## 7.1 Amplitude Modulation

**Statement for Q.1-3.**

An AM signal is represented by

$$v_c(t) = (10 + 4\sin 1000\pi t)\cos(2\pi \times 10^6 t) \text{ V}$$

**1.** The modulation index is

(A) 10 (B) 4

(C) 0.4 (D) 2.5

**2.** The total signal power is

(A) 108 W (B) 116 W

(C) 100 W (D) 132 W

**3.** The total side band power is

(A) 8 W (B) 16 W

(C) 0 W (D) 32 W

**4.** A 1 kW carrier is to be modulated to a 80% level. The total transmitted power would be

(A) 2 kW (B) 1.32 kW

(C) 1.4 kW (D) None of the above

**5.** An AM broadcast station operates at its maximum allowed total output of 100 kW with 90% modulation. The power in the intelligence part is

(A) 28.8 kW (B) 71.2 kW

(C) 35.6 kW (D) None of the above

**6.** The aerial current of an AM transmitter is 16 A when unmodulated but increases to 18 A when modulated. The modulation index is

(A) 0.73 (B) 0.63

(C) 0.89 (D) None of the above

**7.** A modulating signal is amplified by a 80% efficiency amplifier before being combined with a 10 kW carrier to generate an AM signal. The required DC input power to the amplifier, for the system to operate at 100% modulation, would be

(A) 5 kW (B) 8.46 kW

(C) 10 kW (D) 6.25 kW

**8.** A 2 MHz carrier is amplitude modulated by a 500 Hz modulating signal to a depth of 60%. If the unmodulated carrier power is 1 kW, the power of the modulated signal is

(A) 1.83 kW (B) 1.36 kW

(C) 1.18 kW (D) 1.26 kW

**9.** An AM transmitter is coupled to an aerial. The input current is observed to be 5 A. With modulation the current value increases to 5.9 A. The depth of modulation is

(A) 83.4 % (B) 88.6 %

(C) 78.2 % (D) 74.3 %

**10.** A carrier is amplitude modulate to 100 % by a polar rectangular signal as shown in fig. P7.1.10. The percentage increase in signal power is

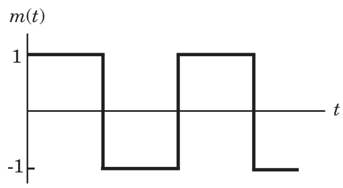



Fig. P7.1.10

(A) 83.3 % (B) 100 %

(C) 50 % (D) None of the above

**11.** A carrier is amplitude modulated by two sinusoidal signals of different frequencies with individual modulation depths of 0.3 and 0.4. The power in side band would be

(A) 12 % (B) 9 %

(C) 11.1 % (D) 10 %

**12.** In 50 % modulated AM signal, the carrier is suppressed before transmission. The saving in transmitted power would be

(A) 88.9 % (B) 11.1 %

(C) 72 % (D) 18 %

**13.** A 20 kW carrier is sinusoidally modulated by two carriers corresponding to a modulation index of 30 % and 40 % respectively. The total radiated power is

(A) 25 kW (B) 22.5 kW

(C) 30 kW (D) 35 kW

**14.** In a broadcast transmitter, the RF output is represented as

$$x_c(t) = 100[1 + 0.9\cos 5000t + 0.3\sin 9000t]\cos(6\times10^6 t) \text{ V.}$$

The sidebands frequencies are

(A) 5.991, 5.995, 6.005, 6.009 MHz

(B) 953.5, 954.1, 955.7, 956.4 kHz

(C) 5, 9 kHz

(D) 795.8, 432.4 Hz

**15.** A diode detector has a load of 1 kΩ shunted by a 10000 pF capacitor. The diode has a forward resistance of 1 Ω. The maximum permissible depth of modulation, so as to avoid diagonal clipping, with modulating signal frequency of 10 kHz will be

