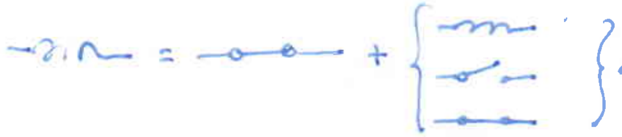
Transmission du signal.

Théorie de l'E (noeud, maille, thevenin, norton, millman)

RLC C°, sinus, diode ampli op, transistors, ampli de puissance, alimentat°, ampli audio

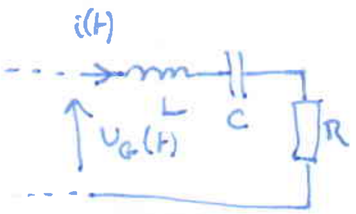
$X(t) = \langle X(t) \rangle + x(t)$ $\quad \omega = 2\pi f$. $\quad$ Impédance $= \frac{1}{C\omega}$

dépends de $\omega \Rightarrow \frac{1}{c\omega}$



dépends de $\omega \Rightarrow L\omega$

Application 1 : RLC série



$|Z| = \frac{|U|}{|i|}(\omega)$?

facteur de qualité.

$Q = Q_s \times Q_p$

$$Z = jL\omega + \frac{1}{jC\omega} + R$$

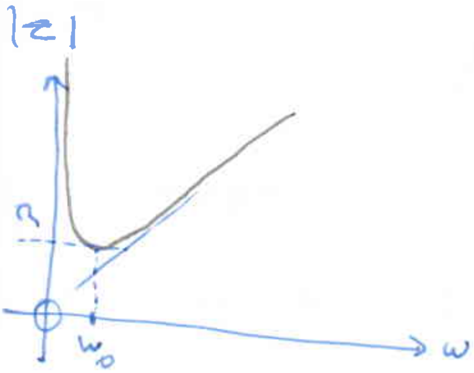
$$Z = R + jL\omega - j\frac{1}{c\omega}$$

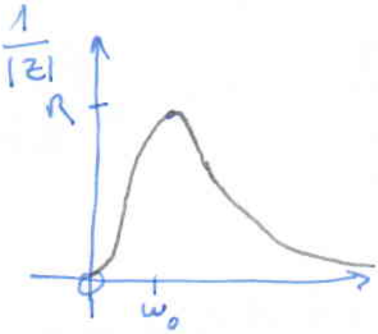
$$Z = R\left(1 + j\frac{L\omega\,\omega_0}{R\,\omega_0} - j\frac{1\,\omega_0}{RC\omega\,\omega_0}\right)$$

$$Q_s = \frac{L\omega_0}{R} = \frac{1}{RC\omega_0} \quad \text{(sans unité)}$$

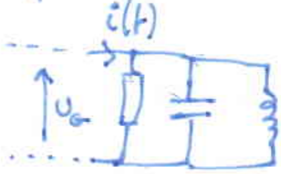
$$Z = R\left(1 + jQ_s\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)\right)$$

$$|Z| = R\sqrt{1 + Q_s^2\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)^2}$$





Application 2 : RLC parallèle



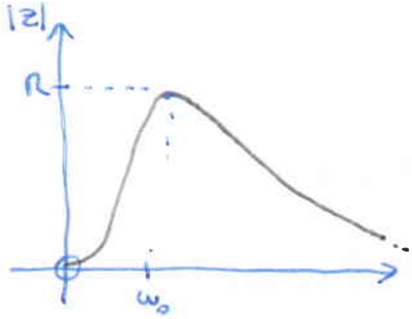
$$Y = \frac{1}{R} + jC\omega + \frac{1}{jL\omega} = \frac{1}{R}\left(1 + jRC\omega\frac{\omega_0}{\omega_0} - j\frac{R}{L\omega}\frac{\omega_0}{\omega_0}\right)$$

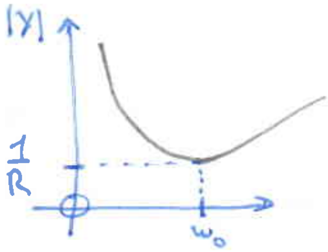
$$Q_p = RC\omega_0 = \frac{R}{L\omega_0}$$

$$Y = \frac{1}{R}\left(1 + jQ_p\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)\right)$$

$$|Y| = \frac{1}{R}\sqrt{1 + Q_p^2\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)^2}$$

$$|Z| = \frac{R}{\sqrt{1 + Q_p^2\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)^2}}$$





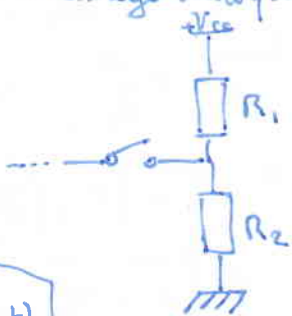
Rappel 2 : rôle des condensateurs

Condensateur de couplage

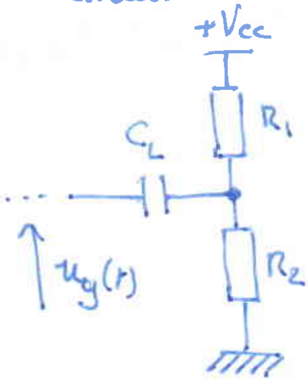
$$u_g(t) = \underset{\text{Static}}{E_S} + \underset{\text{dyn}}{E_D\cos(\omega t)}$$

