

TAREA SEMANAL 4 BIS

$F_{CI} = 1600 \text{ KHz}$, $F_{CS} = 2500 \text{ KHz}$; $\alpha_{\min} = 20 \text{ dB}$ EN $1250 \text{ KHz} \times 3200 \text{ KHz}$

WP

WS

$$\alpha_{\max} = 3 \text{ dB}$$

2) BUSCO LOS VALORES DE LA PLANTILLA PASA-BAJO

$$\omega_0 = \sqrt{WP_1 \cdot WP_2} \Rightarrow \omega_0 = \sqrt{1600 \text{ KHz} \cdot 2500 \text{ KHz}} \Rightarrow \omega_0 = 2 \text{ MHz}$$

$$WP_{1-N} = 1600 \text{ KHz} / 2 \text{ MHz} \Rightarrow WP_{1-N} = 0,8 ; WS_{1-N} = 0,625$$

$$WP_{2-N} = 1,25 ; WS_{2-N} = 1,6$$

$$B-W-N = WP_{2-N} - WP_{1-N} \Rightarrow BW-N = 0,450 \rightarrow Q = \omega_{0-N} / BW-N$$

$$Q = \frac{20}{9} \approx 2,22$$

$$\kappa_{P1-N} = Q \frac{(WP_{1-N}^2 - 1)}{WP_{1-N}} \Rightarrow \kappa_{P1-N} = -1$$

$$\kappa_{P2-N} = Q \frac{(WP_{2-N}^2 - 1)}{WP_{2-N}} \Rightarrow \kappa_{P2-N} = 1$$

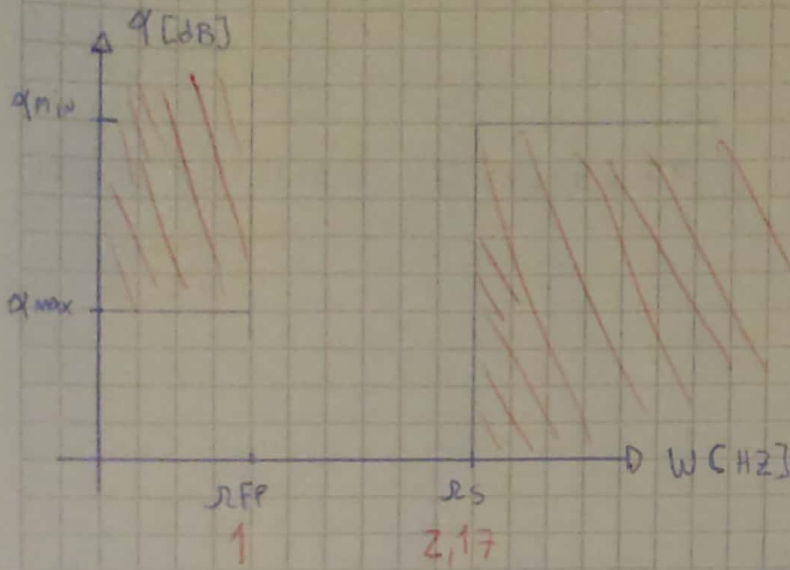
$$1 = \kappa_P$$

$$\kappa_{S1-N} = Q \frac{(WS_{1-N}^2 - 1)}{WS_{1-N}} \Rightarrow \kappa_{S1-N} = -2,17$$

$$\kappa_{S2-N} = Q \frac{(WS_{2-N}^2 - 1)}{WS_{2-N}} \Rightarrow \kappa_{S2-N} = +2,17$$

$$\kappa_S = 2,17$$

PLANTILLA DEL PASABANDAS



▷ GANANCIA DE 10 dB, ENTONCES

$$q_{max} = 10 \text{ dB} - 3 \text{ dB} = 7 \text{ dB}$$

$$q_{min} = 10 \text{ dB} - 20 \text{ dB} = -10 \text{ dB}$$

$$\frac{z}{\epsilon} = 10^{-1} \quad -1$$

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$$\frac{z}{\epsilon} = 0,9953$$

$$\frac{z}{\epsilon} = 4,0120$$

$$\epsilon = 0,9976$$

$$\epsilon = 2,0030$$



CASO ①



CASO ②

CASO ①:

$$q_{min}(n) = 10 \log \left(1 + \epsilon^2 r_s^{2n} \right); \quad q_{min 2} = 10 \log \left(1 + \epsilon^2 \underbrace{r_s}_{2,17}^4 \right)$$

$$q_{min 3} = 10 \log \left(1 + \epsilon^2 r_s^5 \right)$$

$$q_{min 2} = 13,63 \text{ dB}$$

$$q_{min 3} = 20,20 \text{ dB} \rightarrow n = 3$$

CASO ②

$$\alpha_{\min 2} = 10 \log (1 + \epsilon^2 \omega_s^4) \Rightarrow \alpha_{\min 2} = 19,54 \text{ dB}$$

