5.1-1:

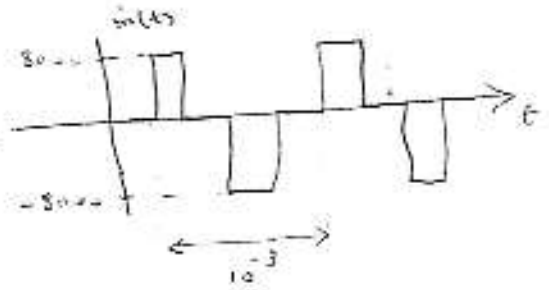
FM: $\Delta\omega = k_f m_p = 10^5$

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

$\omega_{max} = \omega_c + k_f = 10^3 + 10^5$ rad/s

$\omega_{min} = \omega_c - k_f = 10^3 - 10^5$ rad/s

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



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

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

$= 10^8 + 2\pi \times 10^5$ rad/s

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

5.1-3

(a) $\phi_{PM}(t) = A\cos[\omega_c t + k_p m(t)] = 10\cos[10{,}000t + k_p m(t)]$

Therefore: $k_p m(t) = 3000t$, so if $k_p = 1000$, $m(t) = 3t$

(b) $\phi_{FM}(t) = A\cos\left[\omega_c t + k_f \int^t m(\alpha)d\alpha\right] = 10\cos\left[10{,}000t + k_f \int^t m(\alpha)d\alpha\right]$

Therefore $k_f \int^t m(\alpha)d\alpha = 1000\int^t m(\alpha)d\alpha = 3000t$

and $3t = \int^t m(\alpha)d\alpha \Rightarrow m(t) = 3$

5.2-1:

$$m(t) = 2\cos 10^4 t + 15\cos 2000\pi t$$

a) **FM:**

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

$$= 10\cos\left[10^6 t + 1000\pi\left(\frac{1}{50}\sin 10^4 t + \frac{9}{1000\pi}\sin 2000\pi t\right)\right]$$

$$= 10\cos\left[10^6 t + 20\pi\sin 10^4 t + 9\sin 2000\pi t\right]$$

PM:

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

$$= 10\cos\left[10^6 t + 2\cos 10^4 t + 15\cos 2000\pi t\right]$$

b) **FM:** $\Delta\omega = k_f m_p = 1000\pi(2+15) = 2\times 10^4\pi$

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

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

PM: $\Delta\omega = k_f m_p' = 20\pi + 15(2000\pi) = 36200\pi$

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

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

5.2-3

$\varphi_{EM}(t) = 5\cos(\omega_c t + 20\sin 1000\pi t + 10\sin 2000\pi t)$

$\omega_c = 2\pi \times 10^6$

[a] The power of the modulated signal is

$P_{EM} = \frac{1}{2}A^2 = \frac{25}{2} = 12.5$

[b] Frequency Deviation

$\omega_i = \omega_c + 20000\pi \cos 1000\pi t + 20000\pi \cos 2000\pi t$

$\therefore \Delta f = \frac{40000\pi}{2\pi} = 20000\ Hz$.

[c] Phase deviation $\Delta\phi$

$\phi(t) = \omega_c t + 20\sin 1000\pi t + 10\sin 2000\pi t$

$\therefore \Delta\phi = 20 + 10 = 30\ rad$.

[d] BW of $\varphi_{EM}(t)$

$B_{EM} = 2(\Delta f + B)$

$= 2\left(20000 + \frac{2000\pi}{2\pi}\right) = 2(21000)$

$= 42000\ Hz$.