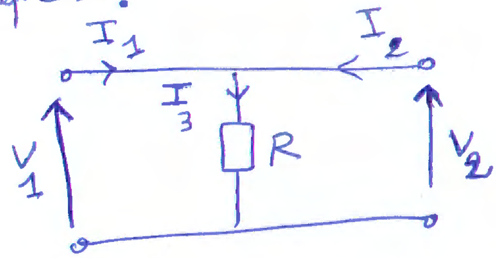
2020/2021

Solution TD N° 2
Electronique fondamentale I

Exercice N° 1 :

* La matrice impédance [Z] du quadripôle Q' :

on a deux équations caractéristiques :



$$\begin{cases} I_1 + I_2 = I_3 = V_1/R & \text{--- (1)} \\ V_1 = V_2 & \text{--- (2)} \end{cases}$$

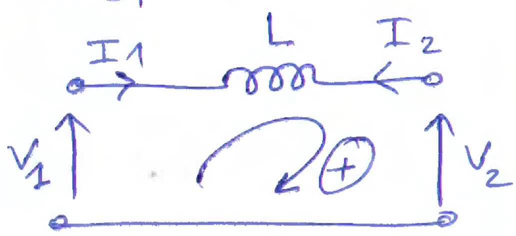
de (1) : $V_1 = R(I_1 + I_2)$

et $V_1 = V_2 = R(I_1 + I_2)$ donc :

$$\begin{cases} V_1 = R I_1 + R I_2 \\ V_2 = R I_1 + R I_2 \end{cases}$$

sous forme matricielle on a : $\begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} R & R \\ R & R \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix}$

* La matrice [Y] du Quadripôle Q'' :



$$\begin{cases} I_1 = -I_2 & \text{--- (1)} \\ V_1 - jL\omega I_1 - V_2 = 0 & \text{--- (2)} \end{cases}$$

de (2) : $I_1 = \dfrac{V_1 - V_2}{jL\omega}$ donc

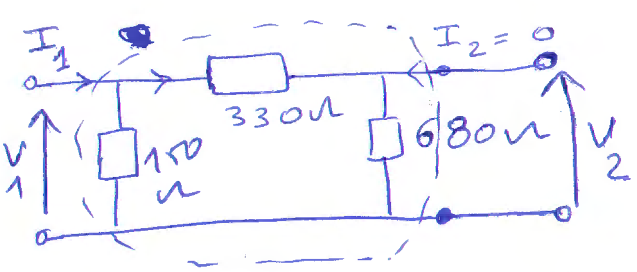
$$\begin{cases} I_1 = \dfrac{1}{jL\omega} V_1 - \dfrac{1}{jL\omega} V_2 \\ I_2 = -\dfrac{1}{jL\omega} V_1 + \dfrac{1}{jL\omega} V_2 \end{cases}$$

sous forme matricielle : $[Y] = \begin{pmatrix} \dfrac{1}{jL\omega} & -\dfrac{1}{jL\omega} \\ -\dfrac{1}{jL\omega} & \dfrac{1}{jL\omega} \end{pmatrix}$

Exercice N° 2 :

1°/ La matrice [Z] :

$Z_{11} = \dfrac{V_1}{I_1}\Big|_{I_2=0}$ et $Z_{21} = \dfrac{V_2}{I_1}\Big|_{I_2=0}$:



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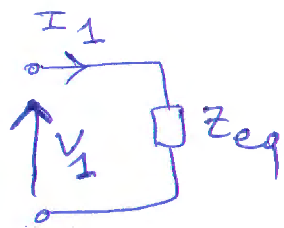


on a : $V_1 = Z_{eq} I_1$ avec : $Z_{eq} = (330 + 680) // 150$

$\Rightarrow Z_{eq} = \dfrac{1010 \cdot 150}{1010 + 150}$

$= 130,6\,\Omega$

donc : $Z_{eq} = \dfrac{V_1}{I_1} = Z_{11} = 130,6\,\Omega$

* $Z_{21} = V_2/I_1 \big|_{I_2=0}$; D'après le diviseur de tension :

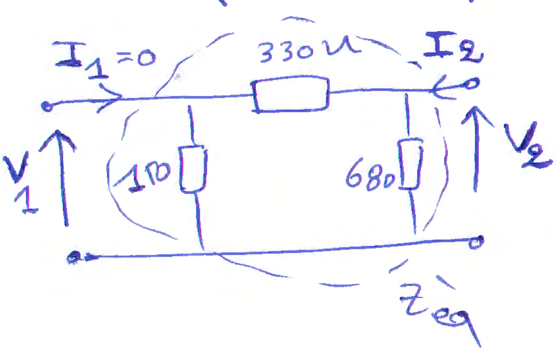
$V_2 = \dfrac{680\ V_1}{680 + 330}$ avec ; $V_1 = Z_{eq} I_1 = Z_{11} I_1$

$\Rightarrow V_2 = \dfrac{680 \cdot Z_{11} I_1}{1010} \Rightarrow \dfrac{V_2}{I_1} = \dfrac{680 \cdot Z_{11}}{1010}$

$\Rightarrow$ $Z_{21} = 87,9\,\Omega$

avec : $Z_{12} = Z_{21} = 87,9\,\Omega$ (propriété de ~~[illegible]~~ réciprocité)

* $Z_{22} = V_2/I_2 \big|_{I_1=0}$



$Z'_{eq} = (150 + 330) // 680$

$= \dfrac{480 \cdot 680}{480 + 680} = 281,37\,\Omega$

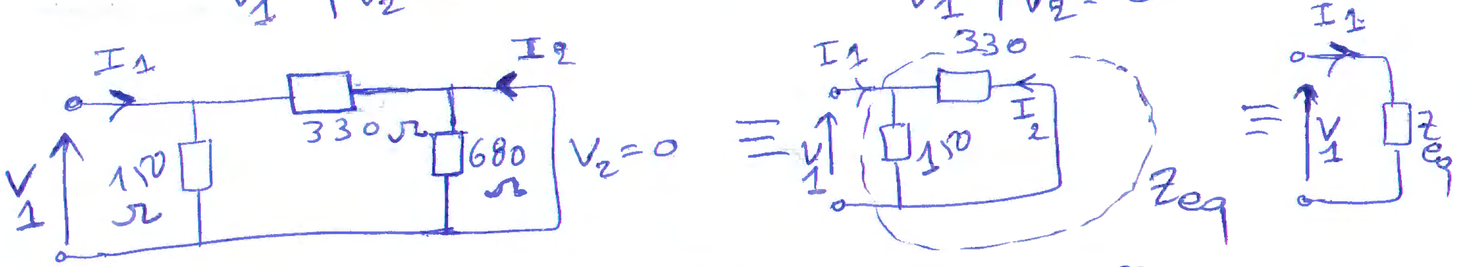
on a : $V_2 = Z'_{eq} I_2 \Rightarrow Z_{22} = V_2/I_2 = 281,37\,\Omega$

$$[Z] = \begin{pmatrix} 130,6 & 87,9 \\ 87,9 & 281,37 \end{pmatrix}$$

2°/ La matrice $[Y]$:

