CLASS TEST

S.No.: 02SKEC_JKLMNOPQ_30925

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COMMUNICATIONS

ELECTRONICS ENGINEERING

Date of Test : 30/09/2025

ANSWER KEY

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

Detailed Explanations

1. (c)

$$E_{max} = 40\text{ V and } E_{min} = 10\text{ V}$$

Modulation index,
$$\mu = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} = \frac{40-10}{40+10} = 0.60$$

2. (b)

From the given angle modulated signal,

Modulation index, $\beta = 4$

Message signal frequency, $f_m = \frac{2000\pi}{2\pi} = 1000\text{ Hz} = 1\text{ kHz}$

According to Carson's rule,

$$BW = (1+\beta)2f_m = (1+4)(2\times 1)\text{ kHz}$$
$$= 10\text{ kHz}$$

3. (c)

Given, $\beta = 0.25$; $P_{FM} = 10$ kW

The normalized power of the carrier component in FM signal,

$$P_N = J_0^2 P_{FM} (0.98)^2 \times 10\text{ kW} = 9.604\text{ kW}$$

Since, there is only one significant sideband whose relative amplitude is equal to $J_1 = 0.12$. The power of each sideband = $(0.12)^2 \times 10$ kW

= 0.144 kW

The normalized power in the carrier and first order sideband,

= 9.604 + 2(0.144)

= 9.892 kW

4. (d)

Given that,
$$f_{LO} > f_c$$
$$\text{IF or } f_{IF} = 450\text{ kHz}$$
$$f_c = 1200\text{ kHz}$$
$$f_{image} = f_c + 2f_{IF} = 1200 + 2(450)\text{ kHz} = 2100\text{ kHz}$$

5. (a)

Speech-processing circuits in AM transmitters are used for,

- Prevention of overmodulation.
- Prevention of excessive signal bandwidth.
- Increasing the average transmitted power.

6. (c)

For coherent BFSK, the condition for orthogonality is,

$$f_1 - f_0 = \frac{n}{2T_b} = n\frac{R_b}{2}; \qquad n = 1, 2, 3, ...$$

Given that, $f_0 = 50$ kHz and $f_1 = 60$ kHz. So,

$$f_1 - f_0 = 10\text{ kHz}$$

For option (a) $\Rightarrow \dfrac{R_b}{2} = 4 \text{ kbps} \Rightarrow 10 \neq n(4)$

For option (b) $\Rightarrow \dfrac{R_b}{2} = 3 \text{ kbps} \Rightarrow 10 \neq n(3)$

For option (c) $\Rightarrow \dfrac{R_b}{2} = 2 \text{ kbps} \Rightarrow 10 = 5(2) = n(2)$

For option (d) $\Rightarrow \dfrac{R_b}{2} = 1.5 \text{ kbps} \Rightarrow 10 \neq n(1.5)$

So, only option (c) satisfies the required condition.

7. (a)

$$(\text{BW})_{M\text{-PSK}} = \frac{(\text{BW})_{\text{BPSK}}}{\log_2(M)}$$

$$(\text{BW})_{32\text{-PSK}} = \frac{100}{\log_2(32)} \text{ kHz} = \frac{100}{5} \text{ kHz} = 20 \text{ kHz}$$

8. (c)

Given, $P(X_1) = 0.5$

$P(X_2) = 0.5$

The transmission probability matrix of the given binary channel is,

$$P[Y/X] = \begin{bmatrix} 0.7 & 0.3 \\ 0.4 & 0.6 \end{bmatrix}$$

The joint probability matrix is,

$$P[X, Y] = P[X_d] \cdot P[Y/X]$$

$$= \begin{bmatrix} 0.5 & 0 \\ 0 & 0.5 \end{bmatrix} \begin{bmatrix} 0.7 & 0.3 \\ 0.4 & 0.6 \end{bmatrix} = \begin{bmatrix} 0.35 & 0.15 \\ 0.2 & 0.3 \end{bmatrix}$$

9. (a)

It is given that, X and Y are statistically independent.

