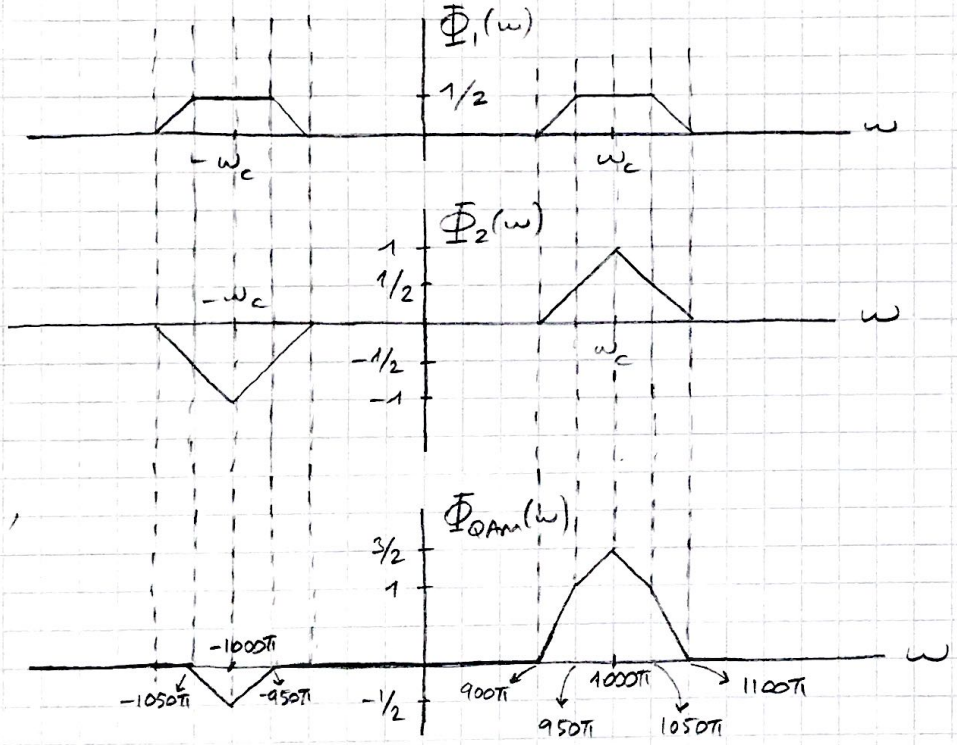
EECEN 322 HW #1 SOL'N

Pr 1

a) $\varphi_{QAM}(t) = m_1(t)\cos\omega_c t + m_2(t)\sin\omega_c t$

$$\Rightarrow \Phi_{QAM}(\omega) = \underbrace{\frac{1}{2}[M_1(\omega-\omega_c)+M_1(\omega+\omega_c)]}_{\Phi_1(\omega)} + \underbrace{\frac{1}{2j}[M_2(\omega-\omega_c)-M_2(\omega+\omega_c)]}_{\Phi_2(\omega)}$$



Hence,

b) Let $y_1(t) = 2\varphi_{QAM}(t)\cos\omega_c t$ (according to the block diagram)

$$\Rightarrow y_1(\omega) = \Phi_{QAM}(\omega-\omega_c) + \Phi_{QAM}(\omega+\omega_c)$$

