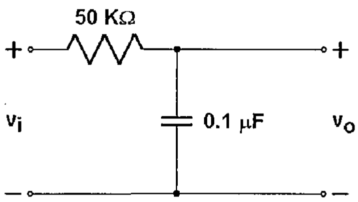
PROBLEMAS DE CIRCUITOS ELECTRÓNICOS
2° Curso de Grado en Ingeniería Informática – 17/18

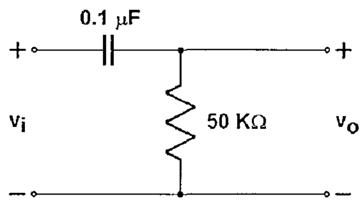
TEMA 2: <u>Introducción a los circuitos selectivos en frecuencia</u>

1.- Encontrar la función de transferencia A_V de las siguientes redes y dibujar los correspondientes diagramas de Bode utilizando la simulación del circuito basada en LTspice IV.

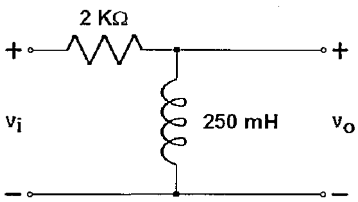
(a)



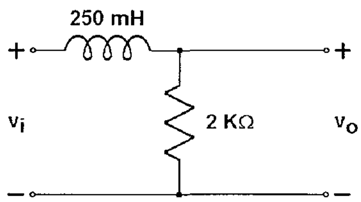
(b)



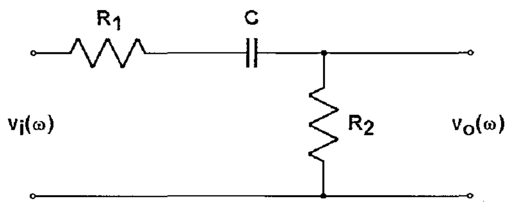
(c)



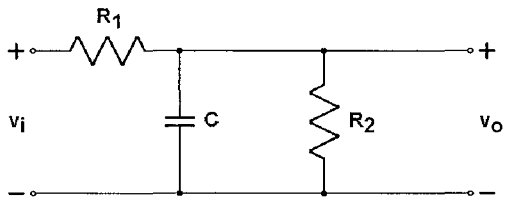
(d)



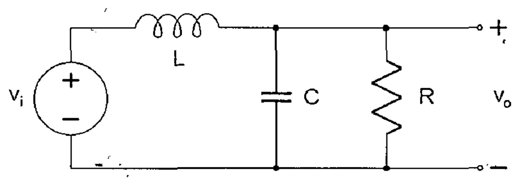
2.- En el circuito de la figura, siendo R_1 = 1 KΩ, R_2 = 4 KΩ y C = 10^{-6} F,
a) Encontrar la función de transferencia A_V.
b) ¿De qué tipo de filtro se trata?
c) Encontrar la frecuencia para la que $|A_V| = 0.2$.



3.- Para el circuito de la figura:
a) Calcular la función de transferencia A_V e identificar el tipo de filtro por su comportamiento.
b) Identificar las frecuencias de corte.
c) Suponiendo: R_1 = 9 KΩ, R_2 = 1 KΩ y C = 0.177 μF, dibujar esquemáticamente el diagrama de Bode del módulo de la función de transferencia A_V.



4.- Dado el siguiente circuito de corriente alterna:
a) Hallar la función de transferencia $H(j\omega) = v_o/v_i$.
b) Calcular el valor de la frecuencia angular, ω, para la cuál la impedancia equivalente del circuito, Z_{eq}, es puramente resistiva.



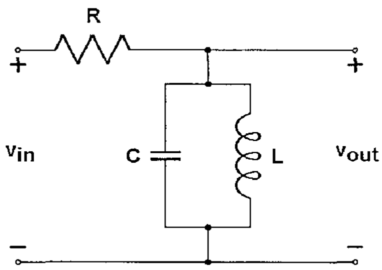
5.- El circuito de la figura es un filtro paso de banda. Calcular:

a) El módulo de la ganancia de voltaje en función de la frecuencia f.

b) La frecuencia f_0 para la cual la ganancia es máxima.

c) La ganancia $|A_V^{máx}|$ para dicha frecuencia.

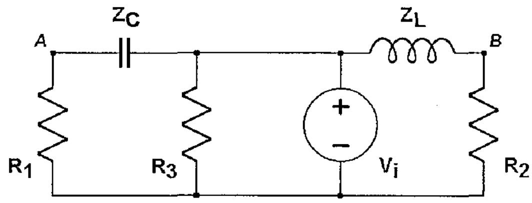
d) Las dos frecuencias de corte, f_1 y f_2, y su separación Δf (no considerar las soluciones negativas).



6.- En el circuito siguiente la fuente de tensión es una fuente sinusoidal de amplitud V_i y frecuencia variable ω.

a) Deducir la expresión de la función de transferencia v_{AB}/v_i en función de la frecuencia, y calcular el valor de su módulo para los casos $\omega \to 0$ y $\omega \to \infty$.

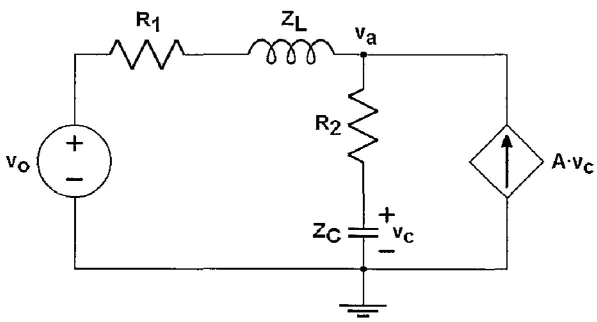
b) Dibujar los circuitos equivalentes para los dos casos anteriores ($\omega \to 0$ y $\omega \to \infty$) y calcular en ellos v_{AB}/v_i.



7.- Para el circuito de la figura, y suponiendo que V_O sea una tensión sinusoidal:

a) Determinar una expresión para el cociente (v_a/v_o), así como los límites de su módulo cuando ω tiende a cero y a infinito.

b) Para una amplitud de v_o de 6 V y unos valores de $R_1 = 1\ \Omega$, $R_2 = 3\ \Omega$, $A = 2\ \Omega^{-1}$ y a una frecuencia a la que $Z_L = j\ 2\ \Omega$ y $Z_C = -j\ 5\ \Omega$ determinar la amplitud de v_a así como su fase con respecto a v_o.

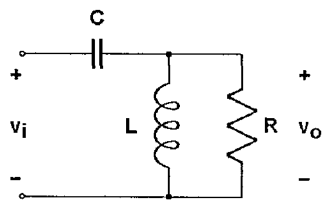


8.- El circuito de la figura es un filtro:

a) Dibujar el circuito equivalente en los casos $\omega = 0$ y $\omega \to \infty$, y estimar el valor del módulo de la función de transferencia en ambos casos.

b) Calcular la impedancia vista desde la entrada $Z(j\omega)$.

c) Calcular la función de transferencia $A_v(j\omega)$, su módulo y su fase.

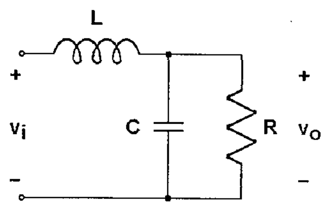


9.- El circuito de la figura es un filtro:

a) Dibujar el circuito equivalente en los casos $\omega = 0$ y $\omega \to \infty$, y estimar el valor del módulo de la función de transferencia en ambos casos.

b) Calcular la impedancia vista desde la entrada $Z(j\omega)$.

c) Calcular la función de transferencia $A_v(j\omega)$, su módulo y su fase.



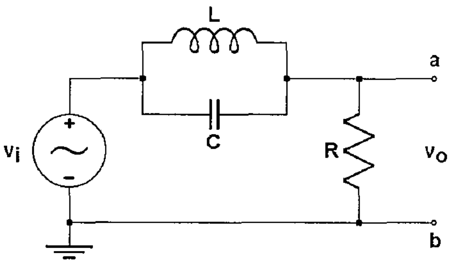
10.- Para cada uno de los filtros, de las siguientes figuras:

a) Deducir la expresión de la función de transferencia v_o/v_i (ganancia en tensión, A_v), proporcionando además las de su módulo y su fase (en la forma: $A_v = |A_v|\, e^{j\theta}$).

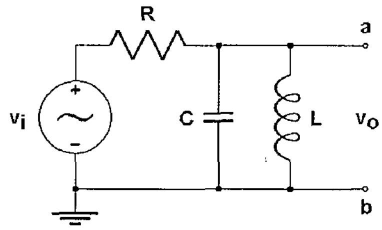
b) Estimar la dependencia asintótica del módulo de la ganancia cuando $\omega \to 0$ y cuando $\omega \to \infty$.

c) Deducir la expresión de la frecuencia natural del filtro (i.e., la frecuencia del mínimo o máximo de $|A_v|$).

d) Esbozar gráficamente el módulo de la ganancia en función de la frecuencia.

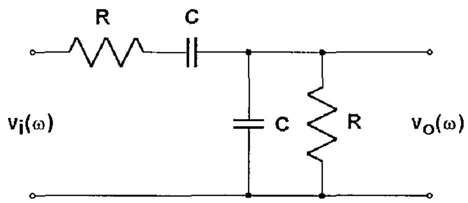


(i)



(ii)

11.- Para el circuito de la figura, y con señales sinusoidales a la entrada, determinar:



a) La forma aproximada del módulo de la ganancia de voltaje, $G = |v_o/v_i|$, en función de la frecuencia.

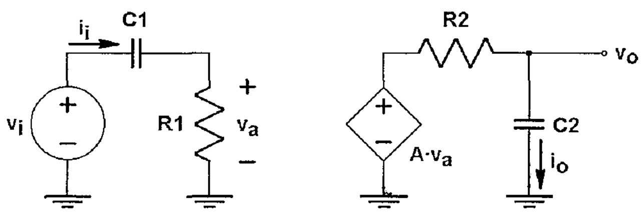
b) La frecuencia para la cual G es máxima.

c) Valor de G a la frecuencia del apartado anterior.

d) Desfase entre las señales de entrada y salida para frecuencias mucho menores, iguales y mucho mayores que la del apartado b).

e) Si la señal de entrada es una señal cosenoidal de amplitud 1V y periodo T=20ms, dibujar la forma de la señal v_o que se obtendrá a la salida, siendo $R = 6K3\Omega$ y $C = 1\mu F$.

12.- En el circuito de la figura la fuente v_i es una fuente de tensión alterna.



a) Hallar la expresión de la impedancia equivalente de Thévenin del circuito, vista entre su terminal de salida y el origen de potencial.

b) Encontrar la expresión de la ganancia de voltaje, $A_v = v_o/v_i$, en función de la frecuencia.

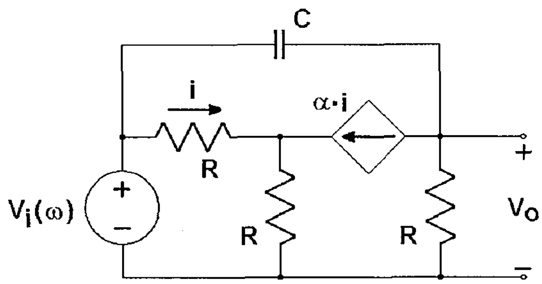
c) Obtener el módulo de la ganancia y deducir de él la función que realiza el circuito.

d) Representar gráficamente los diagramas de Bode del módulo y de la fase entre 0.1Hz y 100MHz, sabiendo que $R_1 = 100\ K\Omega$, $R_2 = 1K\Omega$, $C_1 = 1\mu F$, $C_2 = 1nF$ y $A = 100$.

13.- En el siguiente circuito:

a) Hallar el módulo y la fase de la ganancia en tensión en el circuito de la figura, siendo $\alpha > 0$.

b) Calcular el valor de módulo en los casos $\omega \rightarrow 0$ y $\omega \rightarrow \infty$. Evaluar a continuación el tipo de filtro (paso alto o paso bajo) que resulta en el caso $\alpha \rightarrow 0$.

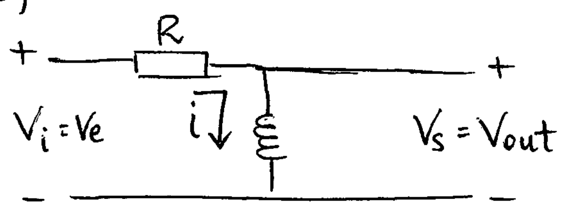


14.- Diseñar un circuito RCL que actúe como filtro paso-banda, con una frecuencia natural (frecuencia en el máximo, ω_0) de $16\pi \cdot 10^5$ rad/s, y un ancho de banda (Δ) de $2\pi \cdot 10^4$ rad/s.

