(iv) *Draw spectrum of modulated wave.*

(v) *Calculate total average power.*

(vi) *Calculate power carried by sidebands.*

Given :

$$V_c = 10\text{ V}$$
$$f_c = 30\text{ kHz}$$
$$V_m = 3\text{ V}$$
$$f_m = 1\text{ kHz}$$
$$R = 50\ \Omega$$

Solution :

(i) Equation of modulated wave

$$v = (V_c + V_m \sin \omega_m t) \sin \omega_c t$$
$$= [10 + 3 \sin (2\pi \times 10^3 t)] \sin (6\pi \times 10^4 t)$$
$$v = 10[1 + 0.3 \sin (2\pi \times 10^3 t)] \sin (6\pi \times 10^4 t)$$

(ii) Plot the modulated wave

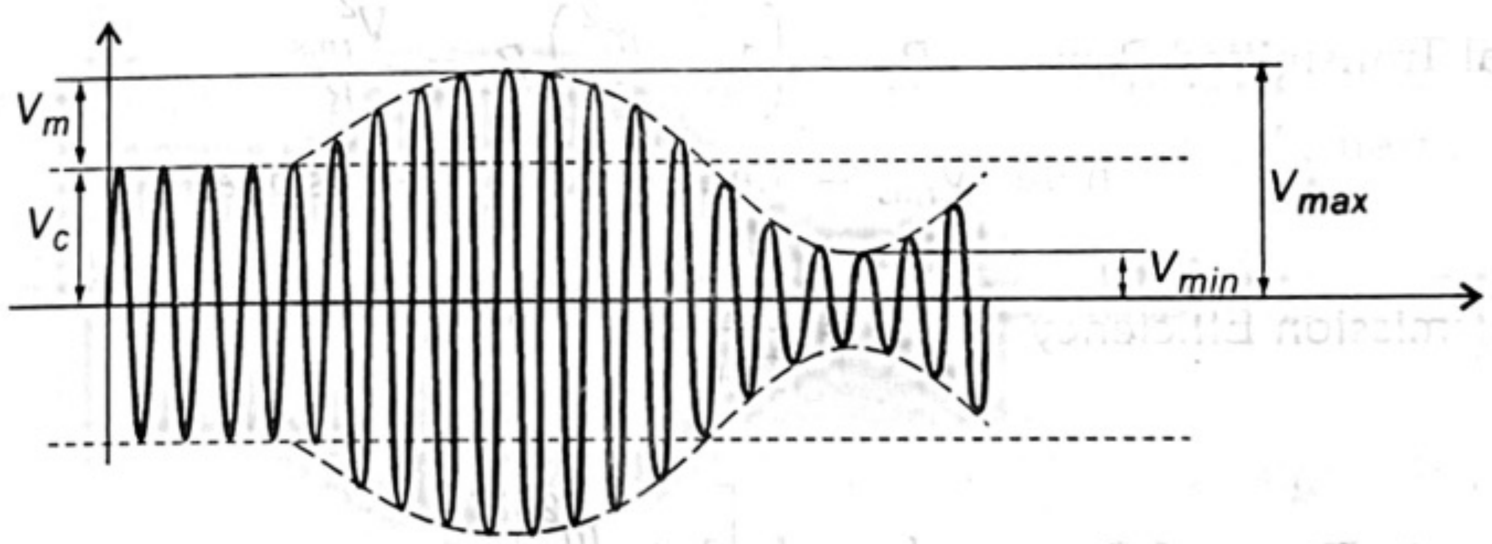


Fig. 3.26

$$V_{max} = V_c + V_m = 13\text{ V}$$
$$V_{min} = V_c - V_m = 7\text{ V}$$

(iii) Modulated index

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

$$m = 0.3$$

(iv) *Draw spectrum of modulated wave.*

(v) *Calculate total average power.*

(vi) *Calculate power carried by sidebands.*

Given :

$$V_c = 10 \text{ V}$$
$$f_c = 30 \text{ kHz}$$
$$V_m = 3 \text{ V}$$
$$f_m = 1 \text{ kHz}$$
$$R = 50\ \Omega$$

Solution :

(i) Equation of modulated wave

$$v = (V_c + V_m \sin \omega_m t) \sin \omega_c t$$
$$= [10 + 3 \sin (2\pi \times 10^3 t)] \sin (6\pi \times 10^4 t)$$
$$v = 10[1 + 0.3 \sin (2\pi \times 10^3 t)] \sin (6\pi \times 10^4 t)$$