(A) 0.847 (B) 0.628

(C) 0.734 (D) None of the above

**16.** 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 %

**17.** A message signal is periodic with period $T$, as shown in fig. P7.1.17. This message signals is applied to an AM modulator with modulation index $\beta = 0.4$. The modulation efficiency would be

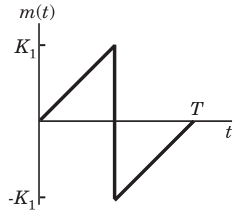



Fig. P7.1.17

(A) 51 % (B) 11.8 %

(C) 5.1 % (D) None of the above

**Statement for Q.18-21:**

The fig. P1.7.18-21 shows the positive portion of the envelope of the output of an AM modulator .The message signal is a waveform having zero DC value.

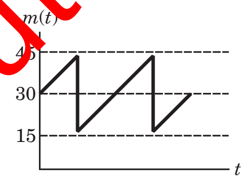



Fig. P7.1.18-21

**18.** The modulation index is

(A) 0.5 (B) 0.6

(C) 0.4 (D) 0.8

**19.** The modulation efficiency is

(A) 8.3% (B) 14.28%

(C) 7.69% (D) None of the above

**20.** The carrier power is

(A) 60 W (B) 450 W

(C) 30 W (D) 900 W

**21.** The power in sidebands is

(A) 85 W (B) 42.5 W

(C) 56 W (D) 37.5 W

**Statement for Q.22-23:**

An AM modulator operates with the message signal $m(t) = 9\cos 20\pi t + 7\cos 60\pi t$. The unmodulated carrier is given by $100\cos 200\pi t$, and the system operates with an index of 0.5.

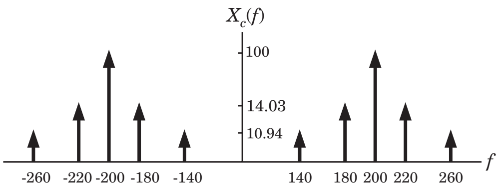
**22.** The power in normalized message signal $m_n(t)$ would be

(A) 0.693 (B) 0.542

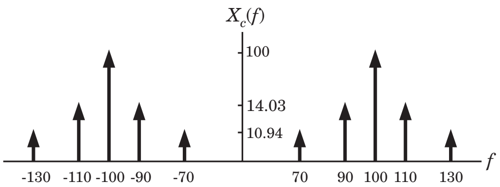
(C) 0.254 (D) None of the above

**23.** The double-sided spectrum of $x_c(t)$ would be

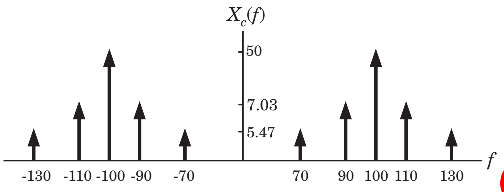
(A)




(B)




(C)




(D) None of the above

**24.** An AM modulator has output

$$x_c(t) = 40\cos 400\pi t + 4\cos 360\pi t + 4\cos 440\pi t$$

The modulation efficiency is

(A) 0.01 (B) 0.02

(C) 0.03 (D) 0.04

**25.** 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

**Statement for Q.26-27:**

Consider the system shown in fig. P7.1.26-27. The average value of $m(t)$ is zero and maximum value of $|m(t)|$ is $M$. The square-law device is defined by $y(t) = 4x(t) + 10x^2(t)$

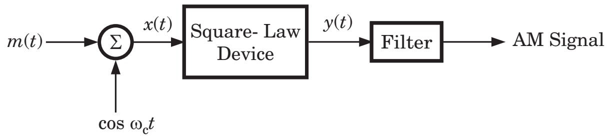



Fig. P7.1.26-27

**26.** The value of $M$, required to produce modulation index of 0.8, is

(A) 0.32 (B) 0.26

(C) 0.52 (D) 0.16

**27.** Let $W$ be the BW of message signal $m(t)$. AM signal would be recovered if.

(A) $f_c > W$ (B) $f_c > 2W$

(C) $f_c > 3W$ (D) $f_c > 4W$

**28.** A super heterodyne receiver is designed to receive transmitted signals between 5 and 10 MHz. High-side tuning is to be used. The tuning range of the local oscillator for IF frequency 500 kHz would be

