Q3) $s_{FM}(t) = 20\cos\left[10^8\pi t + 1000\pi\int_{-\infty}^{t}\cos(10^3\pi\tau)\,d\tau\right]$, phase $= \left[10^8\pi t + 1000\pi\int_{-\infty}^{t}\cos(10^3\pi\tau)\,d\tau\right]$

1) $f(t) = \frac{1}{2\pi}\frac{d\Psi(t)}{dt} = \frac{1}{2\pi}\left[10^8\pi + \pi(1000)\cos(10^3\pi t)\right] = 5\times10^7 + 500\cos(10^3\pi t)$

$f_c = 5\times10^7 = 50\text{MHz}$, $\Delta f = \max_t|f(t) - f_c| = 500\text{Hz}$

2) $\beta = \frac{\Delta f}{f_m} = \frac{500}{500} = 1$

3) $P_t = \frac{A^2}{2} = \frac{20^2}{2} = 200\text{W}$

P at 2nd side: $P_2 = 2P_t|J_2(1)|^2 = 400\times0.1149^2 = 5.28\text{W}$

4) At 49.9999MHz, $49.9999 = f_c - 0.2f_m$, no frequency component $\Rightarrow P = 0$

$49.9995 = f_c - 1f_m$, $P = P_t|J_1(1)|^2 = 200\times0.44^2 = 38.72\text{W}$

5) $|J_0(1)|\times5\% = 0.03826 \Rightarrow$ when $n>2$, $|J_n(1)| < |J_0(1)|$

$\therefore$ sidebands $f_c - 2f_m$ to $f_c + 2f_m$ transmit, required channel $B = 4f_m = 2000\text{Hz}$

6) $50.0005\text{M} = f_c + 1f_m$ when $\beta \approx 4$, $J_1(\beta) = 0$

$\therefore$ effective $B = 2(\beta+1)f_m = 5000\text{Hz}$