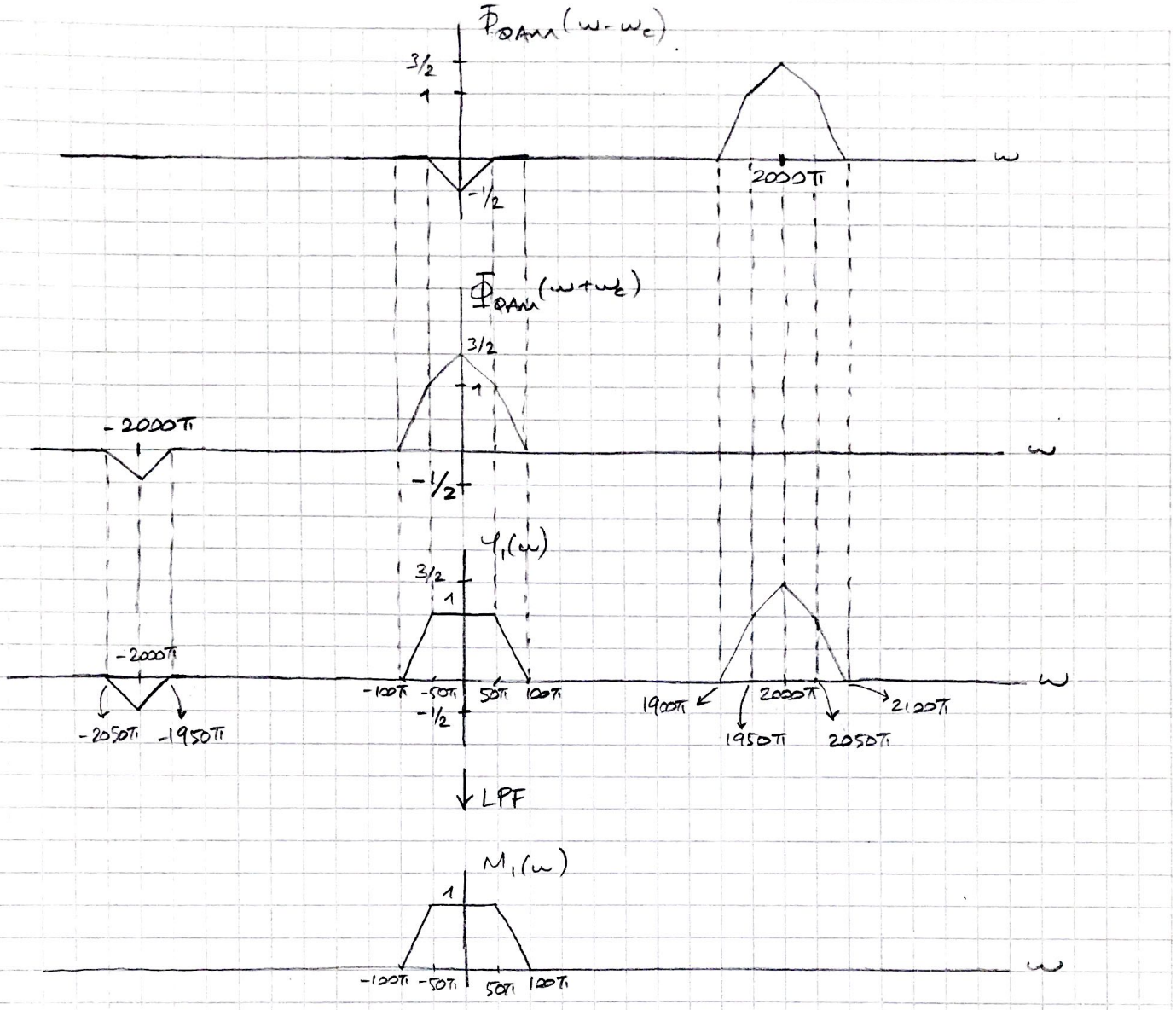
Substitute $\Phi_{QAM}(\omega)$ expression found in (a)

$$\Rightarrow y_1(\omega) = \frac{1}{2}[M_1(\omega-2\omega_c)+M_1(\omega)] + \frac{1}{2j}[M_2(\omega-2\omega_c)-M_2(\omega)]$$

$$+ \frac{1}{2}[M_1(\omega)+M_1(\omega+2\omega_c)] + \frac{1}{2j}[M_2(\omega)-M_2(\omega+2\omega_c)]$$

$$\Rightarrow y_1(\omega) = \underbrace{\frac{1}{2}M_1(\omega-2\omega_c) + \frac{1}{2j}M_2(\omega-2\omega_c)}_{\text{suppressed by the LPF}} + M_1(\omega) + \underbrace{\frac{1}{2}M_1(\omega+2\omega_c) - \frac{1}{2j}M_2(\omega+2\omega_c)}_{\text{suppressed by the LPF}}$$

The low-pass filter will suppress the spectrum components at $\pm 2\omega_c$, therefore the output will be $m_1(t)$.



