① -a $\phi(t) = \cos 2\pi\, 110\, 10^3 t \cdot \cos 2\pi\, 150\, 10^3 t$

$= \frac{1}{2}\cos 410\, 10^3 t + \frac{1}{2}\cos 260\, 10^3 t$

-b $\phi_{FI(t)} = \frac{1}{2}\cos 410\, 10^3 t$

-c $\phi(t) = \frac{1}{2}\cos 410\, 10^3 t \cdot \cos 50\, 10^3 t$

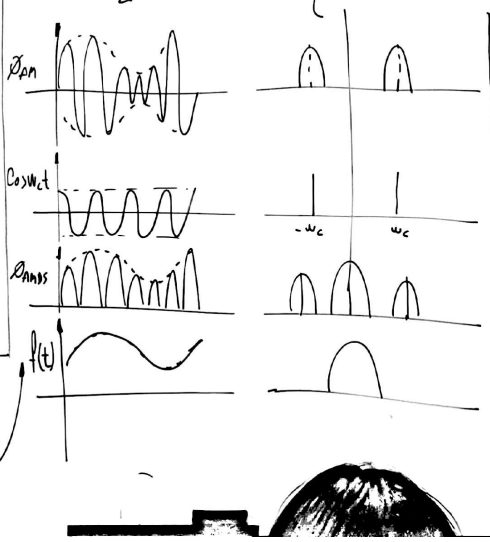
$= \frac{1}{4}\cos 10^4 t + \frac{1}{4}\cos 90\, 10^3 t$

-d $f(t) = \frac{1}{4}\cos 10^4 t$

② $\phi_{AMDS} = \left[A + f(t)\right]\left[\frac{1}{2} + \frac{1}{2}\cos 2\omega_c t\right]$

$= \frac{A}{2} + \frac{f(t)}{2} + \frac{A}{2}\cos 2\omega_c t + \frac{f(t)}{2}\cos 2\omega_c t$

$\phi_{AMDS} = \frac{A}{2}S(w) + \frac{F(w)}{2} + \frac{\pi}{2}A\left[\delta(w+2w_c) + \delta(w-2w_c)\right] + \frac{1}{4}\left[F(w+2w_c) + F(w-2w_c)\right]$



③ A- ϕ_{FM} — $\frac{d}{dt}$ — N — FPB — $f(t)$

B- $\frac{d\phi_{FM}}{dt} = E_c\left[w_c + k_f f(t)\right]\cdot \cos\left[w_c t + k\int f(t)dt\right]$

④ A- $m_f = \frac{\Delta f}{f_m} \Rightarrow \Delta f = m_f \cdot f_m = 1 \cdot 10kHz = 10kHz$

B- $\phi_{FM} = 0{,}77 \operatorname{Sen} 2\pi 10^5 t - 0{,}44\cos 2\pi\, 110\, 10^3 t - 0{,}44\cos 2\pi\, 90\, 10^3 t - 0{,}11 \operatorname{Sen} 2\pi\, 120\, 10^3 t - 0{,}11 \operatorname{Sen} 2\pi\, 80\, 10^3 t + 0{,}02\cos 2\pi\, 130\, 10^3 t + 0{,}02\cos 2\pi\, 70\, 10^3 t$

C- $B_{FM} = 2\left(\Delta f_c + B\right) = 2\left(10k + 10k\right) = 40kHz$

D- $P_T = E_c^2/2Z_L = \frac{1}{2}W$

(5) $G = \frac{Z_2}{Z_1 + Z_2} = \frac{87}{260 + 87} = \frac{1}{4} \Rightarrow F = 4$

$Te = (F - 1) \cdot Ts$

$= (4 - 1) \cdot 290 = \boxed{870\,k}$