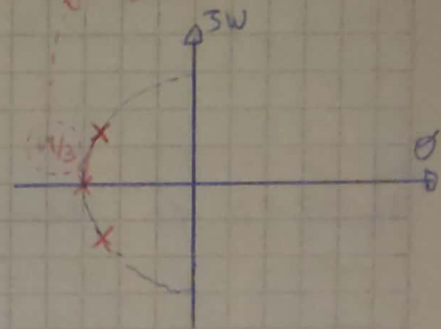
$$\alpha_{\min 1} = 10 \log (1 + \epsilon^2 \omega_s^2) \Rightarrow \alpha_{\min 1} = 12,98 \text{ dB} \rightarrow n = 1$$

CASO ①

FILTRO PASA BAJOS ORDEN 3 NORMALIZADO (BUTTER)

$$Q = \frac{1}{2 \cos(45^\circ)} = 1$$

$$T_{LP}(\omega) = \frac{1}{\omega^2 + \omega + 1} \cdot \frac{1}{\omega + 1}$$



CASO ②

11 11 11 11 1 11 (BUTTER)

$$T_{LP}(\omega) = \frac{1}{\omega + 1}$$

ELIJO SEGUIR POR EL CASO 1. PRIMERO LO RESUEVO CON T NORMALIZADA.

$$T_{BP}(s) = T_{LP}(\omega) \Big|_{\omega = Q \frac{s^2 + 1}{s}} = \frac{1}{Q^2 \frac{(s^2 + 1)^2}{s^2} + Q \frac{(s^2 + 1)}{s} + 1} \cdot \frac{1}{Q \frac{s^2 + 1}{s} + 1}$$

NOTA

$$T(s)_{BP} = \frac{s^2}{Q^2(s^4 + 2s^2 + 1) + Q(s^3 + s) + s^2} \cdot \frac{s}{Q(s^2 + 1) + s}$$

$$T(s)_{BP} = \frac{s^2}{Q^2 s^4 + 2Q^2 s^2 + Q^2 + Qs^3 + Qs + s^2} \cdot \frac{s}{Qs^2 + Q + s}$$

$$T(s)_{BP} = \frac{1}{Q^2} \frac{s^2}{s^4 + \frac{1}{Q} s^3 + \left(2 + \frac{1}{Q^2}\right) s^2 + \frac{1}{Q} s + 1} \cdot \frac{\frac{1}{Q} s}{s^2 + \frac{1}{Q} s + 1}$$

FACTORIZO EL DENOMINADOR: $\left(s^4 + \frac{1}{Q} s^3 + \left(2 + \frac{1}{Q^2}\right) s^2 + \frac{1}{Q} s + 1\right)$

$$s^4 + 0,450 s^3 + 2,2030 s^2 + 0,450 s + 1 = 0$$

CON CALCULADORA:

- $s_1 = -0,1342 + j1,208$
- $s_2 = -0,1342 - j1,208$
- $s_3 = -0,09082 + j0,8177$
- $s_4 = -0,09082 - j0,8177$

$$(s - s_1)(s - s_2)(s - s_3)(s - s_4) = (s^2 + 0,2684s + 1,47) + (s^2 + 0,1816s + 0,6769)$$

