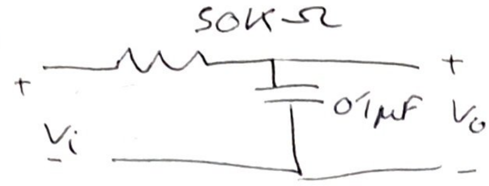
Repaso ejercicios hoja 2

Ej 1 a)



$V_o = I Z_c$

$V_i = I(R + Z_c)$

$IR + IZ_c - V_i = 0$

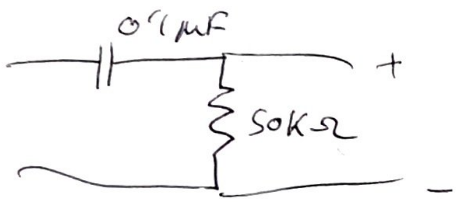
$$\frac{V_o}{V_i} = \frac{Z_c}{R+Z_c} = \frac{1}{\frac{R}{Z_c}+1} = \frac{1}{jwCR+1}$$

$$|Av| = \frac{1}{\sqrt{(wCR)^2+1}} = \frac{1}{\sqrt{\left(\frac{w}{\frac{1}{CR}}\right)^2+1}}$$

$f_p = \frac{1}{CR} = 200$

$20\log\sqrt{\left(\frac{w}{\frac{1}{CR}}\right)^2+1}$

b)



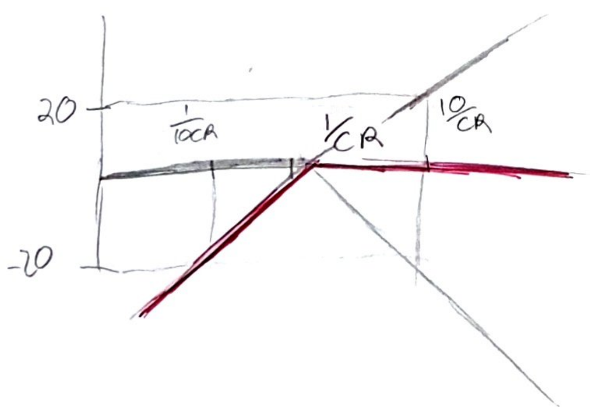
$V_o = IR$

$V_i = I(Z_c + R)$

$$\frac{V_o}{V_i} = \frac{R}{Z_c+R} = \frac{1}{\frac{Z_c}{R}+1} = \frac{1}{\frac{1}{jwCR}+1} = \frac{1}{\frac{1+jwCR}{jwCR}} = \frac{jwCR}{1+jwCR}$$

$$|Av| = wCR \cdot \frac{1}{\sqrt{1+(wCR)^2}}$$

$$20\log\left(\frac{w}{\frac{1}{CR}}\right) - 20\log\left(\sqrt{1+\left(\frac{w}{\frac{1}{CR}}\right)^2}\right)$$



$V_o = I Z_L$

$V_i = I(R + Z_L)$

$$\frac{V_o}{V_i} = \frac{Z_L}{R+Z_L} = \frac{1}{\frac{R}{Z_L}+1} = \frac{1}{\frac{R}{j\omega L}+1} = \frac{1}{\frac{R+j\omega L}{j\omega L}} =$$

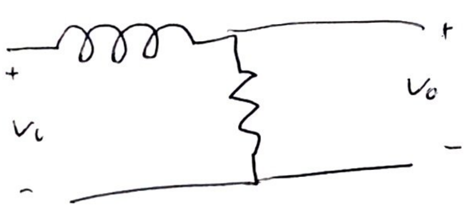
$$= \frac{j\omega L}{R+j\omega L} = \frac{j\omega L/R}{\frac{R+j\omega L}{R}} = \frac{j\,\omega\frac{L}{R}}{1+j\frac{\omega L}{R}}$$

$$|Av| = \omega\frac{L}{R}\cdot\frac{1}{\sqrt{1+\left(\frac{\omega L}{R}\right)^2}}$$

$$20\log\left(\omega\frac{L}{R}\right) - 20\log\left(\sqrt{1+\left(\frac{\omega L}{R}\right)^2}\right)$$

$$\omega\left(\frac{L}{R}\right) = \frac{\omega}{\frac{R}{L}} \qquad \frac{\omega}{1}\cdot\frac{L}{R} = \frac{\omega R}{L}$$