So, $\sigma_Z^2 = \sigma_X^2 + \sigma_Y^2$

$$\sigma_X^2 = \frac{(8-0)^2}{12} = \frac{64}{12} = \frac{16}{3}$$

$$\sigma_Y^2 = \frac{(4-0)^2}{12} = \frac{16}{12} = \frac{4}{3}$$

$$\sigma_Z^2 = \frac{16}{3} + \frac{4}{3} = \frac{20}{3} = 6.66$$

10. (b)

The entropy of the source is,

$$H(x) = -\sum_{i=1}^{6} P_i \log_2 P_i$$

$$= -[\log_2 P_1 + \log_2 P_2 + \log_2 P_3 + \log_2 P_4 + \log_2 P_5 + \log_2 P_6]$$

given, $P_1 = 0.2; P_2 = 0.1, P_3 = 0.15, P_4 = 0.05, P_5 = 0.3$ and $P_6 = 0.2$

$$= -[0.2 \log_2 0.2 + 0.1 \log_2 0.1 + 0.15 \log_2 0.15 + 0.05 \log_2 0.05] + 0.3 \log_2 0.3 + 0.2 \log_2 0.2]$$

$$H(x) = 2.4087 \text{ bits/sample}$$

The sampling rate is, $f_s = 2000 + 2 \times 6000 = 14000$ Hz

i.e., 14000 samples are taken per second.

Hence, the entropy of the source,

$$H(x) = 2.4087 \times 14000 = 33721.8 \text{ bits/second}$$

11. (b)

For 16-PSK, theoretical minimum channel BW required is,

$$(\text{BW})_{16\text{-PSK}} = \frac{2(R_b/2)}{\log_2(16)} = \frac{R_b}{4}$$

$$= \frac{10^8}{4} \text{ Hz} = 25 \text{ MHz}$$

Note :

- Minimum bandwidth required for base-band data transmission = $\frac{R_b}{2}$
- Minimum bandwidth required for BPSK transmission = 2 × (Base-band BW) = $2 \times \left(\frac{R_b}{2}\right) = R_b$
- Minimum bandwidth required for M-PSK transmission = $\frac{\text{BW of BPSK}}{\log_2(M)} = \frac{R_b}{\log_2(M)}$

12. (b)

$$f_m = 10 \text{ kHz, G.B} = 1 \text{ kHz}$$

Sampling frequency $(f_s) = 2 \times 1.25 \times 10 + 1$

$= 26$ kHz

∴ Symbol rate; $r = f_s = 26$ K symbols/sec

Now, Entropy; $H = -\sum_{i=1}^{4} P(x_i)\log_2 P(x_i)$

From graph; $P(1) = \frac{1}{2}$

$$P(2) = P(3) = \frac{1}{8}$$

$$P(4) = \lambda = \frac{1}{4}$$

$$\therefore \quad H = -\left[\frac{1}{2}\times\log_2 2^{-1} + 2\times\frac{1}{8}\log_2 8^{-1} + \frac{1}{4}\log_2 4^{-1}\right]$$

$$H = \frac{7}{4} = 1.75 \text{ bits/symbol}$$

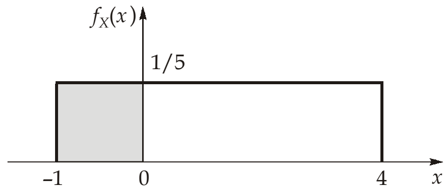
Now, Data rate $= r.H = 26 \times 1.75$

$= 45.5$ kbps

13. (c)

$$P(Y \le 3) = P(2X + 3 \le 3)$$
$$= P(2X \le 0) = P(X \le 0)$$

$$P(X \le 0) = \text{Shaded area} = \frac{1}{5}$$



So, $$P(Y \le 3) = P(X \le 0) = \frac{1}{5} = 0.2$$

14. (d)

Given that, $X(t)$ is a WSS process.