(ii) Plot the modulated wave

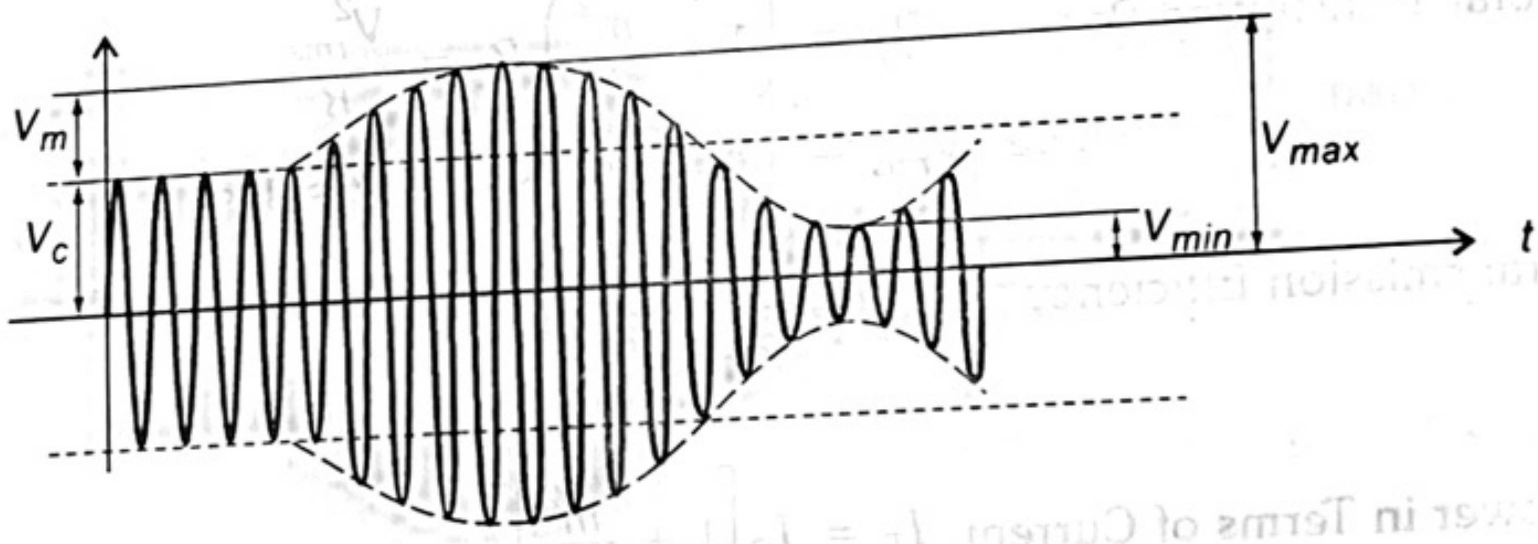


Fig. 3.26

$$V_{max} = V_c + V_m = 13 \text{ V}$$
$$V_{min} = V_c - V_m = 7 \text{ V}$$

(iii) Modulated index

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

$$m = 0.3$$

(iv) Spectrum of modulated wave

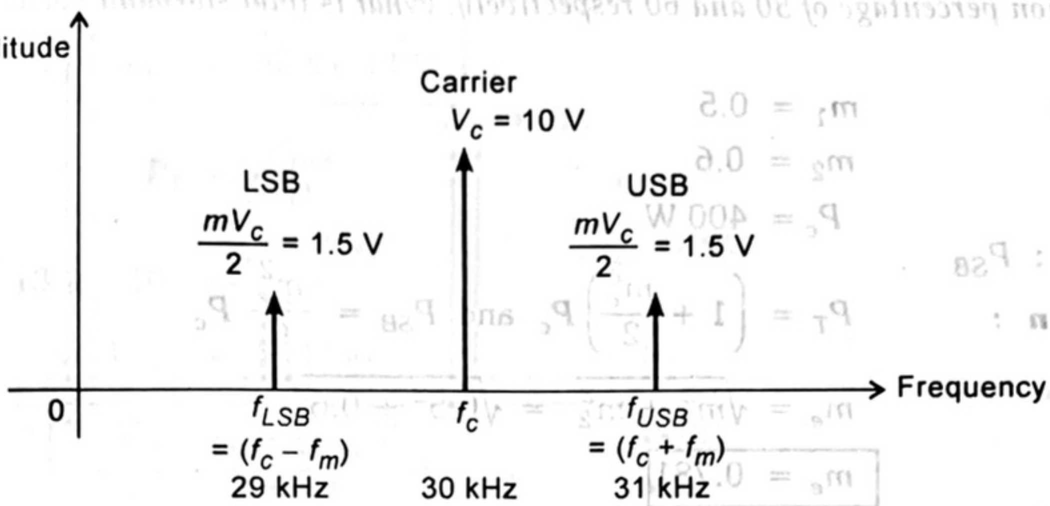


Fig. 3.27

$$f_{USB} = f_c + f_m = 30 + 1 = 31 \text{ kHz}$$

$$f_{LSB} = f_c - f_m = 30 - 1 = 29 \text{ kHz}$$

$$f_{USB} = 31 \text{ kHz}, \quad f_{LSB} = 29 \text{ kHz}$$

$$\text{Amplitude of each sideband} = \frac{mV_c}{2} = \frac{0.3 \times 10}{2}$$

$$\boxed{\text{Amplitude of each sideband} = 1.5 \text{ V}}$$

(v) Total average power

$$\text{Carrier power, } P_C = \frac{V_c^2}{2R} = \frac{10^2}{2 \times 50} = 1 \text{ W}$$

$$\therefore \text{ Total power, } P_T = \left(1 + \frac{m^2}{2}\right) P_c = 1.045 \text{ W}$$

(vi) Power carried by each sideband

$$P_{USB} = P_{LSB} = \frac{m^2 V_c^2}{8R} = \frac{0.3^2 \times 10^2}{8 \times 50}$$

$$\boxed{P_{USB} = P_{LSB} = 0.0225 \text{ W}}$$

$\therefore$ Power carried by sidebands

$$P_{SB} = 2P_{USB} = 2P_{LSB} = 0.045 \text{ W}$$

$$\boxed{\therefore P_{SB} = 0.045 \text{ W}}$$

Problem 2 : *A 400 W carrier is simultaneously modulated by two audio waves with modulation percentage of 50 and 60 respectively. What is total sideband power radiated ?*

Given :

$$m_1 = 0.5$$
$$m_2 = 0.6$$
$$P_c = 400 \text{ W}$$

To find : P_{SB}

Solution :

$$P_T = \left(1 + \frac{m_e^2}{2}\right) P_c \text{ and } P_{SB} = \frac{m_e^2}{4} P_c$$

$$m_e = \sqrt{m_1^2 + m_2^2} = \sqrt{0.5^2 + 0.6^2}$$

$$\boxed{m_e = 0.781}$$

$$P_{SB} = \frac{m_e^2}{4} P_c = 61 \text{ W}$$

$$P_{SB} = 61 \text{ W}$$

Problem 3 : *AM transmitter supplies 10 kW of carrier power to a 50 Ω load. It operates at a carrier frequency of 1.2 MHz and is 80 % modulated by a 3 kHz sine wave.*

(i) *Sketch the signal in frequency domain, with frequency and power scales. Show the power in dBW.*

(ii) *Calculate the total average power in signal in watts and dBW.*

(iii) *Calculate RMS voltage of AM signal.*

(iv) *Calculate peak voltage of AM signal.*

Given :

$$P_c = 10 \text{ kW}$$
$$R = 50\ \Omega$$
$$f_c = 1.2 \text{ MHz}$$
$$m = 0.8$$
$$f_m = 3 \text{ kHz}$$