PROBLEMAS TEMA 2

$\boxed{1.}$

c)



$$A_v = \frac{V_s}{V_e} = \frac{Z_L \cdot i}{(R+Z_L)\,i} = \frac{Z_L}{R+Z_L} = \frac{j\omega L}{R+j\omega L} =$$

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

$L/R \longrightarrow$ inverso de una frecuencia $\Rightarrow$ $L/R \longrightarrow$ inverso de una frecuencia

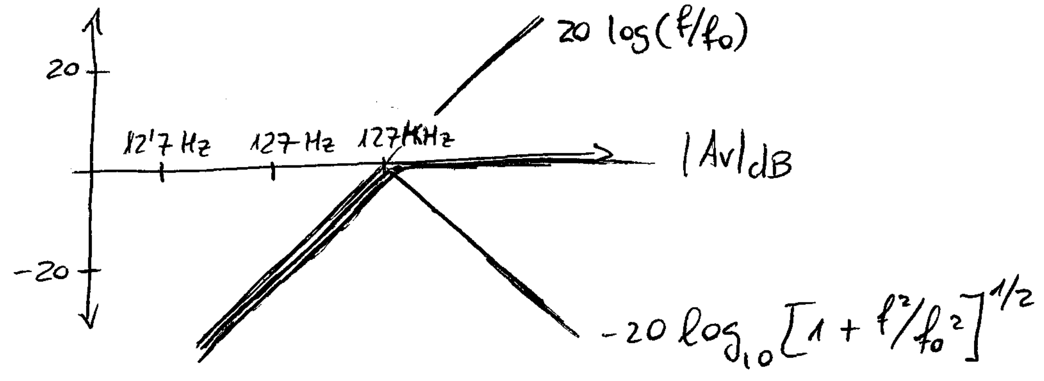
$$\Rightarrow A_v = \frac{j\omega L/R}{1 + j\omega L/R}$$

$$|A_v| = \frac{\omega/\omega_0}{\left[1+\frac{\omega^2}{\omega_0^2}\right]^{1/2}} = \frac{f/f_0}{\left[1+f^2/f_0^2\right]^{1/2}}$$

$$\boxed{\begin{array}{l} RC^{-1} = \omega_0 \\ 1\Omega \cdot 1F = 1/1s \\ 1\Omega/1H = 1s \Rightarrow 1H/1\Omega = s^{-1} \end{array}}$$

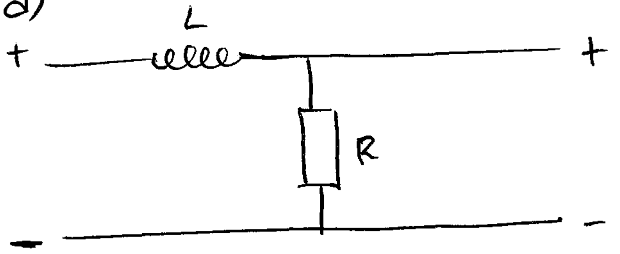
DATOS $\left\{\begin{array}{l} R = 2k\Omega \\ L = 250mH \end{array}\right\} \omega_0 = 8000 \text{ rad/s} \Rightarrow \frac{\omega_0}{2\pi} = 1'27 \text{ KHz}$

$$|A_v|_{dB} = 20\log_{10}\left(f/f_0\right) - 20\log_{10}\left[1+f^2/f_0^2\right]^{1/2}$$

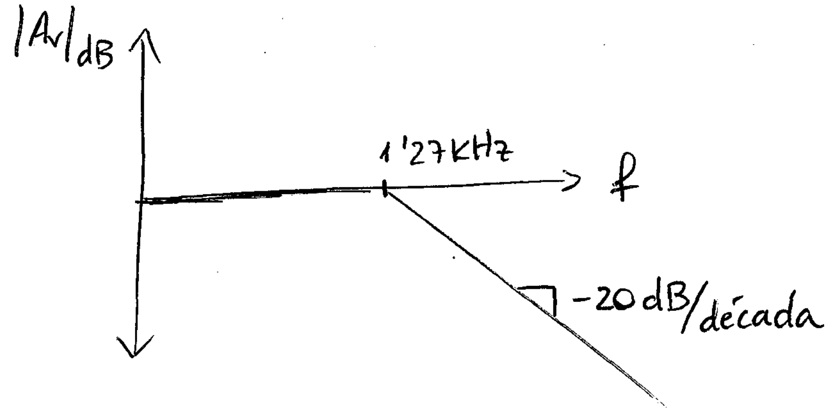


$|A_v|_{dB} = 0 = 20\log(|A_v|) \Rightarrow |A_v| = 1$ pues $20\log(1) = 0$

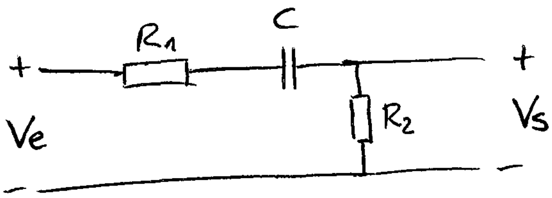
d)



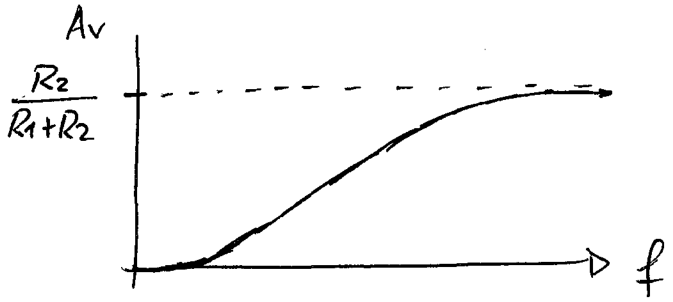
$$A_v = \frac{V_s}{V_e} = \frac{R}{R+Z_L} = \frac{R}{R+j\omega L} = \frac{1}{1+j\omega L/R}$$

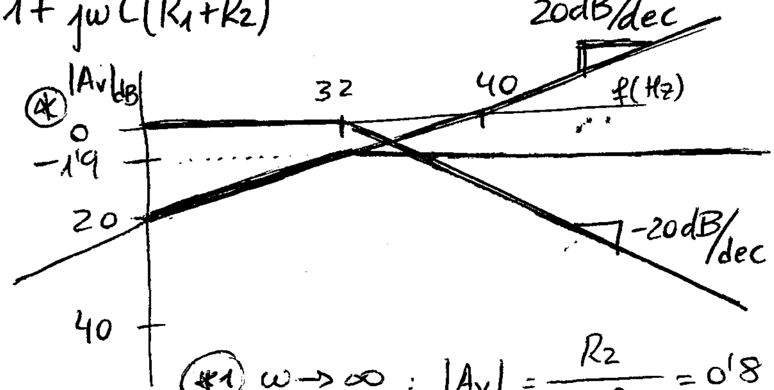


2.



$$A_v = \frac{V_s}{V_e} = \frac{R_L}{R_2+R_1+Z_c} = \frac{R_2}{R_1+R_2+\frac{1}{j\omega C}} = \frac{j\omega C R_2}{1+j\omega C(R_1+R_2)} \quad (*1)$$





(*1) $\omega \to \infty$: $|A_v| = \frac{R_2}{R_1+R_2} = 0'8$

$20 \log(0'8) = -1'9$

¿ω? $|A_v| = 0'2$

$$|A_v| = \frac{\omega C R_2}{\left[1+\omega^2 C^2 (R_1+R_2)^2\right]^{1/2}}$$

ponemos nombres a las frecuencias:

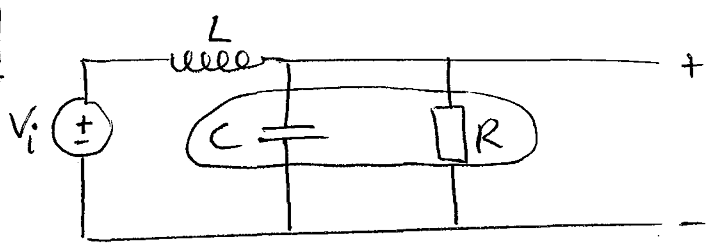
$\omega_2 \equiv (CR_2)^{-1} \rightarrow f_2 = 40\,Hz$

$\omega_1 \equiv \left[C(R_1+R_2)\right]^{-1} \rightarrow f_1 = 32\,Hz$

$$|A_v| = \frac{\omega/\omega_2}{\underbrace{\left[1+\frac{\omega^2}{\omega_1^2}\right]^{1/2}}} = 0'2 \Rightarrow \frac{\omega^2}{\omega_2^2} = (0'2)^2\left[1+\frac{\omega^2}{\omega_1^2}\right] \Rightarrow \omega = 8\,Hz$$

(*) con estos datos hacemos el diagrama de Bode

4.



a) $$A_v = \frac{R \| Z_C}{(R\|Z_C) + Z_L} = \frac{\left(1/R + j\omega C\right)^{-1}}{\left(\frac{1}{R} + j\omega L\right)^{-1} + j\omega L} = \frac{1}{1 + \frac{j\omega L}{R} + j^2\omega^2 LC} =$$

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

b) $$Z_{eq} = Z_L + (Z_C \| R) = Z_L + \frac{1}{\frac{1}{Z_C} + \frac{1}{R}} = \frac{R Z_L + Z_C Z_L + Z_C R}{R + Z_C} =$$

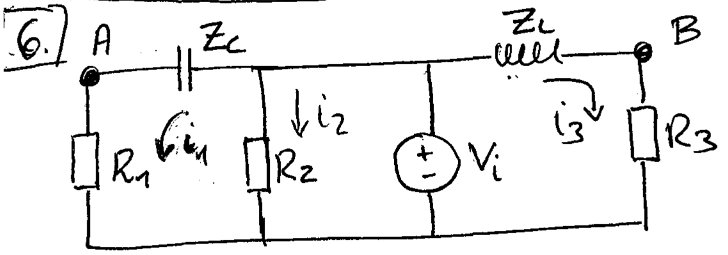
multiplicamos por $R - Z_C$

para dejar el denominador real

$$\Rightarrow \mathrm{Im}(Z_{eq}) = R^2 \cdot Z_L + R^2 Z_C - Z_C^2 Z_L = 0 \Rightarrow$$

$$\Rightarrow \boxed{\omega^2 = \frac{1}{LC} - \frac{1}{R^2 C^2}}$$

6.



$$i_1 = \frac{V_i}{Z_C + R_1}$$

$$i_2 = \frac{V_i}{R_2}$$

$$i_3 = \frac{V_i}{Z_L + R_3}$$

dos formas de hacerlo

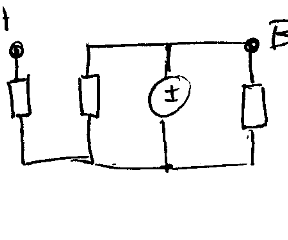
$$\begin{cases} V_{AB} = i_3 Z_L - i_1 Z_C = \dfrac{j\omega L/R_2}{1 + j\omega \frac{L}{R_2}} - \dfrac{1}{1 + j\omega C R_1} \\ V_{AB} = -i_3 R_3 + i_1 R_1 \end{cases}$$

$$= \frac{-1}{1 + j\omega \frac{L}{R_2}} + \frac{j\omega C R_1}{1 + j\omega C R_1}$$

$$V_{AB}(\omega \to 0) \longrightarrow -1$$

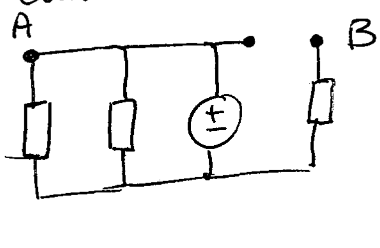
$$V_{AB}(\omega \to \infty) \longrightarrow 1$$

Cuando $\omega \to 0$



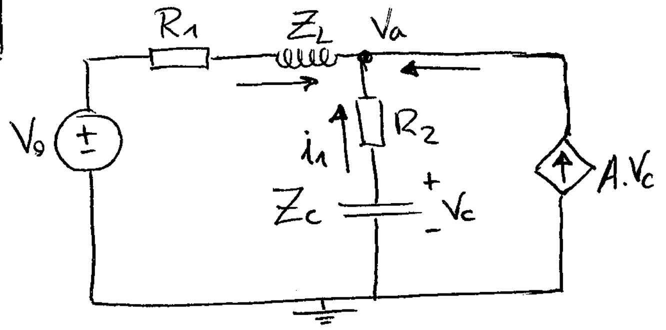
$V_{AB} = -V_i$

Cuando $\omega \to \infty$



$V_{AB} = V_i$

7.