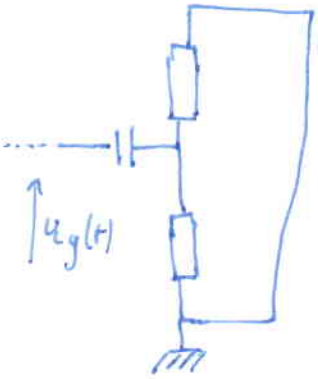
Montage dynamique.

Montage statique



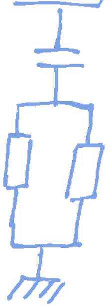
Circuit





$\equiv$

$u_g(t) = E_D \sin(\omega t)$



$$\boxed{\langle u(t)\rangle = U_0 = V_{cc}\frac{R_2}{R_1+R_2}}$$

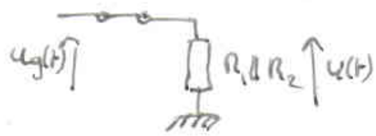
$$\underline{u} = \underline{u_g}\left(\frac{R_1 \parallel R_2}{R_1 \parallel R_2 + \frac{1}{jC\omega_0}}\right)$$

$\frac{1}{jC\omega_0}$ négligeable

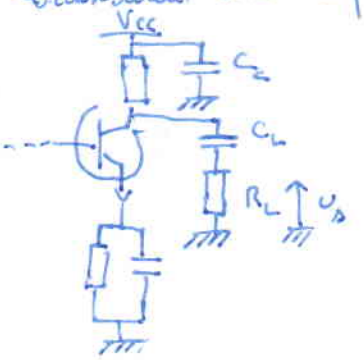
$\Downarrow$

$\underline{u} \sim \underline{u_g}$

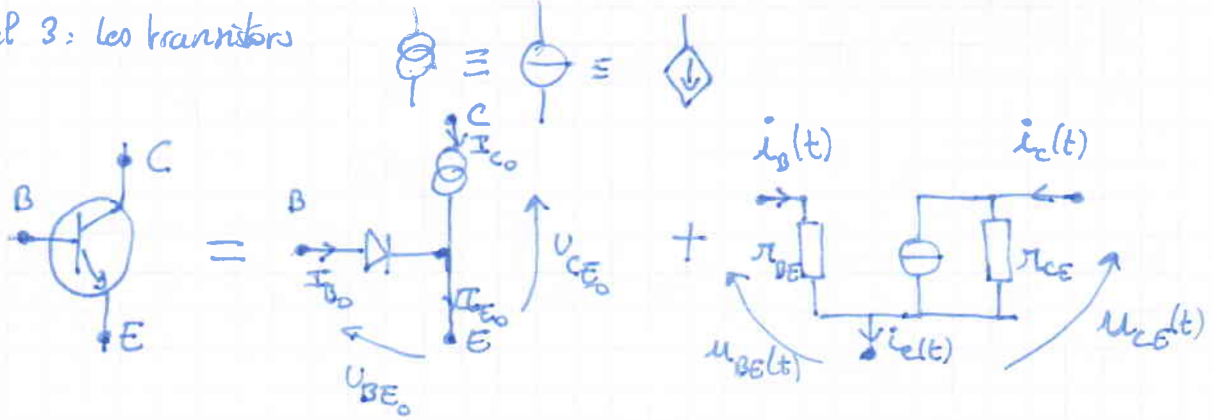
$\Updownarrow$



Condensateur de découplage : supprime le rôle des résistances ou de l'alim en dynamique en les ramenant à la masse.