To find : (1) Total power P_T in watts and dBW

(2) RMS voltage V_{rms}

(3) Peak voltage V_c

Solution :

$$P_T = \left(1 + \frac{m^2}{2}\right) P_c = \left(1 + \frac{0.8^2}{2}\right) 10 \times 10^3$$

$$= 13.2 \times 10^3 \text{ W}$$

$$\boxed{\therefore\ P_T = 13.2 \text{ kW}}$$

Now power in dBW is

$$P_{T(dB)} = 20 \log_{10} P_T$$

$$\boxed{P_{T(dB)} = 82.41 \text{ dBW}}$$

$$P_T = \frac{V_{rms}^2}{R}$$

$$\therefore\ 13.2 \times 10^3 = \frac{V_{rms}^2}{50}$$

$$\therefore\ V_{rms}^2 = 660000$$

$$\boxed{\therefore\ V_{rms} = 812.40 \text{ V}}$$

Similarly

$$P_c = \frac{V_c^2}{2R} = \frac{V_c^2}{2 \times 50}$$

$$\therefore\ V_c^2 = 1000000$$

$$\boxed{\therefore\ V_c = 1000 \text{ V}}$$

Now,

$$m = \frac{V_m}{V_c}$$

$$\boxed{\therefore\ V_m = 800 \text{ V}}$$

$$\text{Peak voltage} = V_c + V_m$$

$$\boxed{\text{Peak voltage} = 1800 \text{ V}}$$

. Frequency domain representation

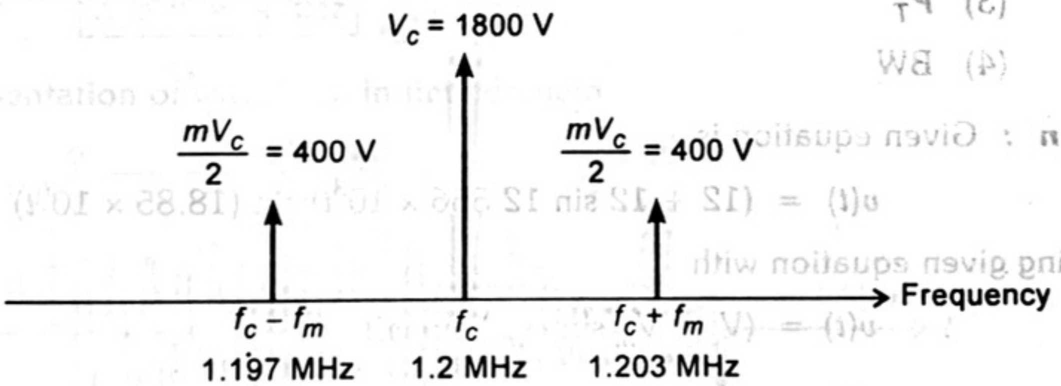


Fig. 3.28

$$f_{USB} = f_c + f_m = 1.2 \text{ MHz} + 3 \text{ kHz} = 1.203 \text{ MHz}$$

$$f_{LSB} = f_c - f_m = 1.2 \text{ MHz} - 3 \text{ kHz} = 1.197 \text{ MHz}$$

$$\text{Amplitude of sideband} = \frac{mV_c}{2} = \frac{0.8 \times 1000}{2}$$

$$\therefore \text{ Amplitude of sideband} = 400 \text{ V}$$

Power spectrum

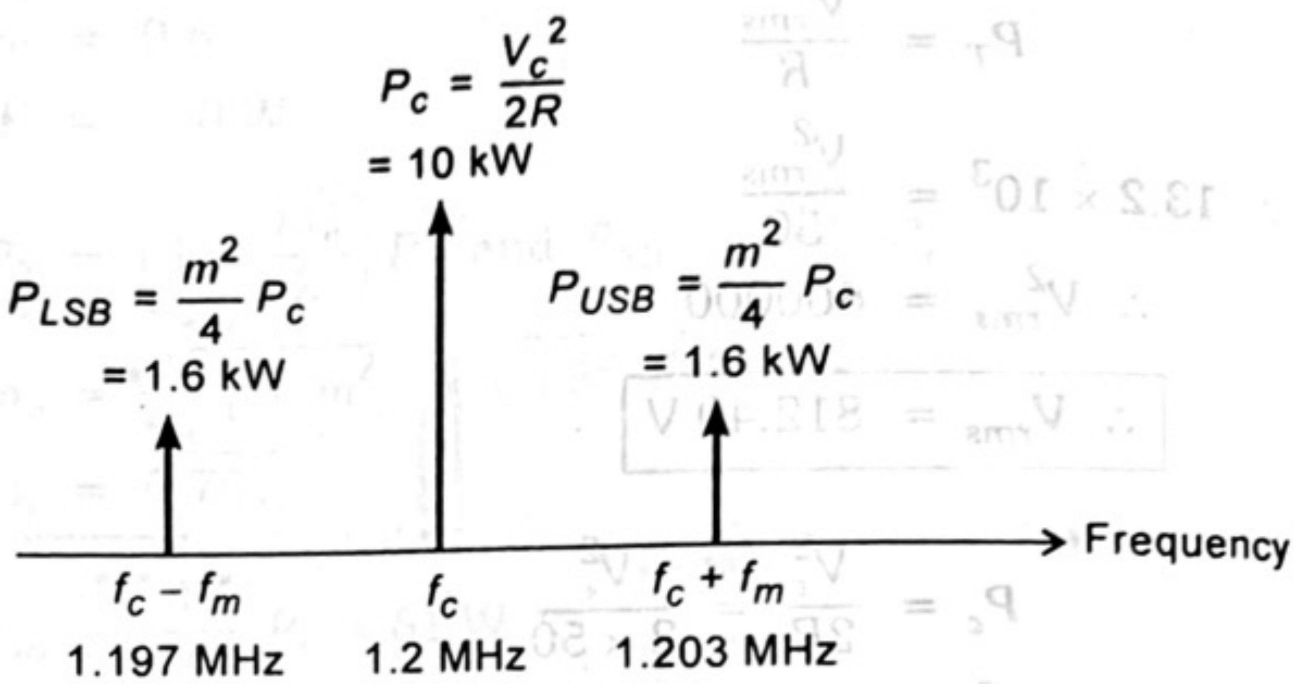


Fig. 3.29

Problem 4 : *An AM signal appears across a 50 Ω load and has following equation.*