$$\left.\begin{aligned} &\frac{V_0 - V_a}{R_1 + Z_L} + \frac{0 - V_a}{Z_C + R_2} + AV_C = 0 \\ &V_C = -Z_C . i_1 = -Z_C . \frac{V_a}{Z_C + R_2} \end{aligned}\right\} \Rightarrow$$

$$\Rightarrow \boxed{\frac{V_a}{V_0} = \frac{R_2 + Z_C}{R_2 + Z_C + (R_1 + Z_L)(1 - AZ_C)}} \quad (*)$$

Sustituimos

$$\frac{1}{j\omega C} = Z_C \quad \xrightarrow{\omega \to 0} \infty \qquad \xrightarrow{\omega \to \infty} 0$$

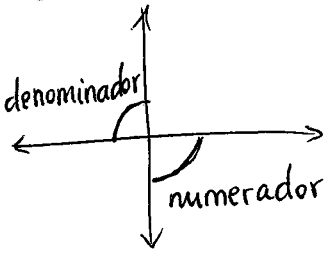
$$j\omega C = Z_L \quad \xrightarrow{\omega \to 0} 0 \qquad \xrightarrow{\omega \to \infty} \infty$$

$$\Rightarrow \frac{V_a}{V_0} = \begin{cases} \xrightarrow{\omega \to 0} \dfrac{Z_C}{Z_C + R_1(-AZ_C)} = \dfrac{1}{1 - AR_1} \\ \xrightarrow{\omega \to \infty} 0 \end{cases}$$

b) DATOS: $R_1 = 1\Omega$, $R_2 = 3\Omega$, $A = 2\Omega^{-1}$, $Z_L = 2j\Omega$, $Z_C = -5j\Omega$

Sustituimos los datos en (*):

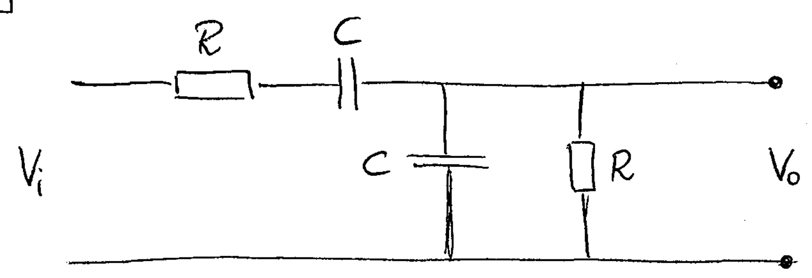
$$\frac{V_a}{V_0} = \frac{3 - 5j}{-16 + 7j} = \frac{\sqrt{34} . e^{-j59°}}{\sqrt{305} . e^{j156°}}$$



hay que fijarse
en los signos de los números
para determinar el cuadrante del ángulo.

$$\frac{V_a}{V_0} = 0'334 . e^{-j215°} \Rightarrow V_a = \underbrace{V_0}_{6V} . 0'334 . e^{-j215°} = 2V . e^{-j215°}$$

11.

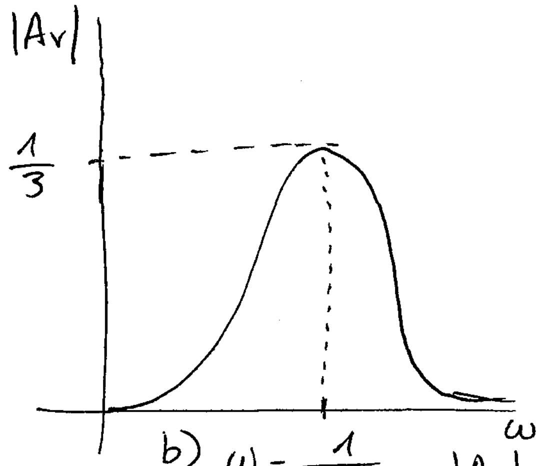


multiplicamos por $(j\omega c + 1/R)$

$$\frac{V_o}{V_i} = \frac{(Z_c \| R)}{(Z_c\|R) + Z_c + R} = \frac{(j\omega c + 1/R)^{-1}}{(j\omega c + 1/R)^{-1} + \frac{1}{j\omega c} + R} = \frac{1}{1 + 1 + j\omega c R + \frac{1}{R j\omega c} + 1} =$$

$$= \boxed{\frac{1}{3 + j\left(\omega c R - \frac{1}{\omega c R}\right)}}$$

$$\left|\frac{V_o}{V_i}\right| = \frac{1}{\left[9 + \left(\omega c R - \frac{1}{\omega c R}\right)^2\right]^{1/2}}$$



b) $\omega = \frac{1}{CR} = |A_v|_{máx}$

) $\Phi\left(\frac{V_o}{V_i}\right) = -\operatorname{arctg}\left(\frac{\omega c R - \frac{1}{\omega c R}}{3}\right) = \begin{cases} \xrightarrow{\omega \to 0} 90^\circ \\ \xrightarrow{\omega = \frac{1}{CR}} 0^\circ \\ \xrightarrow{\omega \to \infty} -90^\circ \end{cases}$

e) $R = 6300\,\Omega$ $\quad C = 1\,\mu F$ $\quad T = 20\,ms$ $\quad A = 1V$

$T = 20ms \rightarrow f = \frac{1}{T} = 50\,Hz \rightarrow \omega = 2\pi f = 100\pi$ rad/s

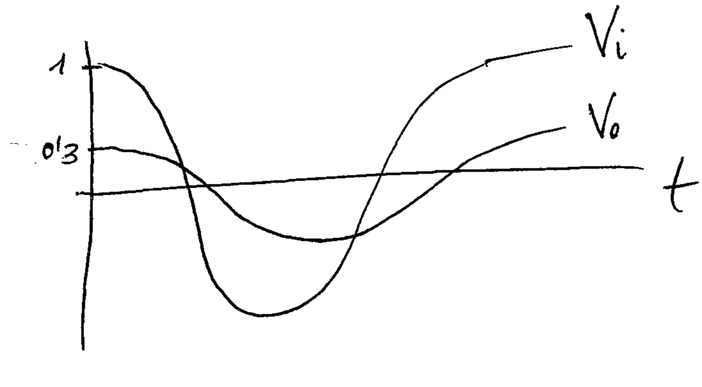
$\omega c R \simeq 2$; $\frac{1}{\omega c R} = 0'5$

$|A_v| = 0'3$; $\Phi\left(\frac{V_o}{V_i}\right) = -26^\circ$

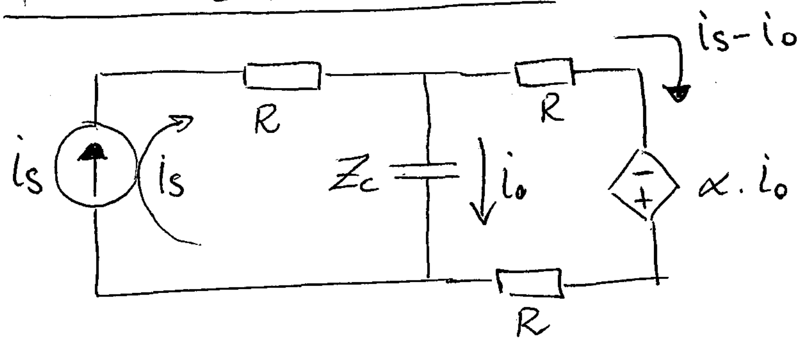
$V_i = 1V \cos(100\pi t)$

$V_o = V_i \cdot 0'3 \cdot e^{-j26^\circ}$

$V_o(t) = 0'3 \cos(100\pi t - 26^\circ)$



EJEMPLO EJERCICIO PARCIAL



$$A_i = \frac{i_o}{i_s}$$

$$i_o Z_c - (i_s - i_o)R + \alpha i_o - (i_s - i_o)R = 0 \Rightarrow$$

$$\Rightarrow \frac{i_o}{i_s} = \frac{2R}{2R+\alpha+Z_c} = \frac{2R}{2R+\alpha+\frac{1}{j\omega C}} = \boxed{\frac{2R\,j\omega C}{1+(2R+\alpha)j\omega C}}$$

$$|A_i| = \left|\frac{i_o}{i_s}\right| = \frac{2R\omega C}{\left[1+(2R+\alpha)^2\omega^2C^2\right]^{1/2}}$$

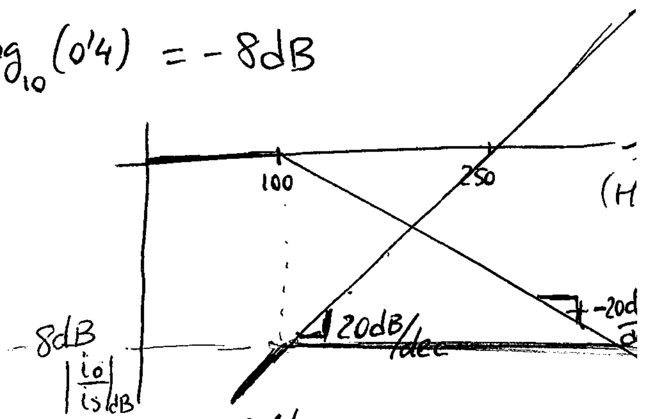
$; (2RC)^{-1} \equiv 2\pi f_1 \rightarrow f_1 \approx 250\,Hz$

$; \left[(2R+\alpha)C\right]^{-1} \equiv 2\pi f_2 \rightarrow f_2 \approx 100\,Hz$

$$\Phi\left(\frac{i_o}{i_s}\right) = \frac{\pi}{2} - \operatorname{arctg}\left(\frac{(2R+\alpha)\omega C}{1}\right) = \frac{\pi}{2} - \operatorname{arctg}\left((2R+\alpha)\omega C\right)$$

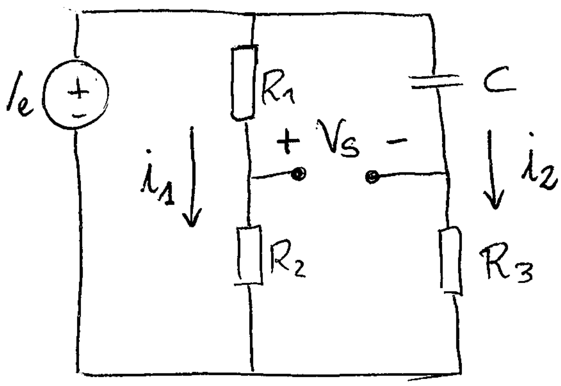
$$\left|\frac{i_o}{i_s}\right| = \begin{cases} \xrightarrow{\omega\to 0} 0 \\ \xrightarrow{\omega\to\infty} \frac{2R}{2R+\alpha} = \underbrace{0'4}_{\text{con los datos del último apartado}} \longrightarrow 20\log_{10}(0'4) = -8dB \end{cases}$$

$$\Phi\left(\frac{i_o}{i_s}\right) = \begin{cases} \xrightarrow{\omega\to 0} 90^\circ \\ \xrightarrow{\omega\to\infty} 0^\circ \end{cases}$$



$$|A_i|_{dB} = 20\log_{10}\left(\frac{f}{250Hz}\right) - 20\log_{10}\left[1+\frac{f^2}{(100Hz)^2}\right]^{1/2}$$

EJEMPLO EJERCICIO PARCIAL



$$V_S = i_2 R_3 + i_1 R_2 = i_2 Z_C - i_1 R_1$$

$$i_1 = \frac{V_e}{R_1 + R_2} \qquad i_2 = \frac{V_e}{Z_C + R_3}$$

mult. $j\omega C$

$$\frac{V_S}{V_e} = \frac{R_2 Z_C - R_1 R_3}{(R_1+R_2)(R_3+Z_C)} = \frac{\frac{R_2}{j\omega C} - R_1 R_3}{(R_1+R_2)\left(R_3 + \frac{1}{j\omega C}\right)} =$$