$$(a + jB)(a - jB) = a^2 + B^2$$

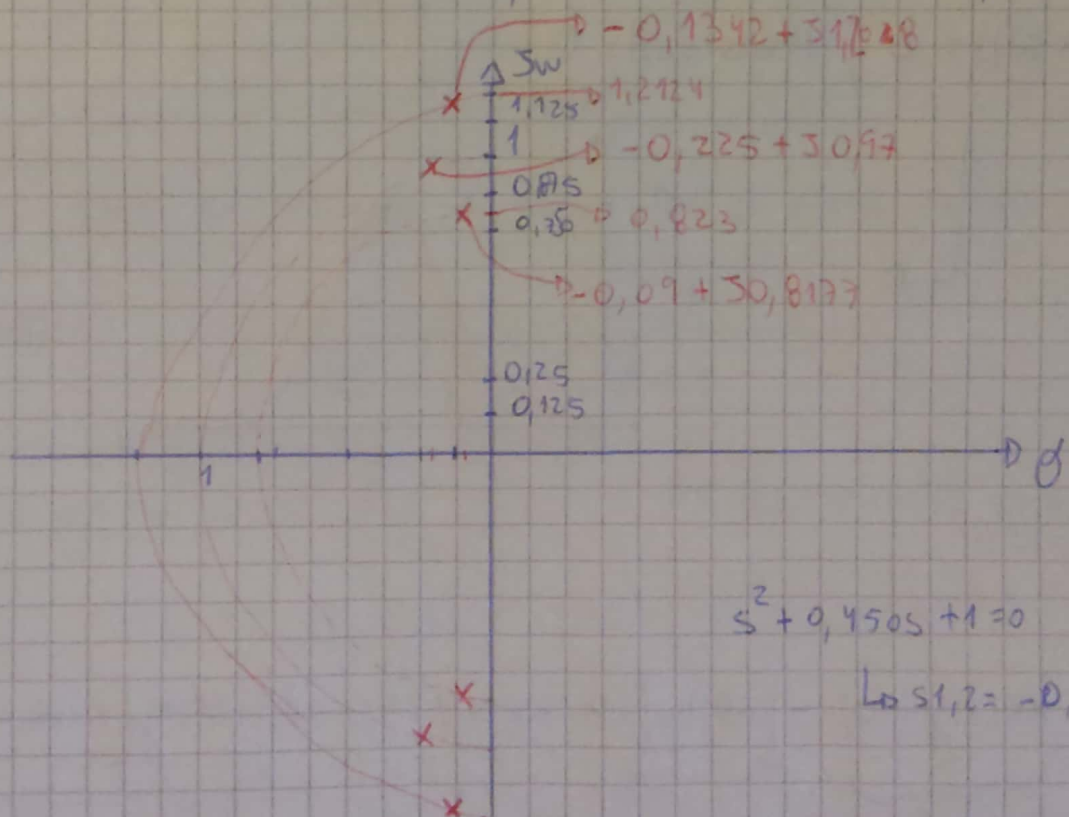
$$TPB(s) = \frac{\frac{1}{Q} s}{s^2 + 0,2684s + 1,47} \cdot \frac{\frac{1}{Q} s}{s^2 + 0,1816s + 0,6767} \cdot \frac{\frac{1}{Q} s}{s^2 + 0,450s + 1}$$

$$K1 = Q \cdot 0,2684 \Rightarrow K1 = 0,5960 ; K2 = Q \cdot 0,1816 \Rightarrow K2 = 0,4031$$

↓
2,22

$$TPB(s) = \frac{1}{K1} \frac{K1 \frac{1}{Q} s}{s^2 + 0,2684s + 1,47} \cdot \frac{1}{K2} \frac{K2 \frac{1}{Q} s}{s^2 + 0,1816s + 0,6767} \cdot \frac{\frac{1}{Q} s}{s^2 + 0,450s + 1}$$

b) $\omega_{01} = \sqrt{1,47} \Rightarrow \omega_{01} = 1,2124 ; \omega_{02} = \sqrt{0,67} \Rightarrow \omega_{02} = 0,823 ; \omega_{03} = 1$



c)
MODULO:

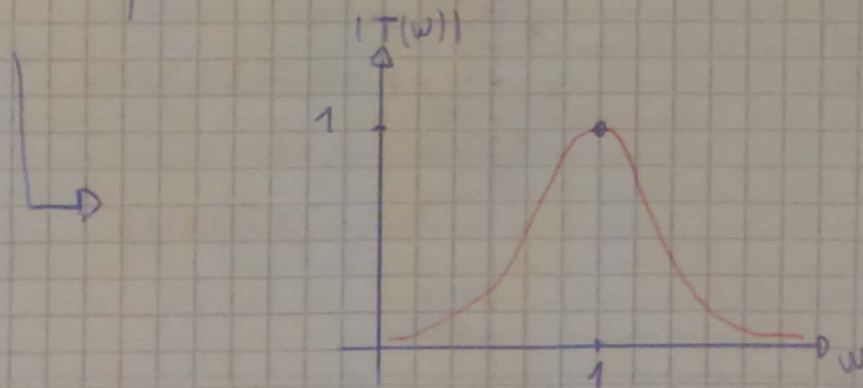
$$T(w) = \left(T(s) \right) \Big|_{s=jw} = 4,1624 \frac{0,26845w}{-w^2 + 0,26845w + 1,47} \frac{0,18163w}{-w^2 + 0,18163w + 0,47} \frac{0,4503w}{-w^2 + 0,4503w + 1}$$