(A) 4.5 MHz– 9.5 MHz

(B) 5.5 MHz – 10.5 MHz

(C) 4.5 MHz – 10.5 MHz

(D) None of the above

**29.** A super heterodyne receiver uses an IF frequency of 455 kHz. The receiver is tuned to a transmitter having a carrier frequency of 2400 kHz. High-side tuning is to be used. The image frequency will be

(A) 2855 kHz (B) 3310 kHz

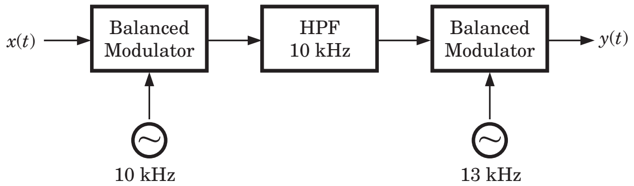
(C) 1945 kHz (D) 1490 kHz

**30.** A super heterodyne 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

**31.** Consider a system shown in fig. P7.1.31. Let $X(f)$ and $Y(f)$ denote the Fourier transform of $x(t)$ and $y(t)$ respectively. The positive frequencies where $Y(f)$ has spectral peak are



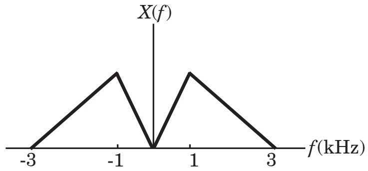




Fig. P7.1.31b

(A) 1 kHz and 24 kHz (B) 2 kHz and 24 kHz

(C) 1 kHz and 14 kHz (D) 2 kHz and 14 kHz

**32.** In fig. P7.1.32, $m(t)=\frac{2\sin 2\pi t}{t}$, $s(t)=\cos 200\pi t$ and $n(t)=\frac{\sin 199\pi t}{t}$. The output $y(t)$ is

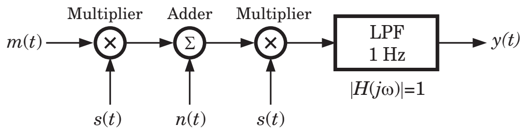



Fig. P7.1.32

(A) $\frac{\sin 2\pi t}{2t}$

(B) $\frac{\sin 2\pi t}{2t}+\frac{\sin \pi t}{t}\cos 3\pi t$

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

(D) $\frac{\sin 2\pi t}{2t}+\frac{\sin \pi t}{t}\cos 0.75\pi t$

**33.** In the circuit shown in fig. P7.1.33 between the terminal 1 and 2 an a.c. voltage source of frequency 400 Hz is connected. Another a.c. voltage of 1.0 MHz is connected between 3 and 4. The output between 5 and 6 contains components at

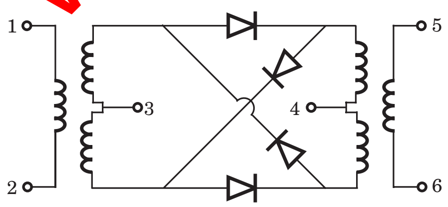



Fig. P7.1.33

(A) 400 Hz, 1 MHz, 1000.4 kHz, 999.6 kHz

(B) 1 MHz, 1000.4 kHz, 999.6 kHz

(C) 400 Hz, 1000.4 kHz, 999.6 kHz

(D) 1000.4 kHz, 999.6 kHz

**34.** 12 signals each band-limited to 5 kHz are to be transmitted over a single channel by frequency division multiplexing . If AM-SSB modulation guard band of 1 kHz is used, then the band width of the multiplexed signal will be

(A) 131 kHz (B) 81 kHz

(C) 121 kHz (D) 71 kHz

**35.** Let $x(t)$ be a signal band-limited to 1 kHz. Amplitude modulation is performed to produce signal $g(t)=x(t)\sin 2000\pi t$. A proposed demodulation technique is illustrated in fig. P7.1.35. The ideal low pass filter has cutoff frequency 1 kHz and pass band gain 2. The $y(t)$ would be