c) Let $y_2(t) = 2\, y_{DSB}(t) \sin w_c t$ (according to the block diagram)

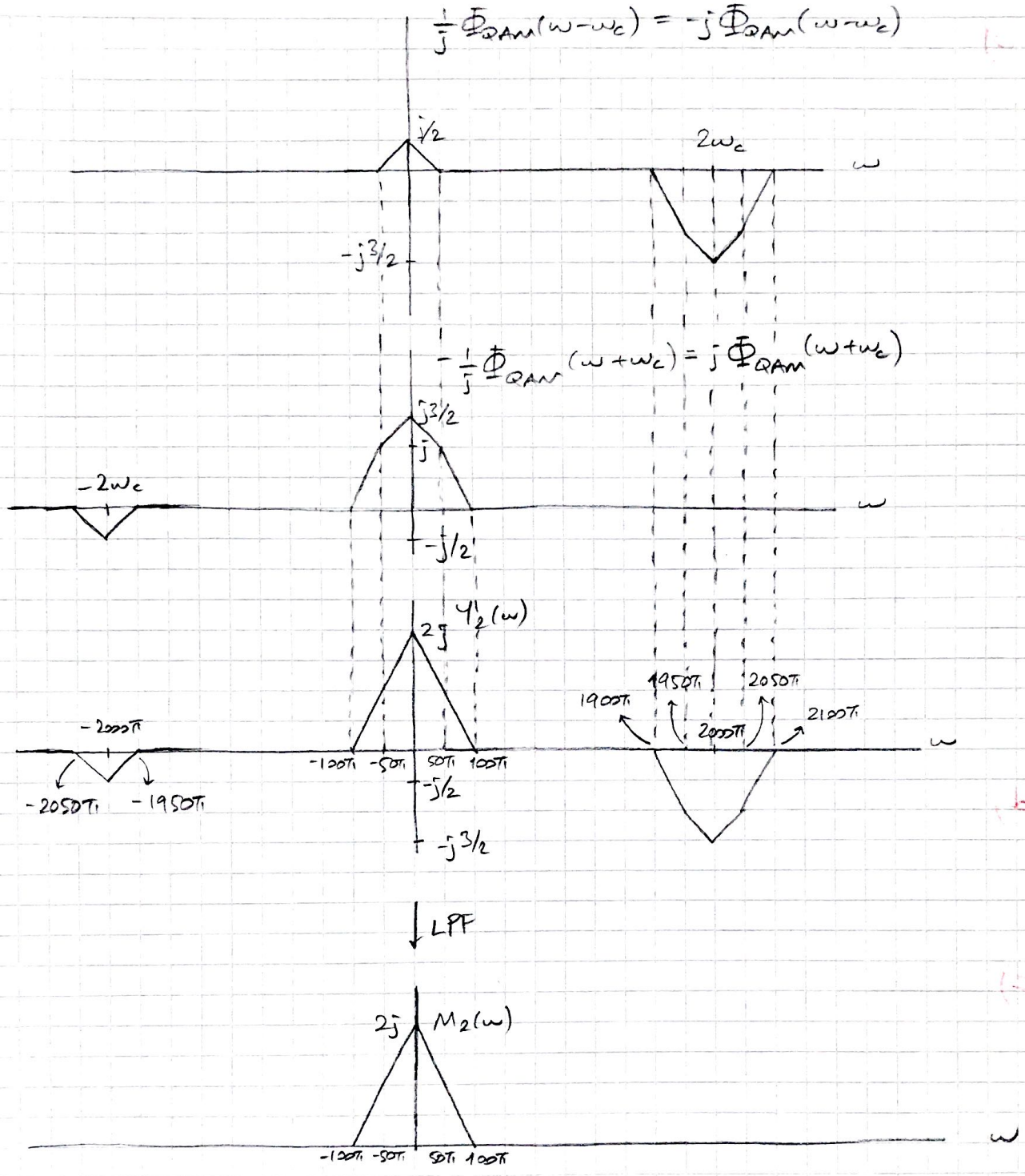
$$\Rightarrow Y_2(w) = \frac{1}{j}\left[\Phi_{DSB}(w-w_c) - \Phi_{DSB}(w+w_c)\right]$$

