{2\pi} = 1.27$$

13. (c)

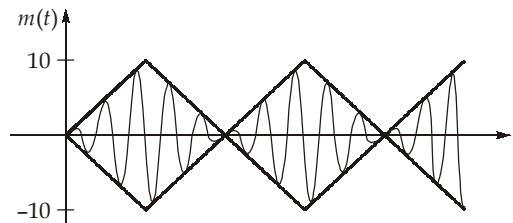
For $\mu = \infty$, given $A_m = 10$ V

$$\mu = \infty = \frac{A_m}{A_c}$$

$$A_c = 0 \text{ V}$$

$\therefore$ Modulated signal,

$$s(t) = m(t) \cos(2\pi f_c t)$$



This is the representation of DSB-SC signal.

$\Rightarrow$ For $\mu = 1$, it represents the AM signal with

$$A_{\max} = A_c(1 + \mu) = 2A_c = 20 \text{ V}$$

$$A_{\min} = A_c(1 - \mu) = 0$$

$$\mu = 1 = \frac{A_m}{A_c}$$

$\Rightarrow$

$$A_c = 10 \text{ V}$$

14. (b)

15. (d)

$$\begin{aligned} v(t_1)\omega(t_2) &= XY[\cos(\omega_0 t_1)\cos(\omega_0 t_2) - \sin(\omega_0 t_1)\sin(\omega_0 t_2)] \\ &\quad - X^2 \cos(\omega_0 t_1)\sin(\omega_0 t_2) + Y^2 \sin(\omega_0 t_1)\cos(\omega_0 t_2) \end{aligned}$$

Since, X and Y are independent, hence,

$$E[XY] = E[X] \cdot E[Y] = 0$$

$$E[X^2] = E[Y^2] = \sigma^2$$

Cross-correlation of $v(t)$ and $\omega(t)$

$$\begin{aligned} R_{v\omega}(t_1, t_2) &= E[v(t_1)\omega(t_2)] \\ &= [\cos(\omega_0 t_1)\cos(\omega_0 t_2) - \sin(\omega_0 t_1)\sin(\omega_0 t_2)]E[XY] \\ &\quad - \cos(\omega_0 t_1)\sin(\omega_0 t_2)E[X^2] + \sin(\omega_0 t_1)\cos(\omega_0 t_2)E[Y^2] \\ R_{v\omega}(t_1, t_2) &= 0 + \sigma^2[\sin(\omega_0 t_1)\cos(\omega_0 t_2) - \cos(\omega_0 t_1)\sin(\omega_0 t_2)] \\ &= \sigma^2 \sin(\omega_0 t_1 - \omega_0 t_2) \\ R_{v\omega}(t_1, t_2) &= \sigma^2 \sin \omega_0(t_1 - t_2) \end{aligned}$$

16. (b)

Given, $m(t) = x(t) \cdot \hat{x}(t)$

$\therefore$ Hilbert transform do NOT impact frequency of signal.

$\therefore$ Maximum frequency of message signal is given as

$$\begin{aligned}(f_m)_{\max} &= f_{m1} + f_{m2} \\ &= 50 + 50 \\ &= 100 \text{ Hz}\end{aligned}$$

$$\begin{aligned}\text{Now, sampling freq. } \Rightarrow f_s &= 1.25[2 \times (f_m)_{\max}] \\ &= 250 \text{ Hz}\end{aligned}$$

$$\text{Now, Bit rate, } R_b = n \cdot f_s = 8 \times 250 = 2 \text{ kbps}$$

$$\text{Symbol Rate; } R_s = \frac{R_b}{\log_2 M} = \frac{2}{2} = 1 \text{ K symbols/sec}$$

$$\therefore \text{ Minimum Tx. Bandwidth} = \frac{R_s}{2} = 0.5 \text{ kHz}$$

17. (c)

We know;

Distance from origin to signalling point is $\sqrt{E_b}$

$$\begin{aligned}\therefore \sqrt{E_b} &= 0.02 \quad \dots \text{from diagram} \\ E_b &= 4 \times 10^{-4} \text{ J}\end{aligned}$$

$$\text{Since; } E_b = \frac{A_c^2}{2} \times T_b \quad \{T_b = \text{bit duration}\}$$

$$\begin{aligned}4 \times 10^{-4} &= \frac{(2)^2}{2} \times T_b \\ T_b &= 2 \times 10^{-4} \text{ sec}\end{aligned}$$

$$\text{Now, } R_b = \frac{1}{T_b} = 5 \text{ kbps}$$

$$\text{We have, Symbol Rate } (R_s) = \frac{R_b}{\log_2 M} \text{ (symbol/sec)}$$

