A sinusoidal carrier has an amplitude of 10V and freq 30KHz. It is amplitude modulated by a sinusoidal voltage of amplitude 3V and frequency 1KHz. Modulated voltage is developed across 50 Ω

[12 Marks]

1. Write eqn of modulated wave
2. Plot modulated wave showing maxima & minima
3. Determine modulation Index
4. Draw the spectrum of modulated wave
5. Calculate total power
6. Calculate power carried by sidebands

Solution

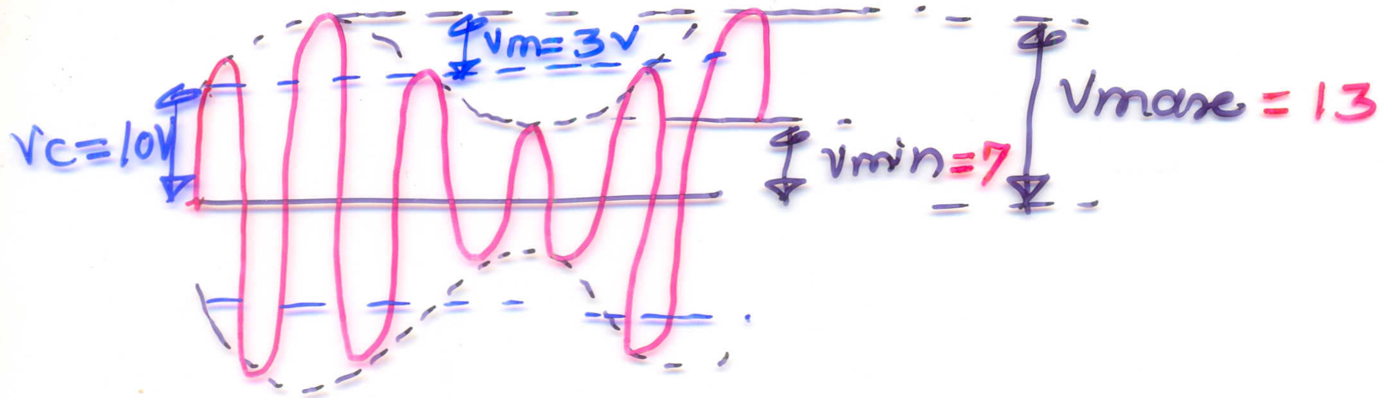
$V_c = 10V, \quad V_m = 3V$

$m = \frac{V_m}{V_c} = \frac{3}{10} = 0.3, \quad \boxed{m = 0.3}$

$f_m = 1KHz, \quad f_c = 30KHz$

$$v = V_c \sin \omega_c t + \frac{mV_c}{2} \cos(\omega_c - \omega_m)t - \frac{mV_c}{2} \cos(\omega_c + \omega_m)t$$

$$\boxed{v = 10 \sin(60\pi \times 10^3)t + 1.5 \cos(58\pi \times 10^3)t - 1.5 \cos(62\pi \times 10^3)t}$$



