

$\alpha_{MAX} [dB]$	$\alpha_{min} [dB]$	$F_p [Hz]$	$F_s [Hz]$
1	12	1500	3000

Como $\alpha_{MAX} \neq 3 dB \Rightarrow$ No es Butter
 $\epsilon \neq 1$

$$1) \Omega_w = 2\pi \cdot 1500 \text{ Hz}$$

$$\frac{\Omega_{w0}}{\Omega_w} = \frac{2\pi \cdot 3000 \text{ Hz}}{2\pi \cdot 1500 \text{ Hz}} = 2$$

$$\epsilon^2 = 10^{\alpha_{MAX}/10} - 1 = 0,259$$

$$\epsilon = 0,51$$

$$n = \frac{\log(10^{0,1 \cdot \alpha_{min}} - 1) / (10^{0,1 \cdot \alpha_{MAX}} - 1)}{2 \log(\omega_s)} = 2,92 \Rightarrow \boxed{n=3}$$

$$|T(j\omega)|^2 = \frac{1}{1 + \epsilon^2 \omega^{2n}} \bigg|_{\omega=s/j} = [T(s) \cdot T(-s)]$$

$$= \frac{1}{1 + \epsilon^2 \left(\frac{s}{j}\right)^6} = \frac{1}{1 - \epsilon^2 s^6} = T(s) \cdot T(-s)$$

$$\frac{1/\epsilon^2}{-s^6 + 1/\epsilon^2} = \frac{1}{as^3 + bs^2 + cs + d} \cdot \frac{1}{-as^3 + bs^2 - cs + d} = T(s) \cdot T(-s)$$

$$\boxed{\begin{matrix} d=1 \\ a=\epsilon^2 \end{matrix}}$$

$$bs^2d + bs^2d - s^2c^2 = 0$$

$$2bd = c^2 \rightarrow c = \sqrt{2b}$$

$$-2acs^4 - 2acs^4 + b^2s^4 = 0$$

$$+22c = b^2 - b^2 = 2\epsilon^2$$

$$\therefore b^2 = 2\epsilon^2 \sqrt{2b}$$

$$\left(\frac{b^2}{2\epsilon^2}\right)^2 = 2b$$

$$b^4 = b$$

$$\text{NOT } 2,4\epsilon^4$$

$$b^3 = 8\epsilon^4 \rightarrow b = 2\sqrt[3]{\epsilon^4}$$

$$c = \frac{(2\epsilon^{4/3})^2}{2\epsilon^2} = \frac{4\epsilon^{8/3}}{2\epsilon^2}$$

$$c = 2\epsilon^{2/3} \rightarrow \boxed{c = 2\sqrt[3]{\epsilon^2}}$$

$$T(s) = \frac{1}{\varepsilon^2 s^3 + 2\sqrt[3]{\varepsilon^4} s^2 + 2\sqrt[3]{\varepsilon^2} s + 1}$$

$$T(s) = \frac{1/\varepsilon^2}{s^3 + \frac{2}{\sqrt[3]{\varepsilon^2}} s^2 + \frac{2}{\sqrt[3]{\varepsilon^4}} s + 1/\varepsilon^2}$$

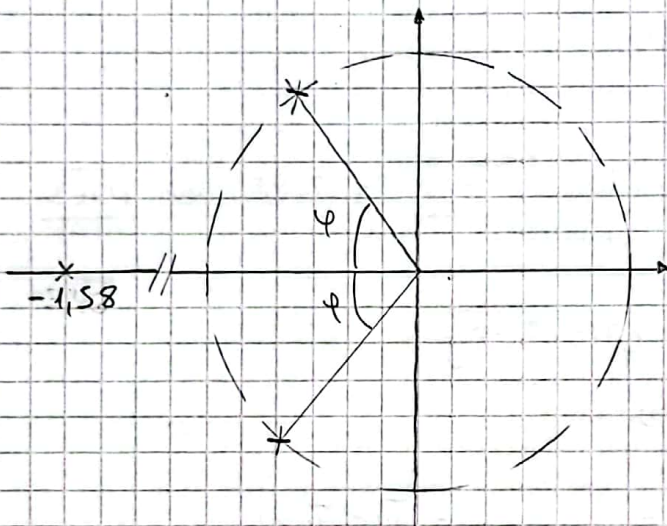
2)

$$s^3 + 3,14 s^2 + 4,91 s + 3,86$$

$$\text{raíces: } s_1 = -1,58$$

$$s_2 = 0,78 + j1,35$$

$$s_3 = 0,78 - j1,35$$



$$\tan \varphi = \left(\frac{1,35}{0,78} \right)$$

$$\varphi = 59,98 \approx 60^\circ$$

Rta en frecuencia

$$T(s) \Big|_{s=j\omega} = \frac{1/\varepsilon^2 \cdot 3,86}{-j\omega^3 - j3,14\omega^2 + j\omega 4,91 + 3,86} = \frac{1/\varepsilon^2 \cdot 3,86}{3,86 - j(\omega^3 + 3,14\omega^2 - 4,91\omega)}$$

$$|T(j\omega)| = \frac{3,86}{\sqrt{(3,86)^2 + (\omega^3 + 3,14\omega^2 - 4,91\omega)^2}}$$

$$\omega \rightarrow 0 \Rightarrow T(j\omega) = 1$$

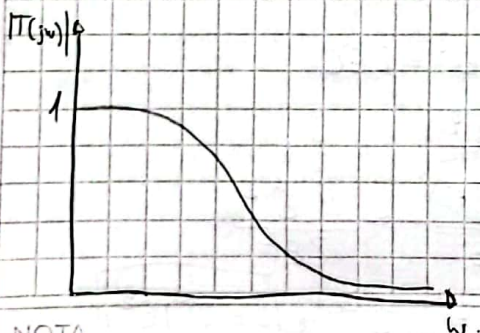
$$\omega \rightarrow \infty \Rightarrow T(j\omega) \rightarrow 0$$

$$\omega = 1 \Rightarrow T(j\omega) = 0,98 \approx 1$$

$$\omega = 2 \Rightarrow T(j\omega) = 0,34$$

$$\omega = 3 \Rightarrow T(j\omega) = 0,095$$

$$\omega = 4 \Rightarrow T(j\omega) = 0,041$$



NOTA