@

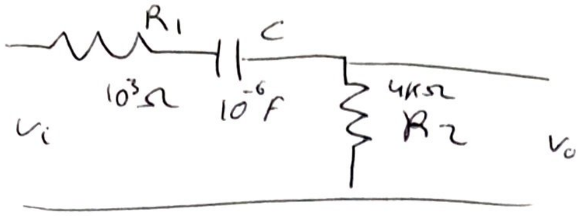


$V_o = IR \qquad v_i = I(Z_L + R)$

$$\frac{V_o}{V_i} = \frac{\cancel{I}R}{\cancel{I}(Z_L+R)} = \frac{1}{\frac{Z_L}{R}+1} =$$

$$= \frac{1}{\frac{j\omega L}{R}+1} = \frac{1}{j\omega\frac{L}{R}+1} \qquad |Av| = \frac{1}{\sqrt{\left(\omega\frac{L}{R}\right)^2+1}}$$

$$-20\log\sqrt{\left(\omega\frac{L}{R}\right)^2+1} = -20\log\sqrt{\left(\frac{\omega}{\frac{1}{\frac{L}{R}}}\right)^2+1}$$



$$V_i = I\,(Z_{eq} + R_2)$$
$$V_o = I R_2$$

$$Z_{eq} = \frac{1}{jwC} + R_1 = \frac{jwCR_1 + 1}{jwC}$$

$$\frac{V_o}{V_i} = \frac{R_2}{Z_{eq}+R_2} = \frac{1}{\frac{Z_{eq}}{R_2}+1} = \frac{1}{\frac{\frac{jwCR_1+1}{jwC}}{R_2}+1} =$$

$$\frac{1}{\frac{jwCR_1+1}{R_2 jwC}+1} = \frac{1}{\frac{jwCR_1+1+R_2jwC}{R_2jwC}} = \frac{R_2 jwC}{1+jwC(R_1+R_2)} =$$

$$R_2 jwC \cdot \frac{1}{1+jwC(R_1+R_2)}$$

$$\lim_{w\to 0}|A_v| = 0 \qquad \lim_{w\to\infty}|A_v| \quad \frac{R_2 wC}{\sqrt{1+[wC(R_1+R_2)]^2}} =$$

$$= \lim_{w\to\infty}\frac{R_2 \cancel{w} C}{\cancel{w}\sqrt{\underbrace{\frac{1}{w^2}}_{0}+(C(R_1+R_2))^2}} = \frac{R_2 C}{C(R_1+R_2)^2} \quad \text{Filtro paso alto}$$

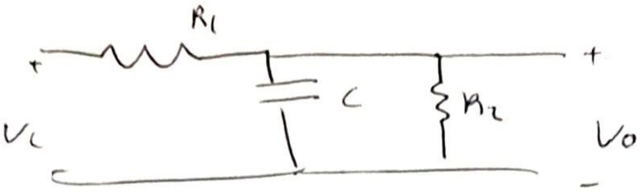
$$|A_v| = 0'2 \qquad 0'2 = \frac{R_2 wC}{\sqrt{\underbrace{1+[wC(R_1+R_2)]^2}_{x}}}$$

$$0'2\sqrt{x} = R_2wC \qquad 0'04\,(1+w^2C^2(R_1+R_2)^2 = (R_2wC)^2 =$$

$$= 0'04\,(1+w^2\,10^{-12}\cdot 2'5\cdot 10^7) = 1'6\cdot 10^{-5}w^2 = 0'04 + 10^{-6}w^2 = 1'6\,10^{-5}w^2$$

$$0'04 = 1'5\cdot 10^{-5}w^2 \qquad w = \sqrt{\frac{0'04}{1'5\cdot 10^{-5}}} = 51'64 \text{ rad}$$

Ej 3



$$Z_{eq} = \frac{Z_c \cdot R_2}{Z_c + R_2} = \frac{\frac{R_2}{jwC}}{\frac{1}{jwC} + R_2} = \frac{\frac{R_2}{\cancel{jwC}}}{\frac{1+jwCR_2}{\cancel{jwC}}} = \frac{R_2}{1+jwCR_2}$$

$$V_i = I(R_1 + Z_{eq}) \qquad V_o = I\,Z_{eq}$$

$$\frac{V_o}{V_i} = \frac{Z_{eq}}{R_1 + Z_{eq}} = \frac{1}{\frac{R_1}{Z_{eq}} + 1} = \frac{1}{\frac{R_1}{\frac{R_2}{1+jwCR_2}} + 1} =$$

$$= \frac{1}{\frac{R_1(1+jwCR_2) + R_2}{R_2}} = \frac{R_2}{R_1(1+jwCR_2) + R_2} =$$

$$= \frac{R_2}{R_1 + jwCR_2R_1 + R_2} = \frac{R_2}{R_1+R_2} \cdot \frac{1}{\left(\frac{jwCR_2R_1}{R_1+R_2} + 1\right)}$$

$$|Av| = \frac{R_2}{R_1+R_2} \frac{1}{\sqrt{\left(\frac{wCR_2R_1}{R_1+R_2}\right)^2 + 1}}$$