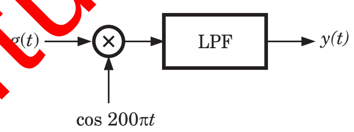



Fig. P7.1.35

(A) $2y(t)$ (B) $y(t)$

(C) $\frac{y(t)}{2}$ (D) 0

**36.** Suppose we wish to transmit the signal $x(t)=\sin 200\pi t+2\sin 400\pi t$ using a modulation that create the signal $g(t)=x(t)\sin 400\pi t$. If the product $g(t)\sin 400\pi t$ is passed through an ideal LPF with cutoff frequency 400π and pass band gain of 2, the signal obtained at the output of the LPF is

(A) $\sin 200\pi t$ (B) $\frac{1}{2}\sin 200\pi t$

(C) $2\sin 200\pi t$ (D) 0

**37.** In a AM signal the received signal power is $10^{-10}$ W with a maximum modulating signal of 5 kHz. The noise spectral density at the receiver input is $10^{-18}$ W/Hz. If the noise power is restricted to the message signal bandwidth only, the signals-to-noise ratio at the input to the receiver is

(A) 43 dB (B) 66 dB

(C) 56 dB (D) 33 dB

************

# Solutions

**1.** (C) $v_c(t) = 10[1 + 0.4 \sin(1000\pi t) \cos(2\pi \times 10^6 t)]$ V

$\beta = 0.4$

**2.** (A) $P_t = P_c\left(1 + \frac{\beta^2}{2}\right)$, $P_c = (10)^2 = 100$ , $\beta = 0.4$

$$P_t = 100\left(1 + \frac{(0.4)^2}{2}\right) = 108 \text{ W}$$

**3.** (A) $P_t = 108$ , $P_c = 100$ , $P_{sb} = 108 - 100 = 8$ W

**4.** (B) $P_t = P_c\left(1 + \frac{\beta^2}{2}\right) = 1000\left(1 + \frac{(0.8)^2}{2}\right) = 1.32$ kW

**5.** (A) $P_t = P_c\left(1 + \frac{\beta^2}{2}\right)$

$$\Rightarrow \quad 100 \times 10^3 = P_c\left(1 + \frac{(0.9)^2}{2}\right)$$

$\Rightarrow \quad P_c = 71.2$ kW

$P_i = (P_t - P_c) = (100 - 71.2) = 28.8$ kW

**6.** (A) $I_t = I_c\left(1 + \frac{\beta^2}{2}\right)^{\frac{1}{2}}$

$$\Rightarrow \quad 18 = 16\left(1 + \frac{\beta^2}{2}\right)^{\frac{1}{2}} \quad \Rightarrow \quad \beta = 0.73$$

**7.** (D) $P_t = 10\text{k}\left(1 + \frac{1}{2}\right)$, $P_t = 15$ kW

$P_i = 15 - 10 = 5$ kW

The DC input power $= \frac{5}{0.8} = 6.25$ kW

**8.** (C) $P_c = 1$ kW , $\beta = 60\ \% = 0.6$

$$P_t = P_c\left(1 + \frac{\beta^2}{2}\right)^{\frac{1}{2}} = 1\left(1 + \frac{(0.6)^2}{2}\right) = 1.18 \text{ kW}$$

**9.** (B) $I_t = I_c\left(1 + \frac{\beta^2}{2}\right)^{\frac{1}{2}}$,

$$\Rightarrow \quad 5.9 = 5\left(1 + \frac{\beta^2}{2}\right)^{\frac{1}{2}} \quad \Rightarrow \quad \beta = 0.886, \text{ depth } = 88.6\%$$

**10.** (B) $\beta = 1.0$ or 100%

The modulating signal $m(t)$ assumes any of the two values +1, or –1, with $m(t)$ being a poler rectangular signal so