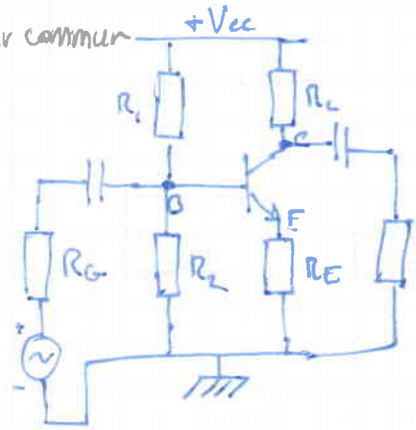


Rappel 3 : les transistors

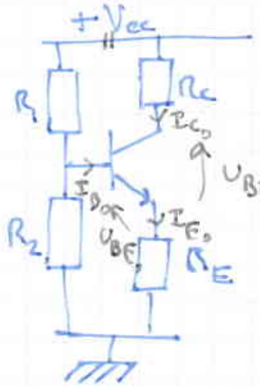


$$X(t) = \langle X(t) \rangle + x(t)$$

Emetteur commun

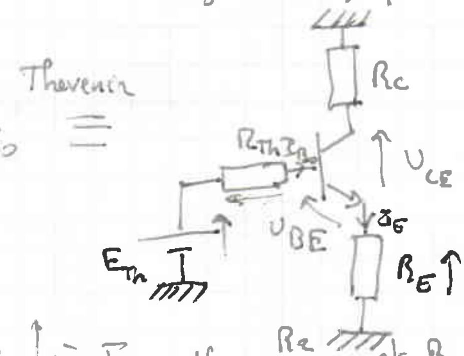


1) Schéma statique



2) Point de polarisation

$U_{BE_0} = 0,68\,V$; $\beta = 100$

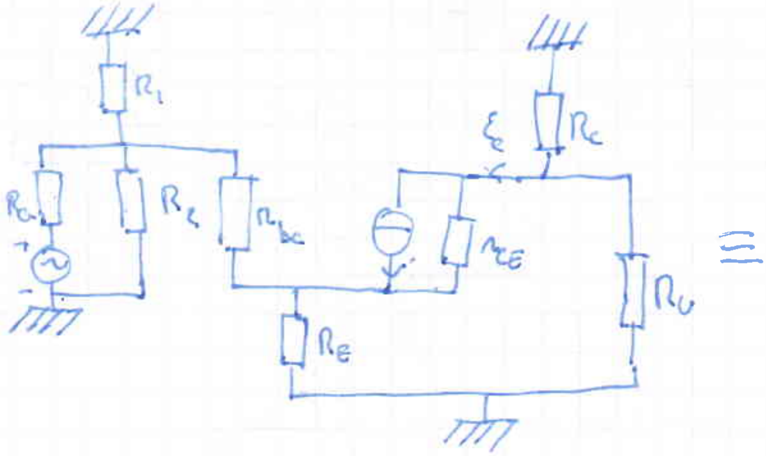


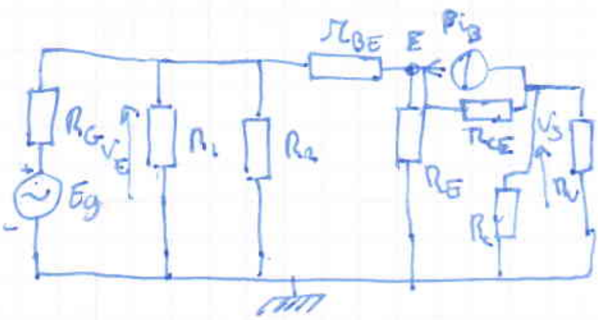
$I_{C_0} = \beta I_{B_0}$ et $I_{E_0} = I_{C_0} + I_{B_0} = (\beta+1) I_{B_0} \approx \beta I_{B_0}$ | où $E_{Th} = V_{cc} \frac{R_2}{R_2+R_1}$ et $R_{Th} = R_1 \| R_2$

$$\begin{cases} 0 = I_E R_E + U_{BE} + R_{Th} I_B - E_{Th} \\ 0 = R_E I_C + U_{CE} + R_C I_C - V_{cc} \end{cases} \Leftrightarrow \begin{cases} I_{B_0} = \dfrac{E_{Th} - V_{BE_0}}{R_{Th} + \beta R_E} \\ I_{C_0} = \beta I_{B_0} = 6,9\,mA \end{cases}$$

$U_{CE_0} \sim 6,35\,V$

3) Schéma dynamique





$V_E = R_E (i_b + i_c) + r_{BE}\, i_b$

$V_s = (R_U \| R_C)\, i_c$

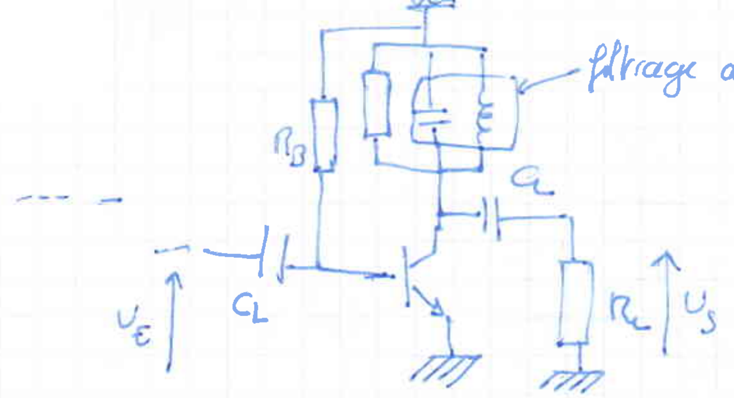
$$\frac{V_s}{V_e} = \frac{-(R_U \| R_C)\beta}{R_E(\beta+1) + r_{BE}}$$

Impédance d'entrée : $\frac{V_e}{I_e} = (R_1 \| R_2) \| (r_{BE} + (\beta+1) R_E) = Z_{entrée}$

