I

1.) Não inversora → Série-Paralelo → $Z_o \downarrow$

c)

2.) B)

3.) C)

4.) D)

5.) E)

II a) $\omega_{p_1} \cdot \omega_{p_2} = \omega_0^2$, $\omega_{s_1} \cdot \omega_{s_2} = \omega_0^2$ $\Rightarrow \omega_{p_1}\omega_{p_2} = \omega_{s_1}\omega_{s_2}$

$800 \times 1200 = 5500 \times 160 \Leftrightarrow$

$\Leftrightarrow 960 \times 10^3 = 880 \times 10^3$ (Não verifica simetria)

$\omega_{s_1} = \dfrac{\omega_{p_1}\omega_{p_2}}{\omega_{s_2}} = 1097 \text{ rad/s} \Rightarrow 174{,}5 \text{ Hz}$

$\Omega_S = \dfrac{\omega_{s_1} - \omega_{s_2}}{\omega_{p_1} - \omega_{p_2}} = 13{,}3$

$A(\Omega) = 10 \log(1 + \varepsilon^2 \Omega^{2n})$

$A(1) = 3\text{dB} \Rightarrow 3 = 10\log(1+\varepsilon^2) \Rightarrow \varepsilon = 1$

$A(13{,}3) = 18\text{dB} \Rightarrow 18 = 10\log(1 + 13{,}3^{2n}) \Rightarrow n = 1 \rightarrow A(13{,}3) = 22.5 \text{ dB}$

$n = 1 \quad \varepsilon = 1 \quad S = \dfrac{s^2 + \omega_0^2}{Bs}$

$H(S) = S + 1 \rightarrow T(s) = \dfrac{1}{H(S)}\Bigg|_{S = \frac{s^2+\omega_0^2}{Bs}} = \dfrac{Bs}{s^2 + \omega_0^2 + Bs}$

$B = \omega_{p_1} - \omega_{p_2} = 400 \cdot 2\pi \text{ rad/s}$

$\omega_0 = \sqrt{\omega_{p_1}\omega_{p_2}} = 979.79 \cdot 2\pi \text{ rad/s}$

$\Rightarrow \dfrac{2513s}{s^2 + 2513s + 37.9 \times 10^6}$ //

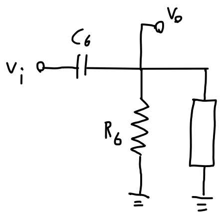
b) $n = 1$

$A_B(\Omega) = 10\log(1 + \varepsilon^2\Omega^2)$

$A_C(\Omega) = 10\log(1 + \varepsilon^2\Omega^2)$

$\Rightarrow$ Para $n = 1$ Cheby e Butter são iguais

c)



$Y_1 = \dfrac{1}{R^2 C_4 s} \Rightarrow Z_1 = R^2 C_4 s$

Bobine de R^2C_4 Henry //

$R = R_1 = R_2 = R_3 = R_5$

$V_o = \dfrac{R_6 // Z_1}{\frac{1}{sC_6} + R_6 // Z_1} v_i \Rightarrow T(s) = \dfrac{\left(\frac{1}{R_6} + \frac{1}{R^2C_4 s}\right)^{-1}}{\frac{1}{sC_6} + \left(\frac{1}{R_6} + \frac{1}{R^2C_4s}\right)^{-1}} = \dfrac{1}{\frac{1}{sC_6R_6} + \frac{1}{s^2C_6C_4R^2} + 1} = \dfrac{s^2}{s^2 + \frac{1}{C_6R_6}s + \frac{1}{C_6C_4R^2}}$

$\omega_p^2 = 2{,}527 \times 10^8$

$Q_p = \sqrt{5}$

$\dfrac{Ks^2}{s^2 + \frac{\omega_p}{Q_p}s + \omega_p^2}$ $K = 1$

$\begin{cases} \omega_p^2 = \dfrac{1}{C_6C_4R^2} \Rightarrow C_4 = \dfrac{1}{\omega_p^2 C_6 R^2} = 39.6 \text{ mF} \\ \dfrac{\omega_p}{Q_p} = \dfrac{1}{C_6R_6} \Rightarrow R_6 = \dfrac{Q}{\omega_p C_6} = 1.407 \text{ k}\Omega \end{cases}$

d) TFL ⇒ Malhas encaixadas ⇒ Menos sensibilidade

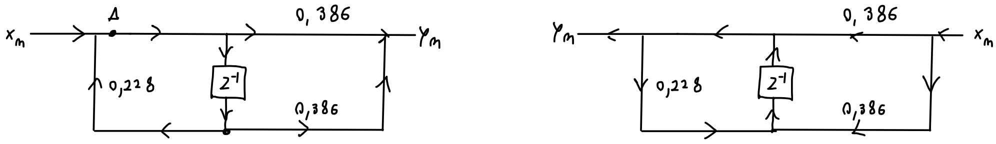
a) $s = \frac{2}{T}\frac{1-z^{-1}}{1+z^{-1}} \Rightarrow z^{-1} = \frac{2-sT}{2+sT}$

$\alpha = 0{,}38587 \quad \beta = 0{,}22826$

$$T(s) = T(z)\Big|_{z^{-1}=\frac{2-sT}{2+sT}} = \frac{\alpha\left(1+\frac{2-sT}{2+sT}\right)}{1-\beta\frac{2-sT}{2+sT}} = \frac{\alpha(2+sT+2-sT)}{2+sT-\beta(2-sT)} = \frac{4\alpha}{2-2\beta+sT(1+\beta)} = \frac{\frac{4\alpha}{T(1+\beta)}}{s+\frac{2(1-\beta)}{T(1+\beta)}} = \frac{31.4\times10^3}{s+31.4\times10^3}$$

b) $A\left(\frac{f_s}{2}\right) = T(s)\Big|_{s\to\infty} = 0 \Rightarrow A=\infty$

c)



IV a) $A = -k$

$$\beta = \left(\frac{R}{R+\frac{1}{sC}}\right)^3 = \left(\frac{sCR}{1+sCR}\right)^3$$

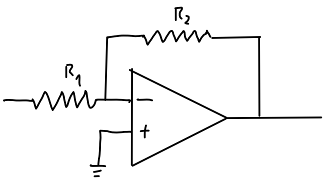
$A\beta = 1$

$$A\beta = \frac{-K\cdot s^3C^3R^3}{1+3sCR+3s^2C^2R^2+s^3C^3R^3} = \frac{-K}{\frac{1}{s^3C^3R^3}+\frac{3}{s^2C^2R^2}+\frac{3}{sCR}+1}$$

Re: $\frac{-K}{1-\frac{3}{\omega^2C^2R^2}} = 1 \Leftrightarrow -K = 1-\frac{3}{\frac{1}{3R^2C^2}\cdot R^2C^2} \Rightarrow K = 8$

Im: $-\frac{3}{\omega CR}+\frac{1}{\omega^3C^3R^3} = 0 \Leftrightarrow \omega = \frac{1}{\sqrt{3}\,RC} = 5{,}774\times10^3\ rad/s \Rightarrow 918{,}9\ Hz$

b)



$G = -8 = -\frac{R_2}{R_1}$

$R_2 = 8R_1 = 1.6\ M\Omega$

$R' = R /\!/ R_1 = 100k\Omega \Rightarrow R = 200k\Omega$ //

c) A Ponte de Wien filtra

d) Um divisor de tensão na entrada