* Méthode 1 :

$$Y_{11} = \frac{I_1}{V_1}\Big|_{V_2=0} \quad ; \quad Y_{21} = \frac{I_2}{V_1}\Big|_{V_2=0}$$



avec : $Z_{eq} = \frac{330 \cdot 150}{330+150} = \frac{330 \cdot 150}{330+150} = 103,12\,\Omega$

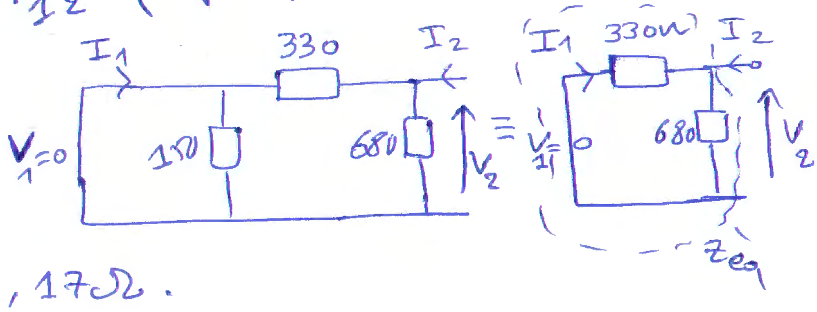
on a : $V_1 = Z_{eq} I_1 \Rightarrow Y_{11} = \frac{I_1}{V_1} = \frac{1}{Z_{eq}} = 9,6 \cdot 10^{-3}$

$Y_{21} = \frac{I_2}{V_1}\Big|_{V_2=0}$; on a : $V_1 = -330\, I_2 \Rightarrow$

$$\frac{I_2}{V_1} = -1/330$$

$\Rightarrow Y_{21} = -3,03 \cdot 10^{-3} = Y_{12}$ (propriété de réciprocité)

* $Y_{22} = \frac{I_2}{V_2}\Big|_{V_1=0}$



$Z'_{eq} = \frac{330 \cdot 680}{330+680} = 222,17\,\Omega$.

$V_2 = Z'_{eq} I_2 \Rightarrow Y_{22} = \frac{I_2}{V_2} = \frac{1}{Z'_{eq}} = \frac{1}{222,17} = 4,5\, 10^{-3}$.

$$[Y] = \begin{pmatrix} 9,69 \cdot 10^{-3} & -3,03 \cdot 10^{-3} \\ -3,03 \cdot 10^{-3} & 4,5\, 10^{-3} \end{pmatrix}$$

* 2ème méthode : on a : $[Y] = [Z]^{-1} = \frac{1}{\det[Z]} \operatorname{adj}[Z]$

$$\operatorname{adj}[Z] = \begin{pmatrix} Z_{22} & -Z_{12} \\ -Z_{21} & Z_{11} \end{pmatrix}$$

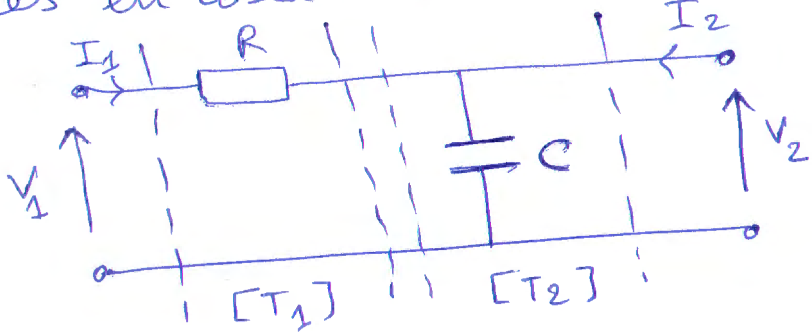
$$[Y] = \frac{1}{130,6 \cdot 281,37 - (87,9)^2} \cdot \begin{pmatrix} 281,37 & -87,9 \\ -87,9 & 130,6 \end{pmatrix}$$

$$= \begin{pmatrix} 9,69\, 10^{-3} & -3,03\, 10^{-3} \\ -3,03\, 10^{-3} & 4,5\, 10^{-3} \end{pmatrix}$$

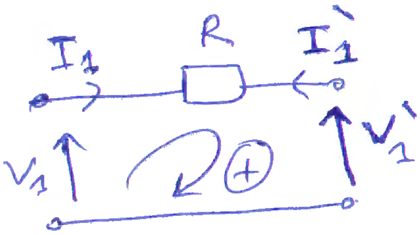
Exercice N° 3 :

1°/ La matrice de transfert [T] :

on décompose le quadripôle en deux quadripôles associés en cascade :



on détermine $[T_1]$ et $[T_2]$:

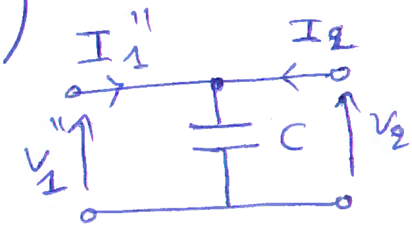


$[T_1]$ $\begin{cases} V_1 - R I_1 - V_1' = 0 \\ I_1 = - I_1' \end{cases}$

$\begin{pmatrix} V_1' \\ I_1' \end{pmatrix} = [T_1] \begin{pmatrix} V_1 \\ -I_1 \end{pmatrix}$ donc : $\begin{cases} V_1' = V_1 - R I_1 . \\ I_1' = 0 V_1 - I_1 . \end{cases}$

donc : $[T_1] = \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix}$

$[T_2]$?



on a : $\begin{cases} V_2 = V_1'' & (1) \\ I_1'' + I_2 = \dfrac{V_1''}{1/jC\omega} & (2) \end{cases}$

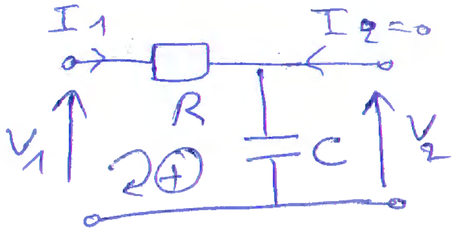
de (2) on a : $I_2 = jC\omega \, V_1'' - I_1''$.