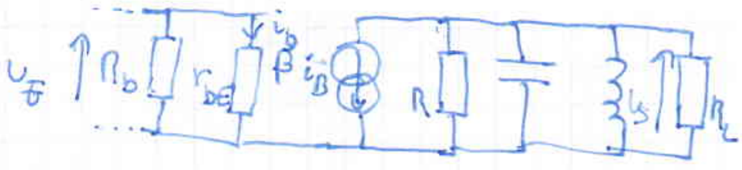
" de sortie : $\left.\frac{V_s}{i_s}\right|_{e_g = 0}$

Meilleur ampli idéal :
- $Z_{entrée}$: forte => i_e petit
- Z_{sortie} : petit

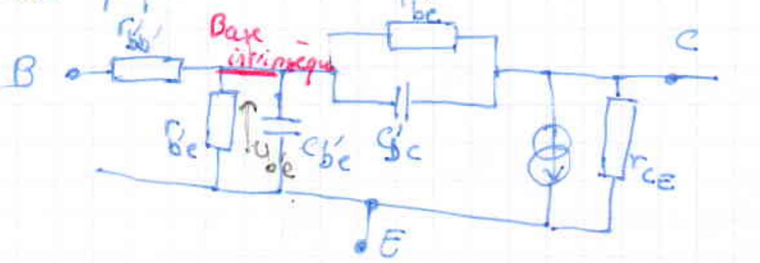
$A_{V_0} \to +\infty$



filtrage donc ne pas remplacer ni par un circuit ouvert ni par un fil

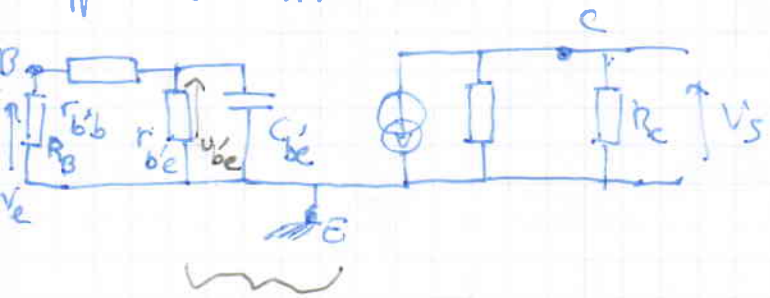


Haut fréquence : Exam :



$r_{b'b}$ négligée en BF, mais non negligeable en HF

Approximation HF :

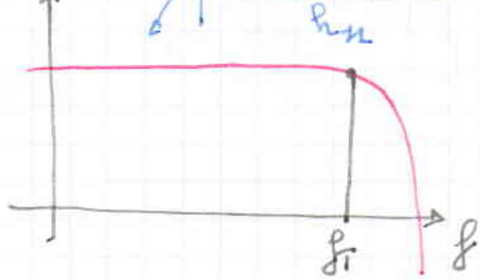


$$\frac{r_{b'b}}{1+jr_{b'e}C_{b'e}\omega}$$ on a $$U_{b'e} = U_e \cdot \frac{\dfrac{r_{b'b}}{1+jr_{b'e}C_{b'e}\omega}}{\dfrac{r_{b'b}}{1+jr_{b'e}C_{b'e}\omega} + r_{bb'}}$$