So, the following two conditions should be satisfied by $X(t)$.

Condition - 1 : $E[X(t)]$ should be independent of t.

Condition - 2 : $E[X(t + \tau)X(t)]$ should be a function of τ only.

Check for condition - 1:

$$E[X(t)] = E[A\cos t + B\sin t]$$
$$= E[A\cos t] + E[B\sin t]$$
$$= E[A]\cos t + E[B]\sin t$$

$E[X(t)]$ will be independent of t, when and only $E[A] = E[B] = 0$.

Check for condition - 2:

$$E[X(t + \tau)\, X(t)] = E\left[\left(A\cos(t+\tau) + B\sin(t+\tau)\right)\left(A\cos t + B\sin t\right)\right]$$

$$= E\left[A^2\cos(t+\tau)\cos t + AB\sin(t+\tau)\cos t + AB\cos(t+\tau)\sin t + B^2\sin(t+\tau)\sin t\right]$$

$$= E\left[\frac{A^2}{2}\cos(\tau) + \frac{A^2}{2}\cos(2t+\tau) + \frac{AB}{2}\sin(2t+\tau) + \frac{AB}{2}\sin(\tau) + \frac{AB}{2}\sin(2t+\tau)\right.$$
$$\left. - \frac{AB}{2}\sin(\tau) + \frac{B^2}{2}\cos(\tau) - \frac{B^2}{2}\cos(2t+\tau)\right]$$

$$= E\left[\left(\frac{A^2+B^2}{2}\right)\cos(\tau) + \left(\frac{A^2-B^2}{2}\right)\cos(2t+\tau) + AB\sin(2t+\tau)\right]$$

$$= E\left[\frac{A^2+B^2}{2}\right]\cos(\tau) + E\left[\frac{A^2-B^2}{2}\right]\cos(2t+\tau) + E[AB]\sin(2t+\tau)$$

If the above equation is to be a function of "τ" only, then

$$E\left[\frac{A^2-B^2}{2}\right] = 0 \quad \Rightarrow \quad E[A^2] = E[B^2]$$

and $E[AB] = 0$

So, if $X(t)$ is a WSS process, then the conditions to be satisfied are,

$$E[A] = E[B] = 0$$
$$E[AB] = 0$$
$$E[A^2] = E[B^2]$$

15. **(b)**

For AWGN channels, as per Shanon Hartley Theorem

Channel capacity, $C = B\log_2(1 + SNR)$

$= 5\log_2(1 + 15)$ Mbps

$= 5 \times 4 = 20$ Mbps

16. **(b)**

Sampling rate, $f_s = 2 \times 4000 = 8000$ Hz $= 8$ kHz

Entropy of alphabets,

$$H(X) = \frac{1}{2}\log_2(2) + \frac{1}{4}\log_2(4) + \frac{1}{8}\log_2(8) + \frac{2}{16}\log_2(16) \text{ bits/symbol}$$

$$= \frac{1}{2} + \frac{1}{2} + \frac{3}{8} + \frac{1}{2} \text{ bits/symbol} = 1.875 \text{ bits/symbol}$$

Bit rate, $R_b = H(X)f_s = 8 \times 1.875 = 15$ kbps

Minimum baseband channel bandwidth required is,

$$(BW)_{min} = \frac{R_b}{2} = 7.50 \text{ kHz}$$

17. **(c)**

For Hilbert transform, the impulse response is,

$$h(t) = \frac{1}{\pi t}$$

$$H(\omega) = -j\,\text{sgn}(\omega)$$

$$|H(\omega)|^2 = 1$$

So, the input and output power spectral densities are related as,

$$S_Y(\omega) = |H(\omega)|^2 S_X(\omega) = (1)\, S_X(\omega) = S_X(\omega)$$

Since $S_Y(\omega) = S_X(\omega)$, $R_Y(\tau) = R_X(\tau) \Rightarrow$ Hence, R_1 is correct