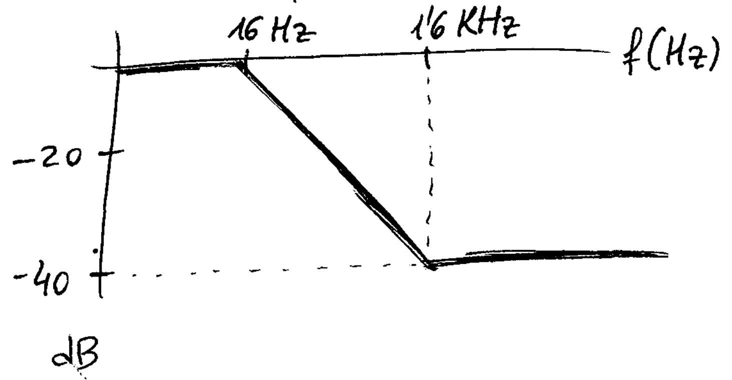
$$= \frac{R_2 - j\omega C R_1 R_3}{(R_1+R_2)(1 + j\omega C R_3)} = \boxed{\frac{1 - j\omega C \frac{R_1 R_3}{R_2}}{\frac{R_1+R_2}{R_2} \cdot (1 + j\omega C R_3)}}$$

$$\left(C \frac{R_1 R_3}{R_2}\right)^{-1} \equiv \omega_1$$

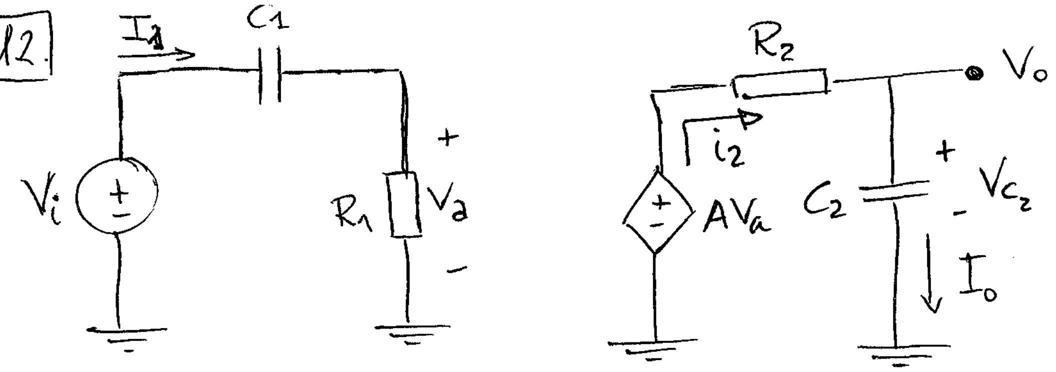
$$(C R_3)^{-1} \equiv \omega_2$$

$$|A_v| = \frac{\left[1 + \frac{\omega^2}{\omega_1^2}\right]^{1/2}}{\left[1 + \frac{\omega^2}{\omega_2^2}\right]^{1/2}} \cdot \frac{R_2}{R_1+R_2} \quad ; \quad \Phi\left(\frac{V_s}{V_e}\right) = \operatorname{arctg}\left(\frac{-\omega}{\omega_1}\right) - \operatorname{arctg}\left(\frac{\omega}{\omega_2}\right)$$

No nos da tiempo, diagrama de Bode resultante:



12.



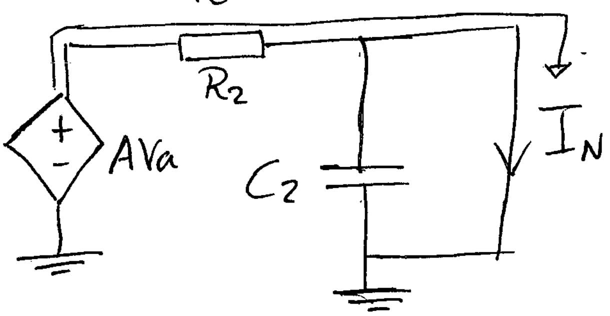
a)

$$V_{Th} = V_{C_2} = i_2 \cdot Z_{C_2} = \frac{A . V_a}{R_2 + Z_{C_2}} \cdot Z_{C_2}$$

$$V_a = R_1 \cdot I_1 = R_1 \cdot \frac{V_i . R_1}{R_1 + Z_{C_1}}$$

$$\Rightarrow V_{Th} = V_{C_2} = A \cdot \frac{R_1 . V_i}{R_1 + Z_{C_1}} \cdot \frac{Z_{C_2}}{R_2 + Z_{C_2}}$$

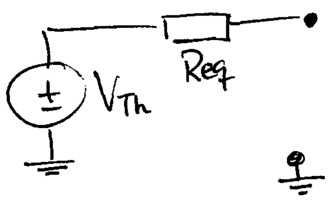
Ahora, ¿I_N?



$$I_N = \frac{AV_a}{R_2}$$

$$R_{eq} = \frac{V_{Th}}{I_N} = \frac{R_2 \cdot Z_{C_2}}{R_2 + Z_{C_2}} =$$

$$= \frac{R_2 \cdot \frac{1}{j\omega C_2}}{R_2 + \frac{1}{j\omega C_2}} = \frac{R_2}{1 + j\omega C_2 R_2}$$



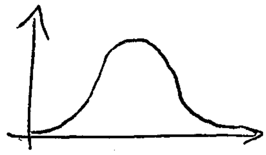
b) $$A_v = \frac{V_o}{V_i} = \frac{A R_1 Z_2}{(R_1 + Z_1)(R_2 + Z_2)} = \frac{AR_1}{R_1 + \frac{1}{j\omega C_1}} \cdot \frac{\frac{1}{j\omega C_2}}{R_2 + \frac{1}{j\omega C_2}} =$$

$$= \frac{AR_1 j\omega C_1}{1 + j\omega C_1 R_1} \cdot \frac{1}{1 + j\omega C_2 R_2}$$

c) $$|A_v| = \frac{A R_1 \omega C_1}{\left[1+\omega^2 C_1^2 R_1^2\right]^{1/2} \cdot \left[1+\omega^2 C_2^2 R_2^2\right]^{1/2}}$$

$|A_v|_{\omega \to 0} \longrightarrow 0$

$|A_v|_{\omega \to \infty} \longrightarrow 0$



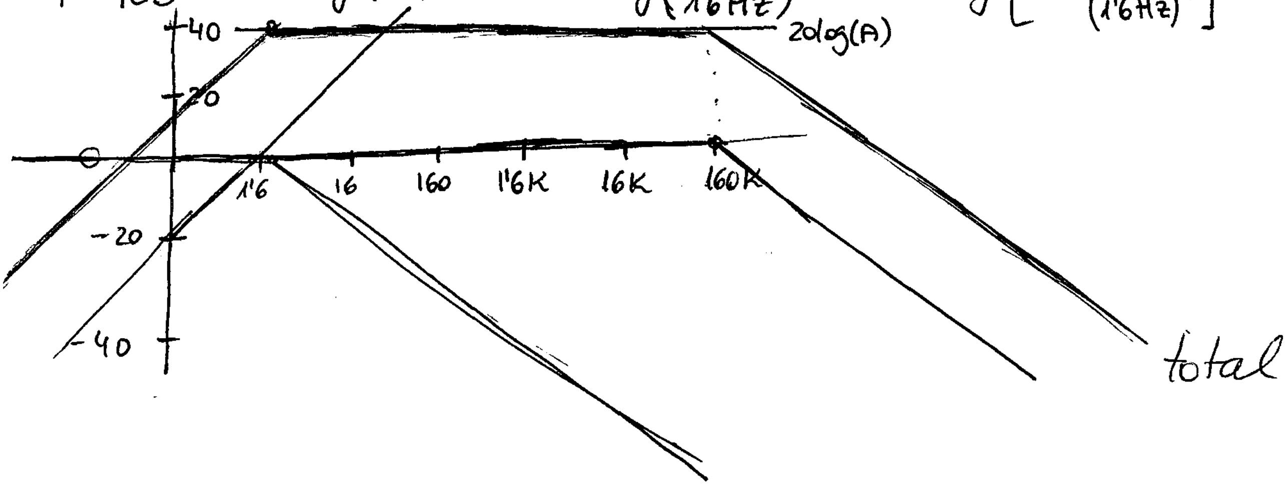
circuito pasa-banda

d) Nos dan datos...

$(C_1 R_1)^{-1} = 10 \, rad/s = 2\pi f \longrightarrow f_1 = 1'6 \, Hz$

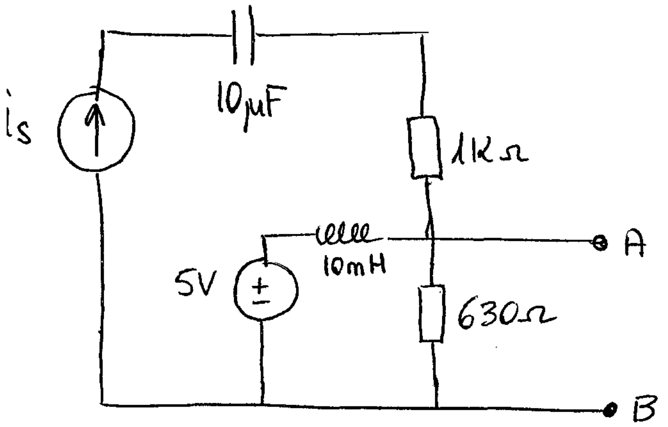
$(C_2 R_2)^{-1} = 10^6 \, rad/s = 2\pi f \longrightarrow f_2 = 160 \, KHz$

$$|A_v|_{dB} = 20\log(A) + 20\log\left(\frac{f}{1'6\,Hz}\right) - 20\log\left[1+\frac{f^2}{(1'6\,Hz)^2}\right]^{1/2} - 20\log\left[1+\frac{f^2}{(160\,KHz)^2}\right]$$



EJERCICIO EXAMEN

PRINCIPIO DE SUPERPOSICIÓN



- $i_s = 10mA \cdot sen(2\pi f t)$

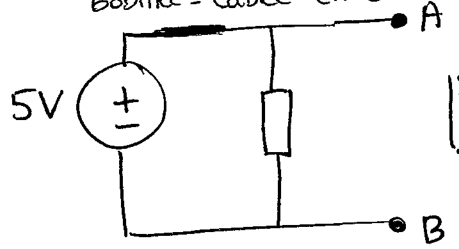
  $f = 5\,KHz$

  $\omega = 10^4 \pi$ rad/s

→ i_s (fasor) $= 10mA \cdot e^{j0} = 10mA$

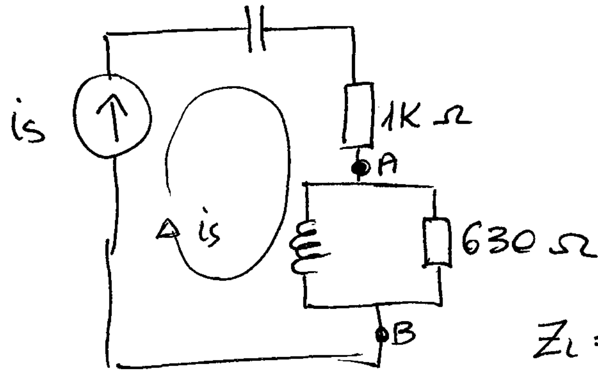
▶ Anulamos fuente de corriente alterna

bobina ≡ cable en continua



$\boxed{V_{AB}^{=} = 5V}$

▶ Anulamos fuente de tensión continua.