$$= \frac{1}{2j}\left[M_1(w-2w_c)+M_1(w)\right] - \frac{1}{2}\left[M_2(w-2w_c) - M_2(w)\right]$$

$$- \frac{1}{2j}\left[M_1(w)+M_1(w+2w_c)\right] + \frac{1}{2}\left[M_2(w) - M_2(w+2w_c)\right]$$

$$\Rightarrow Y_2(w) = \underbrace{\frac{1}{2j}M_1(w-2w_c) - \frac{1}{2}M_2(w-2w_c)}_{\text{suppressed by the LPF}} + M_2(w) \underbrace{- \frac{1}{2j}M_1(w+2w_c) - \frac{1}{2}M_2(w+2w_c)}_{\text{suppressed by the LPF}}$$

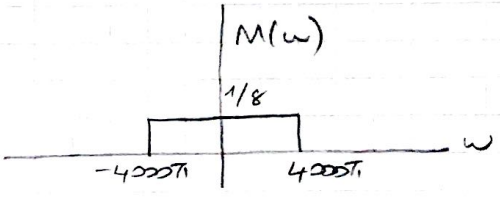
The low-pass filter will suppress the spectrum components at $\pm 2w_c$, therefore the output will be $m_2(t)$.



Pr 2

a) $m(t) = 500\,\mathrm{sinc}(4000\pi t)$

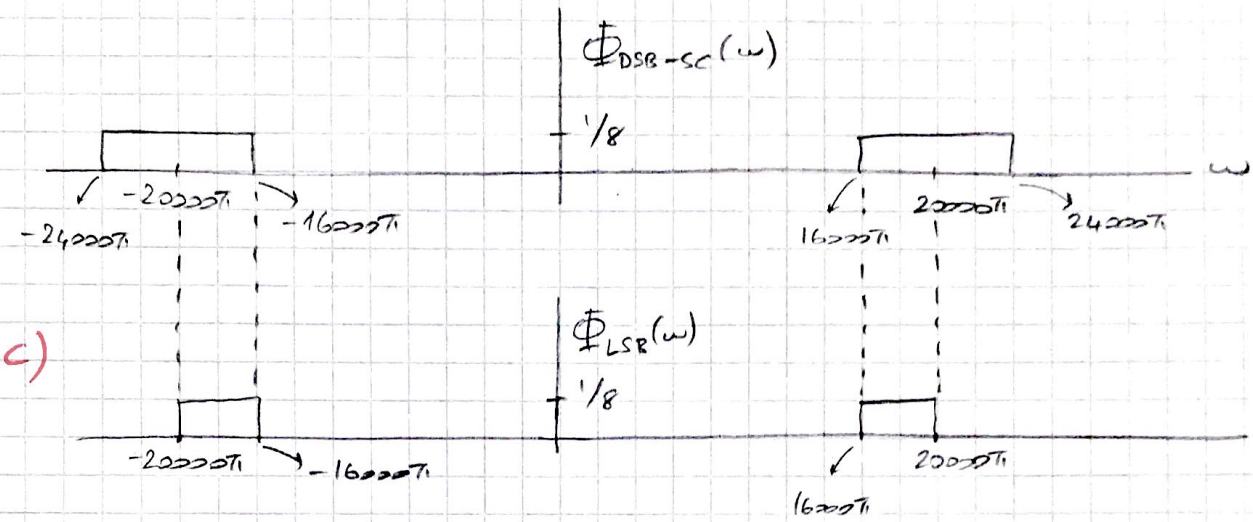
$\Rightarrow M(\omega) = \frac{1}{8}\,\mathrm{rect}\left(\frac{\omega}{8000\pi}\right)$



b) $\varphi_{DSB-SC}(t) = 2m(t)\cos\omega_c t$

$\Rightarrow \Phi_{DSB-SC}(\omega) = M(\omega-\omega_c) + M(\omega+\omega_c)$

$= \frac{1}{8}\,\text{rect}\left(\frac{\omega - 2000\pi}{800\pi}\right) + \frac{1}{8}\,\text{rect}\left(\frac{\omega + 2000\pi}{800\pi}\right)$