(i) *Sketch the envelope of this signal in time domain.*

(ii) *Calculate modulation index, sideband frequencies, total power and bandwidth*

Given :

$$v(t) = (12 + 12 \sin 12.566 \times 10^3 t) \sin (18.85 \times 10^6 t)$$

$$R = 50\ \Omega$$

To find : (1) Modulation index

(2) f_{USB} and f_{LSB}

(3) P_T

(4) BW

Solution : Given equation is

$$v(t) = (12 + 12 \sin 12.566 \times 10^3 t) \sin (18.85 \times 10^6 t)$$

Comparing given equation with

$$v(t) = (V_c + V_m \sin \omega_m t) \sin \omega_c t$$

We get,

$$V_c = 12 \text{ V}, \; V_m = 12 \text{ V}$$

$$\omega_m = 12.566 \times 10^3$$

$$2\pi f_m = 12.566 \times 10^3$$

$$\therefore\ f_m = 1.999 \times 10^3 \text{ Hz}$$

$$\therefore\ f_m = 1.99 \text{ kHz}$$

$$\omega_c = 18.85 \times 10^6$$

$$2\pi f_c = 18.85 \times 10^6$$

$$\therefore\ f_c = 3 \times 10^6 \text{ Hz}$$

$$\therefore\ f_c = 3 \text{ MHz}$$

(1) Modulation index

$$m = \frac{V_m}{V_c} = 1$$

(2) $$f_{USB} = f_c + f_m = 3001.99 \text{ kHz}$$

$$f_{LSB} = f_c - f_m = 2998.01 \text{ kHz}$$

(3) $$P_c = \frac{V_c^2}{2R} = \frac{12^2}{2 \times 50}$$

$$\therefore\ P_c = 1.44 \text{ W}$$

$$\therefore \text{Total power } P_T = \left(1 + \frac{m^2}{2}\right) P_c$$

$$\boxed{P_T = 2.16 \text{ W}}$$

(4) Bandwidth $\quad BW = 2f_m = 2 \times 1.99 \text{ kHz}$

$$= 3.98 \text{ kHz}$$

$$\boxed{\therefore\ BW \approx 4 \text{ kHz}}$$

Representation of waveform in time domain

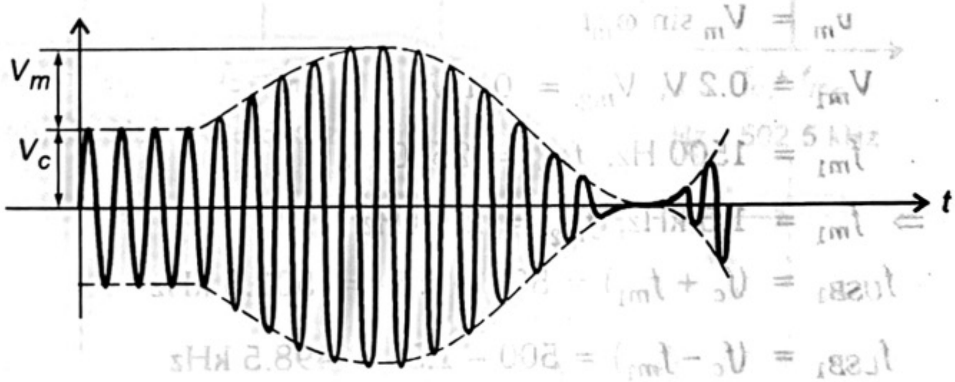


Fig. 3.30

***Problem 5** : A carrier wave $v_c = 4 \sin [2\pi \times 500 \times 10^3 t]$ is amplitude modulated by an audio wave $v_m = 0.2 \sin 3[2\pi \times 500t] + 0.1 \sin 5[2\pi \times 500t]$*

Determine the upper and lower sidebands and sketch spectrum of modulated wave, and find total power in sidebands. Also calculate bandwidth.

Given :

$$v_c = 4 \sin [2\pi \times 500 \times 10^3 t]$$

$$v_m = 0.2 \sin 3[2\pi \times 500t] + 0.1 \sin 5[2\pi \times 500t]$$

To find : (1) Upper sideband

(2) Lower sideband

(3) Total power in sidebands

(4) Sketch spectrum of modulated wave.

(5) Bandwidth

(6) what will happed when m = 0

***Solution** :* Given equation is

$$v_c = 4 \sin [2\pi \times 500 \times 10^3 t]$$

Comparing given equation with

$$v_c = V_c \sin \omega_c t$$

We get,

$$V_c = 4 \text{ V}$$

$$\omega_c = 2\pi \times 500 \times 10^3$$

$$2\pi f_c = 2\pi \times 500 \times 10^3$$

$$\therefore f_c = 500 \times 10^3 = 500 \text{ kHz}$$

$$\boxed{f_c = 500 \text{ kHz}}$$

$$v_m = 0.2 \sin 3[2\pi \times 500t] + 0.1 \sin 5[2\pi \times 500t]$$

The v_m signal consists of two sine waves.