$$R_{XY}(\tau) = R_X(\tau) * h(\tau)$$

$$R_{XY}(-\tau) = R_X(-\tau) * h(-\tau)$$

$$h(\tau) = \frac{1}{\pi\tau} \text{ and } h(-\tau) = -h(\tau)$$

$$R_X(-\tau) = R_X(\tau)$$

$\because$ ACF of a WSS process is an even function

So, $R_{XY}(-\tau) = R_X(\tau) * [-h(\tau)] = -[R_X(\tau) * h(\tau)]$

$R_{XY}(-\tau) = -R_{XY}(\tau) \Rightarrow$ Hence, R_2 is correct

So, both the given relations are correct.

18. **(d)**

$$P(z_0) = P(x_0) + 0.50P(x_1) = 0.40 + (0.50 \times 0.20) = 0.50$$

$$P(z_1) = P(x_2) + 0.50P(x_1) = 0.40 + (0.50 \times 0.20) = 0.50$$

$$P(y_0) = 0.50P(z_0) = 0.50 \times 0.50 = 0.25$$

$$P(y_1) = 0.50P(z_0) + 0.50P(z_1) = (0.50 \times 0.50) + (0.50 \times 0.50) = 0.50$$

$$P(y_2) = 0.50P(z_1) = 0.50 \times 0.50 = 0.25$$

So, the entropy of the output symbols can be given by,

$$H(Y) = -[0.25\log_2(0.25) + (0.25)\log_2(0.25) + 0.50\log_2(0.50)] \text{ bits/}$$

symbol

$$= 1.50 \text{ bits/symbol}$$

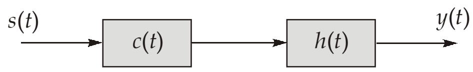
19. **(a)**

$$E[Y] = E\left[\int_0^{10} X(t)\,dt\right] = \int_0^{10} E[X(t)]\,dt$$

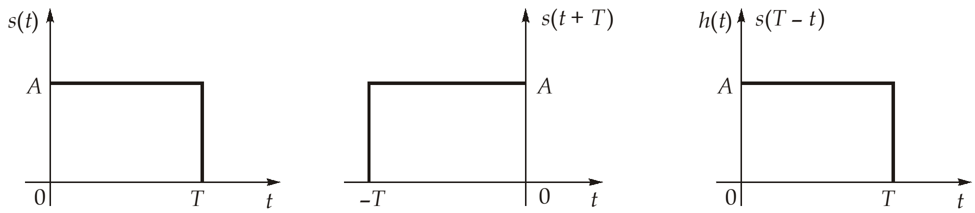
$$= \int_0^{10} 8\,dt = 80$$

$\because E[X(t)] = 8$

20. **(c)**

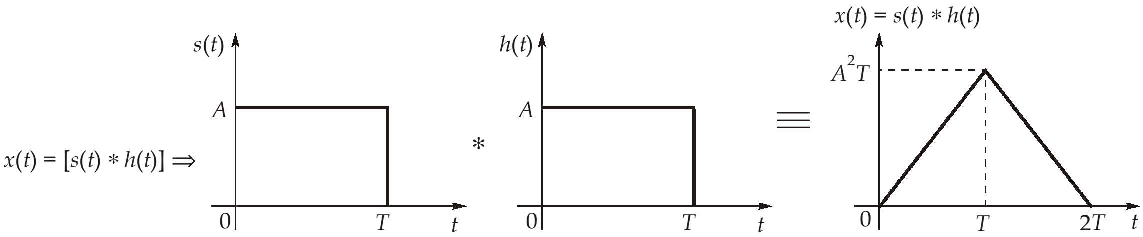


$$h(t) = s(T - t)$$



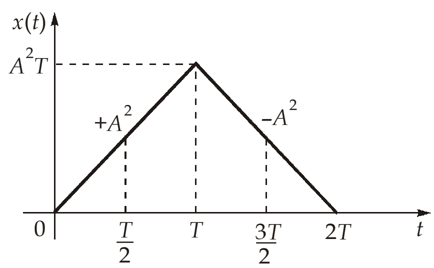
Given that, $c(t) = \delta(t) + \frac{1}{2}\delta\left(t - \frac{T}{2}\right)$