$|Av_{max}|$ con menor denominador $\qquad Av_{max} = \frac{R_2}{R_1+R_2}$

$$|Av|_{w=w_{corte}} = \frac{\frac{R_2}{R_1+R_2}}{\sqrt{2}} \qquad 2 = \left(\frac{wCR_2R_1}{R_1R_2}\right)^2 + 1$$

$$\cancel{\frac{R_2}{R_1+R_2}} \frac{1}{\sqrt{\left(\frac{wCR_2R_1}{R_1+R_2}\right)^2 + 1}} = \frac{\cancel{\frac{r_2}{R_1+R_2}}}{\sqrt{2}} \qquad 1 = \left(\frac{wCR_2R_1}{R_1+R_2}\right)^2$$

$$\pm 1 = \frac{wCR_2R_1}{R_1+R_2}$$

no existen w negativas

$$\sqrt{2} = \sqrt{\left(\frac{wCR_2R_1}{R_1+R_2}\right)^2 + 1} \qquad \frac{R_1+R_2}{CR_2R_1} = w$$

Ej 1

$V_i = I(Z_L + Z_{eq})$

$V_o = I\, Z_{eq}$

$$Z_{eq} = \frac{Z_C \cdot R}{Z_C + R} = \frac{\frac{R}{jwC}}{\frac{1}{jwC} + R} = \frac{\frac{R}{\cancel{jwC}}}{\frac{1+jwCR}{\cancel{jwC}}} = \frac{R}{1+jwCR}$$

$$\frac{V_o}{V_i} = \frac{Z_{eq}}{Z_L + Z_{eq}} = \frac{1}{\frac{Z_L}{Z_{eq}} + 1} = \frac{1}{\frac{jwL}{\frac{R}{1+jwCR}} + 1} = \frac{1}{\frac{(jwL)(1+jwCR)}{R} + 1} =$$

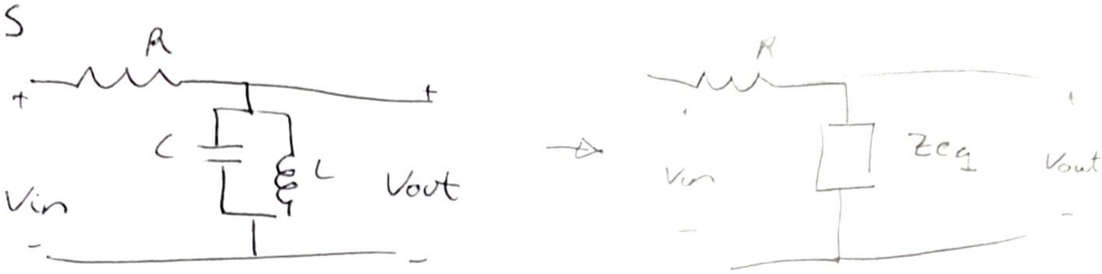
$$= \frac{1}{\frac{(jwL) - (w^2 CRL)}{R} + 1} = \frac{1}{\left(jw\frac{L}{R}\right) - w^2 CL + 1}$$

$$Z_{eqt} = Z_{eq} + Z_L = \frac{R}{1+jwCR} + jwL \qquad \frac{1}{\frac{1}{R} + jwC} + jwL \rightarrow 0$$

resistividad imaginaria nula

$$jwL + \frac{1}{jwC} = 0 \qquad jwL = -\frac{1}{jwC} \qquad -w^2CL = -1 \qquad w = \frac{1}{\sqrt{CL}}$$

Ej 5



$$\frac{Z_C Z_L}{Z_C+Z_L} = \frac{\frac{1}{j\omega C}\cdot j\omega L}{\frac{1}{j\omega C}+j\omega L} = \frac{\frac{L}{C}}{\frac{j^2\omega^2 LC+1}{j\omega C}} =$$

$$= \frac{\frac{L}{C}}{\frac{1-\omega^2 LC}{j\omega C}} = \frac{j\omega CL}{C-\omega^2 LC^2} = \frac{j\omega \cancel{C}L}{\cancel{C}(1-\omega^2 LC)} = \frac{j\omega L}{(1-\omega^2 LC)}$$

$$V_{in} = I(R+Z_{eq}) \qquad V_o = I Z_{eq}$$

$$\frac{V_o}{V_{in}} = \frac{Z_{eq}}{R+Z_{eq}} = \frac{1}{\frac{R}{Z_{eq}}+1} = \frac{1}{\frac{R}{\frac{j\omega L}{1-\omega^2 LC}}+1} = \frac{1}{\frac{R(1-\omega^2 LC)+1}{j\omega L}} =$$