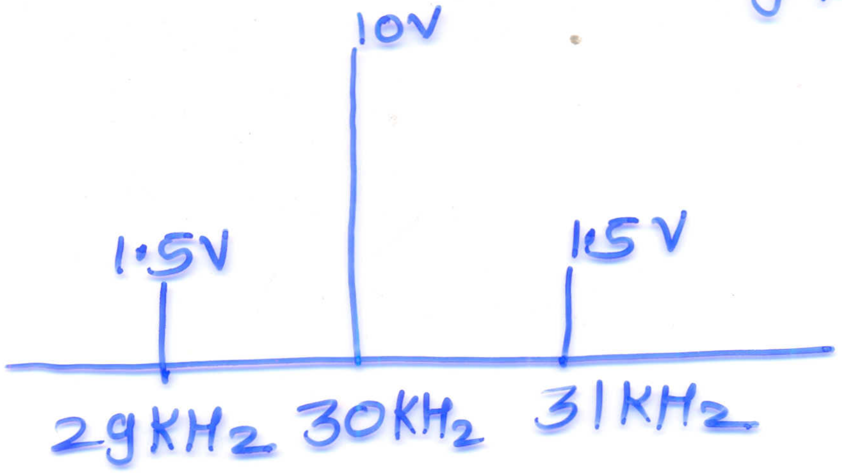
$V_{max} = V_c + V_m = 10 + 3 = 13$

$V_{min} = V_c - V_m = 10 - 3 = 7$

Spectrum of modulated wave

$f_c + f_m = 30 + 1 = 31\,KHz$

$f_c - f_m = 30 - 1 = 29\,KHz$



$P_T = P_c(1 + m^2/2)$

$P_c = \dfrac{V_c^2}{2R} = \dfrac{10 \times 10}{2 \times 50} = 1W$

$P_T = 1\left(1 + \dfrac{(0.3)^2}{2}\right) = 1.045\ \text{watt}$

$\boxed{P_T = 1.045\ \text{watt}}$

$\boxed{P_{SB} = P_T - P_c = 0.045\ W}$

$P_{LSB} = P_{USB} = 0.045/2 = 0.0225 W$

Antenna current of an AM T_x^r is 8 amp when only the carrier is sent, but increases to 8·93 Amp when carrier is modulated by a single sine wave. Find the percentage modulation. Determine the antenna current when the depth of modulation changes to 0·8

solution -

i) $\frac{I_t}{I_c} = \sqrt{1+\frac{m^2}{2}}$, $I_c = 8$ amp, $I_t = 8·93$ amp

$\left(\frac{I_t}{I_c}\right)^2 - 1 = \frac{m^2}{2}$, $m = \sqrt{2\left[\left(\frac{I_t}{I_c}\right)^2 - 1\right]}$

$m = \sqrt{2\left[\left(\frac{8·93}{8}\right)^2 - 1\right]}$

$= 0·7014471$

$\boxed{m = 70·1\,\%}$

ii) $m = 0·8$, $I_c = 8$ amp, $I_t = ?$

$I_t = I_c\sqrt{1+\frac{m^2}{2}}$

$= 8\sqrt{1+\frac{(0·8)^2}{2}}$

$\boxed{I_t = 9·19 \text{ Amp}}$

A certain Tx^r radiates 9 KW with the carrier unmodulated and 10.125 KW when the carrier is sinusoidally modulated. Calculate modulation index.

If another sine wave corresponding to 40% modulation is transmitted simultaneously, determine total radiated power.

1) $P_c = 9\text{ KW}$, $P_t = 10.125\text{ KW}$

$$\frac{P_t}{P_c} = 1 + \frac{m^2}{2}$$

$$\frac{10.125}{9} = 1 + \frac{m^2}{2}$$

$$\frac{10.125 - 9}{9} = \frac{m^2}{2}$$

$$m = \sqrt{\frac{1.125}{9} \times 2}$$

$$\boxed{m = 0.5}$$

2) $m_1 = 0.5$, $m_2 = 0.4$

$$m_t = \sqrt{m_1^2 + m_2^2} = \sqrt{(0.5)^2 + (0.4)^2}$$

$$m_t = \sqrt{0.25 + 0.16} = 0.64$$

$$\boxed{m_t = 0.64}$$

$$\frac{P_t}{P_c} = 1 + \frac{m_t^2}{2}$$

$$P_t = 9\left(1 + \frac{(0.64)^2}{2}\right)$$

$$= 9(1 + 0.205)$$

$$\boxed{P_t = 10.845\ KW}$$

A 360 W carrier is simultaneously modulated by two audio waves with modulation percentage of 55 and 65 respectively. What is total sideband power radiated.

