MADE EASY PUBLICATIONS

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ELECTRICAL ENGINEERING

CONVENTIONAL Practice Sets

CONTENTS

COMMUNICATION SYSTEMS

1 CHAPTER

Amplitude Modulation

Q.1 A two-tone modulating signal $e_m(t)$ = 5 cos $2\pi \times 10^3$ (t) + 4 cos $4\pi \times 10^3 t$ modulates a carrier voltage $e_c(t)$ = 10 cos $2\pi \times 10^6 t$. Find various frequency components present and corresponding modulation indices. Also obtain the amplitude of the signals present in each sidebands and the bandwidths.

Solution:

The expression of AM is given by,

$$\phi_{AM}(t) = 10\left[1+\frac{5}{10}\cos(2\pi\times 10^3 t)+\frac{4}{10}\cos(4\pi\times 10^3 t)\right]\cos(2\pi\times 10^6 t)$$

$$= 10\left[1+0.5\cos(2\pi\times 10^3 t)+0.4\cos 4\pi\times 10^3 t\right]\cos(2\pi\cdot 10^6 t)$$

$$m_1 = 0.5 \text{ and } m_2 = 0.4$$

$$\phi_{AM}(t) = 10\cos 2\pi\, 10^6 + 5\cos(2\pi\times 10^3 t)\cos(2\pi\times 10^6 t) + 4\cos(4\pi\times 10^3 t)\cos(2\pi\times 10^6 t)$$

$$= 10\cos(2\pi\times 10^6)+\frac{5}{2}\cos\left[2\pi\times(10^6+10^3)t\right]+\frac{5}{2}\cos\left[2\pi\times(10^6-10^3)t\right]$$
$$+2\cos\left[2\pi\times(10^6+2\times 10^3)t\right]+2\cos\left[2\pi\times(10^6-2\times 10^3)t\right]$$

Upper sidebands, $F_C + F_1 = 10^6 + 10^3 = 1.001$ MHz

⇒ $F_C + F_2 = 10^6 + 2\times 10^3 = 1.002$ MHz

Now, Lower sidebands, $F_C - F_1 = 10^6 - 10^3 = 0.999$ MHz

⇒ $F_C - F_2 = 10^6 - 2\times 10^3 = 0.998$ MHz

Each sidedband W_1, $\dfrac{m_1 E_c}{2} = \dfrac{0.5\times 10}{2} = 2.5$ V

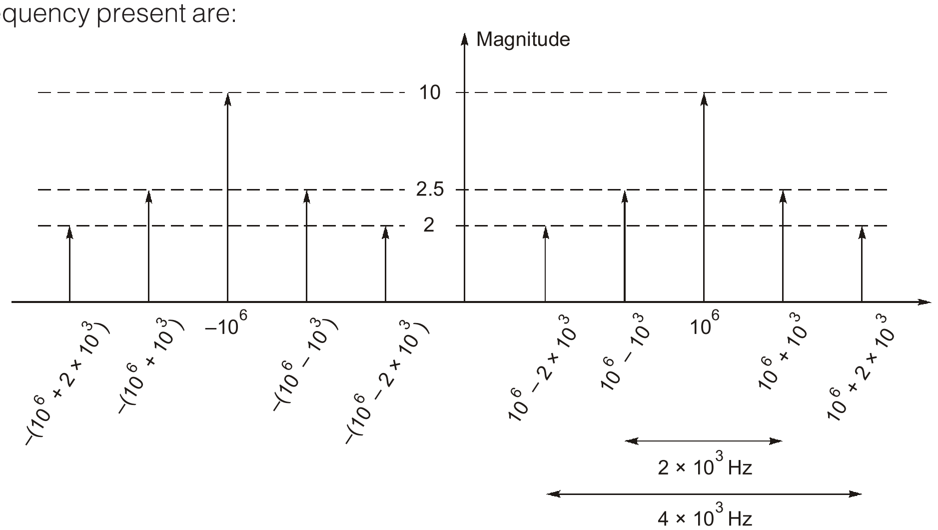
Each sideband W_2, $\dfrac{m_1 E_c}{2} = \dfrac{0.4\times 10}{2} = 2$ V

Total bandwidth = 2 × Bandwidth of message signal m_2

W_m = 2 kHz

Total bandwidth = 2 × 2 = 4 kHz

So, the frequency present are:



Q.2 Show that power contained in one sideband is 1/6 to the total power of amplitude modulated signal at 100% modulation index.