$$V_{s_0} = -(r_{CE} // R_c)\, g_m\, U_{b'e}$$

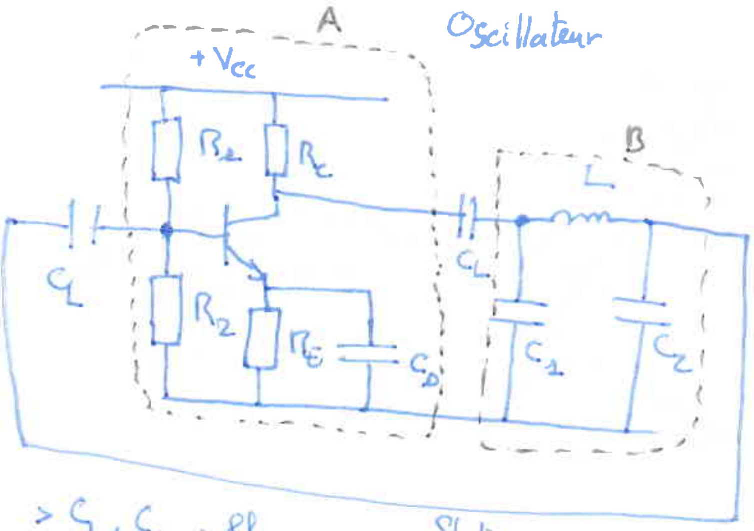
⇒ Filtre passe-bas 1er ordre

$$\left| \frac{-\beta (R_c // r_{CE})}{h_{11}} \right.$$



$$f_T = \frac{1}{2\pi (r_{b'e} // r_{b'b})\, C_{b'e}}$$

Oscillateur

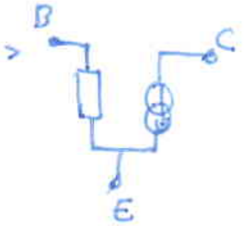


1) Calculer la fréquence des oscillations

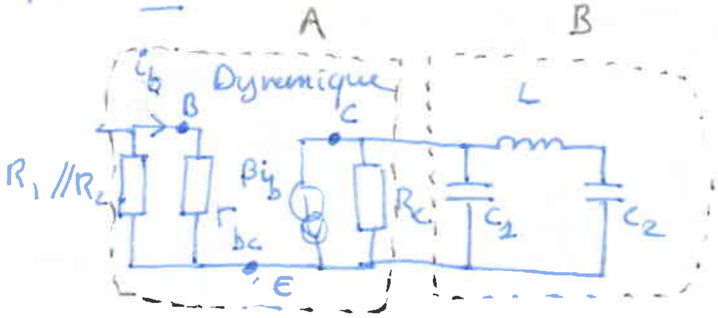
2) Calculer le gain de l'amplificateur A

> C_1, C_D ⇒ fils.

Statique

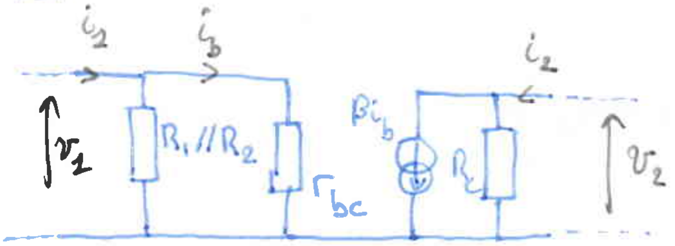


≡



⇒ Ce sont des quadripoles.

A:



Paramètre (y) du Q.

$$\begin{cases} i_1 = y_{11} v_1 + y_{12} v_2 \\ i_2 = y_{21} v_1 + y_{22} v_2 \end{cases}$$

on a : $i_1 = \dfrac{v_1}{(R_1//R_2)//r_{be}} = y_{11} v_1 + y_{12} v_2$

$y_{11} = \dfrac{1}{(R_1//R_2)//r_{be}}$ et $y_{12} = 0$

on a $i_2 = \dfrac{v_2}{R_c} + \beta i_b$

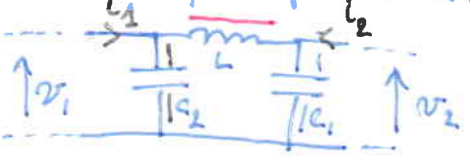
or $i_b = \dfrac{v_1}{r_{be}}$

donc $i_2 = \dfrac{v_2}{R_c} + \beta \dfrac{v_1}{r_{be}}$

on en conclut $y_{21} = \dfrac{\beta}{r_{be}}$ et $y_{22} = \dfrac{1}{R_c}$

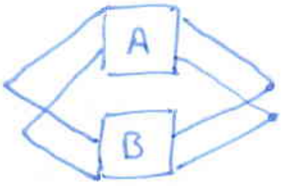
$$\Rightarrow \boxed{(y_A) = \begin{pmatrix} \dfrac{1}{(R_1//R_2)//r_{be}} & 0 \\ \dfrac{\beta}{r_{be}} & \dfrac{1}{R_c} \end{pmatrix}}$$

Etude du quadripole B : ⚠ Entrée par C_2

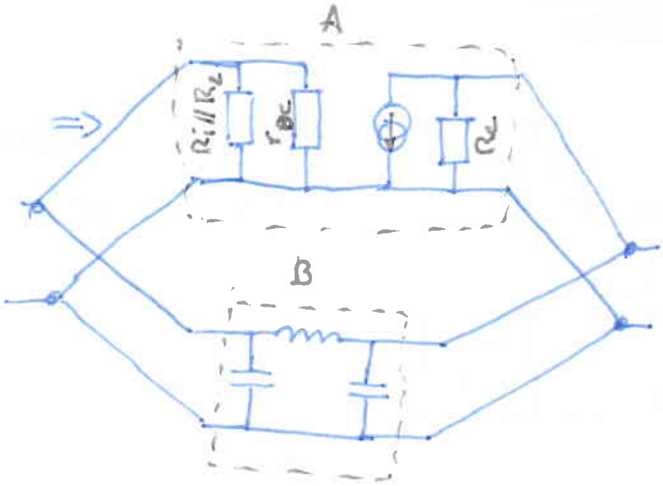


on a $\begin{cases} i_1 = jC_2\omega v_1 + \dfrac{v_1 - v_2}{jL\omega} \\ i_2 = jC_1\omega v_2 + \dfrac{v_2 - v_1}{jL\omega} \end{cases}$

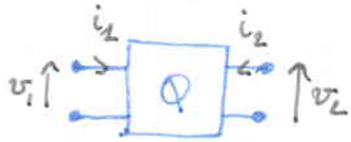
$$\Rightarrow \boxed{(y_B) = \begin{pmatrix} jC_2\omega + \dfrac{1}{jL\omega} & -\dfrac{1}{jL\omega} \\ -\dfrac{1}{jL\omega} & jC_1\omega + \dfrac{1}{jL\omega} \end{pmatrix}}$$