$Z_L = 314j\ \Omega$

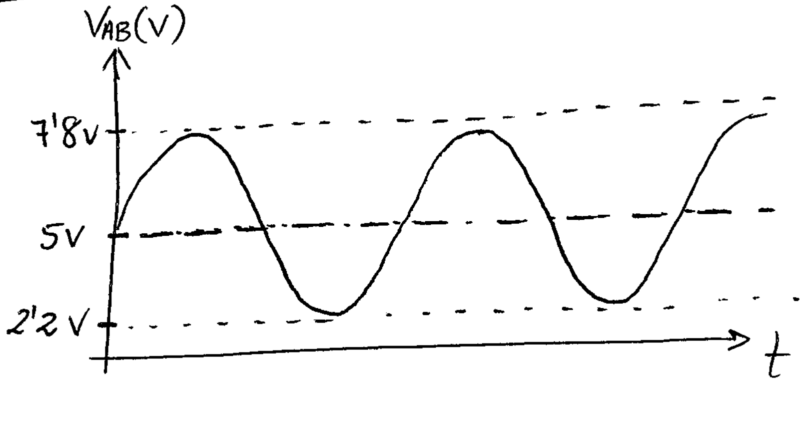
$$V_{AB} = i_s (630 \parallel Z_L) = 10mA \cdot \frac{630 \cdot 314j}{630 + 314j} = 10mA \cdot \frac{630 \cdot 314}{\left[630^2 + 314^2\right]} \cdot$$

$$\cdot\, e^{j\left[90^\circ - arctg\left(\frac{314}{630}\right)\right]} = 2'81V \cdot e^{j63'5^\circ}$$

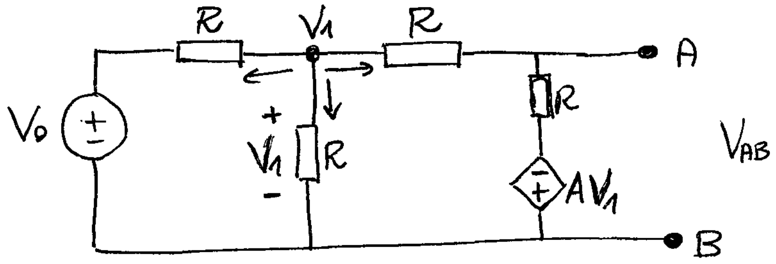
$$\Rightarrow \boxed{V_{AB}^{\sim} = 2'81V \cdot sen(2\pi f t + 63'5^\circ)}$$

Sumando ambos resultados:

$$\boxed{V_{AB} = 5V + 2'81V \cdot sen(2\pi f t + 63'5^\circ)}$$



EJEMPLO EJERCICIO EXAMEN

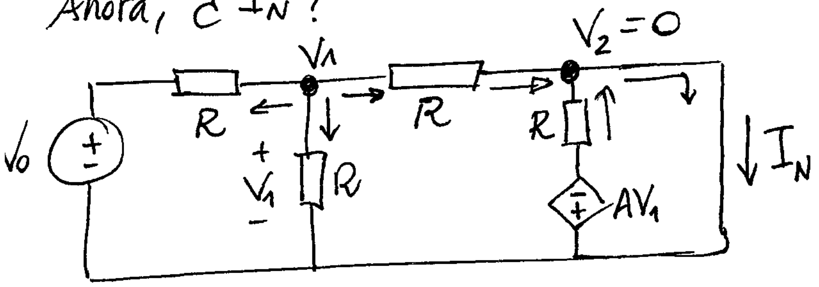


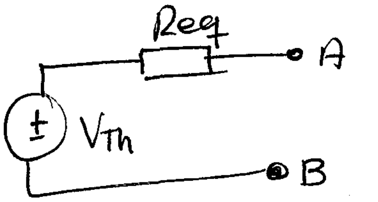
$$\frac{V_1 - V_0}{R} + \frac{V_1}{R} + \frac{V_1 - (-AV_1)}{2R} = 0$$

$$V_{Th} = V_{AB} = -AV_1 + \frac{V_1 + AV_1}{2R} \cdot R$$

$$V_{Th} = V_0 \cdot \frac{1-A}{5+A}$$

Ahora, ¿I_N?

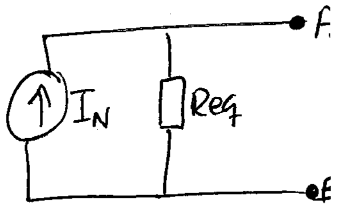




$$\frac{V_1 - V_0}{R} + \frac{V_1}{R} + \frac{V_1}{R} = 0$$

$$\frac{V_1}{R} + \frac{-A \cdot V_1}{R} = I_N$$

$$I_N = V_0 \frac{(1-A)}{3R}$$

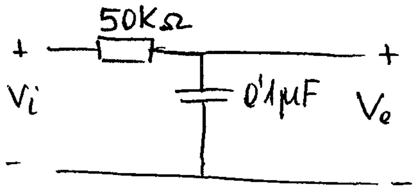


$$Req = \frac{V_{Th}}{I_N} = \frac{3R}{5+A}$$

HOJA 2 — CIRCUITOS SELECTIVOS DE FRECUENCIA

1.

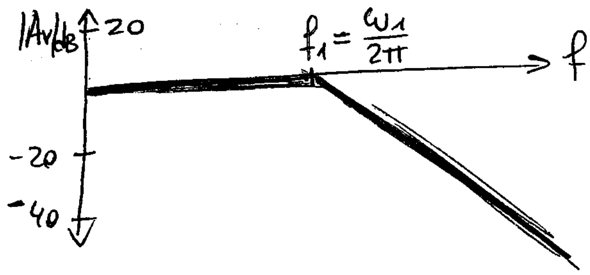
a)



$$A_v = \frac{V_o}{V_i} = \frac{i Z_c}{i(R+Z_c)} = \frac{Z_c}{R+Z_c} = \frac{1/j\omega c}{R + j\omega c^{-1}} =$$

$$= \frac{1}{1+j\omega cR} \qquad \omega_1 = (CR)^{-1}$$

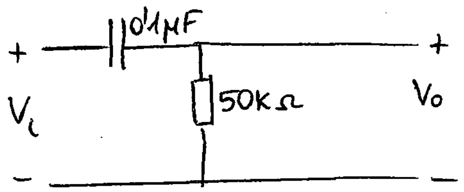
$$|A_v| = \frac{1}{\sqrt{1+\left(\frac{\omega}{\omega_1}\right)^2}}$$



$$A_v|_{dB} = 20 \overset{0}{\cancel{\log(1)}} - 20\log\left(\sqrt{1+\left(\frac{\omega}{\omega_1}\right)^2}\right)$$

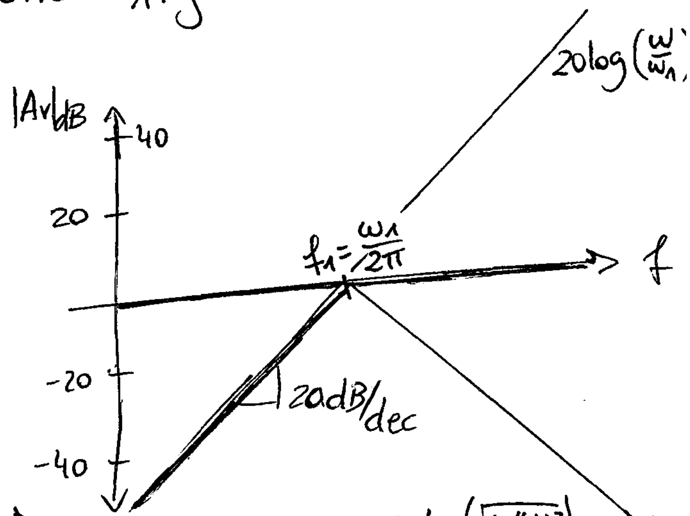
$$\varphi = -\text{arctg}(\omega CR) = -\text{arctg}\left(\frac{\omega}{\omega_1}\right)$$

b)



$$A_v = \frac{V_o}{V_i} = \frac{R}{Z_c + R} = \frac{j\omega CR}{1+j\omega CR} \qquad \omega_1 = (CR)^{-1}$$

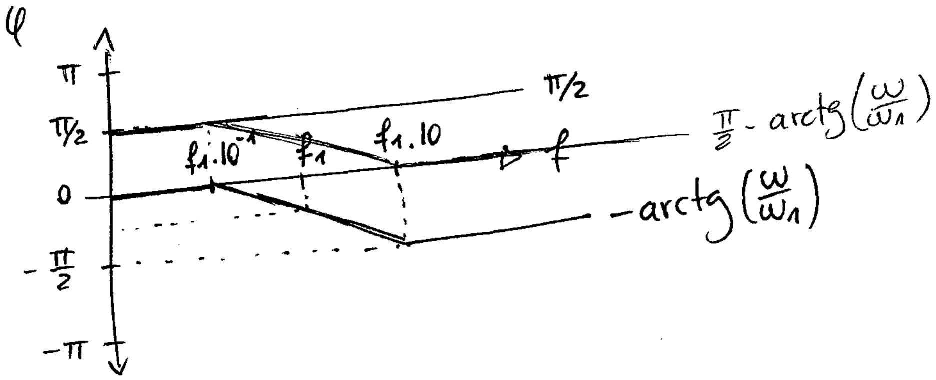
$$|A_v| = \frac{\omega/\omega_1}{\sqrt{1+(\omega/\omega_1)^2}}$$



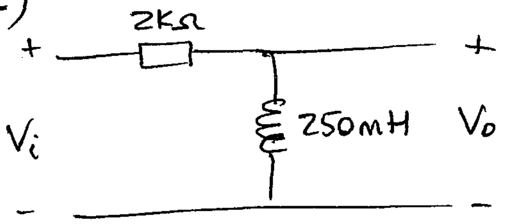
$$|A_v|_{dB} = 20\log\left(\frac{\omega}{\omega_1}\right) - 20\log\left(\sqrt{1+(\omega/\omega_1)^2}\right)$$

$$\varphi = \frac{\pi}{2} - \text{arctg}\left(\frac{\omega CR}{1}\right) = \frac{\pi}{2} - \text{arctg}(\omega CR) \Rightarrow$$

$$\Rightarrow \varphi = \frac{\pi}{2} - \text{arctg}\left(\frac{\omega}{\omega_1}\right)$$



c)

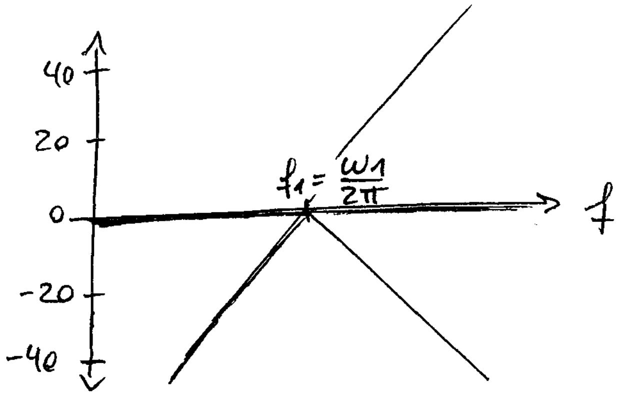


$$A_v = \frac{V_o}{V_i} = \frac{Z_L}{R+Z_L} = \frac{j\omega L}{R+j\omega L} = \frac{j\omega L/R}{1+j\omega L/R} = \frac{j\omega/\omega_1}{1+j\omega/\omega_1} \qquad \omega_1 = \left(\frac{L}{R}\right)^{-1} = \frac{R}{L}$$

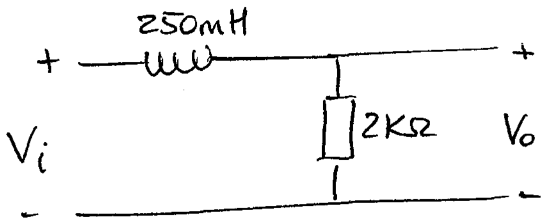
$$|A_v| = \frac{\omega/\omega_1}{\sqrt{1+\left(\frac{\omega}{\omega_1}\right)^2}}$$

$$A_v\big|_{dB} = 20\log\left(\frac{\omega}{\omega_1}\right) - 20\log\left(\sqrt{1+\left(\frac{\omega}{\omega_1}\right)^2}\right)$$

$$\varphi = \frac{\pi}{2} - \operatorname{arctg}\left(\frac{\omega}{\omega_1}\right)$$



d)



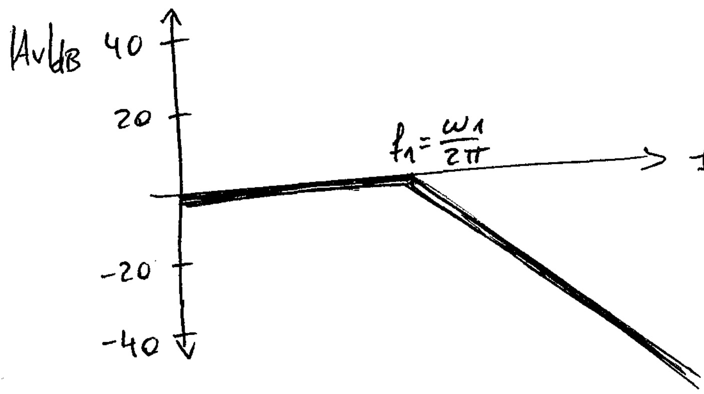
$$A_v = \frac{V_o}{V_i} = \frac{R}{R+Z_L} = \frac{1}{1+j\omega\frac{L}{R}} = \frac{1}{1+j\frac{\omega}{\omega_1}}$$