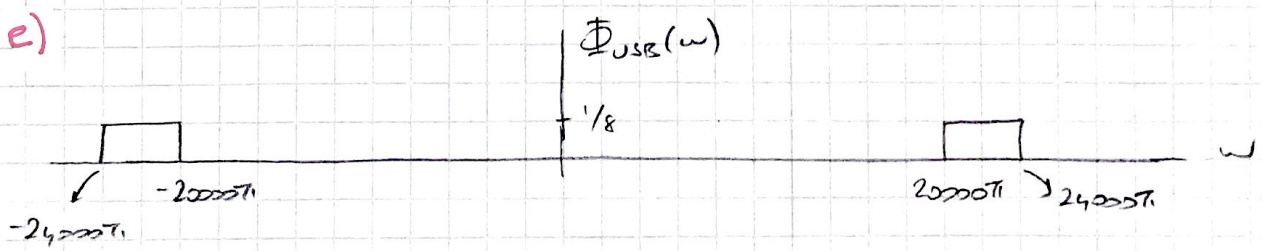
c)

$\Phi_{LSB}(\omega) = \frac{1}{8}\,\text{rect}\left(\frac{\omega - 1800\pi}{400\pi}\right) + \frac{1}{8}\,\text{rect}\left(\frac{\omega + 1800\pi}{400\pi}\right)$

d) $\varphi_{LSB}(t) = \frac{2000\pi}{8\pi}\,\text{sinc}(2000\pi t)\,e^{j1800\pi t} + \frac{2000\pi}{8\pi}\,\text{sinc}(2000\pi t)\,e^{-j1800\pi t}$

$= 500\,\text{sinc}(2000\pi t)\cos 1800\pi t$

e)



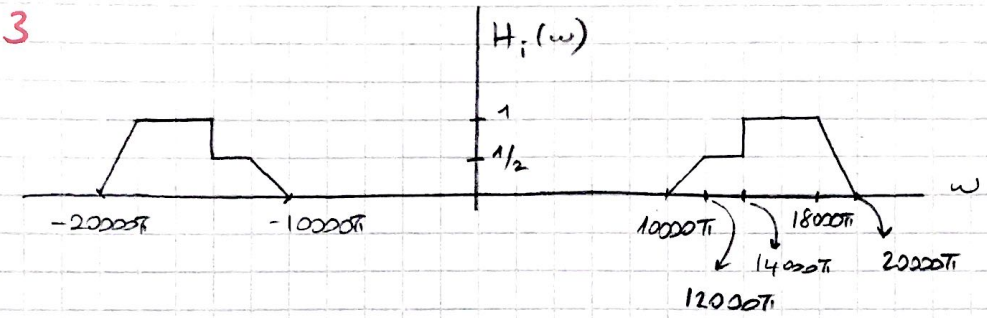
$\Phi_{USB}(\omega) = \frac{1}{8}\,\text{rect}\left(\frac{\omega - 2200\pi}{400\pi}\right) + \frac{1}{8}\,\text{rect}\left(\frac{\omega + 2200\pi}{400\pi}\right)$

$\Rightarrow \varphi_{USB}(t) = \frac{2000\pi}{8\pi}\,\text{sinc}(2000\pi t)\,e^{j2200\pi t}$