$$v_1 = 0.2 \sin 3[2\pi \times 500t]$$

$$v_2 = 0.1 \sin 5[2\pi \times 500t]$$

Comparing above two equations with

$$v_m = V_m \sin \omega_m t$$

We get

$$V_{m1} = 0.2 \text{ V}, \ V_{m2} = 0.1 \text{ V}$$

$$f_{m1} = 1500 \text{ Hz}, \ f_{m2} = 2500 \text{ Hz}$$

$$\Rightarrow f_{m1} = 1.5 \text{ kHz}, \ f_{m2} = 2.5 \text{ kHz}$$

$$f_{USB_1} = (f_c + f_{m1}) = 500 + 1.5 = 501.5 \text{ kHz}$$

$$f_{LSB_1} = (f_c - f_{m1}) = 500 - 1.5 = 498.5 \text{ kHz}$$

$$f_{USB_2} = (f_c + f_{m2}) = 500 + 2.5 = 502.5 \text{ kHz}$$

$$f_{LSB2} = (f_c - f_{m2}) = 500 - 2.5 = 497.5 \text{ kHz}$$

Modulation index of first signal

$$m_1 = \frac{V_{m1}}{V_c} = \frac{0.2}{4} = 0.05 \text{ V}$$

Modulation index of second signal

$$m_2 = \frac{V_{m2}}{V_c} = \frac{0.1}{4} = 0.025 \text{ V}$$

$$\text{Amplitude of USB}_1 = \text{Amplitude of LSB}_1$$

$$= \frac{m_1 V_c}{2} = \frac{0.05 \times 4}{2} = 0.1 \text{ V}$$

$$\text{Amplitude of USB}_2 = \text{Amplitude of LSB}_2$$

$$= \frac{m_2 V_c}{2} = \frac{0.025 \times 4}{2} = 0.05 \text{ V}$$

The effective modulation index

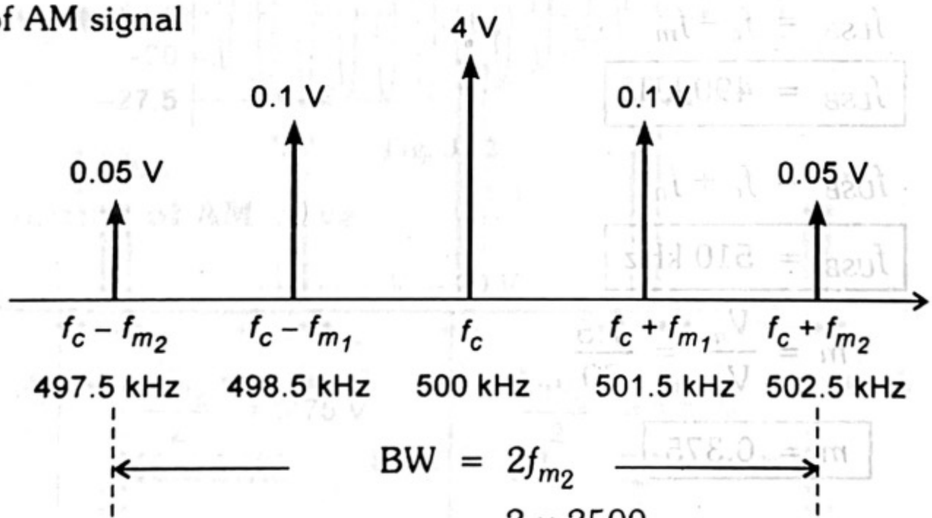
$$m_e = \sqrt{m_1^2 + m_2^2} = \sqrt{0.05^2 + 0.025^2}$$

$$\boxed{m_e = 0.0559}$$

$$\text{Total power in sideband } P_{SB} = \frac{m_e^2 V_c^2}{4R} = \frac{0.0559^2 \times 4^2}{4R}$$

$$P_{SB} = \frac{0.0125}{R} \text{ W}$$

Spectrum of AM signal



$$\text{BW} = 2f_{m2}$$
$$= 2 \times 2500$$
$$= 5000 \text{ Hz}$$
$$= 5 \text{ kHz}$$

Fig. 3.31

Problem 6 : *One input to a conventional AM modulator is a 500 kHz carrier with an amplitude of 20 V_p. The second input is a 10 kHz modulating signal that is of sufficient amplitude to cause a change in the output wave of ±7.5 V_p. Determine :*

(i) Side frequencies and modulation index.

(ii) Peak amplitude of the modulated carrier and the upper and lower side frequency voltages.

(iii) Maximum and minimum amplitudes of the envelope.

(iv) Expression for the modulated wave.

(v) Draw the output spectrum and output envelope.

Given :

$$V_c = 20\text{ V}$$
$$V_m = 7.5\text{ V}$$
$$f_c = 500\text{ kHz}$$
$$f_m = 10\text{ kHz}$$

To find :

(i) f_{LSB}, f_{USB} and m

(ii) Peak amplitude of modulated wave, LSB and USB

(iii) V_{max} and V_{min}

(iv) Expression of v_{AM}

(v) Spectrum and envelope.

Solution :

(i) f_{LSB}, f_{USB} and m

$$f_{LSB} = f_c - f_m$$

$$\boxed{f_{LSB} = 490\text{ kHz}}$$

$$f_{USB} = f_c + f_m$$

$$\boxed{f_{USB} = 510\text{ kHz}}$$

$$m = \frac{V_m}{V_c} = \frac{7.5}{20}$$

$$\boxed{m = 0.375}$$

(ii) Peak Amplitude of Modulated Wave, LSB and USB

Peak amplitude of modulated wave $= V_c + V_m$

$= 27.5\text{ V}$

Peak amplitude of LSB and USB $= \dfrac{mV_c}{2} = 3.75$ V

(iii) V_{max} and V_{min}

$$V_{max} = V_c + V_m = 27.5 \text{ V}$$
$$V_{min} = V_c - V_m = 12.5 \text{ V}$$

(iv) Expression of v_{AM}

$$v_{AM} = V_c \sin \omega_c t + \frac{mV_c}{2} \cos(\omega_c - \omega_m)t - \frac{mV_c}{2} \cos(\omega_c + \omega_m)t$$
$$= V_c \sin 2\pi f_c t + \frac{mV_c}{2} \cos 2\pi(f_c - f_c)t - \frac{mV_c}{2} \cos 2\pi(f_c + f_m)t$$

Substituting V_c, f_c, f_m and m we get,

$$\boxed{v_{AM} = 20 \sin 1000\,\pi t + 3.75 \cos 980\,\pi t - 3.75 \cos 1020\,\pi t}$$