$$\frac{1}{\frac{R(1-\omega^2 LC)+j\omega L}{j\omega L}} = \frac{j\omega L}{R(1-\omega^2 LC)+j\omega L} = \frac{\cancel{\frac{j\omega L}{j\omega L}}}{\frac{R(1-\omega^2 LC)}{j\omega L}+\cancel{\frac{j\omega L}{j\omega L}}} =$$

$$= \frac{1}{R\left(\frac{1-\omega^2 LC}{j\omega L}\right)+1} = \frac{1}{R\left(\frac{\cancel{1}\,\omega^2 \cancel{L}C}{\cancel{\omega L}} - \frac{j}{\omega L}\right)+1} = \frac{1}{R\left(j\omega C - \frac{j}{\omega L}\right)+1} =$$

$$\frac{1}{R\left(j\left[\omega C - \frac{1}{\omega L}\right]\right)+1} \qquad |A_v| = \frac{1}{\sqrt{R^2\left(\omega C-\frac{1}{\omega L}\right)^2+1}}$$

Fmax → denominador mínimo

$$\left(\omega C - \frac{1}{\omega L}\right)^2 = 0 \qquad \omega C - \frac{1}{\omega L} = 0 \qquad \omega C = \frac{1}{\omega L}$$

$$\omega^2 CL = 1 \qquad \omega = \sqrt{\frac{1}{CL}}$$

$$|A_v|_{max} = 1$$

Calcular las frecuencias de corte f_1 y f_2 y ΔF

$$|A_v|_{f=f_{corte}} = \frac{|A_v|_{max}}{\sqrt{2}} \qquad \frac{1}{\sqrt{1+R^2\left(wC-\frac{1}{wL}\right)^2}} = \frac{1}{\sqrt{2}}$$

$$\sqrt{1+R^2\left(wC-\frac{1}{wL}\right)^2} = \sqrt{2} \qquad 1+R^2\left(wC-\frac{1}{wL}\right)^2 = 2$$

$$R\left(wC-\frac{1}{wL}\right) = \pm 1 \qquad \frac{Rw^2CL-R}{wL} = \pm 1$$

1° solución 1 +
2° solución 1 −

$$Rw^2CL - R = wL$$

$$\underbrace{Rw^2CL}_{a}\ \underbrace{-wL}_{b}\ \underbrace{-R}_{c} = 0 \qquad \frac{L+\sqrt{L^2-4\cdot(RCL)\cdot(-R)}}{2(RCL)}$$

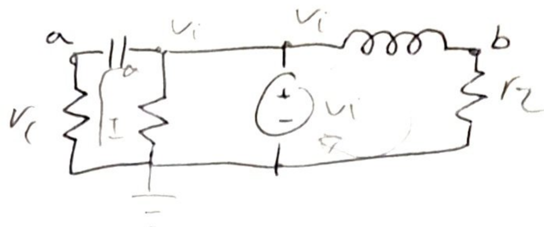
$$Rw^2CL + wL - R = 0 \qquad \frac{-L+\sqrt{L^2-4\cdot(RCL)\cdot(-R)}}{2(RCL)}$$

$$\Delta F = \frac{L}{2(RCL)} + \cancel{\frac{\sqrt{L^2-4(RCL)\cdot(-R)}}{2(RCL)}} + \frac{L}{2(RCL)} - \cancel{\frac{\sqrt{L^2-4(RCL)\cdot(-R)}}{2(RCL)}}$$

$$\Delta F = \frac{\cancel{2}L}{\cancel{2}(RCL)} \qquad w/2\pi = F$$

$$\Delta F = \frac{\cancel{L}}{2\pi RC\cancel{L}} = \frac{1}{2\pi RC}$$

Ej6



deducir la expresión de la función de transferencia

$$I = \frac{\cancel{V_0}^{0} - V_i}{R + Z_C} \qquad I R = V \qquad \frac{-V_i}{R + Z_C} \cdot Z_C = V_a - V_i$$

$$LKM \Rightarrow \frac{V_i}{Z_L + R} = I \qquad I(Z_L) + I(R) = V_i \qquad I(Z_L + R) = V_i$$

$$I = \frac{V}{R} \qquad I R = V \qquad \frac{V_i}{Z_L + R} \cdot Z_L = V_i - V_b$$

