Calculate the modulation index and percentage modulation if instantaneous voltages of modulating signal and carrier are 40 sin ω_m t and 50 sin ω_c t, respectively.

Sol. : From the given instantaneous equation we have,

$$E_m = 40 \quad \text{and} \quad E_c = 50$$

Hence modulation index will be,

$$m = \frac{E_m}{E_c} = \frac{40}{50} = 0.8$$

or $$\% \text{ modulation} = m \times 100 = 0.8 \times 100 = 80\ \%$$

The tuned circuit of the oscillator in a simple AM transmitter employs a 40 μH coil and 12 nF capacitor. If the oscillator output is modulated by audio frequency of 5 kHz, what are the lower and upper sideband frequencies and the bandwidth required to transmit this AM wave ?

Sol. : The frequency of the LC oscillator is given as,

$$f_c = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{40\times10^{-6}\times12\times10^{-9}}} = 230 \text{ kHz}$$

The modulating frequency is $f_m = 5$ kHz

$$\therefore \quad f_{USB} = f_c + f_m = 230 + 5 = 235 \text{ kHz}$$

and

$$f_{LSB} = f_c - f_m = 230 - 5 = 225 \text{ kHz}$$

We know that bandwidth of AM wave is,

$$BW = 2\, f_m = 2 \times 5\, kHz = 10 \text{ kHz}$$

An audio frequency signal $10 \sin 2\pi \times 500\ t$ is used to amplitude modulate a carrier of $50 \sin 2\pi \times 10^5\ t$. Calculate

i) Modulation index

ii) Sideband frequencies

iii) Amplitude of each sideband frequencies

iv) Bandwidth required

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Sol. : i) The given modulating signal is $e_m = 10 \sin 2\pi \times 500\, t$. Hence, $E_m = 10$. The given carrier signal is $e_c = 50 \sin 2\pi \times 10^5\, t$, hence, $E_c = 50$. Therefore modulation index will be,

$$m = \frac{E_m}{E_c} = \frac{10}{50} = 0.2 \quad \text{or} \quad 20\ \%$$

ii) From the given equations,

$\omega_m = 2\pi \times 500,$ Hence $f_m = 500$ Hz

And $\omega_c = 2\pi \times 10^5$ Hence $f_c = 10^5$ Hz or 100 kHz

We know that $f_{USB} = f_c + f_m = 100\text{ kHz} + 500\text{ Hz} = 100.5\text{ kHz}$

and $P_{LSB} = f_c - f_m = 100\text{ kHz} - 500\text{ Hz} = 99.5\text{ kHz}.$

iii) From equation we know that the amplitudes of upper and lower sidebands is given as,

$$\text{Amplitude of upper and lower sidebands} = \frac{m\,E_c}{2} = \frac{0.2 \times 50}{2} = 5\text{ V}$$

iv) Bandwidth of AM wave is given by equation

$$BW \text{ of } AM = 2 f_m = 2 \times 500\text{ Hz} = 1\text{ kHz}$$

In an AM modulator, 500 kHz carrier of amplitude 20 V is modulated by 10 kHz modulating signal which causes a change in the output wave of $\pm$ 7.5 V. Determine :

1) Upper and lower side band frequencies
2) Modulation index
3) Peak amplitude of upper and lower side frequency
4) Maximum and minimum amplitudes of envelope.

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Find the carrier, modulating frequency, modulation index and maximum deviation of the FM wave represented by the equation $e_{FM}(t) = 12\sin\left(6\times10^{8}\,t + 5\sin 1250\,t\right)$. *What power will FM wave dissipate in a 10 Ω resistance ?*

Solution : The given FM equation can be compared with standard equation, i.e.

$$e_{FM}(t) = E_c \sin(\omega_c t + m \sin \omega_m t)$$

We get,

$$E_c = 12 \text{ V}$$

$$\omega_c = 6 \times 10^8 \text{ rad/sec}$$

$$m = 5$$

$$\omega_m = 1250 \text{ rad/sec}$$

$$R = 10\ \Omega$$

i) Carrier frequency (ω_c) :

The carrier frequency is

$$\omega_c = 6 \times 10^8 \text{ rad/sec}$$

or $$f_c = \frac{6 \times 10^8}{2\pi} = 95.5 \text{ MHz}$$

ii) Modulating frequency (ω_m or f_m) :

The modulating frequency is,

$$\omega_m = 1250 \text{ rad/sec}$$

or $$f_m = \frac{1250}{2\pi} = 198.5 \text{ Hz}$$

Solution : The given FM equation can be compared with standard equation, i.e.

$$e_{FM}(t) = E_c \sin(\omega_c t + m \sin \omega_m t)$$

We get,

$$E_c = 12 \text{ V}$$

$$\omega_c = 6 \times 10^8 \text{ rad/sec}$$

$$m = 5$$

$$\omega_m = 1250 \text{ rad/sec}$$

$$R = 10 \ \Omega$$

i) Carrier frequency (ω_c) :

The carrier frequency is

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The modulating frequency is,

$$\omega_m = 1250 \text{ rad/sec}$$

or $$f_m = \frac{1250}{2\pi} = 198.5 \text{ Hz}$$

iii) Modulation index (m) :

The modulation index is, $m = 5$.

iv) Maximum frequency deviation (δ) :

Modulation index, $m = \dfrac{\delta}{f_m}$

$\therefore \quad \delta = m\, f_m = 5 \times 198.5 = 992.50 \text{ Hz}$