$\Rightarrow [T_2] = \begin{pmatrix} 1 & 0 \\ jC\omega & 1 \end{pmatrix}$

donc : $[T] = [T_2] . [T_1] = \begin{pmatrix} 1 & 0 \\ jC\omega & 1 \end{pmatrix} . \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & R \\ jC\omega & 1+j \end{pmatrix}$

2°/ La matrice [Z] du Q :

$Z_{11} = V_1 / I_1 \Big|_{I_2 = 0}$; $Z_{21} = V_2 / I_1 \Big|_{I_2 = 0}$



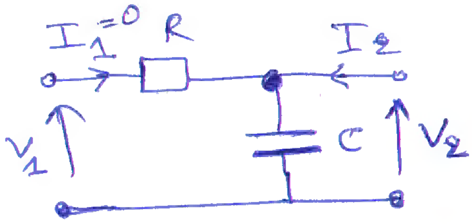
Maille : $V_1 - R I_1 - \frac{1}{jC\omega} I_1 = 0$

$$\Rightarrow V_1 = \left(R + \frac{1}{jC\omega}\right) I_1$$

donc : $Z_{11} = V_1 / I_1 = R + 1/jC\omega$

$Z_{21} = V_2 / I_1$? on a : $V_2 = \frac{1}{jC\omega} I_1 \Rightarrow \frac{V_2}{I_1} = \frac{1}{jC\omega}$

$$Z_{21} = \frac{1}{jC\omega} = Z_{12}$$



* Z_{22} ? $= V_2 / I_2 \big|_{I_1 = 0}$

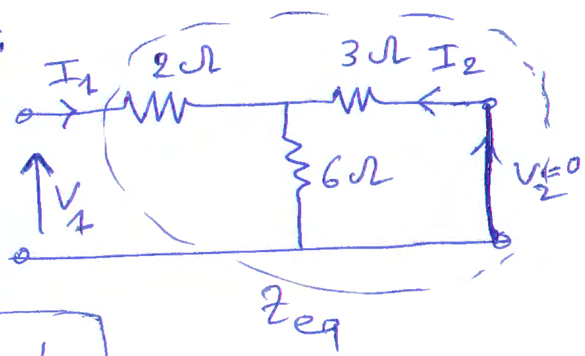
$$V_2 = \frac{1}{jC\omega} I_2$$

$$\Rightarrow \frac{V_2}{I_2} = \frac{1}{jC\omega} = Z_{22}$$

donc : $$[Z] = \begin{pmatrix} R + \frac{1}{jC\omega} & 1/jC\omega \\ 1/jC\omega & 1/jC\omega \end{pmatrix}$$

Exercice N°4 :

La matrice hybride du Q :



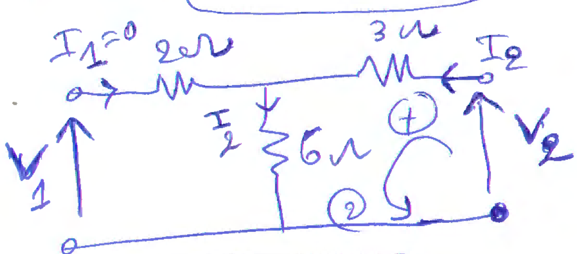
on a : $h_{11} = \frac{V_1}{I_1}\Big|_{V_2 = 0}$; $h_{21} = \frac{I_2}{I_1}\Big|_{V_2 = 0}$

$$Z_{eq} = (3 // 6) + 2 = \frac{3 \cdot 6}{3 + 6} + 2 = 4$$

$$V_1 = Z_{eq} I_1 \Rightarrow V_1 / I_1 = Z_{eq} = \boxed{h_{11} = 4}$$

* h_{21} ? on applique le diviseur de courant :

$$I_2 = \frac{-6 I_1}{6 + 3} = -2/3 \, I_1 \Rightarrow \boxed{h_{21} = -2/3}$$



* $h_{22} = \frac{I_2}{V_2}\Big|_{I_1 = 0}$

Maille 2 : $V_2 - 3 I_2 - 6 I_2 = 0$

$$\Rightarrow V_2 = 9 I_2 \Rightarrow V_2 / I_2 = \boxed{1/9 = h_{22}}$$

Le diviseur de tension :

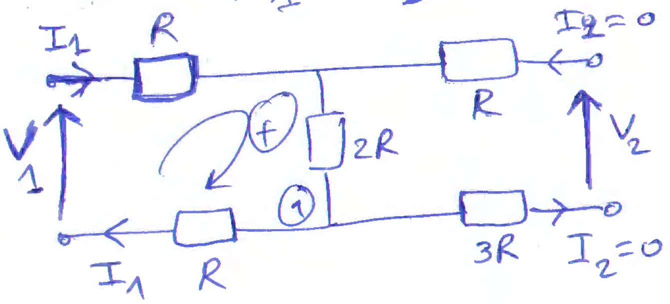
$$V_1 = \frac{6 \cdot V_2}{6+3} = \frac{2}{3} V_2 \Rightarrow h_{12} = \frac{V_1}{V_2} = 2/3 .$$

$$\Rightarrow [h] = \begin{pmatrix} 4 & 2/3 \\ -2/3 & 1/9 \end{pmatrix} .$$

Exercice N° 5 :

* $[Z]$ du quadripôle Q_1 :

$$Z_{11} = V_1/I_1 \Big|_{I_2=0} \quad ; \quad Z_{21} = \frac{V_2}{I_1} \Big|_{I_2=0}$$



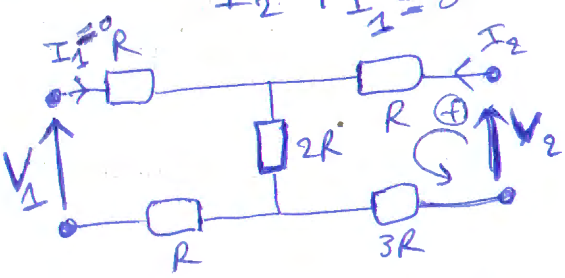
Maille (1) : $V_1 - RI_1 - 2RI_1 - RI_1 = 0$

$$\Rightarrow V_1 = 4RI_1$$

$$\Rightarrow Z_{11} = \frac{V_1}{I_1} = 4R .$$

* Z_{21} ? on a : $V_2 = 2RI_1 \Rightarrow \frac{V_2}{I_1} = 2R = Z_{21}$.