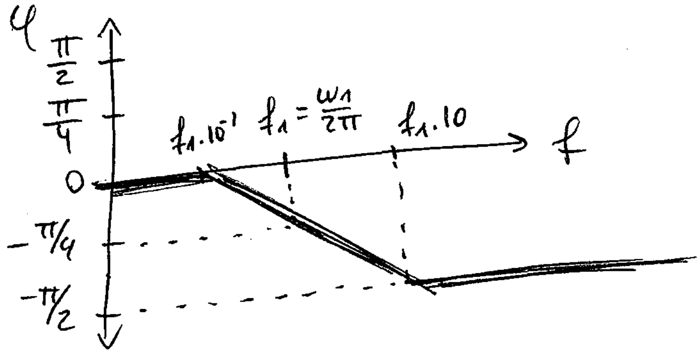
$$\omega_1 = \left(\frac{L}{R}\right)^{-1}$$

$$|A_v| = \frac{1}{\sqrt{1+\left(\frac{\omega}{\omega_1}\right)^2}}$$

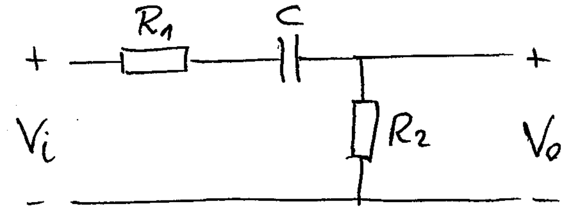
$$|A_v|_{dB} = -20.\log\left(\sqrt{1+\left(\frac{\omega}{\omega_1}\right)^2}\right)$$

$$\varphi = -\operatorname{arctg}\left(\frac{\omega}{\omega_1}\right)$$





2.



$$A_v = \frac{V_o}{V_i} = \frac{R_2}{R_1 + Z_C + R_2} = \frac{j\omega C R_2}{j\omega C R_1 + 1 + j\omega C R_2} = \frac{j\omega C R_2}{1 + j\omega C (R_1 + R_2)}$$

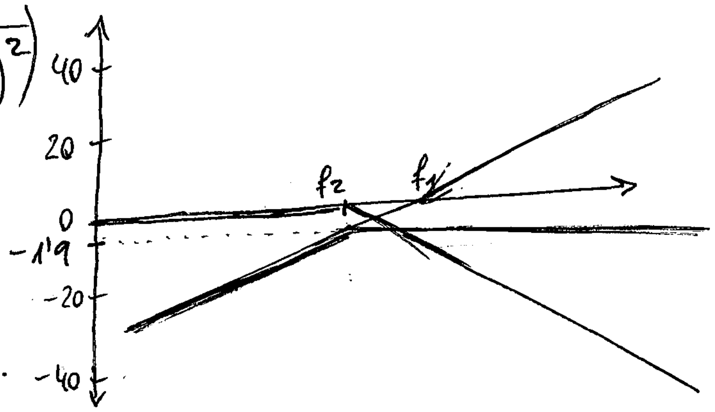
a)

$$|A_v| = \frac{\omega C R_2}{\sqrt{1 + [\omega C (R_1 + R_2)]^2}}$$

$$\omega_1 = (C R_2)^{-1} = (10^{-6} \cdot 4000)^{-1} = 250 \rightarrow \boxed{f_1 = 39'8 \text{ Hz}}$$

$$\omega_2 = (C(R_1+R_2))^{-1} = (10^{-6}(4000+1000))^{-1} = 200 \rightarrow \boxed{f_2 = 31'83 \text{ Hz}}$$

$$|A_v|_{dB} = 20 \log\left(\frac{\omega}{\omega_1}\right) - 20 \cdot \log\left(\sqrt{1 + \left(\frac{\omega}{\omega_2}\right)^2}\right)$$



Cuando $\omega \rightarrow \infty$: $|A_v| \rightarrow \frac{R_2}{R_1+R_2} = 0'8$

$$|A_v|_{dB} \rightarrow 20 \log\left(\frac{R_2}{R_1+R_2}\right) = -1'9$$

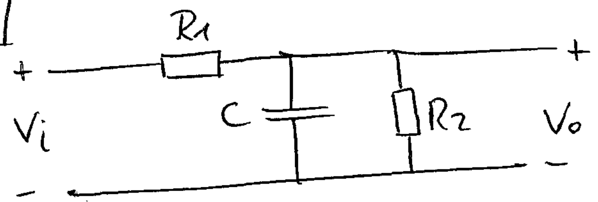
b) Se trata de un FILTRO PASO ALTO.

c) $$\frac{f/f_1}{\sqrt{1+(f/f_2)^2}} = 0'2 \rightarrow \left(\frac{f}{f_1}\right)^2 = (0'2)^2\left(1 + (f/f_2)^2\right) \rightarrow \frac{x^2}{1584'04} = 0'04 + \frac{0'04x^2}{1013'15} \rightarrow$$

$$\rightarrow 1013'15x^2 = 64201'14 + 63'362x^2 \rightarrow 949'79\,x^2 = 64201'14 \rightarrow$$

$$\rightarrow x = \sqrt{\frac{64201'14}{949'79}} \rightarrow \boxed{f = 8'22 \text{ Hz}}$$

3.



$$A_v = \frac{V_o}{V_i} = \frac{Z_C \| R_2}{R_1 + Z_C \| R_2} = \frac{\frac{Z_C R_2}{Z_C + R_2}}{R_1 + \frac{Z_C R_2}{Z_C + R_2}} = \frac{Z_C R_2}{Z_C R_2 + R_1(Z_C + R_2)} = \frac{R_2 / j\omega C}{R_2/j\omega C + R_1\left(\frac{1}{j\omega C} + R_2\right)} =$$

a)

$$= \frac{R_2}{R_2 + R_1(1 + j\omega C R_2)} = \frac{R_2}{R_1 + R_2 + j\omega C R_1 R_2} = \frac{1}{R_1+R_2} \cdot \frac{R_2}{1 + \frac{j\omega C R_1 R_2}{R_1+R_2}} = \underbrace{\boxed{\frac{R_2}{R_1+R_2}}}_{K = \text{ ganancia básica}} \cdot \underbrace{\boxed{\frac{1}{1 + j\omega C\left(\frac{R_1 R_2}{R_1+R_2}\right)}}}_{\text{resto de la expresión}}$$

$$|A_v| = K \cdot \frac{1}{\sqrt{1 + \left[\omega C\left(\frac{R_1 R_2}{R_1+R_2}\right)\right]^2}} \quad ; \quad \boxed{\lim_{\omega \to 0} |A_v| = K} \quad ; \quad \boxed{\lim_{K \to \infty} |A_v| = 0}$$

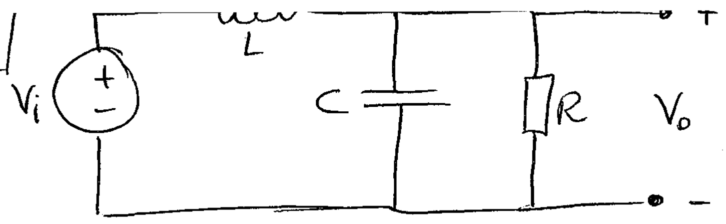
Se trata de un FILTRO PASO BAJO.

b) Solo hay una frecuencia de corte y se trata de:

$$\left(C\frac{R_1 R_2}{R_1+R_2}\right)^{-1} = \frac{R_1+R_2}{C R_1 R_2} \rightarrow \text{esto está en } \frac{rad}{s} \rightarrow \boxed{f_c = \frac{(R_1+R_2)/R_1 R_2 C}{2\pi}}$$

c) Dibujar est... lado unos datos.

4.



$$A_v = \frac{V_o}{V_i} = \frac{Z_C \| R}{Z_L + Z_C \| R} = \frac{\frac{Z_C R}{Z_C + R}}{Z_L + \frac{Z_C R}{Z_C + R}} =$$

a)

$$= \frac{Z_C R}{(Z_C + R) Z_L + Z_C R} = \frac{Z_C R}{Z_C Z_L + Z_L R + Z_C R} =$$

$$= \frac{R/j\omega C}{\frac{L}{C} + j\omega L R + R/j\omega C} = \frac{R}{j\omega L - \omega^2 LCR + R} = \frac{1}{1 - \omega^2 LC + j\omega \frac{L}{R}}$$

$$|A_v| = \frac{1}{\sqrt{(1-\omega^2 LC)^2 + \left(\frac{\omega L}{R}\right)^2}}$$

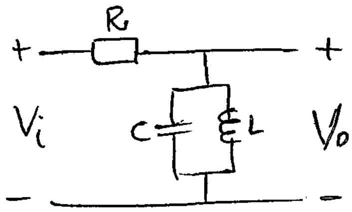
b) $$Z_{eq} = Z_L + (Z_C \| R) = Z_L + \frac{Z_C R}{Z_C + R} = \frac{Z_L Z_C + Z_L R + Z_C R}{Z_C + R} =$$

$$= \frac{L/C + j\omega L R + \frac{R}{j\omega C}}{\frac{1}{j\omega C} + R} = \frac{j\omega L - \omega^2 LCR + R}{1 + j\omega CR} = \frac{(j\omega L - \omega^2 LCR + R)(1 - j\omega CR)}{1 + (\omega CR)^2} = (*)$$

$\mathrm{Im}(Z_{eq}) = 0 \Leftrightarrow j\omega L + j\omega^3 C^2 R^2 L - j\omega C R^2 = 0$

(*) Posiblemente esté mal pero la idea es despejar $\mathrm{Im}(Z_{eq})$, igualarlo a cero y despejar ω.

5.



$$A_v = \frac{V_o}{V_i} = \frac{Z_L \| Z_C}{R + Z_L \| Z_C} = \frac{\frac{Z_L Z_C}{Z_L + Z_C}}{R + \frac{Z_L Z_C}{Z_L + Z_C}} =$$

$$= \frac{Z_L Z_C}{R Z_L + R Z_C + Z_L Z_C} = \frac{L/C}{j\omega L R + \frac{R}{j\omega C} + \frac{L}{C}} =$$

a)

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

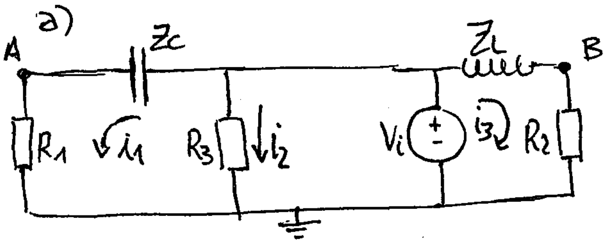
$$|A_v| = \frac{\omega \frac{L}{R}}{\sqrt{(1-\omega^2 LC)^2 + \left(\omega \frac{L}{R}\right)^2}}$$

b) $\omega_o = \frac{1}{\sqrt{LC}}$; $2\pi f_o = \frac{1}{\sqrt{LC}} \Rightarrow f_o = \frac{1}{2\pi\sqrt{LC}}$

c) $$|A_v|_{máx} = \frac{\frac{1}{\sqrt{LC}} \cdot \frac{L}{C}}{\sqrt{(\underbrace{1 - \frac{1}{LC} \cdot LC}_{0})^2 + \left(\frac{1}{\sqrt{LC}} \frac{L}{R}\right)^2}} = \frac{\frac{1}{\sqrt{LC}} \cdot \frac{L}{C}}{\sqrt{\left(\frac{1}{\sqrt{LC}} \cdot \frac{L}{R}\right)^2}} = 1$$

d) $\frac{1}{\sqrt{2}} = |A_v| \rightarrow$ despejamos las dos frecuencias de corte.