$\Rightarrow$



$\Rightarrow$



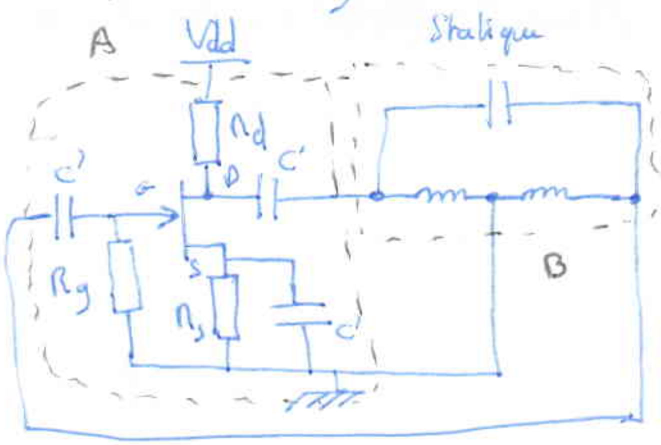
$$(Y_{eq}) = (Y_A) + (Y_B).$$

$$(Y_{eq}) = \begin{pmatrix} \frac{1}{(R_1 // R_2) // r_{BE}} + jC_2\omega + \frac{1}{jL\omega} & \frac{-1}{jL\omega} \\ \frac{\beta}{r_{be}} - \frac{1}{jL\omega} & \frac{1}{R_c} + jC_1\omega + \frac{1}{jL\omega} \end{pmatrix}$$

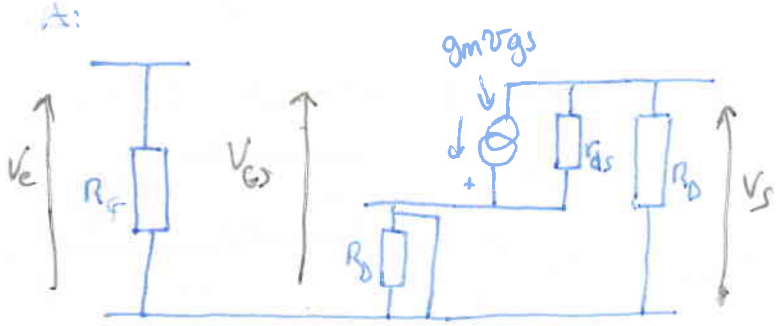
$$\left.\begin{array}{l} i_{1eq} = i_{2eq} = 0 \\ v_{1eq} \neq 0 \\ v_{2eq} \neq 0 \end{array}\right\} \Rightarrow \det(Y_{eq}) = 0 \Rightarrow Y_{11} \times Y_{22} - Y_{12} Y_{21} = 0.$$

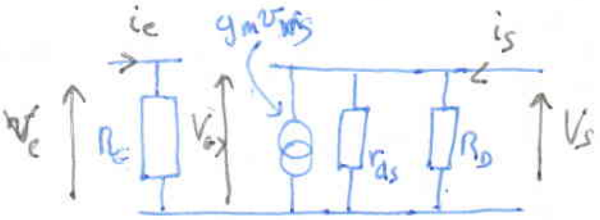
$$\Rightarrow \left(\frac{1}{(R_1 // R_2) // r_{be}} + jC_2\omega + \frac{1}{jL\omega}\right)\left(\frac{1}{R_c} + jC_1\omega + \frac{1}{jL\omega}\right) + \frac{1}{jL\omega}\left(\frac{\beta}{r_{bE}} - \frac{1}{jL\omega}\right) = 0$$

Oscillateur Hartley



Dynamique





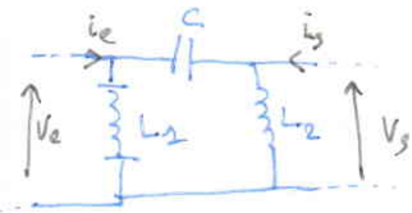
Gain à vide:

$$\begin{cases} V_{s_0} = -g_m v_{gs} (r_{ds} // R_D) \\ v_{gs} = V_e \end{cases}$$

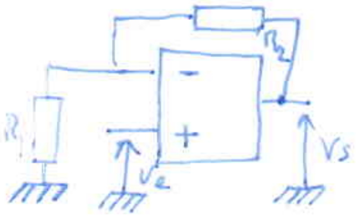
donc

$$A_0 = \frac{V_{s_0}}{V_e} = \frac{-g_m \cancel{v_{gs}} (r_{ds} // R_D)}{\cancel{v_{gs}}} = -g_m (r_{ds} // R_D)$$