Solution:

$$S_{AM}(t) = A_c(1 + \mu\cos 2\pi f_m t)\cos 2\pi f_c t$$
$$= A_c[1 + \cos 2\pi f_m t]\cos 2\pi f_c t \qquad [\mu = 1]$$
$$= A_c\cos 2\pi f_c t + A_c\cos 2\pi f_m t\cos 2\pi f_c t$$
$$= A_c\cos 2\pi f_c t + \frac{A_c}{2}[\cos 2\pi(f_c + f_m)t + \cos 2\pi(f_c - f_m)t]$$
$$= A_c\cos 2\pi f_c t + \frac{A_c}{2}\cos 2\pi(f_c + f_m)t + \frac{A_c}{2}\cos 2\pi(f_c - f_m)t$$

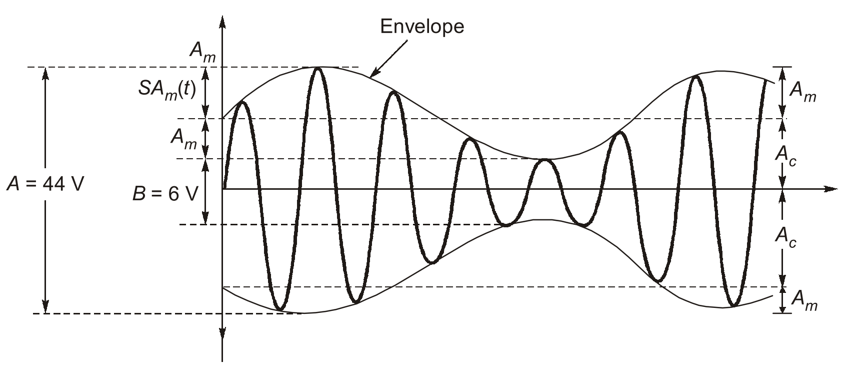
$$\text{Power in one sideband} = \frac{A_c^2}{4\times 2} = \frac{A_c^2}{8}$$

$$\text{Total power} = \frac{A_c^2}{2} + \left(\frac{A_c}{2}\right)^2\times\frac{1}{2} + \left(\frac{A_c}{2}\right)^2\times\frac{1}{2}$$
$$= \frac{A_c^2}{2} + \frac{A_c^2}{8} + \frac{A_c^2}{8} = \frac{3A_c^2}{4}$$

So,
$$\text{Ratio} = \frac{\frac{A_c^2}{8}}{\frac{3A_c^2}{4}} = \frac{1}{6}$$

Q.3 An amplitude modulated signal, viewed on an oscilloscope, has a crest voltage of 44 V peak-to-peak. The bottom (or trough) point of the wave measures 6 V peak-to-peak. Find the modulation factor, percentage modulation and peak-to-peak unmodulated carrier voltage.

Solution:



Modulation factor,
$$m = \frac{A_m}{A_c}$$

From figure,
$$A = 2(A_c + A_m) \qquad \text{...(i)}$$
$$B = 2(A_c - A_m) \qquad \text{...(ii)}$$

Solving equation (i) and (ii),
$$A_c = \frac{A+B}{4}$$
$$A_m = \frac{A-B}{4}$$

Hence,
$$\mu = \frac{A-B}{A+B} = \frac{44-6}{44+6} = \frac{38}{50} = 0.76$$