* $Z_{22} = V_2/I_2 \Big|_{I_1=0}$



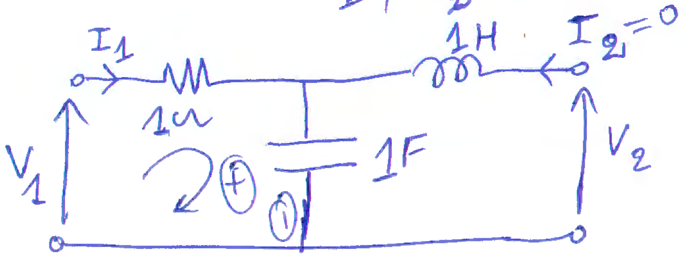
Maille 2 : $V_2 - RI_2 - 2RI_2 - 3RI_2 = 0$

$$\Rightarrow V_2 = 6RI_2 \Rightarrow \boxed{Z_{22} = 6R}$$

donc : $[Z] = \begin{pmatrix} 4R & 2R \\ 2R & 6R \end{pmatrix}$

* $[Z]$ du Q_2 :

$$Z_{11} = V_1/I_1 \Big|_{I_2=0} \quad ; \quad Z_{21} = V_2/I_1 \Big|_{I_2=0}$$



Maille 1 : $V_1 - I_1 - \frac{1}{j\omega} I_1 = 0$

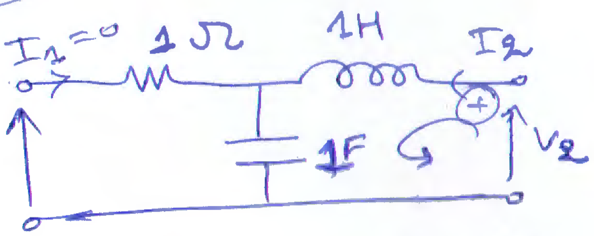
$$\Rightarrow V_1 = \left(1 + \frac{1}{j\omega}\right) I_1$$

$$Z_{11} = \frac{V_1}{I_1} = 1 + \frac{1}{j\omega} .$$

* Z_{21} ? on a : $V_2 = \frac{1}{j\omega} I_1 \Rightarrow \boxed{Z_{21} = \frac{1}{j\omega}}$

$$\boxed{Z_{12} = \frac{1}{j\omega}}$$

$$Z_{22} = \frac{V_2}{I_2} \Big|_{I_1 = 0}$$



$$\sum V_i = 0 \Rightarrow V_2 - j\omega I_2 - \frac{1}{j\omega} I_2 = 0$$

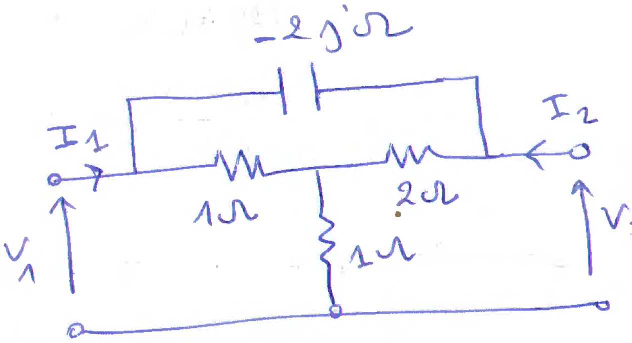
$$\Rightarrow V_2 = \left(j\omega + \frac{1}{j\omega}\right) I_2 = j\left(\omega - \frac{1}{\omega}\right) = j\left(\frac{\omega^2 - 1}{\omega}\right) I_2$$

donc : $\boxed{Z_{22} = j\left(\frac{\omega^2 - 1}{\omega}\right)}$

$$[Z] = \begin{pmatrix} 1 + 1/j\omega & 1/j\omega \\ \frac{1}{j\omega} & j\left(\frac{\omega^2 - 1}{\omega}\right) \end{pmatrix}$$

Exercice N°6 :

* La matrice [Y] du quadripôle en T-ponté :



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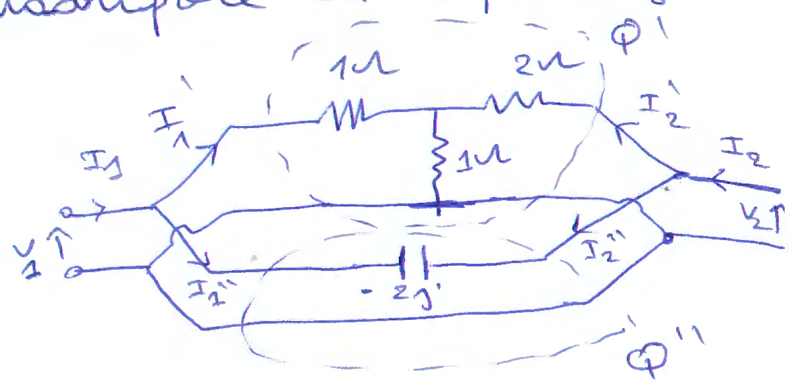
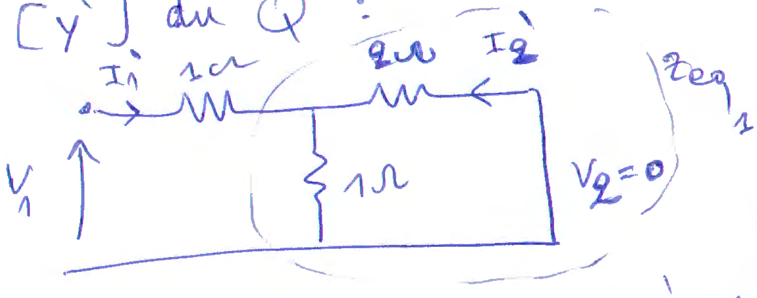


Le quadripôle Q' et Q'' sont en // :

donc : $[Y] = [Y'] + [Y'']$.

$[Y']$ du Q' :



$$Y'_{11} = \frac{I_1'}{V_1} \Big|_{V_2 = 0}$$

on a : $Z_{eq_1} = 2 // 1 = \frac{2.1}{2+1}$

$= 2/3\,\Omega$

$\Rightarrow Z_{eq} = Z_{eq_1} + 1 = 5/3$.

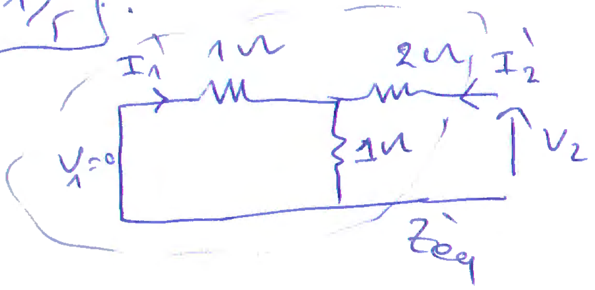
$$V_1 = Z_{eq} I_1' \Rightarrow \frac{I_1'}{V_1} = 1/Z_{eq} = 3/5 .$$

$Y'_{21} = \frac{I'_2}{V_1}\Big|_{V_2=0}$ le diviseur de courant :

on a : $I'_2 = \frac{-1 \cdot I'_1}{1+2}$ et $I'_1 = Y'_{11} V_1$.

donc : $I'_2 = -\frac{3/5\, V_1}{3} \Rightarrow \frac{I'_2}{V_1} = -1/5 = Y'_{21}$

$$\boxed{Y'_{21} = Y'_{12} = -1/5}$$



* $Y'_{22} = \frac{I'_2}{V_2}\Big|_{V_1=0}$

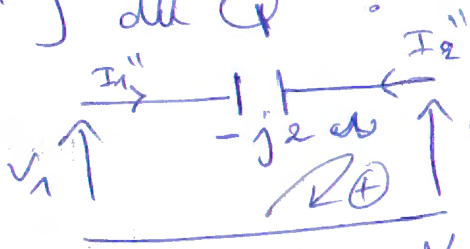
$Z'_{eq} = 1 \,//\, 1\Omega + 2$

$= \frac{1 \cdot 1}{1+1} + 2 = \frac{1}{2} + 2 = \frac{5}{2}$

$V_2 = Z'_{eq} I'_2 \Rightarrow \frac{I'_2}{V_2} = 1/Z'_{eq} = 2/5$.