(v) Spectrum and Envelope

(a) Envelope of AM wave

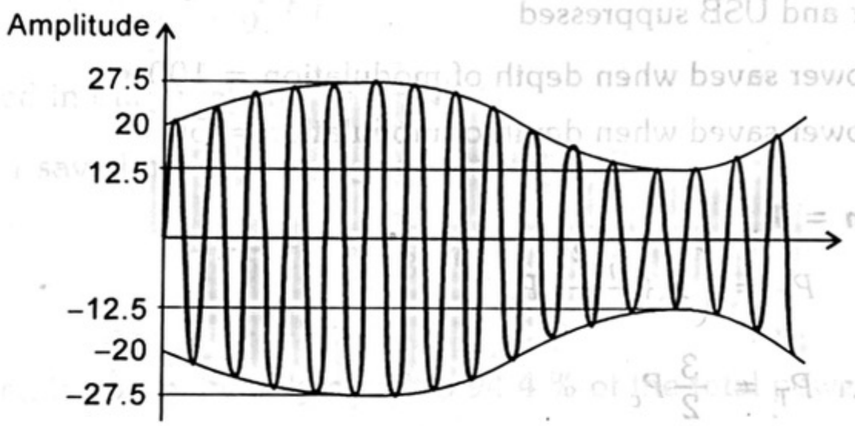


Fig. 3.32

(b) Spectrum of AM wave

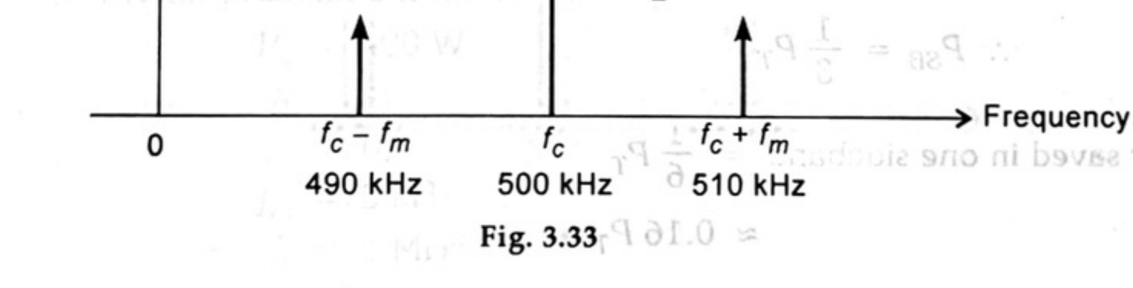


Fig. 3.33

Problem 7 : *A sinusoidal carrier has an amplitude of 10 V and frequency 100 kHz. It is amplitude modulated by a sinusoidal voltage of amplitude 3 V and frequency 500 Hz. Modulated voltage is developed across 75 Ω resistance.*

- ***(i)*** *Write equation for modulated wave.*
- ***(ii)*** *Determine modulation index.*
- ***(iii)*** *Draw spectrum of modulated wave.*
- ***(iv)*** *Calculate total average power.*
- ***(v)*** *Calculate power carried by sidebands.*

Solution : Refer problem 1 from this section with

$$f_c = 100 \text{ kHz}$$

$$f_m = 500 \text{ Hz}$$

$$R = 75\ \Omega$$

Problem 8 : *Calculate the percentage power saving when the carrier and upper side band are suppressed in an AM wave modulated to a depth of 100 percent and 50 percent.*

Given : Carrier and USB suppressed

To find : (1) Power saved when depth of modulation = 100

(2) Power saved when depth of modulation = 50.

Solution :(1) $m = 1$

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

$$\therefore\ P_T = \frac{3}{2} P_c$$

$$\therefore\ P_c = \frac{2}{3} P_T = 0.67\, P_T$$

$$P_{SB} = \frac{m^2}{2} P_c$$

$$= \frac{1}{2} P_c = \frac{1}{2} \times \frac{2}{3} P_T$$

$$\therefore\ P_{SB} = \frac{1}{3} P_T$$

$\therefore$ Power saved in one sideband $= \dfrac{1}{6} P_T$

$$\approx 0.16\, P_T$$

∴ Total power saved in suppressing carrier and USB

$$= \frac{2}{3} P_T + \frac{1}{6} P_T$$

$$= 0.83\ P_T$$

∴ Power saved is approximately equal to 83 % of the total power of DSB-FC.

(2) $m = 0.5$

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

$$\therefore\ P_T = \frac{9}{8}\ P_c$$

$$\therefore\ P_c = \frac{8}{9}\ P_T$$

$$P_{SB} = \frac{m^2}{2}\ P_c$$

$$= \frac{1}{8} P_c = \frac{1}{8} \times \frac{8}{9}\ P_T$$

$$\therefore\ P_{SB} = \frac{1}{9}\ P_T$$

∴ Power saved in one sideband $= \frac{1}{18} P_T$

∴ Total power saved in suppressing carrier and USB

$$= \frac{8}{9}\ P_T + \frac{1}{18} P_T$$

$$= 0.9444\ P_T$$

∴ Power saved is approximately equal to 94.4 % of the total power of DSB-FC.

Problem 9 : *The AM transmitter develops an unmodulated power output of 400 watts, across a 50 Ω load. The carrier is modulated by sinusoidal signal with a modulation index 0.8. Assuming F_m = 5 kHz and F_c = 1 MHz.*

(i) *Find the V_c and write equation of AM.*

(ii) *Find the total power of the modulated output.*

Solution : Refer problem 3 from this section with change in values as follows :

$$P_c = 400\ \text{W}$$

$$R = 50\ \Omega$$

$$m = 0.8$$

$$f_m = 5\ \text{kHz}$$

$$f_c = 1\ \text{MHz}$$

Problem 10 : *A 5 kW unmodulated carrier is simultaneously modulated by two audio signals with modulations index 80 % and 50 %. Find the transmitted power and effective modulation index. Also find the antenna current with ans without modulating signal assuming antenna resistance of 50 Ωs.*

Given :

$$P_c = 5\text{ kW}$$
$$m_1 = 0.8$$
$$m_2 = 0.5$$

Antenna Resistance $R = 50\ \Omega$

To find : (1) m_e (3) I_C

(2) Total power P_T (4) I_T

Solution :

The effective modulation index

$$m_e = \sqrt{m_1^2 + m_2^2} = \sqrt{0.8^2 + 0.5^2}$$

$$\boxed{m_e = 0.9434}$$

$$P_T = \left(1 + \frac{m_e^2}{2}\right) P_c = \left(1 + \frac{0.89}{2}\right) (5\text{ kW})$$

$$\boxed{P_T = 7.225\text{ kW}}$$

$$P_c = I_C^2 R$$

$$\therefore\ I_C = \sqrt{\frac{P_c}{R}} = \sqrt{\frac{5000}{50}}$$

$$\therefore\ \boxed{I_C = 10\text{ A}}$$

$$I_T = I_C\sqrt{1 + \frac{m^2}{2}}$$

$$= 10\sqrt{1 + \frac{0.89}{2}}$$

$$\boxed{I_T = 12.02\text{ A}}$$

Problem 11 : An AM transmitter supplies 10 kW of carrier power to a 50 ohm load. It operates at a carrier frequency of 1.2 MHz and is 80% modulated by a 3 kHz sine wave.