B: Dynamique

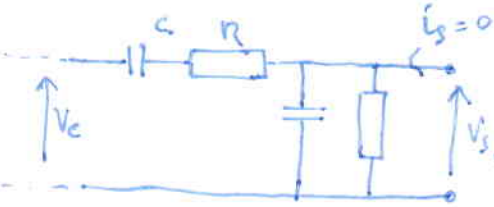


Oscillateur Pont de Wien

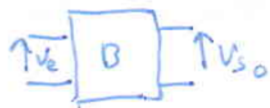


$\equiv$

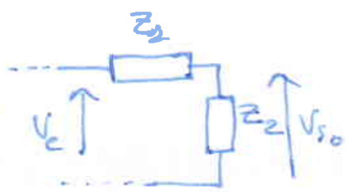
$\frac{V_s}{V_e} = 1 + \frac{R_2}{R_1}$ (pas de déphasage)



$\equiv$



$\equiv$



$$\frac{V_{s_0}}{V_e} = \frac{R}{1+jRC\omega} + \frac{1}{\frac{R}{1+jRC\omega} + R + \frac{1}{jC\omega}}$$

$$\left\{ V_{s_0} = \frac{Z_2}{Z_1+Z_2} V_e \right.$$

$$\frac{V_{s_0}}{V_e} = \frac{R}{R + \left(R + \frac{1}{jC\omega}\right)(1+jRC\omega)} = \frac{jRC\omega}{jRC\omega + (jRC\omega+1)^2} = \frac{jRC\omega}{1 + 3jRC\omega - R^2C^2\omega^2}$$

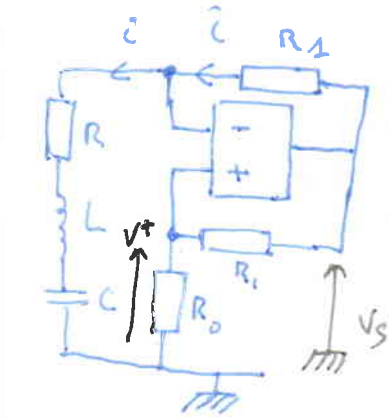
$$\frac{V_{S_1}}{V_{e_1}} = 1 + \frac{R_2}{R_1} = \frac{V_{e_2}}{V_{S_0}} = \frac{1 + 3jRC\omega - R^2\omega^2C^2}{jRC\omega} \Leftrightarrow jRC\omega\left(1 + \frac{R_2}{R_1}\right) = 1 - R^2C^2\omega^2 + j3RC\omega$$

$$jRC\omega + jRC\omega\frac{R_2}{R_1} = 1 - R^2C^2\omega^2 + 3jRC\omega$$

__Réel__ : $1 - R^2C^2\omega^2 = 0 \longrightarrow \boxed{\omega_0 = \frac{1}{RC} = 2\pi f_0}$

__Imagi__ : $RC\omega + RC\omega\frac{R_2}{R_1} = 3RC\omega \longrightarrow \boxed{1 + \frac{R_2}{R_1} = 3}$

Oscillateur :
→ ampli
+
→ déphaseur
↓
Quadripole A
+
Quadripole B



$$\begin{cases} V^+ = V_S\frac{R_0}{R_0+R_1} = U \\ R_1 i = V_S - U \\ V^- = U = V^+ \end{cases}$$

donc $R_1 \cdot i = U\frac{R_0+R_1}{R_0} - U$

$R_1 i = U\frac{R_1}{R_0}$

d'où $U = R_0 i$

Loi noeud + maille
⇓
F° transfert A+B
⇓
Boucle A et B
Expr Cpx

⇓
Associat° parallèle ≠ Série
⇒
⇓
Calcul matrix
$Z \Rightarrow \det(Z) = 0$

$U_C + U_L + Ri = R_0 i$

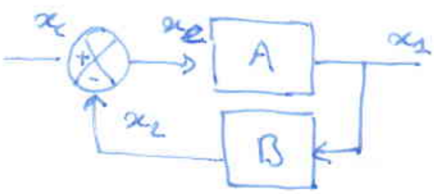
$U_L = L\frac{di}{dt} = LC\frac{du_c^2}{dt^2}$

$i = C$ ....

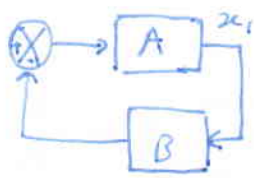
on a $U_c + LC\frac{dU_c}{dt} = i(\underbrace{R_0 - R}_{=0})$

$\omega_0 = \frac{1}{\sqrt{1-c}}$

$+1$



osc ⇒



avec $x_e = 0$

FTBT ⟹ $+\infty$

$$FTBT = \frac{A}{A+AB} = \frac{x_1}{x_e}$$

$1 + AB = 0$ d'où $AB = -1$

Réel$(AB) = -1$ $Im(AB) = 0$

Freq porteuse : $X_p(t) = A_p \cos(2\pi f_p t + \varphi_p)$

AM   FM   PM

$x(t)$ T_0-périodique.