6. a)



$$i_1 = \frac{V_i - 0}{Z_C + R_1} = \frac{V_i}{Z_C + R_1}$$

$$i_2 = \frac{V_i}{R_3} \quad ; \quad i_3 = \frac{V_i}{Z_L + R_2}$$

$$V_A = i_1 R_1 = \frac{V_i R_1}{Z_C + R_1}$$

$$\Rightarrow \quad V_{AB} = \frac{V_i R_1}{Z_C + R_1} - \frac{V_i R_2}{Z_L + R_2} \Rightarrow \frac{V_{AB}}{V_i} = \frac{R_1}{Z_C + R_1} - \frac{R_2}{Z_L + R_2} \Rightarrow$$

$$V_B = i_3 . R_2 = \frac{V_i . R_2}{Z_L + R_2}$$

$$\Rightarrow \frac{V_{AB}}{V_i} = \frac{j\omega C R_1}{1 + j\omega C R_1} - \frac{1}{1 + j\omega L / R_2}$$

$$\left|\frac{V_{AB}}{V_i}\right| = \frac{\omega C R_1}{\sqrt{1 + (\omega C R_1)^2}} - \frac{1}{\sqrt{1 + \left(\frac{\omega L}{R_2}\right)^2}}$$

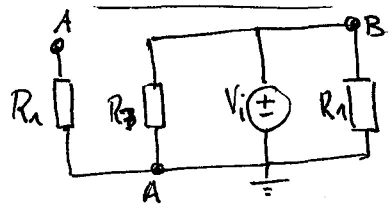
Cuando $\omega \rightarrow 0$

$$\left|\frac{V_{AB}}{V_i}\right| \rightarrow 0 - 1 = -1$$

Cuando $\omega \rightarrow \infty$

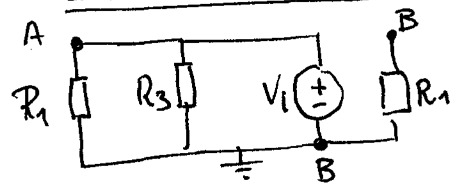
$$\left|\frac{V_{AB}}{V_i}\right| \rightarrow 1 - 0 = 1$$

b) Cuando $\omega \to 0$



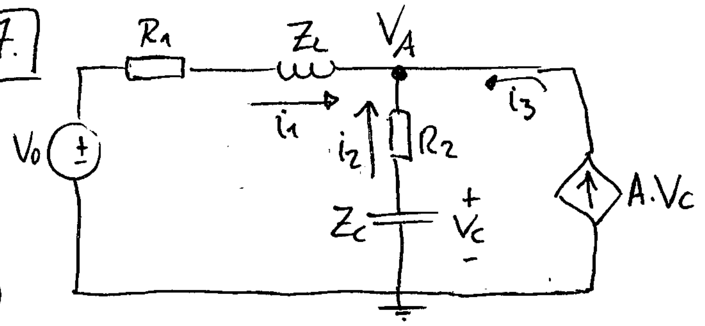
$$\begin{cases} V_A = 0 \\ V_B = V_i \end{cases} \rightarrow V_{AB} = -V_i$$

Cuando $\omega \to \infty$



$$\begin{cases} V_A = V_i \\ V_B = 0 \end{cases} \rightarrow V_{AB} = V_i$$

$\boxed{7.}$



$$\frac{V_0 - V_A}{R_1 + Z_L} + \frac{-V_A}{R_2 + Z_C} + A.V_C$$

$$V_C = -i_2 Z_C = \frac{V_A}{R_2 + Z_C} \cdot Z_C$$

a)

$$\frac{V_0 - V_A}{R_1 + Z_L} + \frac{-V_A}{R_2 + Z_C} + \frac{A V_A Z_C}{R_2 + Z_C} = 0$$

$$\boxed{\frac{V_a}{V_0} = \frac{R_2 + Z_C}{R_2 + Z_C + (R_1 + Z_L)(1 - A Z_C)}} \circledast$$

$$Z_C \begin{array}{l} \xrightarrow{\omega \to 0} \infty \\ \xrightarrow{\omega \to \infty} 0 \end{array}$$

$$Z_L \begin{array}{l} \xrightarrow{\omega \to 0} 0 \\ \xrightarrow{\omega \to \infty} \infty \end{array}$$

$$\frac{V_a}{V_0} \xrightarrow{\omega \to 0} \frac{Z_C}{Z_C + R_1(-A Z_C)} = \frac{1}{1 - A R_1}$$

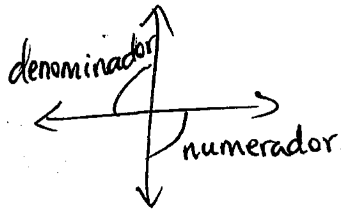
$$\frac{V_a}{V_0} \xrightarrow{\omega \to \infty} 0$$

$\circledast$ No se está al 100% seguro de que esté bien despejado

b) DATOS: $R_1 = 1\Omega$, $R_2 = 3\Omega$, $A = 2\Omega^{-1}$, $Z_L = 2j\,\Omega$, $Z_C = -5j\,\Omega$

Sustituimos datos en $\circledast$:

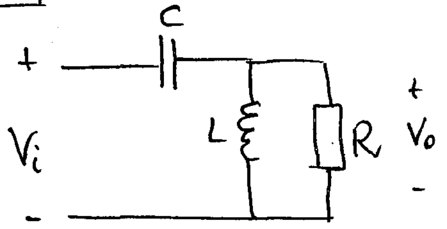
$$\frac{V_a}{V_0} = \frac{3 - 5j}{-16 + 7j} = \frac{\sqrt{34} \cdot e^{-59^\circ j}}{\sqrt{305} \cdot e^{156^\circ j}}$$



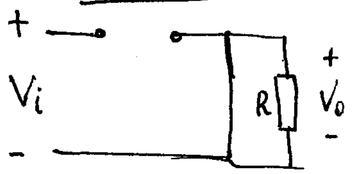
Es importante mirar el signo de las partes de los números complejos para saber en que cuadrante se encuentran.

$$\frac{V_a}{V_0} = 0'334 \cdot e^{-215^\circ j} \Rightarrow V_a = \underbrace{V_0}_{6V} \cdot 0'334 \cdot e^{-215^\circ j} \simeq \boxed{2V \cdot e^{-215^\circ j}}$$

$\boxed{8.}$

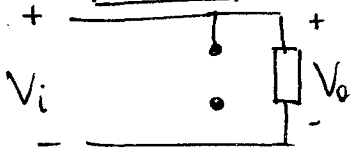


a) $\boxed{\omega \to 0}$



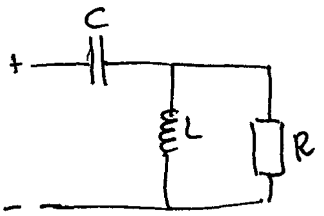
$|A_v| = 0$ cuando $\omega \to 0$

$\boxed{\omega \to \infty}$



$|A_v| = 1$ cuando $\omega \to \infty$

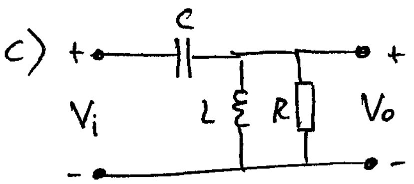
b)



$$Z_{eq} = Z_C + Z_L \| R = Z_C + \frac{Z_L R}{Z_L + R} = \frac{1}{j\omega C} + \frac{j\omega L R}{j\omega L + R} =$$

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

c)



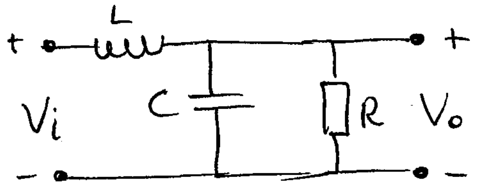
$$A_v = \frac{V_o}{V_i} = \frac{Z_L \| R}{Z_C + Z_L \| R} = \frac{\frac{Z_L R}{Z_L + R}}{Z_C + \frac{Z_L R}{Z_L + R}} = \frac{Z_L . R}{Z_C Z_L + Z_C R + Z_L R} =$$

$$= \frac{j\omega L R}{\frac{L}{C} + \frac{R}{j\omega C} + j\omega L R} = \frac{-\omega^2 C L R}{j\omega L - \omega^2 C L R + R} = \frac{-\omega^2 C L}{1 - \omega^2 C L + j\omega \frac{L}{R}}$$

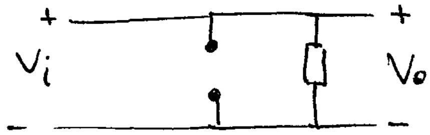
$$|A_v| = \frac{\omega^2 C L}{\sqrt{(1-\omega^2 C L)^2 + \left(\omega \frac{L}{R}\right)^2}}$$

$$\varphi = \pi - \operatorname{arctg}\left(\frac{\omega \frac{L}{R}}{1-\omega^2 C L}\right) = \pi - \operatorname{arctg}\left(\frac{\omega L}{R - \omega^2 C L R}\right)$$

$\boxed{9.}$

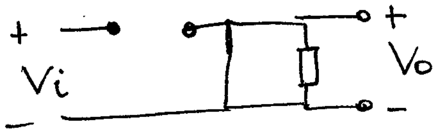


a) $\boxed{\omega \to 0}$



$|A_v| \to 1$

$\boxed{\omega \to \infty}$



$|A_v| \to 0$

b) $$Z_{eq} = Z_L + Z_C \| R = j\omega L + \frac{Z_C R}{Z_C + R} = j\omega L + \frac{R/j\omega C}{\frac{1}{j\omega C} + R} =$$

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

c) $$A_v = \frac{V_o}{V_i} = \frac{Z_C \| R}{Z_L + Z_C \| R} = \frac{\frac{Z_C R}{Z_C + R}}{Z_L + \frac{Z_C R}{Z_C + R}} = \frac{Z_C R}{Z_L Z_C + Z_L R + Z_C R} = \frac{1/j\omega C}{\frac{L}{C} + j\omega L R + \frac{R}{j\omega C}} =$$

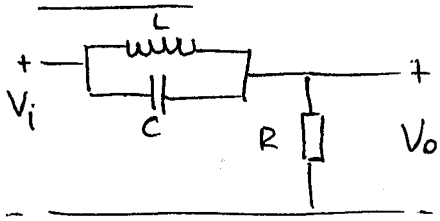
$$= \frac{1}{j\omega L - \omega^2 LCR + R} = \frac{1}{1 - \omega^2 LC + j\omega \frac{L}{R}}$$

$$|A_v| = \frac{1}{\sqrt{(1-\omega^2 LC)^2 + \left(\omega \frac{L}{R}\right)^2}}$$

$$\varphi = 0 - \text{arctg}\left(\frac{\omega \frac{L}{R}}{1 - \omega^2 LC}\right) = -\text{arctg}\left(\frac{\omega L}{R - \omega^2 LRC}\right)$$

$\boxed{10.}$

CIRCUITO 1



a) $$A_v = \frac{V_o}{V_i} = \frac{R}{Z_L \| Z_C + R} = \frac{R}{R + \frac{Z_L Z_C}{Z_L + Z_C}} = \frac{R(Z_L + Z_C)}{(Z_L + Z_C)R + Z_L Z_C}$$

$$= \frac{RZ_L + RZ_C}{Z_L R + Z_C R + Z_L Z_C} = \frac{j\omega LR + \frac{R}{j\omega C}}{j\omega LR + \frac{R}{j\omega C} + \frac{L}{C}} =$$

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

$$|A_v| = \frac{1 - \omega^2 LC}{\sqrt{(1 - \omega^2 LC)^2 + \left(\omega \frac{L}{R}\right)^2}} \qquad \varphi = -\text{arctg}$$

b) Cuando $\omega \to 0$

$|A_v| \to 1$

Cuando $\omega \to \infty$

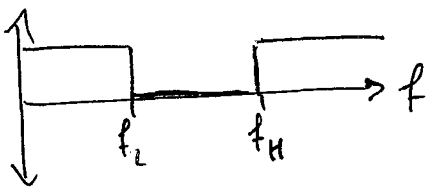
$|A_v| \longrightarrow 1$

c) $\omega_0 = \frac{1}{\sqrt{LC}}$

$$\frac{1 - \frac{1}{LC} LC}{\sqrt{\left(1 - \frac{1}{LC} LC\right)^2 + \left(\frac{1}{\sqrt{LC}} \cdot \frac{L}{C}\right)^2}} = \frac{0}{\frac{1}{\sqrt{LC}} \cdot \frac{L}{C}}$$

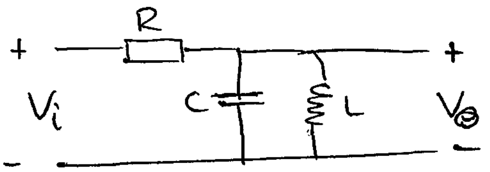
Entonces a la frecuencia natural de resonancia: $\omega_0 = \frac{1}{\sqrt{LC}}$ $|A_v|$ es mínimo y $|A_v| = 0$.

d)



¿f_L y f_H?