(i) Sketch the signal in the frequency domain, with frequency and power scales. Show the power in dBW.

(ii) Calculate the total average power in the signal, in watts and dBW.

(iii) Calculate the RMS voltage of the signal.

(iv) Calculate the peak voltage of the signal.

Solution : Refer problem 3 from this section.

Problem 12 : An AM transmitter radiates 5 MHz carrier with 60 kW power. Carrier is modulated with 300 Hz and 2 kHz signals.

(i) What will be the total modulation index if each signal modulates at 70 % modulation ?.

(ii) What is the total power transmitted ?

(iii) Draw the frequency spectrum of modulated signal.

(iv) What is the power content of each spectral component ?

Given :

$$f_c = 5\text{ MHz}$$
$$P_c = 60\text{ kW}$$
$$f_{m1} = 300\text{ Hz}$$
$$f_{m2} = 2\text{ kHz}$$

To find : (1) m_e if $m_1 = m_2 = 0.7$

(2) P_T

(3) Draw frequency spectrum

(4) Power content of each spectral component.

Solution :

$$m_e = \sqrt{m_1^2 + m_2^2} = \sqrt{0.7^2 + 0.7^2}$$

$$\boxed{m_e = 0.9899}$$

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

$$\boxed{P_T = 89.4\text{ kW}}$$

$$f_{USB_1} = (f_c + f_{m1}) = 5.000300\text{ MHz}$$

$$f_{LSB_1} = (f_c - f_{m1}) = 4.9997\text{ MHz}$$

$$f_{USB2} = (f_c + f_{m2}) = 5.002 \text{ MHz}$$

$$f_{LSB2} = (f_c - f_{m2}) = 4.998 \text{ MHz}$$

$$P_{LSB1} = P_{USB1} = \frac{m_1^2}{4} P_c$$

$$= 0.1225\, P_c = 7.35 \text{ kW}$$

$$P_{LSB2} = P_{USB2} = \frac{m_2^2}{4} P_c$$

$$= 0.1225\, P_c = 7.35 \text{ kW}$$

$$P_c = \frac{V_c^2}{2R}$$

$$\Rightarrow V_c = \sqrt{P_c \times 2R}$$

$$= 346.4\sqrt{R}$$

Spectrum of AM signal

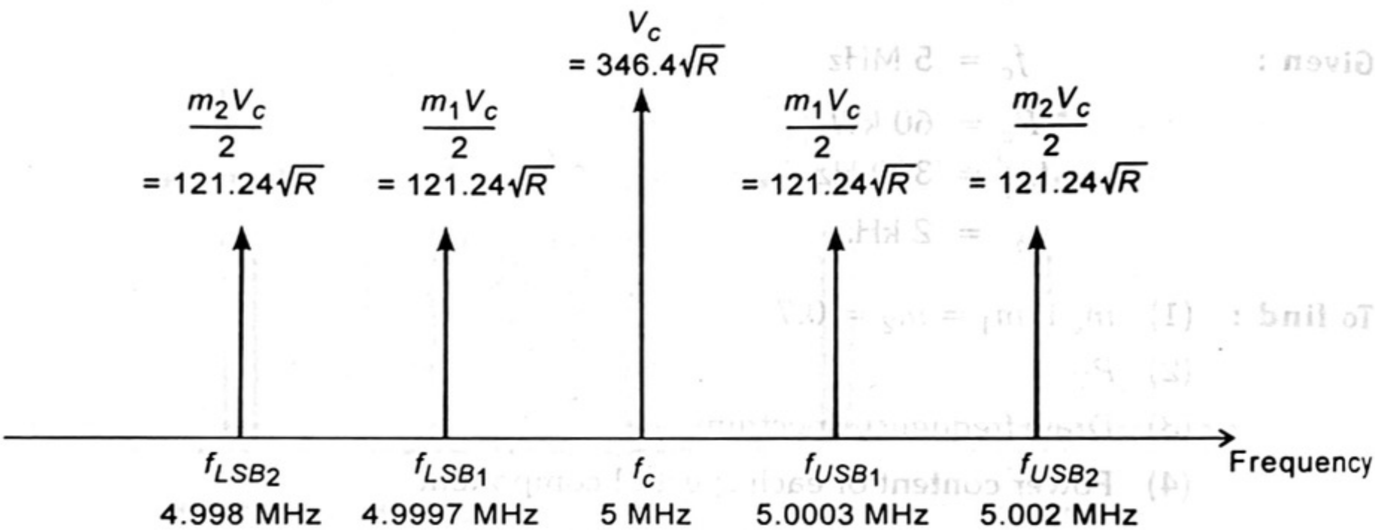


Fig. 3.34

Problem 13 : *The unmodulated carrier power of an AM transmitter is 10 kW and carrier frequency is 2 MHz. The carrier is modulated to a depth of 50 % by an audio signal of 3 kHz.*

(i) *Determine the total power transmitted.*

(ii) *Determine the SSB power.*

(iii) *Percentage of power saving if SSB is transmitted.*

(iv) *Draw the frequency spectrum and find the bandwidth.*

Solution : Refer problem 3 from this section with change in values

$$P_c = 10 \text{ kW}$$
$$f_c = 2 \text{ MHz}$$
$$m = 0.5$$
$$f_m = 3 \text{ kHz}$$

The answer will be in terms of load resistance R as it is not given.

