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

iii) Modulation index (m) :

The modulation index is, $m = 5$.

iv) Maximum frequency deviation (δ) :

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

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

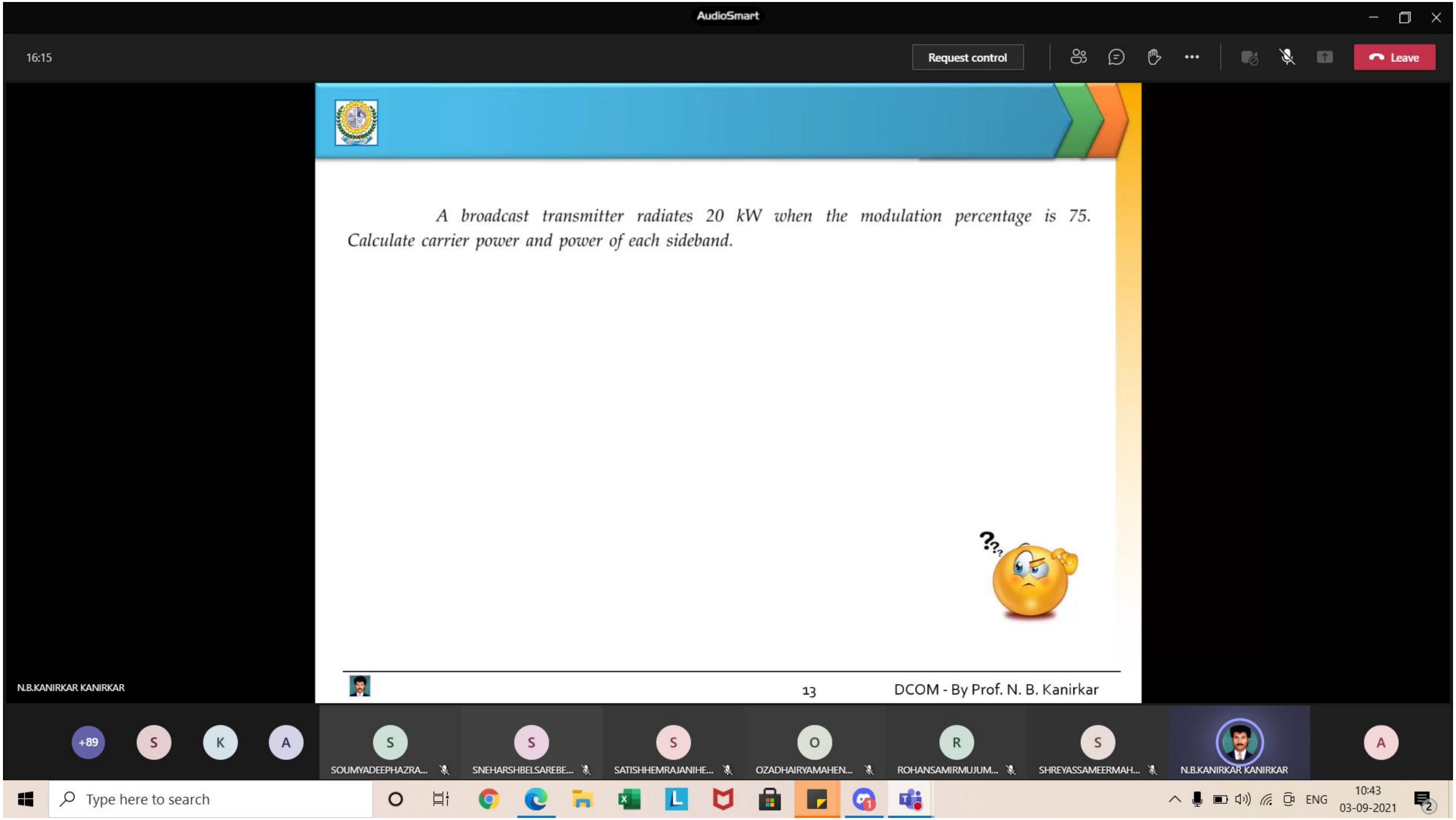
A 400 W carrier is modulated to a depth of 80 % calculate the total power in the modulated wave.