For same symbol rate;

$$\begin{aligned}R_b &\propto \log_2 M \quad \{M \Rightarrow \text{no. of point on constellation diagram}\} \\ \frac{(R_b)_2}{(R_b)_1} &= \frac{\log_2 M_2}{\log_2 M_1} \\ \frac{20}{5} &= \frac{\log_2 M_2}{\log_2 2} \\ M_2 &= 16\end{aligned}$$

18. (c)

$$y(t) = 0.6p(t) + 0.3p(t - 0.3)$$

Using Laplace transform,

$$Y(s) = 0.6P(s) + 0.3 e^{-0.3s} P(s)$$

$$\frac{Y(s)}{P(s)} = H(s) = [0.6 + 0.3e^{-0.3s}]$$

Mean value of output random process is $E[Y] = 1.8$

$$E[Y] = H(s)|_{s=0} \cdot E[P]$$

$$1.8 = [0.6 + 0.3] \times M = 0.9 \times M$$

$$M = 2$$

19. (b)

Given: $f_{\text{upper}} = 100.007 \text{ MHz}$, $f_c = 100 \text{ MHz}$

Frequency deviation,

$$\Delta f = f_{\text{upper}} - f_c$$

$$\Delta f = (100.007 - 100) \text{ MHz} = 7 \text{ kHz}$$

Carrier swing = $2 \times \Delta f = 2 \times 7 = 14 \text{ kHz}$

20. (b)

Given: Bipolar RZ technique,

$$T_b = 500 \mu\text{s}$$

$$R_b = \frac{1}{T_b} = \frac{1}{500} \times 10^6 = 2000 \text{ bits/sec}$$

Bandwidth,

$$\text{BW} = R_b = \frac{1}{T_b} = 2000 \text{ Hz} = 2 \text{ kHz}$$

21. (d)

From the properties of PDF,

$$\int_{-\infty}^{\infty} f_X(x) dx = 1$$

$$\int_2^4 \frac{1}{K} (3 + 2x) dx = 1$$

$$\frac{1}{K} \left[3x + \frac{2x^2}{2} \right]_2^4 = 1$$

$$\frac{1}{K} [3(4 - 2) + (4^2 - 2^2)] = 1$$

$$\frac{1}{K} [6 + 12] = 1$$

$$K = 18$$

22. (d)

Given: $p(x_1) = 0.4$, $p(x_2) = 0.6$

$$H(x) = -p(x_1) \log_2 p(x_1) - p(x_2) \log_2 p(x_2)$$

$$= -0.4 \log_2(0.4) - 0.6 \log_2(0.6) = 0.971 \text{ bits/symbol}$$

Entropy of second order extension,

$$H(X^2) = 2 \times H(X)$$

$$H(X^2) = 2 \times 0.971 = 1.942 \text{ bits/symbol}$$

23. (a)

Given:

Phase modulated signal,

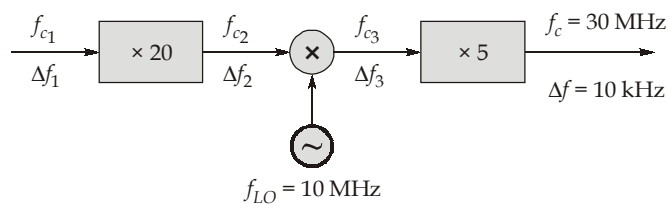
$$x(t) = 20 \cos[10^6 \pi t + 10 \sin 2\pi(10^3)t]$$

$$= 20 \cos[10^6 \pi t + 10 \sin 2\pi(10^3)t]$$

$$\Delta\phi_{\max} = 10 \sin 2\pi(10^3)t \Big|_{\max} = 10 \text{ rad}$$

24. (b)

From the figure



$$f_{LO} = 10 \text{ MHz}$$

$$\Delta f = 10 \text{ kHz}; \quad f_c = 30 \text{ MHz}$$

$$f_{c3} \times 5 = 30$$

$$f_{c3} = 6 \text{ MHz}$$

$\therefore$ Down conversion ($f_{LO} > f_{c2}$)

$$\therefore f_{c2} = f_{LO} - f_{c3}$$

$$f_{c2} = 10 - 6 = 4 \text{ MHz}$$

25. (c)

If information is contained in Amplitude and phase, then it is QAM.