Problem 14 : *The output voltage of a transmitter is given by*

$400(1 + 0.4 \sin 6280\ t) \sin 3.14 \times 10^7\ t$. This voltage is fed to a load of 600 Ω resistance. Determine :

(i) Carrier frequency

(ii) Modulating frequency

(iii) Carrier power

(iv) Total power output

Solution : Refer problem 4 from this section.

Problem 15 : *Draw spectrum of an AM waveform if the modulating signal is*

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

$c(t) = 1.5 \cos (1000\ \pi t)$.

Also calculate (i) the total and sideband power and (ii) bandwidth.

Solution : Refer problem 5 from this section.

Problem 16 : *An audio frequency signal $10 \sin 2\pi \times 500t$ is used to amplitude modulate carrier of $50 \sin 2\pi \times 10^7 t$. Calculate :*

(i) Modulation index

(ii) Sideband frequencies

(iii) Amplitude of each sideband frequencies

(iv) Bandwidth required

(v) Total power delivered to the load of 600 Ω.

Given :

$$\upsilon_m = 10 \sin [2\pi \times 500t] \quad \text{.....(I)}$$
$$\upsilon_c = 50 \sin [2\pi \times 10^5 t] \quad \text{.....(II)}$$
$$R = 600\ \Omega$$

To find : (i) m

(ii) f_{LSB} and f_{USB}

(iii) Amplitudes of sidebands

(iv) Bandwidth

(v) P_T

Solution **:** We have

$$v_m = V_m \sin \omega_m t$$

∴ by comparing with given equation (I)

$$\boxed{V_m = 10 \text{ V}}$$

$$\omega_m = 2\pi \times 500$$

$$2\pi f_m = 2\pi \times 500$$

$$\boxed{\therefore f_m = 500 \text{ Hz}}$$

$$v_c = V_c \sin \omega_c t$$

∴ by comparing with given equation (II)

$$\boxed{V_c = 50 \text{ V}}$$

$$\therefore \omega_c = 2\pi \times 10^5$$

$$2\pi f_c = 2\pi \times 10^5$$

$$\boxed{\therefore f_c = 10^5 \text{ Hz}}$$

Modulation index

$$m = \frac{V_m}{V_c} = \frac{10}{50}$$

$$\boxed{\therefore m = 0.2}$$

$$\therefore f_{USB} = f_c + f_m = 10^5 + 500 = 1.005 \times 10^5 \text{ Hz}$$

$$\boxed{\therefore f_{USB} = 1.005 \times 10^5 \text{ Hz}}$$

$$f_{LSB} = f_c - f_m = 10^5 - 500 = 9.95 \times 10^4 \text{ Hz}$$

$$\boxed{f_{LSB} = 9.95 \times 10^4 \text{ Hz}}$$

$$\text{Amplitudes of sidebands} = \frac{mV_c}{2} = 5 \text{ V}$$

Bandwidth $\quad BW = 2f_m$

$$\boxed{\therefore BW = 1 \text{ kHz}}$$

$$\therefore \text{Total power } P_T = \left(1 + \frac{m^2}{2}\right)$$

$$\text{and } P_c = \frac{V_c^2}{2R} = \frac{50^2}{2 \times 600}$$

$$\therefore P_c = 2.08 \text{ W}$$

$$\therefore P_T = \left(1 + \frac{0.2^2}{2}\right) P_c$$

$$\boxed{P_T = 2.1216 \text{ W}}$$

Problem 17 : For an AM DSBFC modulation with a carrier frequency f_c = 100 kHz and a maximum modulating signal frequency $f_{m(max)}$ = 5 kHz, determine

(i) Frequency limits for the upper and lower sidebands

(ii) Bandwidth

(iii) Upper and lower side frequencies produced when the modulating signal is a single frequency 3 kHz tone.

(iv) Draw the output frequency spectrum.

Given :

$$f_c = 100 \text{ kHz}$$

$$f_{m(max)} = 5 \text{ kHz}$$

To find : (i) $f_{USB(max)}$ and $f_{LSB(max)}$

(ii) Bandwidth

(iii) f_{USB} and f_{LSB} when f_m = 3 kHz

(iv) Draw output frequency spectrum

Solution : We have

$$f_{USB(max)} = f_c + f_{m(max)} = 105 \text{ kHz}$$

$$f_{LSB(max)} = f_c - f_{m(max)} = 95 \text{ kHz}$$

$$BW_{(max)} = 2f_m = 10 \text{ kHz}$$

When $f_{m_1} = 3$ kHz

$$\therefore \; f_{USB} = f_c + f_{m_1} = 103 \text{ kHz}$$

$$f_{LSB} = f_c - f_{m_1} = 97 \text{ kHz}$$

Spectrum of AM signal

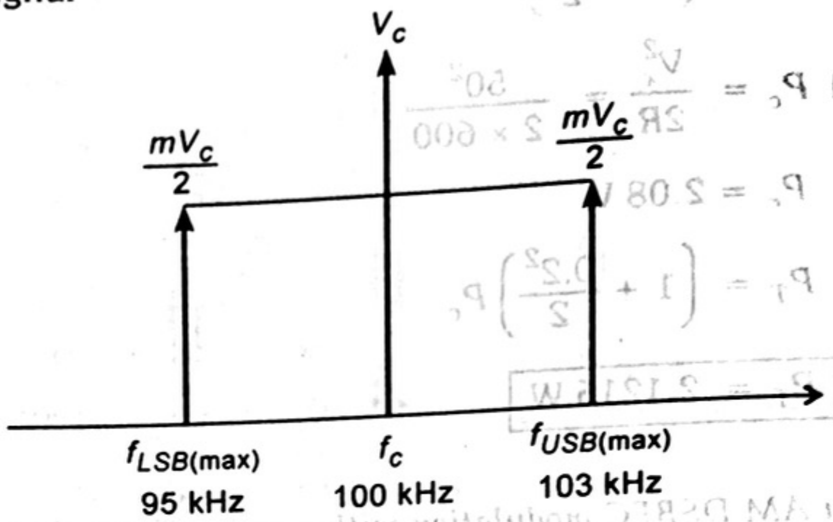


Fig. 3.35