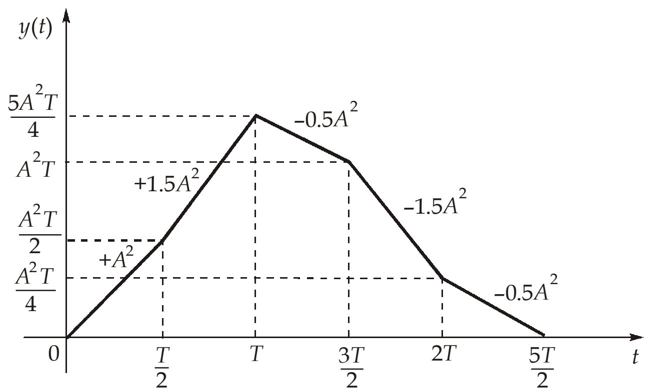
So, $y(t) = s(t) * c(t) * h(t) = [s(t) * h(t)] * c(t)$

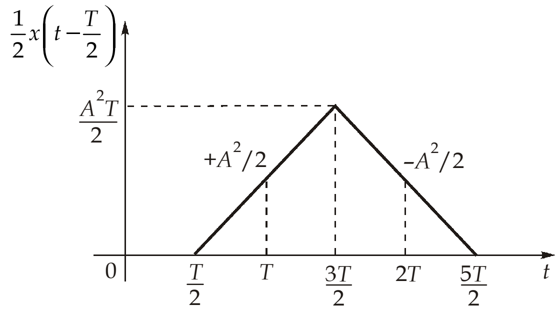


$$y(t) = x(t) * c(t)$$

$$= x(t) * \left[\delta(t) + \frac{1}{2}\delta\left(t - \frac{T}{2}\right)\right] = x(t) + \frac{1}{2}x\left(t - \frac{T}{2}\right)$$







So, the peak value of the filter output is,

$$y_{\max} = \frac{5}{4}A^2T$$

21. (b)

$$f_{m(\max)} = 15 \text{ kHz}$$

Sampling rate, $f_s = 2f_{m(\max)} = 30$ kHz

Bits/sample, $n = \log_2(256) = 8$ bits/sample

Bit rate, $R_b = nf_s = 240$ kbps

Theoretical minimum channel BW required is,

$$(\text{BW})_{\min} = \frac{R_b}{2} = 120 \text{ kHz}$$

22. (b)

$$H(X) = -\sum_{i=0}^{2} P(x_i)\log_2 P(x_i)$$
$$= -[0.25\log_2(0.25) + 0.25\log_2(0.25) + 0.50\log_2(0.50)] \text{ bits/symbol}$$
$$= [0.50\log_2(4) + 0.50\log_2(2)] \text{ bits/symbol}$$
$$= 1.50 \text{ bits/symbol}$$

23. (d)

$$P(y_0|x_0) = (0.8 \times 0.9) + (0.2 \times 0.2) = 0.72 + 0.04 = 0.76$$
$$P(y_0|x_1) = (0.1 \times 0.9) + (0.9 \times 0.2) = 0.09 + 0.18 = 0.27$$
$$P(y_0) = P(y_0|x_0)P(x_0) + P(y_0|x_1)P(x_1)$$
$$= (0.76)\,(0.60) + (0.27)\,(0.40) = 0.456 + 0.108 = 0.564$$