donc : $[Y'] = \begin{pmatrix} 3/5 & -1/5 \\ -1/5 & 2/5 \end{pmatrix}$

* $[Y'']$ du Q'' :



$$\begin{cases} V_1 + j2\, I''_1 - V_2 = 0 \\ I''_2 = -I''_1 \end{cases}$$

$$\Rightarrow \begin{cases} I''_1 = \frac{V_2 - V_1}{2j} \\ I''_2 = -I''_1 = \frac{V_1 - V_2}{2j} \end{cases} \Rightarrow \begin{cases} I''_1 = \frac{-1}{2j} V_1 + \frac{1}{2j} V_2 \\ I''_2 = \frac{1}{2j} V_1 - \frac{1}{2j} V_2 \end{cases}$$

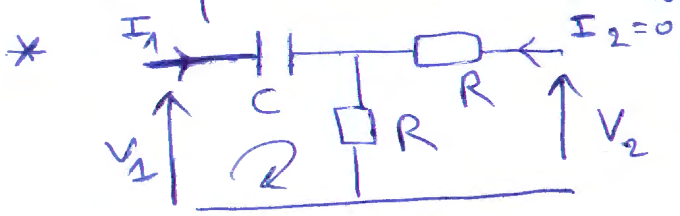
ou : $\begin{cases} I''_1 = j/2\, V_1 - 1/2\, j\, V_2 \\ I''_2 = -j/2\, V_1 + \frac{1}{2} j\, V_2 . \end{cases} \Rightarrow [Y''] = \begin{pmatrix} \frac{1}{2} j & -\frac{1}{2} j \\ -\frac{1}{2} j & \frac{1}{2} j \end{pmatrix}$

$[Y] = [Y'] + [Y''] \Rightarrow [Y] = \begin{pmatrix} \frac{3}{5} + \frac{1}{2} j & -\frac{1}{5} + j\frac{1}{2} \\ -\frac{1}{5} + j\frac{1}{2} & \frac{2}{5} + j\frac{1}{2} \end{pmatrix}$

Exercice N° 7 :

1°/ L'impédance d'entrée : $Z_e = \frac{V_1}{I_1} = Z_{11} - \frac{Z_{12} \cdot Z_{21}}{Z_{11} + Z_{22}}$

on doit calculer la matrice [Z] pour trouver l'impédance d'entrée du quadripôle :

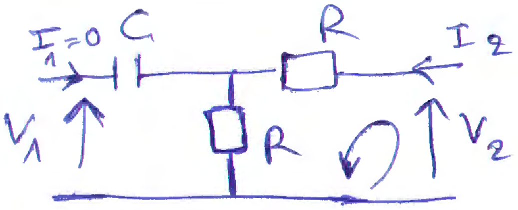
* 

$$\begin{cases} Z_{11} = V_1/I_1 \big|_{I_2 = 0} \\ Z_{21} = V_2/I_1 \big|_{I_2=0} \end{cases}$$

on a : $V_1 - \left(R + 1/jC\omega\right) I_1 = 0$

$\Rightarrow V_1/I_1 = R + 1/jC\omega \Rightarrow \boxed{Z_{11} = R + \frac{1}{jC\omega}}$

et : $V_2 = R I_1 \Rightarrow V_2/I_1 = R \Rightarrow \boxed{Z_{21} = Z_{12} = R}$

* 

$\Sigma V_i = 0 \Rightarrow V_2 - R I_2 - R I_2 = 0$

$\Rightarrow \frac{V_2}{I_2} = 2R \Rightarrow \boxed{Z_{22} = 2R}$

donc : $Z_e = R + \frac{1}{jC\omega} - \frac{R \cdot R}{R + 2R} = \frac{1 + jRC\omega}{jC\omega} - \frac{R^2}{3R}$

$$\boxed{Z_e = \frac{3 + j2RC\omega}{j3C\omega}}$$

2°/ L'impédance de sortie :

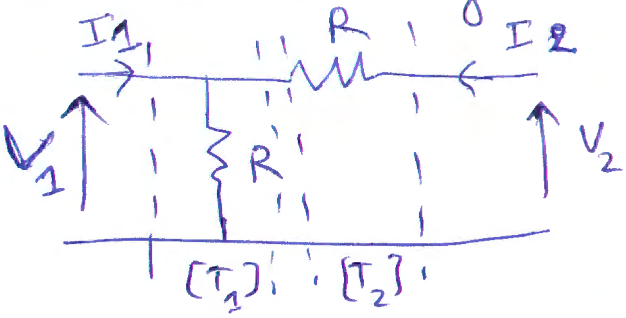
$Z_s = Z_{22} - \frac{Z_{12} \cdot Z_{21}}{Z_g + Z_{11}}$. $\boxed{Z_g = r}$

$Z_s = 2R - \frac{R \cdot R}{r + \frac{1 + jRC\omega}{jC\omega}} = 2R - \frac{R^2}{\frac{1 + j(R+r)C\omega}{jC\omega}}$

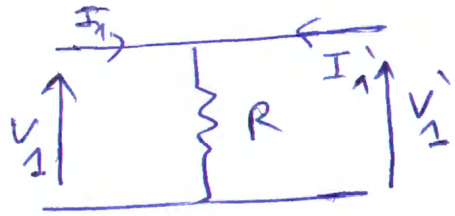
$$\boxed{Z_s = \frac{2R + j(R^2 + 2Rr)C\omega}{1 + j(R+r)C\omega}}$$

Exercice N° 8 :

Pour calculer le gain en tension et le gain en courant il faut calculer la matrice de transfert du quadripôle Q :