$\beta^2 m^2(t) = 1$ , $P_t = P_c[1 + \beta^2 m^2(t)] = 2P_c$

% increase = 100%

**11.** (C) Let $P_c$ be the carrier power.

Total side band power $= \beta^2\ \overline{x^2(t)} P_c$

where $\beta x(t) = 0.3 \cos \omega_1 t + 0.4 \cos \omega_2 t$

$\beta^2\ \overline{x^2(t)} = \overline{(0.3 \cos \omega_1 t + 0.4 \cos \omega_2 t)^2}$

$= \frac{1}{2}((0.3)^2 + (0.4)^2) = 0.125$

$2P_{sb} = 0.125 P_c$

$P_t = P_c + 0.125 P_c = 1.125 P_c$

% side-band power $= \frac{0.125 P_c}{1.125 P_c} = 11.1\%$

**12.** (A) $\beta = \frac{50}{100} = 0.5$

$$P_t = P_c\left(1 + \frac{\beta^2}{2}\right)^{\frac{1}{2}} = P_c\left(1 + \frac{(0.5)^2}{2}\right)$$

$P_t = 1.125 P_c$

Saving will be $P_c$ if carrier is suppressed.

Saving $= \frac{P_c}{1.125 P_c} = 89.9\ \%$

**13.** (B) $P_t = P_c\left(1 + \frac{\beta_1^2}{2} + \frac{\beta_2^2}{2}\right)$, $\beta_1 = 0.3$ , $\beta_2 = 0.4$

$$P_t = 20\left(1 + \frac{0.09}{2} + \frac{0.16}{2}\right) = 22.5 \text{ kW}$$

**14.** (B) Side band frequencies are,

$(6 \times 10^6 \pm 5000)$ rad and $(6 \times 10^6 \pm 9000)$ rad

$\omega_{sb}$ = 5.995, 6.005, 5.991 and 6.009 MHz

$f_{sb} = \frac{\omega_{sb}}{2\pi} = 953.5, 955.7, 954.1, 956.4$ kHz

**15.** (A) $f_m$ = 10 kHz , $R = 1000\ \Omega$ , $C = 10000$ pF

Hence $2\pi f_m RC = 2\pi \times 10^4 \times 10^3 \times 10^{-8} = 0.628$

$\beta_{max} = (1 + (0.628)^2)^{-\frac{1}{2}} = 0.847$

**16.** (C) $v_i(t) = \cos \omega_c t + 0.5 \cos \omega_m t$

$i = 10 + 2(\cos \omega_c t + 0.5 \cos \omega_m t) + 0.2(\cos \omega_c t + 0.5 \cos \omega_m t)^2$

The AM signal

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

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

**17.** (C) The normalized message signal is

$m(t) = \frac{2}{T}\,t, \quad 0 < t \le \frac{T}{2}$

$\overline{m^2(t)} = \frac{2}{T}\int_0^{T/2}\left(\frac{2}{T}t\right)^2 dt = \frac{1}{3}$

$E_{eff} = \frac{\beta^2\,\overline{m^2(t)}}{1+\beta^2\,\overline{m^2(t)}} = \frac{(0.4)^2\frac{1}{3}}{1+(0.4)^2\frac{1}{3}} = 5.1\%$

**18.** (A) $A_c(1+\beta) = 45, \quad A_c(1-\beta) = 15$

$\frac{1+\beta}{1-\beta} = 3 \quad \Rightarrow \quad \beta = 0.5$

**19.** (C) Normalized message

$m_n(t) = \frac{2}{T}t, \quad 0 \le t \le \frac{T}{2}$

$\overline{m_n^2(t)} = \frac{2}{T}\int_0^{T/2}\left(\frac{2}{T}t\right)^2 dt = \frac{1}{3}$