$+ \frac{2000\pi}{8\pi}\,\text{sinc}(2000\pi t)\,e^{-j2200\pi t}$

$= 500\,\text{sinc}(2000\pi t)\cos 2200\pi t$

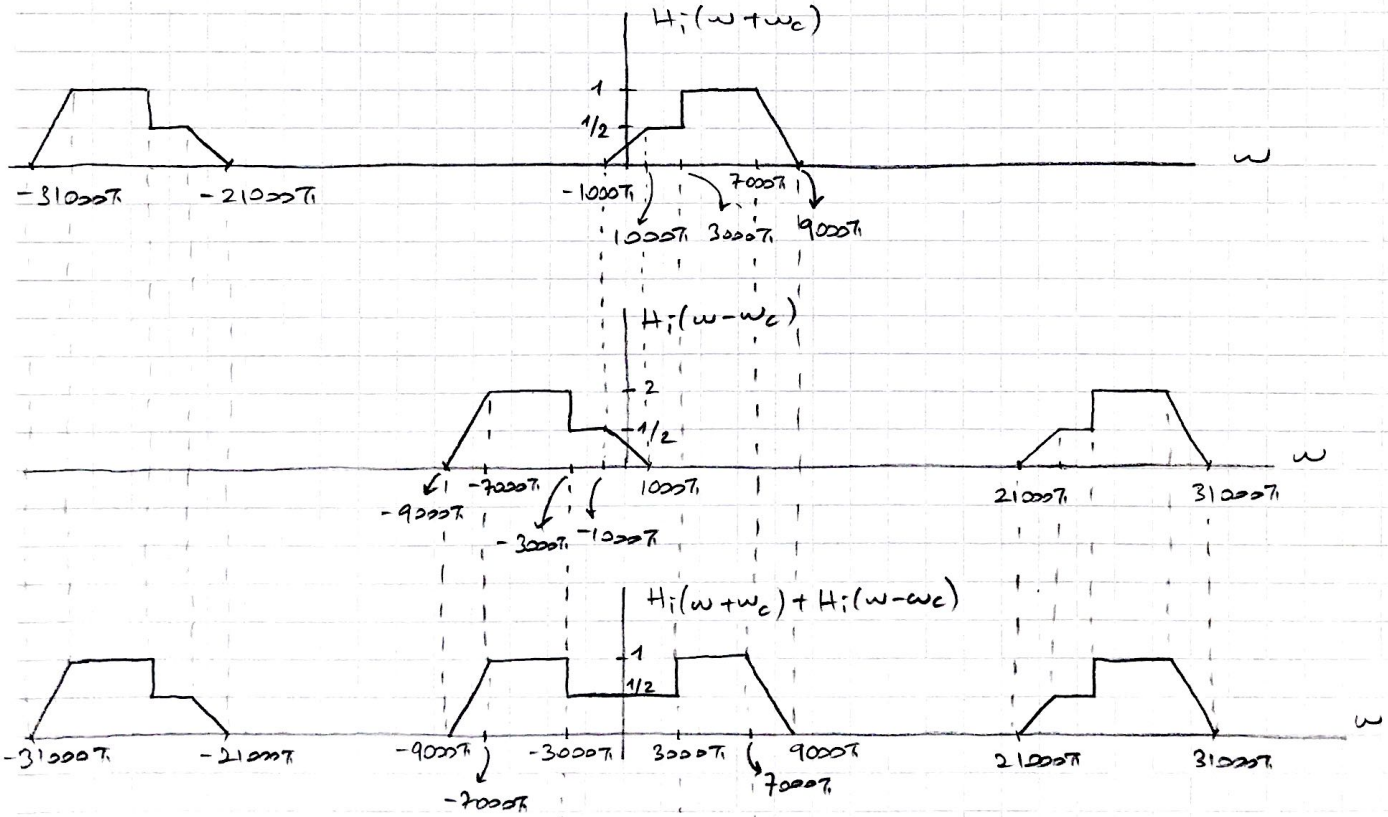
Pr 3



$$H_o(\omega) = \frac{1}{H_i(\omega+\omega_c) + H_i(\omega-\omega_c)} \quad \text{for} \quad -2\pi B \le \omega \le 2\pi B$$

$$\Rightarrow H_o(\omega) = \frac{1}{H_i(\omega+11000\pi) + H_i(\omega-11000\pi)}, \quad -7000\pi \le \omega \le 7000\pi$$

(and $H_o(\omega) = 0$ for $|\omega| \ge 7000\pi$)



Since $H_o(\omega) = \begin{cases} \dfrac{1}{H_i(\omega+11000\pi) + H_i(\omega-11000\pi)}, & |\omega| \le 7000\pi \\ 0, & |\omega| > 7000\pi \end{cases}$

we have

b) $$H_o(\omega) = \text{rect}\left(\frac{\omega}{14000\pi}\right) + \text{rect}\left(\frac{\omega}{6000\pi}\right)$$

c) $$h_o(t) = 7000\,\text{sinc}(7000\pi t) + 3000\,\text{sinc}(3000\pi t)$$