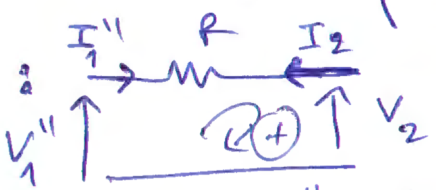
[T1] :



$$\begin{cases} I_1 + I_1' = V_1/R \\ V_1' = V_1 \end{cases} \Rightarrow \begin{cases} I_1' = \frac{1}{R}V_1 - I_1 \\ V_1' = V_1 \end{cases} \Rightarrow \begin{cases} V_1' = V_1 \\ I_1' = \frac{1}{R}V_1 - I_1 \end{cases}$$

$$\Rightarrow [T_1] = \begin{pmatrix} 1 & 0 \\ 1/R & 1 \end{pmatrix}$$

[T2] :



$$\begin{cases} V_1'' - R I_1'' - V_2 = 0 . \\ I_2 = -I_1'' . \end{cases}$$

$$\Rightarrow \begin{cases} V_2 = V_1'' - R I_1'' \\ I_2 = -I_1'' \end{cases} \Rightarrow [T_2] = \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix}$$

$$[T] = [T_2]\cdot[T_1] = \begin{pmatrix} 2 & R \\ 1/R & 1 \end{pmatrix}$$

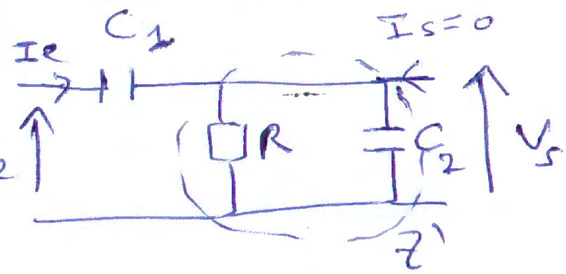
* Le gain en tension :

$$G_V = \frac{V_2}{V_1} = \frac{Z_u}{T_{22} Z_u + T_{12}} = \frac{R}{1 \cdot R + R} = 1/2 .$$

* Le gain en courant :

$$G_I = \frac{I_2}{I_1} = \frac{-1}{T_{11} + T_{21} Z_u} = \frac{-1}{2 + 1/R \cdot R} = -\frac{1}{3} .$$

Exercice N°9 :



* La fonction de transfert :

$$H(j\omega) = V_s / V_e = \frac{Z'}{Z' + 1/jC\omega}$$

avec : $Z' = \dfrac{R \cdot 1/jC_2\omega}{R + \dfrac{1}{jC_2\omega}} = \dfrac{R}{1 + jRC_2\omega}$.

donc : $H(j\omega) = \dfrac{R}{1 + jRC_2\omega} \times \dfrac{1}{1/jC_1\omega + \dfrac{R}{1 + jRC_2\omega}}$

$$= \frac{R}{\cancel{1 + jRC_2\omega}} \times \frac{1}{\dfrac{1 + jRC_2\omega + jRC_1\omega}{jC_1\omega(\cancel{1 + jRC_2\omega})}}$$

$$= \frac{jRC_1\omega}{1 + jR(C_1 + C_2)\omega}$$

$$\boxed{H(j\omega) = \frac{j\,\omega/\omega_1}{1 + j\,\omega/\omega_2}}$$

avec : $\omega_1 = \dfrac{1}{RC_1} = 1000 \text{ rd/s} = 10^3 \text{ rd/s}$.

$\omega_2 = \dfrac{1}{R(C_1 + C_2)} = 100 \text{ rd/s}$.

* Le gain en dB :

$$G_{dB} = 20 \log_{10} |H(j\omega)| = 20 \log \frac{\omega}{\omega_1} - 20 \log \sqrt{1 + \left(\frac{\omega}{\omega_2}\right)^2}.$$

$$= G_1 + G_2.$$

* La phase : $\phi = \pi/2 - \operatorname{arctg} \omega/\omega_2 = \phi_1 + \phi_2$.

* L'étude de ϕ_1, G_1 :

$$\begin{cases} G_1 = 20 \log \omega/\omega_1 \rightarrow \text{c'est une droite de pente } 20\text{dB/déc.} \\ \phi_1 = \pi/2 \text{ rd} \rightarrow \text{droite horizontale.} \end{cases}$$

* L'étude de G_2, ϕ_2 :

Les asymptotes :

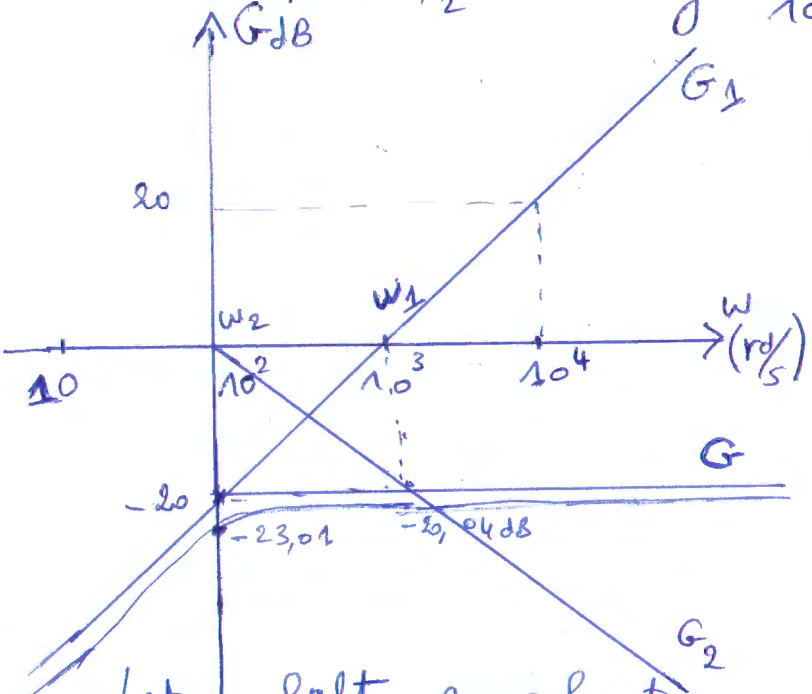
$\omega \ll \omega_2$ $\begin{cases} G_2 = 0\,dB \\ \phi_2 = 0\,rd \end{cases}$

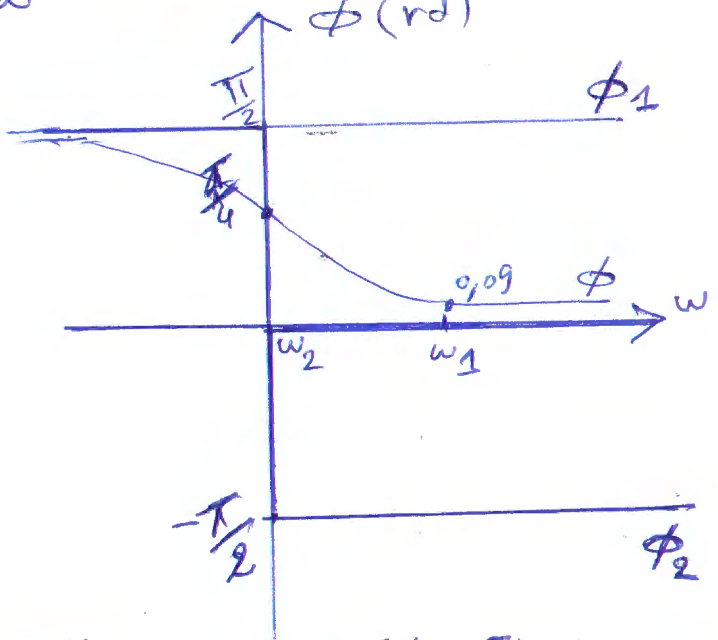
$\omega \gg \omega_2$ $\begin{cases} G_2 = -20 \log \frac{\omega}{\omega_2} \rightarrow \text{droite de pente } -20\,dB/\text{décad} \\ \phi_2 = -\pi/2\ rd \end{cases}$