$$|T(w)| = 4,1624 \cdot \frac{0,2684}{\sqrt{0,47^2 + 0,2684^2}} \cdot \frac{0,1816}{\sqrt{0,3^2 + 0,1816^2}} \cdot \frac{0,450}{0,450}$$

\downarrow
 $w=1$

$$|T(w=1)| = 4,1624 \cdot 0,4959 \cdot 0,4821 \approx 0,99 \approx \underline{1}$$

$$|T(w \rightarrow \infty)| = 0 ; |T(w=0)| = 0$$

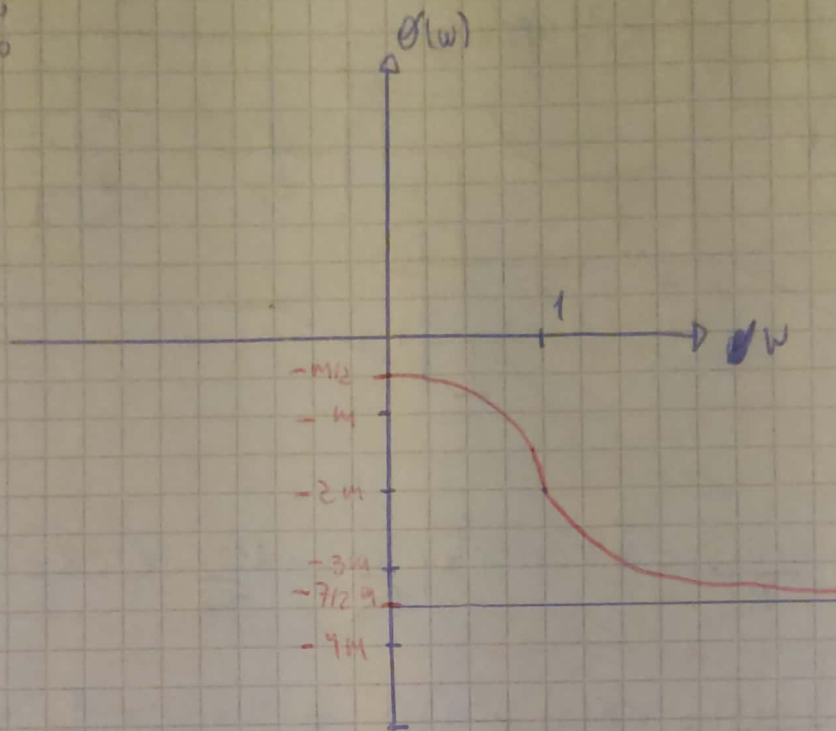


FASE:

$$\phi(w) = \underbrace{\text{ARCTG}(\infty)}_{-\pi/2} - \left[\text{ARCTG}\left(\frac{0,2684w}{(1,47-w^2)} \right) + \text{ARCTG}\left(\frac{0,1816w}{(0,47-w^2)} \right) + \text{ARCTG}\left(\frac{0,450w}{(1-w^2)} \right) \right]$$

$$\phi(\omega=0) = -M/2 \quad ; \quad \phi(\omega \rightarrow \infty) = -M/2 - 3M = -\frac{7}{2}M$$