$E_{eff} = \frac{(0.5)^2\frac{1}{3}}{1+(0.5)^2\frac{1}{3}} = 7.69\ \%$

**20.** (B) $A_c(1+0.5) = 45 \quad \Rightarrow \quad A_c = 30$ ,

carrier power is $P_c = \frac{1}{2}A_c^2 = 450$ W

**21.** (D) $E_{eff} = \frac{P_{sb}}{P_c + P_{sb}} = 0.0769$

$P_{sb} = \frac{0.0769}{1-0.0769}P_c = \frac{0.0769}{0.9231}\times 450 = 37.5$ W

**22.** (C) The maximum value of $m(t) = 16$

$m_n(t) = \frac{1}{16}(9\cos 20\pi t + 7\cos 60\pi t)$

$\overline{m_n^2(t)} = \left(\frac{1}{16}\right)^2\left(\frac{9^2}{2} + \frac{7^2}{2}\right) = 0.254$ W

**23.** (B)

$x_c(t) = 100\left(1 + \frac{1}{16}\frac{1}{2}(9\cos 20\pi t + 7\cos 60\pi t)\right)\cos 200\pi t$

$= 10.94\cos(140\pi t) + 14.06\cos(180\pi t) + 100\cos(200\pi t) + 14.06\cos(220\pi t) + 10.94\cos(260\pi t)$

$= 5.47(e^{j(140\pi t)} + e^{-j(140\pi t)}) + 7.03(e^{j(180\pi t)} + e^{-j(180\pi t)}) + 50(e^{j(200\pi t)} + e^{-j(200\pi t)}) + 7.03(e^{j(220\pi t)} + e^{-j(220\pi t)}) + 5.47(e^{j(260\pi t)} + e^{-j(260\pi t)})$

Hence (B) is correct option.

**24.** (B) $x_c(t)$ can be written as

$x_c(t) = (40 + 8\cos 40\pi t)\cos 400\pi t$

modulation index $\beta = \frac{8}{40} = 0.2$

$P_c = \frac{1}{2}(40)^2 = 800$ W

The components at 180 Hz and 220 Hz are side band

$P_{sb} = \frac{1}{2}(4)^2 + \frac{1}{2}(4)^2 = 16$ W

$E_{eff} = \frac{P_{sb}}{P_c + P_{sb}} = \frac{16}{800+16}$

**25.** (A) Carrier power $P_c = \frac{A^2}{2} = 100$ W , $A = 14.14$

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

$P_{sb} = 66.67$ W

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

**26.** (D) $y(t) = 4(m(t) + \cos\omega_c t) + 10(m(t) + \cos\omega_c t)^2$

$= 4m(t) + 4\cos\omega_c t + 10m^2(t) + 20m(t)\cos\omega_c t + 5 + 5\cos 2\omega_c t$

$y(t) = 5 + 4m(t) + 10m^2(t) + 4(1 + 5m(t))\cos\omega_c t + 5\cos 2\omega_c t$

The AM signal is,

$x_c(t) = 4[1 + 5m(t)]\cos\omega_c t$

$m(t) = Mm_n(t)$

$x_c(t) = 4[1 + 5Mm_n(t)]\cos\omega_c t$

$5M = 0.8$ , $M = 0.16$

**27.** (C) The filter characteristic is shown is fig. S7.1.17

$f_c - W > 2W \quad \Rightarrow \quad f_c > 3W,\ f_c + W < 2f_c \quad \Rightarrow \quad f_c > W$

Therefore $f_c > 3W$.