Pour : $\omega = \omega_1 \Rightarrow G = 20 \log \frac{1000}{1000} - 20 \log \sqrt{1 + \left(\frac{1000}{100}\right)^2}$

$= -20{,}04\ dB$

$\phi = \pi/2 - \text{arctg}\,\frac{1000}{100} = 0{,}09\,rd.$

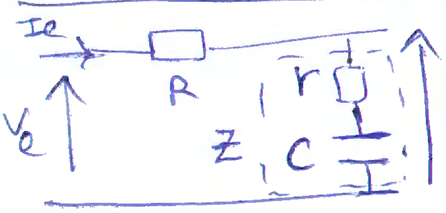




c'est un filtre passe haut.

pour $\omega = \omega_2$: $\begin{cases} \phi = \pi/4\ rd\,. \\ G = -23{,}01\ dB. \end{cases}$

Exercice N°10 : c'est un filtre à avance de phase ; $H(j\omega) = \frac{V_s}{V_e} = \frac{r + \frac{1}{jC\omega}}{R + r + \frac{1}{jC\omega}} = \frac{Z}{Z+R}$



$= \frac{1 + jrC\omega}{1 + j(R+r)C\omega}$

donc : $H(j\omega) = \frac{1 + j\omega/\omega_1}{1 + j\omega/\omega_2}$

avec : $\omega_1 = 1/rC = 10^4\,rd/s$; $\omega_2 = \frac{1}{(R+r)C} = 10^3\,rd/s$.

Le gain en dB :

$G_{dB} = 20 \log_{10} |H(j\omega)| = 20 \log_{10} \sqrt{1 + \left(\frac{\omega}{\omega_1}\right)^2} - 20 \log \sqrt{1 + \left(\frac{\omega}{\omega_2}\right)^2}$

$= G_1 + G_2$

* La phase : $\phi = \arctan\frac{\omega}{\omega_1} - \arctan\frac{\omega}{\omega_2} = \phi_1 + \phi_2$.

Les asymptotes :

G_1, ϕ_1 : $\omega \ll \omega_1$ $\begin{cases} G_1 = 0 \text{ dB} \\ \phi_1 = 0 \text{ rd.} \end{cases}$

$\omega \gg \omega_1$ $\begin{cases} G_1 = 20 \log\frac{\omega}{\omega_1} \rightarrow \text{droite de pente } 20 \text{ dB/décade.} \\ \phi_1 = \pi/2 \text{ rd} \end{cases}$

G_2, ϕ_2 : $\omega \ll \omega_2$ $\begin{cases} G_2 = 0 \text{ dB.} \\ \phi_2 = 0 \text{ rd.} \end{cases}$

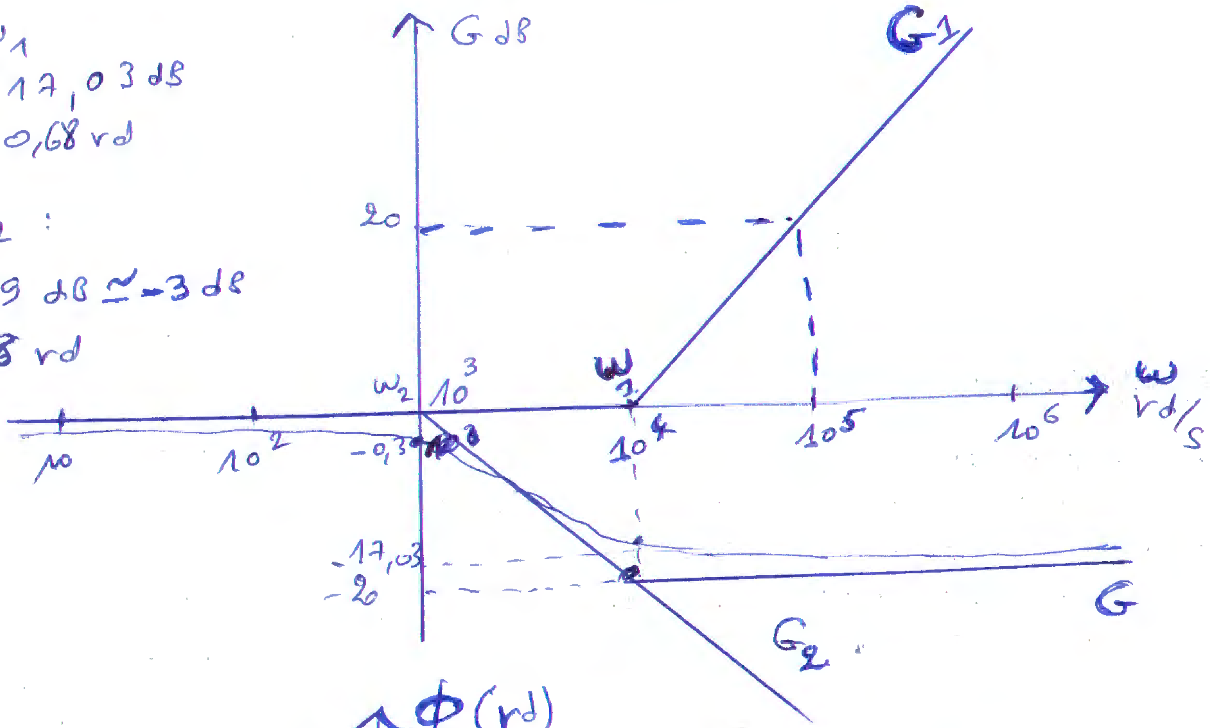
$\omega \gg \omega_2$: $\begin{cases} G_2 = -20 \log\frac{\omega}{\omega_2} \longrightarrow \text{droite de pente } -20 \text{ dB/décade.} \\ \phi_2 = -\pi/2 \text{ rd} \end{cases}$