$$V_a - V_i + V_i - V_b = V_{ab}$$

$$\frac{V_i}{Z_L + R_2} \cdot Z_L - \frac{V_i}{R_1 + Z_C} Z_C = V_{ab}$$

$$\frac{V_i \cdot Z_L}{Z_L + R_2} - \frac{V_i Z_C}{R_1 + Z_C} = V_{ab}$$

$$V_i \left(\frac{Z_L}{Z_L + R_2} - \frac{Z_C}{R_1 + Z_C} \right) = V_{ab} \qquad \frac{V_{ab}}{V_i} = \frac{Z_L}{Z_L + R_2} - \frac{Z_C}{R_1 + Z_C} =$$

$$= \frac{jwL}{jwL + R_2} - \frac{\frac{1}{jwC}}{R_1 + \frac{1}{jwC}} = \frac{jwL}{jwL + R_2} - \cancel{\frac{\frac{1}{jwC}}{\frac{R_1 jwC + 1}{jwC}}}$$

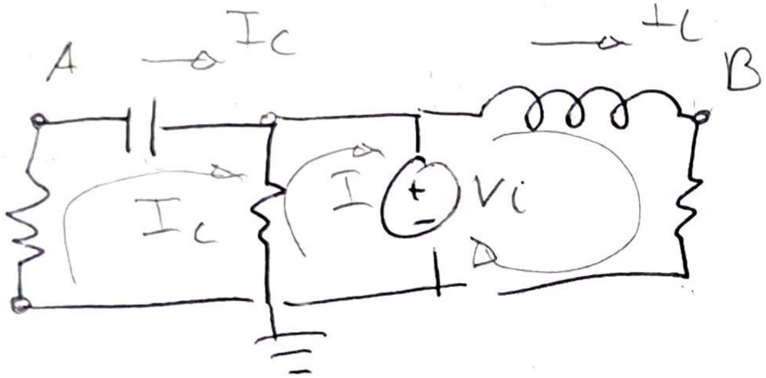
Si $w \to 0$

$A_V = -1 \qquad |A_V| = 1$

$$w \to \infty \qquad \lim_{w \to \infty} \frac{jwL}{jwL + R_2} - \lim_{w \to \infty} \frac{1}{R_1 jwC + 1} \to 0$$

$$\lim_{w \to 0} \frac{jL}{jL} = 1$$

Es 6



$$A_V = \frac{V_{AB}}{V_i}$$

$$V_{AB} = V_C \xrightarrow{\pm R} + V_L$$

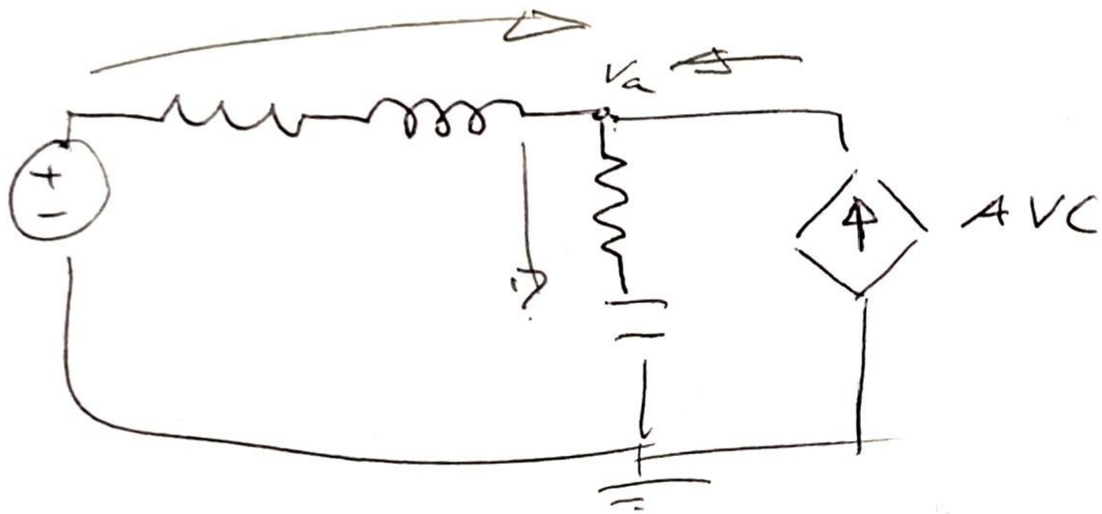
$$V_{AB} = \frac{0 - V_i \cdot Z_C}{R_1 + Z_C} + \frac{V_1 \cdot Z_L}{Z_L + R_2} \qquad V_C = \frac{-V_i}{R + Z_C} + \frac{V_1}{Z_L + R_2}$$