$$\phi(\omega=1) = -M/2$$

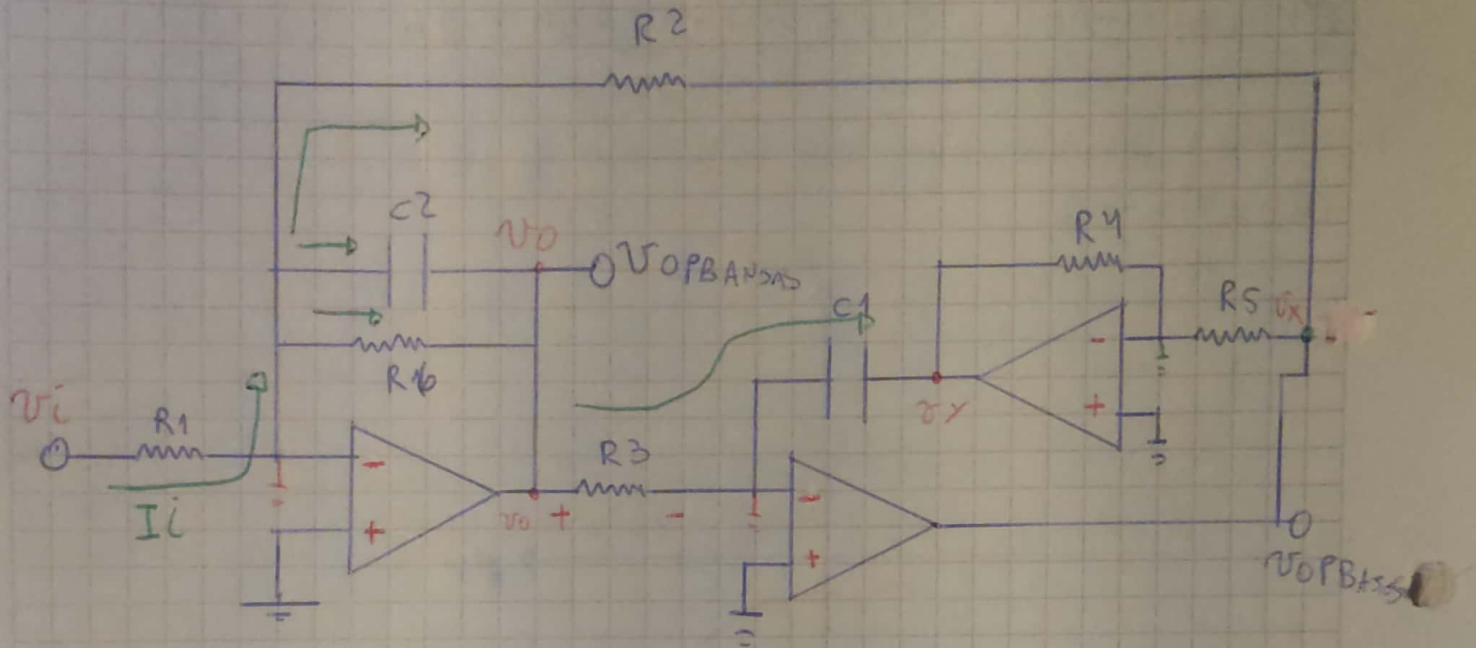


EN EL CASO DE CALCULAR A PARTIR DE UN FILTRO DE MAX. PLANICIDAD:

$$TPB(\delta) = \frac{1}{\delta + \delta + 1} \cdot \frac{1}{\delta + 1}$$

$$\epsilon^{-1/3} = 0,9976 \stackrel{-1\beta}{\Rightarrow} \epsilon^{-1/3} \approx 1 \quad \leftarrow \text{PRACTICAMENTE LO MISMO}$$

d) ACKERBERG-MOSSBERG



$$R_4 = R_5 \cdot \frac{v_{R3}(s)}{v_{R5}(s)} = \frac{v_0(s)}{v_x(s)} \cdot \frac{1}{R_5} \cdot \frac{1}{R_4} \Rightarrow v_x = -\frac{v_0}{R_4} \Rightarrow v_x = -v_0$$

$$v_{R3}(s) = \frac{v_0(s)}{R_3} = v_x(s) \cdot sC_1 \quad (1) \Rightarrow v_x(s) = \frac{1}{sC_1 R_3} v_0(s) \quad (2)$$

$$v_i(s) \cdot \frac{1}{R_1} = -\left[\frac{1}{R_6} v_0 + sC_2 v_0 + \frac{1}{R_2} v_x \right] \quad (3)$$

$$(3) \text{ en } (2) \Rightarrow \frac{1}{R_1} v_i(s) = -\left[\frac{1}{R_6} + sC_2 + \frac{1}{R_2} \frac{1}{sC_1 R_3} \right] v_0(s)$$

