Q.1) $m(t) = 2\cos 100t + 18\cos 2000\pi t$ (PS - VIII)

$A = 10 \quad \omega_c = 10^6 \quad k_f = 1000\pi \quad k_p = 1$ $\quad \Delta f = ?$ $\quad B = ?$

$\rightarrow \dot{m}(t) = -200\sin 100t - 36000\pi \sin 2000\pi t$

$m_p = 20 \qquad \dot{m}_p = 36000\pi + 200$

FM $\rightarrow \Delta f = \frac{k_f \cdot m_p}{2\pi} = \frac{1000\pi \times 20}{2\pi} = 10000$ Hz

$B_{FM} = 2.(\Delta f + B) = 2(10000 + 1000) = 22$ kHz

$\Rightarrow 18.\cos 2000\pi t$

$\omega_c = 2000\pi$

$f_c = 1000$ (B)

PM $\rightarrow \Delta f = \frac{k_p \cdot \dot{m}_p}{2\pi} = \frac{1 \times (36000\pi + 200)}{2\pi} = \left(18000 + \frac{100}{\pi}\right)$ Hz

$B_{PM} = 2.(B + \Delta f) = 36.06366$

Q.2) $e_{FM}(t) = 10.\cos(\underbrace{\omega_c t + 0.1\sin 2000\pi t}_{w_i})$ $\quad \omega_c = 2\pi \times 10^6$

a) $P = \frac{A^2}{2} = \frac{100}{2} = 50$

b) $B = \frac{2000\pi}{2\pi} = 1000$ Hz

c) $\Delta\omega \rightarrow w_i(t) = \omega_c + \underbrace{200\pi}_{\Delta\omega}\cos 2000\pi t = \frac{dw_i}{dt}$

$\Delta\omega = 200\pi \rightarrow \Delta f = 100$ Hz

$B_{FM} = 2(B + \Delta f) = 2.(1000 + 100) = 2.2$ kHz

Q3) $T = 10^{-3}$ s

$B_{M(t)} = \frac{1}{10^{-3}} = 1000$ Hz

3rd harmonic → $3 \times 1000 = 3000$ Hz = 3kHz

For FM → $\Delta f = \frac{k_f \cdot m_p}{2\pi} = \frac{10^5 \times 1}{2\pi} = 15.951$ kHz

$B_{FM} = 2(B + \Delta f) = 2.(3 + 15.951) = 37,831$ kHz

For PM → $\Delta f = \frac{k_p \cdot \dot{m}_p}{2\pi} = \frac{25 \times 8000}{2\pi} = 31,831$ kHz

$\left[\dot{m}_p = \frac{1-(-1)}{a} = \frac{2}{(10^{-3}/4)} = 8000 \right]$

$B_{PM} = 2(B + \Delta f) = 2(3 + 31.831) = 69,662$ kHz

Q4) $m(t) = \sin 2000\pi t$ $k_f = 200000\pi$ $k_p = 10$

a) For FM → $\Delta f = \frac{k_f \cdot m_p}{2\pi} = \frac{200000\pi \times 1}{2\pi} = 100$ kHz

$B = \frac{2000\pi}{2\pi} = 1000$ Hz = 1 kHz

$B_{FM} = 2.(B + \Delta f) = 2.(100 + 1) = 202$ kHz

For PM → $\Delta f = \frac{k_p \cdot \dot{m}_p}{2\pi} = \frac{10 \times 2000\pi}{2\pi} = 10$ kHz

$[\dot{m}(t) = 2000\pi . \cos 2000\pi t \rightarrow \dot{m}_p = 2000\pi]$

$B_{PM} = 2.(B + \Delta f) = 2.(1 + 10) = 22$ kHz

b) Signal amplitude is doubled $m(t) = 2.\sin 2000\pi t$

$$B = \frac{2000\pi}{2\pi} = 1000\,Hz = 1\,kHz$$

For FM → $\Delta f = \frac{k_f \cdot m_p}{2\pi} = \frac{200000\pi \times 2}{2\pi} = 200\,kHz$

$$B_{FM} = 2.(B + \Delta f) = 2.(1 + 200) = 402\,kHz$$

For PM → $\Delta f = \frac{k_p \cdot \dot{m}_p}{2\pi} = \frac{10 \times 4000\pi}{2\pi} = 20\,kHz$

$[\dot{m}(t) = 4000\pi.\cos 2000\pi t \rightarrow \dot{m}_p = 4000\pi]$

$$B_{PM} = 2.(B + \Delta f) = 2.(1 + 20) = 42\,kHz$$

c) Signal frequency is doubled $m(t) = \sin 4000\pi t$

$$B = \frac{4000\pi}{2\pi} = 2000\,Hz = 2\,kHz$$

For FM → $\Delta f = \frac{k_f \cdot m_p}{2\pi} = \frac{200000\pi \times 1}{2\pi} = 100\,kHz$

$$B_{FM} = 2.(B + \Delta f) = 2.(2 + 100) = 204\,kHz$$

For PM → $\Delta f = \frac{k_p \cdot \dot{m}_p}{2\pi} = \frac{10 \times 4000\pi}{2\pi} = 20\,kHz$

$[\dot{m}(t) = 4000\pi.\cos 4000\pi t \rightarrow \dot{m}_p = 4000\pi]$

$$B_{PM} = 2.(B + \Delta f) = 2.(2 + 20) = 44\,kHz$$