$$V_C = V_i \left(\frac{1 \cdot Z_L}{Z_L + R_2} - \frac{1 \cdot Z_C}{R + Z_C} \right)$$

$$\frac{V_{AB}}{V_1} = \frac{Z_L}{Z_L + R_2} - \frac{Z_C}{Z_C + R_1}$$

1

Ej. 7



$$I_1 = \frac{V_o - V_a}{R + Z_C}$$

$$I_2 = \frac{V_a}{R + Z_C} = \frac{V_C}{Z_C} \qquad \frac{V_a}{R + Z_C} \cdot Z_C = V_C$$

$$I_1 + I_2 = I_3 \qquad \frac{V_o - V_a}{R + Z_L} + \frac{V_a}{R + Z_C} = A \frac{V_a}{R + Z_C} \cdot Z_C$$

$$\frac{V_o}{R + Z_L} - \frac{V_a}{R + Z_L} + \frac{V_a}{R + Z_C} = A \frac{V_a}{R + Z_C} \cdot Z_C$$

$$\frac{V_o}{R+Z_L} = \frac{AV_a \cdot Z_C}{R+Z_C} + \frac{V_a}{R+Z_L} - \frac{V_a}{R+Z_C}$$

$$\frac{V_o}{R+Z_L} = V_a\left(\frac{AZ_C}{R+Z_C} + \frac{1}{R+Z_C} - \frac{1}{R+Z_C}\right)$$

$$\frac{V_o}{\cancel{R+Z_L}} = V_a\left(\frac{(AZ_C-1)(R+Z_L) + R+Z_C}{\cancel{(R+Z_L)}(R+Z_C)}\right) \rightarrow \frac{V_a}{V_o} = \frac{R+Z_C}{(AZ_C-1)(R+Z_L) + \cancel{R+Z_C}}$$

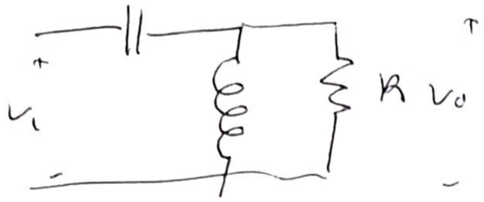
$$= \frac{1}{\dfrac{(AZ_C-1)(R+Z_C)}{R+Z_C} + 1} \qquad \frac{1}{\dfrac{\left(\dfrac{A}{jwC}-1\right)(R+jwL)}{R+jwL} + 1} \quad \circ\circ\circ$$

$$1+\frac{1}{\dfrac{(R_1+jwL)(jwC-A)}{1+jwCR_2}}$$

c

Ej 8

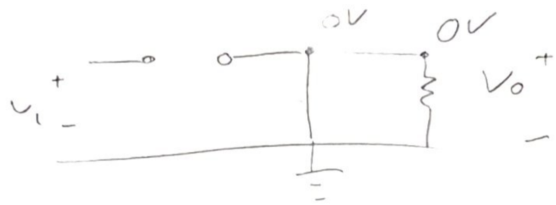
a) Dibujar circuito equivalente en los casos $w=0$ y $w \to \infty$ y estimar el valor del módulo de la función de transf



$Z_C = \frac{1}{jwC}$ si $w=0$ $Z_C = \infty$

$Z_L = jwL$ si $w=0$ $Z_L = 0$

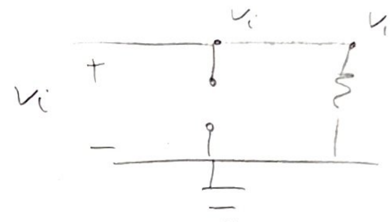
es como si actua en continua



$AV = \frac{0}{V_i} = 0$

$Z_C = \frac{1}{jwC}$ si $w = \infty$ $Z_C = 0$

$Z_L = jwL$ si $w=0$ $Z_L = 0$



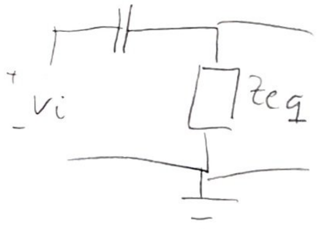
$AV = \frac{V_i}{V_i} = 1$

b) Zeq del circuito

$Z_L // R$ $\frac{R Z_L}{R+Z_L} = \frac{R Z_L}{R+Z_L}$ Zeq en serie con el condensador

$$\frac{1}{jwC} + \frac{R jwL}{R+jwL}$$

c) Calcular la función de transferencia, modulo y fase



$V_i = IR + IZ_{eq}$

$V_o = IZ_{eq}$

$$\frac{V_o}{V_i} = \frac{\cancel{I}Z_{eq}}{\cancel{I}Z_R + \cancel{I}Z_{eq}} = \frac{1}{\frac{Z_R}{Z_{eq}}+1} = \frac{1}{\frac{Z_R}{Z_{eq}}+1} = \frac{1}{\frac{1/jwC}{\frac{R jwL}{R+jwL}}+1} =$$