CIRCUITO 2



a) $$A_v = \frac{V_o}{V_i} = \frac{Z_C \| Z_L}{R + Z_C \| Z_L} = \frac{\frac{Z_C Z_L}{Z_C + Z_L}}{R + \frac{Z_C \cdot Z_L}{Z_C + Z_L}} =$$

$$= \frac{Z_C Z_L}{R Z_C + R Z_L + Z_C Z_L} = \frac{L/C}{\frac{R}{j\omega C} + j\omega L R + \frac{L}{C}} =$$

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

$$|A_v| = \frac{\omega L / R}{\sqrt{(1-\omega^2 LC)^2 + \left(\frac{\omega L}{R}\right)^2}}$$

$$\varphi = \frac{\pi}{2} - \operatorname{arctg}\left(\frac{\frac{\omega L}{R}}{1-\omega^2 LC}\right) = \frac{\pi}{2} - \operatorname{arctg}\left(\frac{\omega L}{R - \omega^2 LCR}\right)$$

b) Cuando $\omega \to 0$

$|A_v| \to 0$

Cuando $\omega \to \infty$

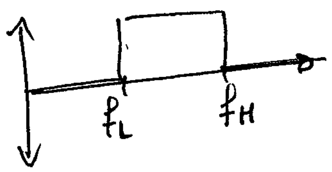
$|A_v| \to 0$

c) $$\omega_0 = \frac{1}{\sqrt{LC}}$$

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

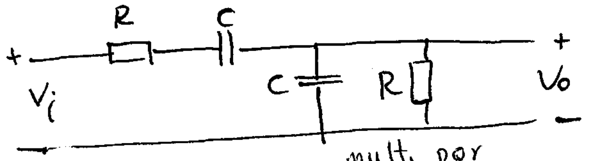
Entonces a la frecuencia natural de resonancia: $\omega_0 = \frac{1}{\sqrt{LC}}$ $|A_v|$ es máximo y $|A_v| = 1$.

d)



¿f_L y f_H?

11.



$$A_v = \frac{V_o}{V_i} = \frac{Z_c \| R}{Z_c + R + Z_c \| R} =$$

a)

$$= \frac{\left(j\omega C + \frac{1}{R}\right)^{-1}}{\left(j\omega C + \frac{1}{R}\right)^{-1} + \frac{1}{j\omega C} + R} \overset{\text{mult. por } \left(j\omega C + \frac{1}{R}\right)}{=} \frac{1}{1 + 1 + \frac{1}{j\omega CR} + j\omega CR + 1} = \frac{1}{3 + j\left(\omega CR - \frac{1}{\omega CR}\right)}$$

$$|A_v| = \frac{1}{\sqrt{9 + \left(\omega CR - \frac{1}{\omega CR}\right)^2}}$$

b)

$$|A_v|_{máx} \iff \omega CR - \frac{1}{\omega CR} = 0 \iff (\omega CR)^2 = 1 \iff \omega CR = 1 \iff \boxed{\omega = \frac{1}{CR}}$$

c)

$$|A_v|_{max} = \frac{1}{3} \quad \text{cuando} \quad \omega = \frac{1}{CR}$$

d)

$$\Phi\left(\frac{V_o}{V_i}\right) = 0 - \operatorname{arctg}\left(\frac{\omega CR - \frac{1}{\omega CR}}{3}\right)$$

$$\xrightarrow{\omega \to 0} \Phi \to \frac{\pi}{2}$$

$$\xrightarrow{\omega \to \frac{1}{CR}} \Phi \to 0$$

$$\xrightarrow{\omega \to \infty} \Phi \to -\frac{\pi}{2}$$

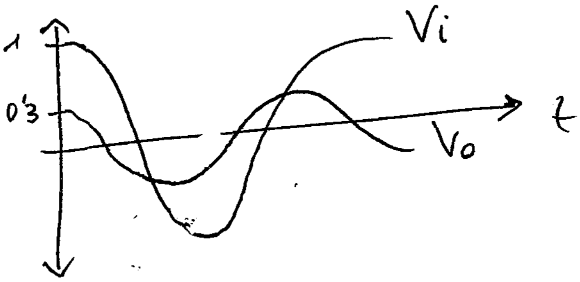
e) $R = 6300\,\Omega \qquad C = 1\,\mu F \qquad T = 20\,ms \qquad A = 1V$

$\omega CR \approx 2 \quad ; \quad \frac{1}{\omega CR} = 0'5$

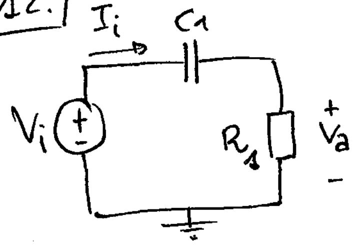
$|A_v| = 0'3 \quad ; \quad \Phi\left(\frac{V_o}{V_i}\right) = -26^\circ$

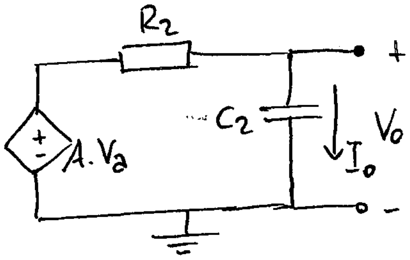
$V_i = 1V.\ \cos(100\pi t)$

$V_o = V_i.\ 0'3.\ e^{-26j} \Rightarrow V_o(t) = 0'3 \cos(100\pi t - 26^\circ)$



12.

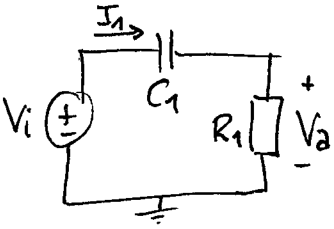


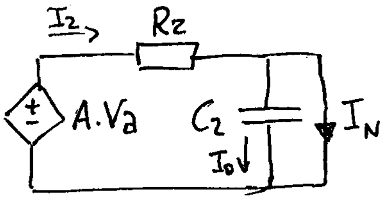


a)

$$I_i = \frac{V_i}{Z_{C_1}+R_1} \qquad I_o = \frac{A.V_a}{R_2+Z_{C_2}} = \frac{A.}{R_2+Z_{C_2}} \cdot \frac{V_i R_1}{Z_{C_1}+R_1}$$

$$V_a = I_i . R_1 = \frac{V_i R_1}{Z_{C_1}+R_1} \qquad V_o = V_{Th} = V_{C_2} = \frac{A V_i R_1 Z_{C_2}}{(R_2+Z_{C_2})(Z_{C_1}+R_1)}$$





$$I_2 = I_N$$

$$V_a = \frac{V_i R_1}{Z_{C_1}+R_1} \qquad I_N = \frac{A V_a}{R_2} = \frac{A}{R_2} \cdot \frac{V_i R_1}{Z_{C_1}+R_1}$$

$$Z_{eq} = \frac{V_{Th}}{I_N} = \frac{\dfrac{A.V_i.R_1.Z_{C_2}}{(R_2+Z_{C_2})(Z_{C_1}+R_1)}}{\dfrac{A.V_i.R_1}{R_2(Z_{C_1}+R_1)}} = \frac{\cancel{A.V_i.R_1}.Z_{C_2}R_2.\cancel{(Z_{C_1}+R_1)}}{(R_2+Z_{C_2}).\cancel{(Z_{C_1}+R_1)}.\cancel{A.V_i.R_1}} = \frac{Z_{C_2}R_2}{Z_{C_2}+R_2}$$

b)

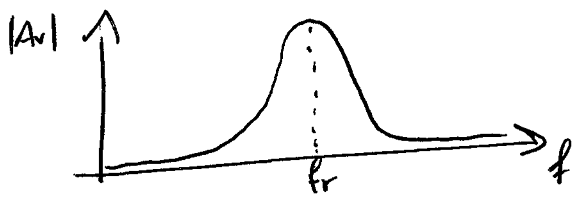
$$A_v = \frac{V_o}{V_i} = \frac{A.R_1.Z_{C_2}}{(R_2+Z_{C_2})(Z_{C_1}+R_1)} = \frac{A.R_1}{R_2+Z_{C_2}} \cdot \frac{Z_{C_2}}{Z_{C_1}+R_1} = \frac{AR_1}{R_1+\frac{1}{j\omega C_1}} \cdot \frac{\frac{1}{j\omega C_2}}{R_2+\frac{1}{j\omega C_2}} =$$

$$= \frac{A.R_1.j\omega.C_1}{1+j\omega C_1 R_1} \cdot \frac{1}{1+j\omega C_2 R_2}$$

c)

$$|A_v| = \frac{AR_1C_1\omega}{\sqrt{1+(\omega C_1R_1)^2}\cdot\sqrt{1+(\omega C_2R_2)^2}} = \frac{A.R_1.C_1.\omega}{\sqrt{1+\omega^2C_1^2R_1^2}\cdot\sqrt{1+\omega^2C_2^2R_2^2}}$$

$$|A_v|_{\omega\to 0} \longrightarrow 0 \qquad |A_v|_{\omega\to\infty} \longrightarrow 0$$



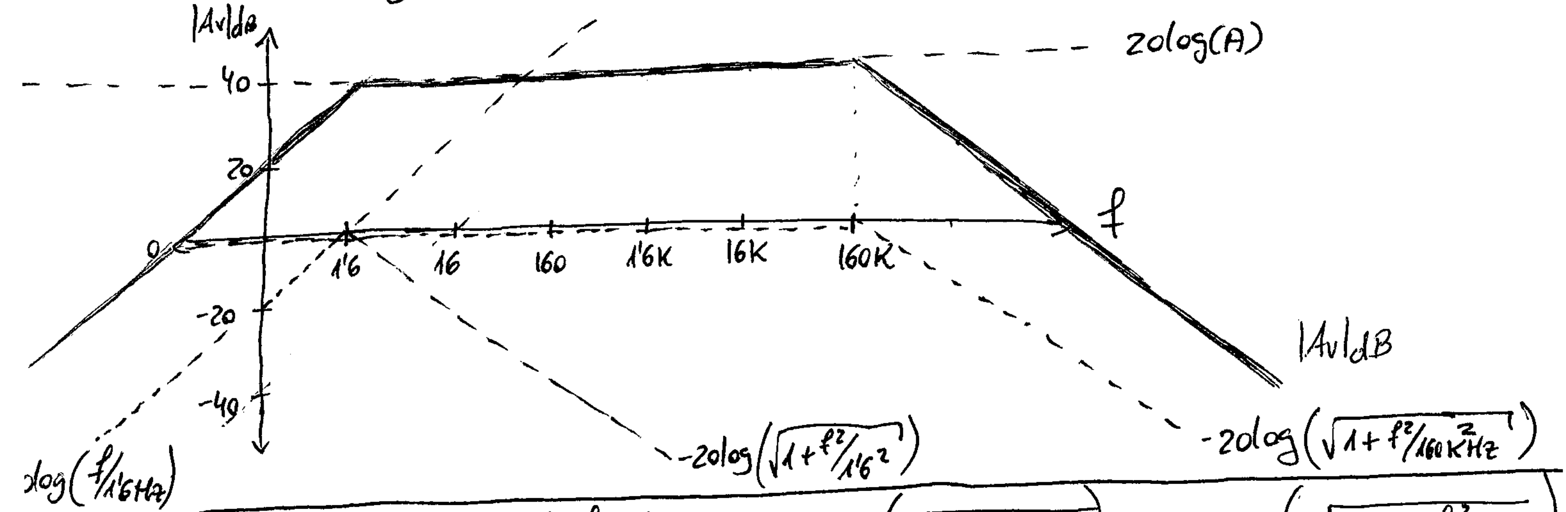
Filtro pasa banda

d) DATOS: $R_1 = 100 K\Omega$, $R_2 = 1000\,\Omega$, $C_1 = 1\mu F$, $C_2 = 1nF$, $A = 100$

Representar gráficamente el módulo y la fase.

$$(C_1R_1)^{-1} = 10\,\text{rad/s} = 2\pi f_1 \longrightarrow f_1 = 1'6\ Hz$$

$$(C_2R_2)^{-1} = 10^6\,\frac{rad}{s} = 2\pi f_2 \longrightarrow f_2 = 160\ KHz$$



$$|A_v|_{dB} = 20\log(A) + 20\log\left(\frac{f}{1'6Hz}\right) - 20\log\left(\sqrt{1+\frac{f^2}{(1'6Hz)^2}}\right) - 20\log\left(\sqrt{1+\frac{f^2}{(160KHz)^2}}\right)$$

$$\varphi_{A_v} = -\operatorname{arctg}\left(\frac{\omega}{(C_1R_1)^{-1}}\right) - \operatorname{arctg}\left(\frac{\omega}{(C_2R_2)^{-1}}\right) = -\operatorname{arctg}\left(\frac{\omega}{1'6Hz}\right) - \operatorname{arctg}\left(\frac{\omega}{160KHz}\right)$$