5.1-1:

FM: $\Delta\omega = k_f m_p = 10^5$

$\omega_i = \omega_c + k_f m(t)$

$\omega_{max} = \omega_c + k_f = 10^8 + 10^5$ rad/s

$\omega_{min} = \omega_c - k_f = 10^8 - 10^5$ rad/s

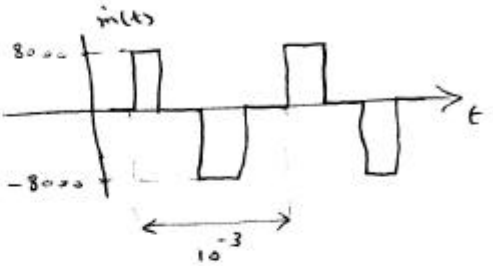
PM: $\Delta\omega = k_p m_p' = 25(8000) = 2*10^5$ rad/s

$\omega_i = \omega_c + k_p \dot{m}(t)$

$\omega_{max} = \omega_c + 25(8000)$

$= 10^8 + 2*10^5$ rad/s

$\omega_{min} = 10^8 - 2*10^5$ rad/s



5.1-2:

FM: $\Delta f = \frac{k_f}{2\pi} m_p = 1000$ Hz

$f_i = f_c + \frac{k_f}{2\pi} m(t)$

$f_{max} = f_c + \frac{k_f}{2\pi}(1) = 10^6 + 1000$ Hz

$f_{min} = 10^6 - 1000$ Hz

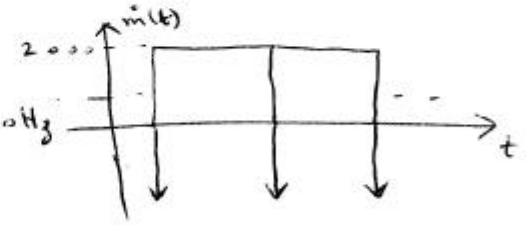
PM: $\Delta f = \frac{k_p}{2\pi} m_p' = \frac{2000}{4} = 500$ Hz

$f_i = f_c + \frac{k_p}{2\pi} \dot{m}(t)$

$\theta_i = 2\pi f_c t + k_p m(t)$

$\theta_{max} = 2\pi f_c t + \frac{\pi}{2}(1) = 2\pi*10^6 t + \frac{\pi}{2}$ rad

$\theta_{min} = 2\pi*10^6 t - \frac{\pi}{2}$ rad



So, phase of the PM signal changes between θ_{min} & θ_{max}

If $k_p \geq \pi$, $\theta_{max} = 2\pi*10^6 t + k_p$

$\theta_{min} = 2\pi*10^6 t - k_p$

So, the range $(\theta_{min}, \theta_{max})$ spans the unit circle more than one time $\Rightarrow$ different input value $\Rightarrow$ same phase.

5.1-1:

$$m(t) = 2\cos 100t + 18\cos 2000\pi t$$

a) **FM:**

$$\varphi_{FM}(t) = A\cos\left[\omega_c t + k_f \int_{-\infty}^{t} m(\tau)\,d\tau\right]$$

$$= 10\cos\left[10^6 t + 1000\pi\left(\frac{1}{50}\sin 100t + \frac{9}{1000\pi}\sin 2000\pi t\right)\right]$$

$$= 10\cos\left[10^6 t + 20\pi\sin 100t + 9\sin 2000\pi t\right]$$

PM:

$$\varphi_{PM}(t) = A\cos\left[\omega_c t + k_p\, m(t)\right]$$

$$= 10\cos\left[10^6 t + 2\cos 100t + 18\cos 2000\pi t\right]$$

b) **FM:** $\Delta\omega = k_f\, m_p = 1000\pi\,(2+18) = 2*10^4\pi$

$$\Rightarrow BW_{FM} = 2\left(\frac{\Delta\omega}{2\pi} + B\right)$$

$$= 2\left(10^4 + 10^3\right) = 21000\ Hz$$

PM: $\Delta\omega = k_p\, m_p' = 200 + 18(2000\pi) = 36200\pi$

$$\Rightarrow BW_{PM} = 2\left(\frac{\Delta\omega}{2\pi} + B\right)$$

$$= 2\left(18100 + 10^3\right) = 38200\ Hz$$

5.2-2:

$$\varphi_{FM}(t) = 10\cos\left(\omega_c t + 0.1\sin 2000\pi t\right)$$

a) Power $= \frac{10^2}{2} = 50\ W$

b) Δf is found from the instantaneous frequency

$$f_i = f_c + \frac{1}{2\pi}\,200\pi\cos(2000\pi t)$$

~~$\Rightarrow k_f = 1000Hz$~~ $\Rightarrow \Delta f = k_f\, m_p = 100\ Hz$

c) $\Delta\varphi = k_p\, m_p = 0.1$ rad

d) $BW = 2(\Delta f + B) = 2(100 + 1000) = 2.2\ KHz$