We have;

$$\begin{array}{l} \text{bit 1 : } \sqrt{2} P(t) \cos \left[\left(\omega_c - \frac{\Delta\omega}{4} \right) t \right] \\ \text{bit 0 : } \sqrt{2} P'(t) \sin \left[\left(\omega_c - \frac{\Delta\omega}{4} \right) t \right] \end{array}$$

Change in amplitude
Change in phase

26. (b)

$$\text{Modulating signal } m(t) = 2 \sin(2000 \pi t)$$

Maximum frequency deviation $[\Delta f]$ is directly proportional to modulating signal frequency f_m , in case of PM only.

Hence, the modulation happening is phase modulation.

$$\therefore [\Delta f] = \frac{K_p}{2\pi} \frac{dm(t)}{dt} \Big|_{\max} = K_p A_m f_m = 3 \times 2 \times \left(\frac{2000\pi}{2\pi} \right)$$

$$[\Delta f] = 6 \text{ kHz}$$

$$f_m = 1 \text{ kHz}$$

As per Carson's rule, Bandwidth = $2[\Delta f + f_m] = 2[6 + 1] = 14 \text{ kHz}$

27. (d)

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

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

28. (d)

$$f_m = 15 \text{ kHz}$$

$$f_s = 2NR = 2 \times 2 \times 15 = 60 \text{ kHz}$$

Since samples are quantized into 256 equally likely levels, there will be,

$$n = \log_2(256) = 8 \text{ bits/sample}$$

The information rate (R) = $n \times f_s = 8 \times 60 \text{ K} = 480 \text{ kbps}$.

$\left(\frac{S}{N}\right)$ ratio for error-free transmission, with $B = 20 \text{ kHz}$ can be calculated using Shanon Capacity

Theorem as

$$R \leq C = B \log_2 \left[1 + \frac{S}{N} \right]$$

$$480 \text{ K} \leq 20 \text{ K} \log_2 \left[1 + \frac{S}{N} \right]$$

$$24 \leq \log_2 \left[1 + \frac{S}{N} \right]$$

$$\frac{S}{N} \geq 16777215$$

$$\left(\frac{S}{N}\right)_{\text{dB}} = 72.24 \text{ dB}$$

29. (d)

For coherent BFSK system:

$$P_e = Q \left[\sqrt{\frac{d_{\min}^2}{2N_o}} \right]$$

$$d_{\min} = \sqrt{2E_b}$$

$$P_e = Q \left[\sqrt{\frac{E_b}{N_o}} \right]$$

$$\therefore Q[x] = \frac{1}{2} \text{erfc} \left[\frac{x}{\sqrt{2}} \right]$$

$$\therefore P_e = \frac{1}{2} \text{erfc} \left[\sqrt{\frac{E_b}{2N_o}} \right]$$

But ; $\text{erf}(x) + \text{erfc}(x) = 1$

At $x = \sqrt{2}$

$$\operatorname{erf}(\sqrt{2}) + \operatorname{erfc}(\sqrt{2}) = 1$$

$$\operatorname{erfc}(\sqrt{2}) = 1 - \operatorname{erf}(\sqrt{2}) = 1 - 0.95 = 0.05$$

$$P_e = \frac{1}{2} \times 0.05 = 0.025$$

$$\therefore \sqrt{\frac{E_b}{2N_o}} = x = \sqrt{2}$$

$$\frac{E_b}{2N_o} = 2$$

$$\therefore \frac{E_b}{N_o} = 4$$

30. (c)

$$P\left(\frac{Z}{X}\right) = \begin{bmatrix} 0.7 & 0.3 \\ 0.3 & 0.7 \end{bmatrix} \begin{bmatrix} 0.6 & 0.4 \\ 0.4 & 0.6 \end{bmatrix}$$

$$P\left(\frac{Z}{X}\right) = \begin{bmatrix} 0.54 & 0.46 \\ 0.46 & 0.54 \end{bmatrix}$$

$$P(Z) = [P(x_1)P(x_2)]P\left[\frac{Z}{X}\right]$$

$$= \begin{bmatrix} 0.9 & 0.1 \end{bmatrix} \begin{bmatrix} 0.54 & 0.46 \\ 0.46 & 0.54 \end{bmatrix}$$

$$P(Z) = [0.532 \quad 0.468]$$

$$\therefore P(z_1) = 0.532$$

$$P(z_2) = 0.468$$

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