$$\frac{1}{R_1} v_i(s) = \frac{s^2 C_1 C_2 R_2 R_3 R_6 + s C_1 R_2 R_3 + R_6}{s C_1 R_2 R_3 R_6} v_0(s) \Rightarrow T(s) = \frac{1}{R_1} \cdot \frac{s C_1 R_2 R_3 R_6}{s^2 C_1 C_2 R_2 R_3 R_6 + s C_1 R_2 R_3 + R_6}$$

$$T(s) = \frac{K \frac{1}{C_2 R_6} \frac{R_6}{R_6}}{s^2 + \frac{1}{C_2 R_6} s + \frac{1}{C_1 C_2 R_2 R_3} \omega_0^2}$$

$$T(s) = \frac{K \omega_0 / Q s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2} ; \omega_0 = \frac{1}{C_1 C_2 R_2 R_3}$$

$$\frac{\omega_0}{Q} = \frac{\omega_0}{Q} = \frac{1}{C_2 R_6} ; K = \frac{R_6}{R_1}$$

NORMALIZAMOS:

$$\omega_0 = 1 \rightarrow C_1 C_2 R_2 R_3 = 1 ; R_2 = R_3 = 1, C_1 \cdot C_2 = 1, R_6 = 1$$

$$\frac{\omega_0}{Q} = \frac{1}{C_2 R_6} \Rightarrow C_2 = Q / \omega_0, C_1 = \omega_0 / Q ; K = \frac{R_6}{R_1} \Rightarrow R_1 = 1/K$$

$K_{dB} = 10 \text{ dB}$; $f_0 = 2 \text{ MHz} \Rightarrow \omega_0 = 2\pi f_0 = 2\pi \cdot 2 \text{ MHz} = 2 \cdot 10^6 \text{ Hz}$; NECESITO UNA GANANCIA DE 10dB

$$K = 3,16 \text{ OSEA } 3,16 \text{ APROX}$$

DESNORMALIZAMOS PARA CADA ETAPA

$$K = 1,47 \rightarrow \text{PARA CADA ETAPA}$$

ETAPA 1: $Q_1 = ?$; $\frac{1,21}{Q_1} = 0,2684$; $Q_1 = 4,50$; $R_6 = 1 \text{ K}\Omega$

$R_2 = 1 \text{ K}\Omega$; $K = \frac{1}{R_1} \rightarrow R_1 = \frac{1}{K} \rightarrow R_1 = \frac{1}{1,47} R_2 = 680,27 \Omega \rightarrow \text{PARA TODAS LAS ETAPAS}$

$$C_1 = \frac{1}{Q_1} \cdot \frac{1,21}{\omega_0 R_2} = 21,3 \text{ nF} ; C_2 = \frac{Q_1}{1,21 \omega_0 R_2} \Rightarrow C_2 = 295,95 \text{ pF}$$

$$R_2 = R_3 = R_2 = 1 \text{ K}\Omega$$

NOTA

ETAPA 2:

$$Q_2 = ? \cdot \frac{0,82}{1} = 0,1816 \Rightarrow Q_2 = 4,51$$

$$C_1 = \frac{1}{Q_2} \frac{0,82}{\pi \cdot 2 \cdot \pi \cdot \omega} \Rightarrow C_1 = 14,46 \text{ PF} \quad ; \quad C_2 = \frac{Q_2}{0,82} \frac{1}{\pi \cdot 2 \cdot \pi \cdot \omega} \Rightarrow C_2 = 437,68 \text{ PF}$$

$$R_2 = R_6 = 1 \text{ K}\Omega \quad ; \quad R_1 = 680,27 \Omega \quad ; \quad R_6 = 1 \text{ K}\Omega$$

ETAPA 3:

$$Q_3 = 2,22 \rightarrow C_1 = \frac{1}{Q_3} \frac{1}{\pi \cdot \omega \cdot \pi \cdot 2} \Rightarrow C_1 = 35,84 \text{ PF}$$

$$C_2 = Q_3 \frac{1}{\pi \cdot \omega \cdot \pi \cdot 2} \Rightarrow C_2 = 176,662 \text{ PF}$$

$$R_2 = R_3 = 1 \text{ K}\Omega \quad ; \quad R_1 = 680,27 \Omega \quad ; \quad R_6 = 1 \text{ K}\Omega$$