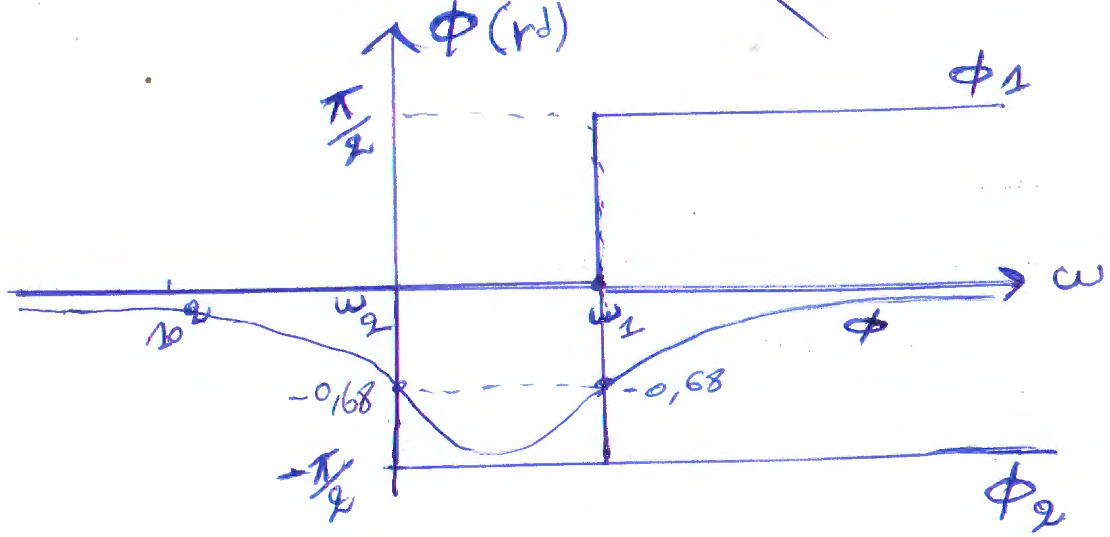
pour $\omega = \omega_1$

$\begin{cases} G = -17{,}03 \text{ dB} \\ \phi = -0{,}68 \text{ rd} \end{cases}$

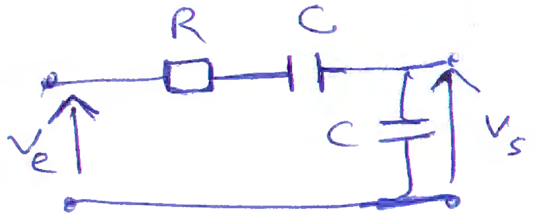
pour $\omega = \omega_2$:

$\begin{cases} G = -2{,}99 \text{ dB} \simeq -3 \text{ dB} \\ \phi = -0{,}68 \text{ rd} \end{cases}$





Exercice N° 11 :



on utilise le diviseur de tension pour calculer la fonction de transfert :

$$H(j\omega) = \frac{V_s}{V_e} = \frac{1/jC\omega}{R + 1/jC\omega + 1/jC\omega} = \frac{1}{jC\omega} \times \frac{jC\omega}{2 + jRC\omega}$$

$$= \frac{1}{2 + jRC\omega} = \frac{1}{2} \cdot \frac{1}{1 + j\frac{RC\omega}{2}} = K \frac{1}{1 + j\frac{\omega}{\omega_0}}$$

avec : $K = 1/2$; $\omega_0 = 2/RC$ rd/s $= 10$ rd/s.

* Le gain en dB :

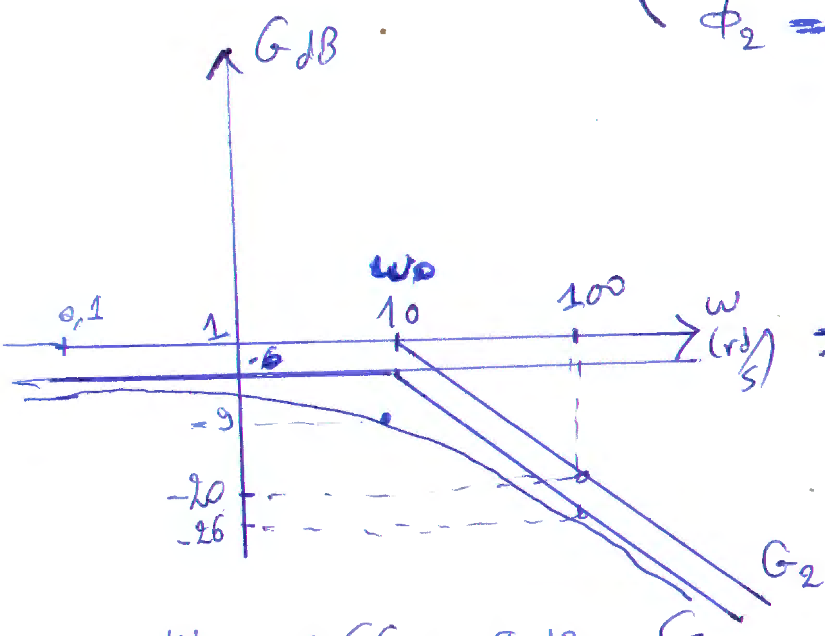
$$G_{dB} = 20 \log_{10} K - 20 \log_{10} \sqrt{1 + \left(\frac{\omega}{\omega_0}\right)^2} = G_1 + G_2$$

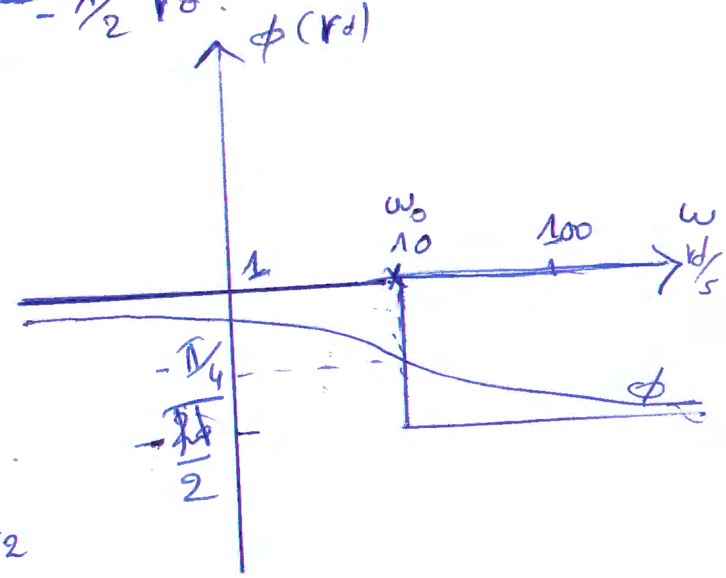
* La phase : $\phi = 0 - \operatorname{arctg} \frac{\omega}{\omega_0} = \phi_1 + \phi_2$

Les asymptotes :

G_2, ϕ_2 : $\omega \ll \omega_0$ $\begin{cases} G_2 = 0 \text{ dB} \\ \phi_2 = 0 \text{ rd} \end{cases}$

$\omega \gg \omega_0$: $\begin{cases} G_2 = -20 \log \frac{\omega}{\omega_0} \rightarrow \text{droite de pente } -20 \text{ dB/décade} \\ \phi_2 = -\pi/2 \text{ rd} \end{cases}$





$\omega = \omega_0$ $\begin{cases} G = -9 \text{ dB} \\ \phi = -\pi/4 \end{cases}$