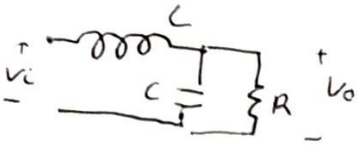
$$\frac{1}{\frac{R+jwL}{R j^2 w^2 LC}+1} = \frac{1}{\frac{R+jwL}{-Rw^2LC}+1} = \frac{1}{\frac{R+jwL-Rw^2LC}{-Rw^2LC}} =$$

$$\varphi = \pi - \operatorname{arctg}\left(\frac{wL}{R-Rw^2LC}\right) \quad \frac{-Rw^2LC}{R+jwL-Rw^2LC}$$

aparece el menos

parte imaginaria / parte real

$$|AV| = \frac{Rw^2LC}{\sqrt{R^2(1+w^2LC)^2+(wL)^2}}$$



$$R \parallel C = \frac{Z_C \cdot R}{Z_C + R}$$

$V_i = I Z_L + I Z_{eq}$ $\qquad V_o = I Z_{eq}$ $\qquad \dfrac{V_o}{V_i} = \dfrac{\cancel{I} Z_{eq}}{\cancel{I}(Z_L + Z_{eq})} =$

$$Z_{eq} = \frac{\frac{R}{jwC}}{\frac{1}{jwC} + R} = \frac{\frac{R}{\cancel{jwC}}}{\frac{jwCR+1}{\cancel{jwC}}} = \frac{R}{jwCR+1}$$

$$\frac{V_o}{V_i} = \frac{1}{\frac{Z_L}{Z_{eq}} + 1} = \frac{1}{\frac{jwL}{\frac{R}{jwCR+1}} + 1} = \frac{1}{\frac{jwL(jwCR+1)}{R} + 1} =$$

$$= \frac{1}{\frac{\cancel{j^2} w^2 CRL + jwL}{R} + 1} = \frac{1}{\frac{jwL - w^2 CRL + R}{R}} =$$

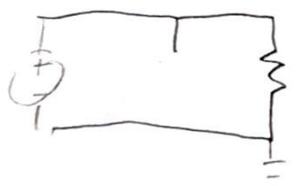
$$\frac{1}{jw\frac{L}{R} - w^2 CL + 1}$$

$$R_{circuito} = R_{eq} + Z_L = jwL + \frac{R}{jwCR+1}$$

si $w \to 0$ $\quad Z_L = jwL = 0$ actua como corto $\quad Z_C = \dfrac{1}{jwC} = \infty$ circ abierto

si $w \to \infty$ $\quad Z_C = \dfrac{1}{jwC} = 0$ actua como corto $\quad Z_L = jwL = \infty$ circ abi

$w = 0$



$V_o = V_i \qquad A_v = 1$

$w = \infty$

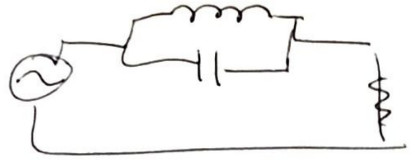
$V_o = 0$

$A_v = 0$

$$|A_v| = \frac{1}{\sqrt{\left(\frac{wL}{R}\right)^2 + \left(1 - w^2 CL\right)^2}}$$

$$\varphi = -\arctg\left(\frac{w\frac{L}{R}}{-w^2CL+1}\right)$$

Ej10



$A_V = \frac{V_o}{V_i} = \frac{IR}{(Z_p+R)}$

$\frac{1}{Z_p} = \frac{1}{Z_L} + \frac{1}{Z_C} = \frac{1}{jwL} + jwC = \frac{1-w^2LC}{jwL}$

$\frac{R(1-w^2LC)}{R(1-w^2LC)+jwL}$

$|A_V| = \frac{R-Rw^2LC}{\sqrt{R^2(1-w^2LC)+w^2L}} =$

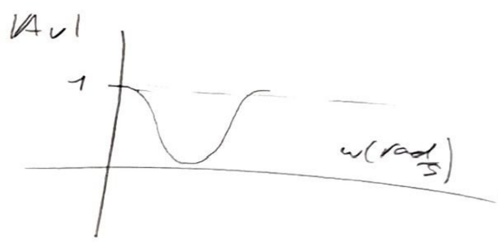
$= \frac{1}{\sqrt{1+\frac{w^2L^2}{(R(1-w^2LC))^2}}}$