6 marks

soln

$P_c = 360 W$

$m_1 = 0.55$, $m_2 = 0.65$

$$m_t = \sqrt{m_1^2 + m_2^2} = \sqrt{(0.55)^2 + (0.65)^2}$$

$$\boxed{m_t = 0.85}$$

$$P_{SBT} = \frac{P_c (m_t^2)}{2}$$

$$\boxed{P_{SBT} = 130 W}$$

The amplitude modulated waveform has the form

$$x(t) = 10(1 + 0.5\cos 2000\pi t + 0.5\cos 4000\pi t) \times \cos 20{,}000\pi t$$

(a) Sketch the amplitude spectrum of $x(t)$

(b) Find average power content of each spectral component including carrier

(c) Find the total power and sideband power

(d) What is the modulation index.

(08 Marks)

→

$$x(t) = 10(1 + 0.5\cos 2000\pi t + 0.5\cos 4000\pi t) \times \cos 20{,}000\pi t$$

This is the case of Amplitude modulation by several waves

$\boxed{m_1 = 0.5}$ $\boxed{m_2 = 0.5}$

$2\pi f_{m_1} = 2000\pi$

$\boxed{f_{m_1} = 1\,KHz}$

$2\pi f_{m_2} = 4000\pi$

$\boxed{f_{m_2} = 2\,KHz}$

$USB_1 = f_c + f_{m_1}$

$USB_1 = (10 + 1)\,KHz$

$\boxed{USB_1 = 11\,KHz}$

$2\pi f_c = 20{,}000\pi$

$\boxed{f_c = 10\,KHz}$

$USB_2 = f_c + f_{m2} = (10+2)\,kHz$

$\boxed{USB_2 = 12\,kHz}$

$LSB_1 = f_c - f_{m1} = (10-1)\,kHz$

$\boxed{LSB_1 = 9\,kHz}$

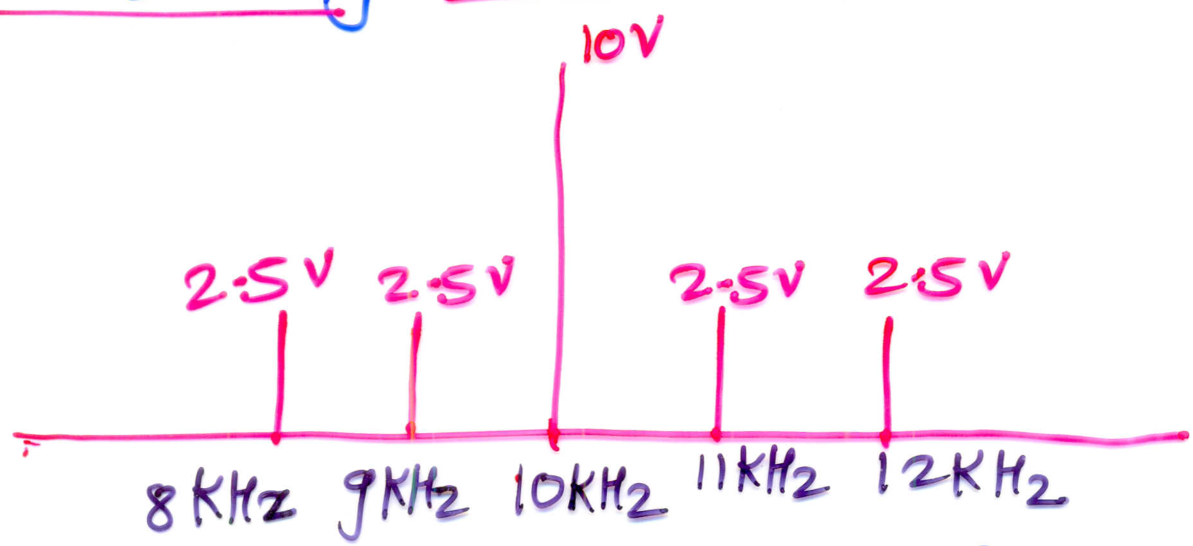
$LSB_2 = f_c - f_{m2} = (10-2)\,kHz$

$\boxed{LSB_2 = 8\,kHz}$

amplitude of sidebands $= \dfrac{mV_c}{2}$

$= \dfrac{0.5 \times 10}{2} = 2.5\,V$

frequency spectrum



carrier Power $= P_c = \dfrac{V_c^2}{2R} = \dfrac{100}{2 \times 1}$

$\boxed{P_c = 50W}$

$P_{LSB1} = P_{LSB2} = P_{USB1} = P_{USB2} = \dfrac{m^2}{4} P_c$

$= \dfrac{(0.5)^2}{4} \times 50 = 3.125\,W$

Total Power

$$P_T = P_c\left(1+\frac{m_t^2}{2}\right)$$

$$m_t = \sqrt{m_1^2+m_2^2} = \sqrt{(0.5)^2+(0.5)^2}$$
$$= \sqrt{0.5}$$