24. (c)

$$H(X) = H(X|A)\,P(A) + H(X|B)\,P(B) + H(X|C)\,P(C)$$
$H(X|A)$ = Entropy of the probabilities {0, 1, 0} = 0 bits/symbol
$H(X|B)$ = Entropy of the probabilities {0, 0.50, 0.50} = 1 bits/symbol
$H(X|C)$ = Entropy of the probabilities {0, 1, 0} = 0 bits/symbol
$$P(A) = P(A|A)\,P(A) + P(A|B)\,P(B) + P(A|C)\,P(C) = 0.50\,P(B)$$
$$P(C) = P(C|A)\,P(A) + P(C|B)\,P(B) + P(C|C)\,P(C) = 0.50\,P(B)$$
$$P(A) + P(B) + P(C) = 0.50P(B) + P(B) + 0.50P(B) = 1 \Rightarrow P(B) = 0.50$$
$$P(A) = P(C) = 0.50P(B) = 0.25$$

So, $H(X) = [0 \times P(A)] + [1 \times P(B)] + [0 \times P(C)]$ bits/symbol

$$= 1 \times P(B) = 1 \times 0.50 = 0.50 \text{ bits/symbol}$$

25. (b)

Let, the bit rate at the output of information source is R_b and at the output of channel encoder is R_c.

For error-free transmission,

$$R_c \le C$$

$$R_{c(\max)} = C = B\log_2(1 + \text{SNR})$$

$$= 50\log_2(1 + 127)\,\text{kbps} = 50\log_2(128)\text{ kbps}$$

$$= 350\text{ kbps}$$

For a (7, 4) Hamming code,

$$R_c = \frac{7}{4}R_b$$

So,

$$\frac{7}{4}R_{b(\max)} = R_{c(\max)} = 350\text{ kbps}$$

$$R_{b(\max)} = \frac{4}{7}\times 350 = 200\text{ kbps}$$

26. (b)

The channel capacity of an AWGN channel can be given by,

$$C = B\log_2(1 + \text{SNR})$$

Given that, B = 4 kHz and SNR = 1023.

So, $C = 4\log_2(1 + 1023)$ kbps = 40 kbps

For error-free transmission, $R_b \le C$.

So, $R_{b(\max)} = C = 40$ kbps

Bit rate, $R_b = R_s H(X)$; R_s = symbol rate

Entropy, $H(X) = \log_2(32) = 5$ bits/symbol

∵ symbols are equiprobable

So, $R_{s(\max)}\, H(X) = R_{b(\max)} = 40$ kbps

Maximum symbol rate,

$$R_{s(\max)} = \frac{R_{b(\max)}}{H(X)} = \frac{40\times 1000\text{ bits/sec}}{5\text{ bits/symbol}} = 8000\text{ symbols/sec}$$

27. (b)

When $m(t)$ is applied as message signal:

$m(t)$ is bandlimited to, $f_1 = 4$ kHz

BW of FM signal, $B_1 = 200$ kHz

$$B_1 = (1 + D_1)2f_1 \;;\; D_1 = \text{deviation ratio}$$

$$(1 + D_1) = \frac{B_1}{2f_1} = \frac{200}{8} = 25$$

$$D_1 = \frac{\Delta f_{\max(1)}}{f_1} = 24$$

When $m(2t)$ is applied as message signal:

$m(2t)$ is bandlimited to, $f_2 = 2f_1 = 8$ kHz

$$|m(2t)|_{\max} = |m(t)|_{\max}$$

So,

$$\Delta f_{\max(2)} = k_f\,|m(2t)|_{\max} = k_f\,|m(t)|_{\max} = \Delta f_{\max(1)}$$

$$D_2 = \frac{\Delta f_{max(2)}}{f_2} = \frac{\Delta f_{max(1)}}{2 f_1} = \frac{D_1}{2} = 12$$

Bandwidth, $B_2 = (1 + D_2)f_2 = (1 + 12)\ (2)\ (8)$ kHz

$= 208$ kHz

28. (b)