Sol. :

Here carrier power $P_c = 400$ W and $m = 0.8$

From equation total power is,

$$P_{total} = P_c\left(1+\frac{m^2}{2}\right) = 400\left(1+\frac{(0.8)^2}{2}\right) = 528 \text{ W}$$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A broadcast transmitter radiates 20 kW when the modulation percentage is 75. Calculate carrier power and power of each sideband.
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Sol. : Here total power $P_{total} = 20{,}000$ W and $m = 0.75$

From equation we have $P_{total} = P_c\left(1+\dfrac{m^2}{2}\right)$

$$\therefore \quad 20{,}000 = P_c\left(1+\frac{(0.75)^2}{2}\right)$$

$$\therefore \quad P_c = 15.6 \text{ kW}$$

We know that $P_{total} = P_c\left(1+\dfrac{m^2}{2}\right) = P_c + P_c\,\dfrac{m^2}{2}$

The second term in above equation represents total sideband power. Hence power of one sideband will be,

$$P_{SB} = \left(P_c\,\frac{m^2}{2}\right)\times\frac{1}{2} = 15.6\times\frac{(0.75)^2}{2}\times\frac{1}{2} = 2.2 \text{ kW}$$

Thus $P_{USB} = P_{LSB} = 2.2$ kW

The total antenna current of an AM transmitter is 5 A. If modulation index is 0.6, calculate the carrier current in antenna.

Sol. : Here $I_{total} = 5\text{ A}$ and $m = 0.6$

From equation we have,

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

$$5 = I_c \sqrt{1 + \frac{(0.6)^2}{2}}$$

$$\therefore \quad I_c = 4.6 \text{ A}$$

A certain AM transmitter radiates 10 kW with the carrier modulated and 11.8 kW when the carrier is sinusoidally modulated. Calculate the modulation index. If another sine wave, corresponding to 30 % modulation, is transmitted simultaneously, determine the total radiated power.

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Sol. : Here $P_c = 10$ kW, $P_{total} = 11.8$ kW

Modulation index,

$$m = \sqrt{2\left(\frac{P_{total}}{P_c} - 1\right)} = \sqrt{2\left(\frac{11.8}{10} - 1\right)} = 0.6$$

This is first signal. Hence $m_1 = 0.6$. The another signal modulates 30 %. Hence $m_2 = 0.3$. Hence combined total modulation index due to two signals is,

$$m_t = \sqrt{m_1^2 + m_2^2} = \sqrt{0.6^2 + 0.3^2} = 0.67$$

Total power is,

$$P_{total} = P_c\left(1 + \frac{m_t^2}{2}\right) \quad \text{... By equation}$$

$$= 10\left(1 + \frac{(0.67)^2}{2}\right) = 12.24 \text{ kW}$$

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For an AM DSBFC wave with a peak unmodulated carrier voltage $V_c = 12\,V$, and modulation coefficient $m = 1$ with load resistance $R_L = 12\ \Omega$, determine the

i) Carrier power and the upper and lower sideband power (P_c, P_{USB}, P_{LSB})

ii) Total power of the modulated wave

iii) Draw the power spectrum.

Sol. : Given : $E_c = V_c = 12\ \text{V},\quad m = 1,\quad R = R_L = 12\ \Omega$

i) Carrier and sidebands power :

Carrier power, $$P_c = \frac{E_c^2}{2R} = \frac{12^2}{2\times 12} = 6\ \text{W}$$

Sidebands power, $$P_{LSB} = P_{USB} = \frac{m^2 E_c^2}{8R} = \frac{1^2 \times 12^2}{8\times 12} = 1.5\ \text{W}$$

ii) Total power of the modulated wave :

$$P_{total} = P_c\left(1+\frac{m^2}{2}\right) = 6\left(1+\frac{1^2}{2}\right) = 9\ \text{W}$$

$$P_{SB} = P_{LSB} + P_{USB} = 2\times\frac{m^2 E_c^2}{8R} = \frac{m^2 E_c^2}{4R}$$

For an AM DSBFC wave with a peak unmodulated carrier voltage $V_c = 12\,V$, and modulation coefficient $m = 1$ with load resistance $R_L = 12\ \Omega$, determine the

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Sol. : Given : $E_c = V_c = 12\ \text{V},\ \ m = 1,\ \ R = R_L = 12\ \Omega$

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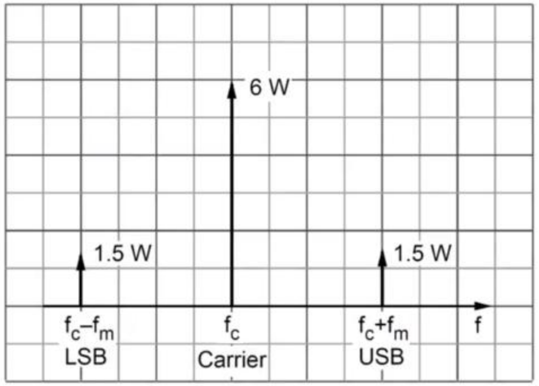
iii) Power spectrum

Fig.   shows the power spectrum based on sideband and carrier powers obtained above.



Power spectrum