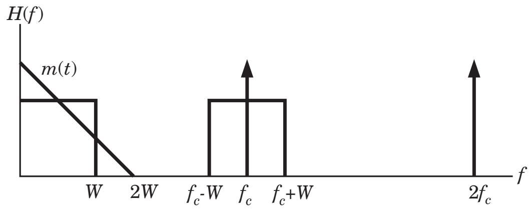



Fig. S7.1.27

**28.** (B) Since High-side tuning is used, $f_{LO} = f_m + f_{IF}$

$f_{IF} = 500$ kHz,

$f_{LOL} = 5 + 0.5 = 5.5$ MHz, $f_{LOU} = 10 + 0.5 = 10.5$ MHz

**29.** (B) $f_{image} = f_L + 2f_{IF} = 2400 + 2\times 455 = 3310$ kHz

**30.** (A) $f_{max} = 1650 + 450 = 2100$ kHz

$f_{min} = 550 + 450 = 1000$ kHz

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

When frequency is minimum, capacitance will be maximum

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

**31.** (B) Since $X(f)$ has spectral peak at 1 kHz so at the output of first modulator spectral peak will be at $(10k + 1k)$ Hz and $(10k - 1k)$ Hz. After passing the HPF frequency component of 11 kHz will remain. The output of 2nd modulator will be $(13k \pm 11k)$ Hz. So $Y(f)$ has spectral peak at 2 k and 24 kHz.

**32.** (C) $m(t)s(t) = y_1(t) = \dfrac{2\sin(2\pi t)\cos(200\pi t)}{t}$

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

$$y_1(t) + n(t) = y_2(t) = \frac{\sin 202\pi t - \sin 198\pi t}{t} + \frac{\sin 198\pi t}{t}$$

$$y_2(t)\, s(t) = y(t) = \frac{[\sin 202\pi t - \sin 198\pi t + \sin 199\pi t]\cos 200\pi t}{t}$$

$$= \frac{1}{2t}[\sin(402\pi t) + \sin(2\pi t) - \{\sin(398\pi t) - \sin(2\pi t)\}$$

$$+ \sin(399\pi t) - \sin(\pi t)]$$

After filtering

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

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

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

**33.** (D) The given circuit is a ring modulator. The output is DSB-SC signal. So it will contain $m(t)\cos(n\omega_c t)$ where $n = 1, 2, 3......$

Therefore there will be only (1 MHz±400 Hz) frequency component.

**34.** (D) The total signal bandwidth $= 5 \times 12 = 60$ kHz

There would be 11 guard band between 12 signal. So guard band width $= 11$ kHz

Total band width $= 60 + 11 = 71$ kHz

**35.** (D) $x_1(t) = g(t)\cos(2000\pi t)$

$$= x(t)\sin(2000\pi t)\cos(2000\pi t) = \frac{1}{2}x(t)\sin(4000\pi t)$$

$$X_1(j\omega) = \frac{1}{4j}X(j(\omega - 4000\pi)) - X(j(\omega + 4000\pi))$$

This implies that $X_1(j\omega)$ is zero for $|\omega| \le 2000\pi$ because $\omega < 2\pi f_m = 2\pi 1000$. When $x_1(t)$ is passed through a LPF with cutoff frequency $2000\pi$, the output will be zero.

**36.** (A) $y(t) = g(t)\sin(400\pi t) = x(t)\sin^2(400\pi t)$

$$= (\sin(200\pi t) + 2\sin(400\pi t))\frac{(1 - \cos(800\pi t))}{2}$$

$$= \frac{1}{2}[\sin(200\pi t) - \sin(200\pi t)\cos(800\pi t)$$

$$+ 2\sin(400\pi t) - \sin(400\pi t)\cos(800\pi t)]$$

$$= \frac{1}{2}\sin(200\pi t) - \frac{1}{4}[\sin(1000\pi t) - \sin(600\pi t)]$$

$$+ \sin(400\pi t) - \frac{1}{4}[\sin(1200\pi t) - \sin(400\pi t)]$$

If this signal is passed through LPF with frequency $400\pi$ and gain 2, the output will be $\sin(200\pi t)$.

**37.** (A) Message signal BW $f_m = 5$ kHz

Noise power density $= 10^{-18}$ W/Hz.

Total noise power $= 10^{-18} \times 5k = 5 \times 10^{-15}$ W

Input signal-to-noise ratio

$$\text{SNR}_i = \frac{10^{-10}}{5 \times 10^{-15}} = 2 \times 10^4$$

$$\text{SNR}_i = 10\log_{10} 2 \times 10^4 = 43 \text{ dB}$$

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