$$\boxed{m_t = 0.707}$$

$$\therefore \quad P_T = 50\left(1+\frac{(0.707)^2}{2}\right) = 50\left(1+\frac{0.5}{2}\right)$$

$$\boxed{P_T = 62.5W}$$

Total sideband power $= P_T - P_c$

$$= 62.5 - 50$$

$$\boxed{P_{SBT} = 12.5W}$$

or

$$P_{SBT} = P_c\frac{m_t^2}{2}$$

$$= 50 \times \frac{0.5}{2} = 12.5W$$

or

$$P_{SBT} = P_{LSB1} + P_{USB1} + P_{LSB2} + P_{USB2}$$
$$= 12.5W.$$

Draw the spectrum of amplitude modulated waveform, if the modulating signal is

$m(t) = \cos 2000\pi t + 0.5 \cos 4000\pi t$

and carrier is

$c(t) = 1.5 \cos 10{,}000\pi t$

Also calculate the total and sideband power.

sol^n →

$V_c = 1.5$ Volt

$V_{m1} = 1$ Volt

$V_{m2} = 0.5$ Volt

① $m_1 = \frac{V_{m1}}{V_c} = \frac{1}{1.5} = 0.67$ $\boxed{m_1 = 0.67}$

② $m_2 = \frac{V_{m2}}{V_c} = \frac{0.5}{1.5} = 0.33$ $\boxed{m_2 = 0.33}$

③ $m_t = \sqrt{m_1^2 + m_2^2} = \sqrt{(0.67)^2 + (0.33)^2}$

$m_t = 0.745355992 \approx 0.75$

$\boxed{m_t = 0.75}$

④ $P_{LSB_1} = P_{USB_1}$ for modulating signal 1

$= \frac{P_c m_1^2}{4}$

$P_c = \frac{V_c^2}{2R} = \frac{(1.5)^2}{2 \times 1} = 1.125$ watt

$\boxed{P_c = 1.125 \text{ watt}}$

$$P_{LSB1} + P_{USB1} = \frac{P_c m_1^2}{2} = 1.125 \times (0.667)^2$$

$$= 0.24999$$

$$\boxed{P_{LSB1} + P_{USB1} = 0.25}$$

$$\boxed{P_{LSB1} = P_{USB1} = \frac{0.25}{2} = 0.125}$$

$$P_{USB2} = P_{LSB2} = \frac{P_c m_2^2}{4} = \frac{1.125 \times (0.33)^2}{2}$$

$$\boxed{P_{USB2} = P_{LSB2} = 0.03125\,W}$$

$$\boxed{P_{LSB2} + P_{USB2} = 0.0625 \text{ watt}}$$

Total sideband band power

$$= 0.25 + 0.0625$$

$$\boxed{P_{SBT} = 0.3125 \text{ watt}}$$

$$P_T = P_C + P_{SBT} = 1.125 + 0.3125$$

$$\boxed{P_T = 1.4375\,W}$$