The standard form of an FM signal can be given as,

$$s(t) = A_c \cos\left[2\pi f_c t + 2\pi k_f \int_{-\infty}^{t} m(t)\,dt\right]$$

The maximum phase deviation of the FM signal can be given as,

$$\Delta\phi_{max} = 2\pi k_f \left|\int_{-\infty}^{t} m(t)\,dt\right|_{max}$$

Since $m(t)$ has only positive values,

$$\left|\int_{-\infty}^{t} m(t)\,dt\right|_{max} = \text{Area under } m(t) = 4 \times 2 = 8 \text{ V-sec}$$

$$\Delta\phi_{max} = 2\pi k_f \left|\int_{-\infty}^{t} m(t)\,dt\right|_{max}$$

$$= 2\pi\,(0.5 \text{ Hz/V})\ (8 \text{ V-sec}) \text{ rad} = 2\pi\,(0.5)\ (8) \text{ rad} = 8\pi \text{ rad}$$

29. (d)

For a uniform quantizer, the maximum quantization error is $\frac{\Delta}{2}$.

So, $\frac{\Delta}{2} \le \frac{0.1}{100}(a)$; Where, Δ = step-size

$$\Delta \le \frac{a}{500}$$

$$\frac{2a}{2^n} \le \frac{a}{500} \quad \text{...(i)}$$

$\because$ $\Delta = \frac{a-(-a)}{L} = \frac{2a}{2^n}$

Where, L = Number of quantization levels and n = number of bits per sample.

So, from equation (i), $2^n \ge 1000$

$n \ge 10$

$\because$ n can be an integer only

$$n_{min} = 10$$

30. (b)

Given,
$$m(t) = 10 \cos 16 \pi t$$

$$u(t) = 10\cos\left[4000\pi t + 2\pi K_f \int_{-\infty}^{t} m(\tau)d\tau\right]$$

$$\text{modulation index, } \beta = \frac{K_f \cdot A_m}{f_m}$$

where,
$$A_m = 10 \text{ V}$$
$$f_m = 8 \text{ Hz}$$

$\therefore$
$$\beta = \frac{10 \times 10}{8} = 12.5$$

$\therefore$ Output of FM modulator can be written as,

$$u(t) = 10\cos\left[2\pi \times 2000 \times t + 2\pi K_f \int_{-\infty}^{t} 10\cos(2\pi \times 8\tau)\,d\tau\right]$$

$$= \sum_{n=-\infty}^{\infty} 10 J_n(\beta)\cos\left(2\pi(2000 + n \cdot 8)t + \phi_n\right)$$

The BPF passes the frequencies in the range 1969 Hz to 2031 Hz. At the output of BPF, the frequency components of signal present are (2000 – 24), (2000 – 16), (2000 – 8), 2000, (2000 + 8), (2000 + 16) and (2000 + 24) Hz. These components are the terms of $u(t)$ for which, n = –3, ..., 3. The power of the output signal is then,

$$P_{SB} = \frac{10^2}{2} J_0^2(\beta) + 2\sum_{n=1}^{3} \frac{10^2}{2} J_n^2(\beta)$$

where,
$$\beta = 12.5$$

$$= \frac{10^2}{2} J_0^2(12.5) + 2\sum_{n=1}^{3} \frac{10^2}{2} J_n^2(12.5)$$

$$= 2\left[50 \times \left[J_1^2(12.5) + J_2^2(12.5) + J_3^2(12.5)\right]\right]$$

$$P_{SB} = 100[(0.2)^2 + (0.3)^2 + (0.25)^2]$$
$$P_{SB} = 19.25 \text{ W}$$

Since the total transmitted power is, $P_{tot} = \frac{10^2}{2} = 50 \text{ W}$, the power at the output of BPF is 19.25 W (38.5%) of the transmitted power.

■■■■