$|A_V|_{max}$ mínimo denominador $w=0$

$|A_V|_{min}$ $R(1-w^2LC)=0$

$\lim_{w\to\infty} |A_V| \to 1$

$\lim_{w\to 0} |A_V| \to 1$



$|A_V|dB$

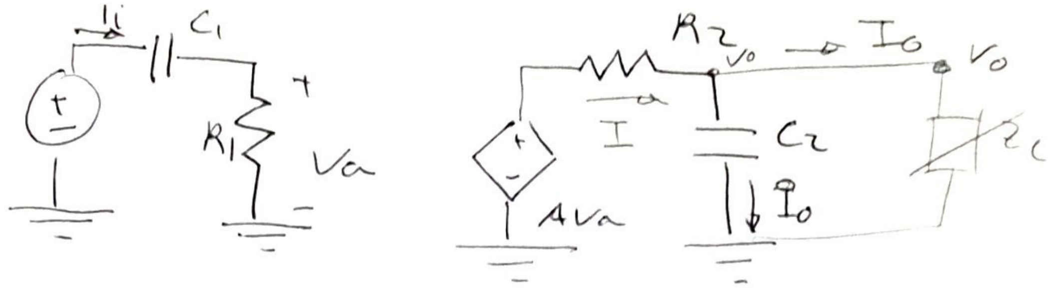
$G = \frac{V_o}{V_i} = \frac{\cancel{I}Z_p}{\cancel{I}(R+Z_C+Z_p)}$ $\quad \frac{1}{Z_p} = \frac{1+jwCR}{R}$

$= \frac{1}{\frac{R+Z_C}{Z_p}+1} = \frac{1}{1+\frac{1+jwCR}{R}\left(R+\frac{1}{jwC}\right)} = \frac{1}{1+1+jwCR+1+\frac{1}{jwCR}}$

$= \frac{1}{3+j\left(wCR-\frac{1}{wCR}\right)}$ $\quad w_0 = \frac{1}{CR}$ $\quad G_{max} = \frac{1}{3}$

$0 \quad \frac{\pi}{2} \quad -\frac{\pi}{2}$

Ej 12



$i_1 = \dfrac{V_i}{Z_{C_1} + R_1}$ $\quad V_i = I Z_{C_1} + I R_1 \to I = \dfrac{V_i}{Z_{C_1} + R_1}$

$\to I = I_0 + i_0 \qquad \dfrac{AV_a - V_0}{R_2} = I_0 + \dfrac{V_0}{Z_{C_2}}$

$\to V_a = I \cdot R_1 = \dfrac{V_i}{Z_{C_1} + R_1} \cdot R_1$

Introducir la ecuación y buscar ecuación caract

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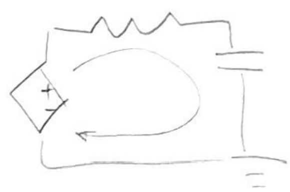

$V_{R_2} + V_C = AV_A \qquad I R_2 + I Z_{C_2} = AV_A$

$I = \dfrac{AV_A}{R_2 + Z_{C_2}} \qquad V_{C_2} = I\, Z_{C_2}$

$V_{C_2} = \dfrac{AV_A}{R_2 + Z_{C_2}} \cdot Z_{C_2} = V_0 \qquad V_a = \dfrac{V_i}{Z_{C_1} + R_1} \cdot R_1$

$V_a = \dfrac{R_1}{Z_C + R_1} \cdot V_i \qquad V_a = \dfrac{R_1}{\frac{1}{jwC} + R_1} V_i = \dfrac{R_1}{\frac{1 + jwCR_1}{jwC}} V_i =$

$= \dfrac{jwCR_1}{1 + jwCR_1} V_i \qquad V_0 = \dfrac{AV_a \cdot Z_{C_2}}{R_2 + Z_{C_2}}$

con mucho cuidado la graficar

$\dfrac{Z_{C_2}}{R_2 + Z_{C_2}} = \dfrac{\frac{1}{jwC}}{R_2 + \frac{1}{jwC_2}} = \dfrac{\frac{1}{\cancel{jwC}}}{\frac{R_2 jwC_2 + 1}{\cancel{jwC_2}}} = \dfrac{1}{R_2 jwC_2 + 1}$

$V_0 = \dfrac{1}{R_2 jwC_2 + 1} \cdot \dfrac{jwCR_1}{1 + jwCR_1} AV_i \qquad \left|\dfrac{V_0}{V_i}\right| = \dfrac{wCR_1 A}{\sqrt{(R_2 wC_2 + 1)^2 + (1 + wC_1R_1)^2}}$