$$x(t) = a_0 + \sum_{n\geq 1} a_n \cos(n\omega_0 t) + b_n \sin(n\omega_0 t)$$

$$a_n = \frac{2}{T}\int_{(T)} x(t)\cos(n\omega_0 t)\,dt$$

$$b_n = \frac{2}{T}\int_{(T)} x(t)\sin(n\omega_0 t)\,dt$$

MAPC : $(X_m(t) + E_0)X_p(t) = X_s(t)$

$$X_s(t) = E_0\left(1 + \frac{X_m(t)}{E_0}\right)X_p(t)$$

On définit l'indice de modulation : $m = \max\left(\frac{X_m(t)}{E_0}\right)$

Exemple: $X_m(t) = A_m\cos(2\pi f_m t)$

$X_p(t) = A_p\cos(2\pi f_p t)$

$X_s(t) = X_p(t)(E_0 + X_m(t))$

$X_s(t) = A_p\cos(2\pi f_p t)(E_0 + A_m\cos(2\pi f_m t))$

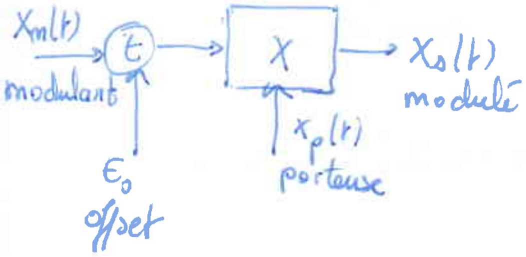
$X_s(t) = \underbrace{A_p E_0}_{A_s}\left(1 + \frac{A_m}{E_0}\cos(2\pi f_m t)\right)\cdot\cos(2\pi f_p t)$,

$x_p(t) = A_p\cos(\omega_p t + \varphi_p)$

et $m = \frac{A_m}{E_0}$, $X_s(t) = A_s(1 + m\cos(2\pi f_m t))\cos(2\pi f_p t)$

$X_s(t) = A_p\cos(2\pi f_p t) + \frac{2m}{2}A_s\cos(2\pi f_m t)\cos(2\pi f_p t)$

$X_s(t) = A_p\cos(2\pi f_p t) + \frac{m}{2}A_s\left(\cos(2\pi(f_m t + f_p t)) + \cos(2\pi(f_p - f_m)t)\right)$



AM → AMPC Porteuse conservée

AM → AMSP Sans Porteuse

AMPC :

$X_m(t)$ BF

$X_m(t) + E_0$ (on ajoute un offset)

$X_s(t) = (E_0 + X_m(t))X_p(t)$

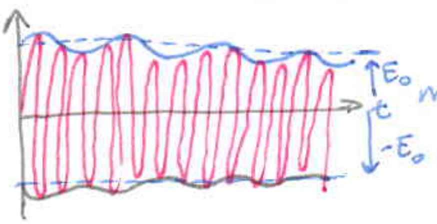
Etude cas particulier

$X_m(t) = A_m\cos(\omega_m t)$ et $X_p(t) = A_p\cos(\omega_p t)$ et $X_s(t) = (E_0 + A_m\cos(\omega_m t)) * A_p\cos(\omega_p t) = X_m(t)$

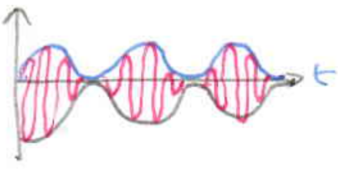
$X_s(t) = E_0 A_p\left[1 + \frac{A_m}{E_0}\cos(\omega_m t)\right]\cos(\omega_p t)$ (m indice de modulation)

$0 < m = \frac{A_m}{E_0}$

$0 < m < 1$



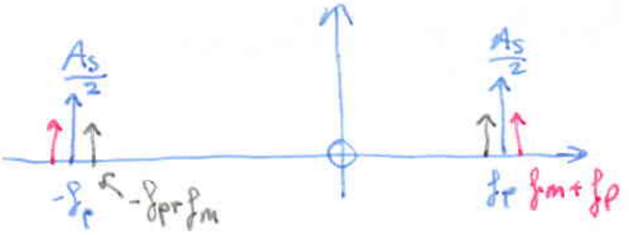
$m = 1$



$$X_s(t) = A_s(1+m\cos(\omega_m t))\cos(\omega_p t) \quad \text{AMPC} \to X_s(f)$$

$$X_s(t) = A_s\cos(\omega_p t) + m A_s\cos(\omega_m t)\cos(\omega_p t)$$

$$X_s(t) = \underbrace{A_s\cos(\omega_p t)}_{\text{porteuse}} + \underbrace{\frac{1}{2} m A_s\cos((\omega_p+\omega_m)t)}_{\text{somme des angles}} + \underbrace{\frac{1}{2} m A_s\cos((\omega_p-\omega_m)t)}_{\text{différence des angles.}}$$



$$p_m(t) = \frac{x_s^2(t)}{R_{ant}}$$

pic de Dirac

$$P_{AM}(t) = \frac{1}{T}\int_{(T)} p_{AM}(t)\,dt = \frac{1}{R_{ANT}}\left(\frac{1}{T}\int_{(T)} x_s^2(t)\,dt\right) = \frac{1}{R_{ANT}}\left(\sum_k \left(\frac{x_k}{\sqrt{2}}\right)^2\right)$$

Exemple

$x_m(t) = A_m\cos(\omega_m t)$

$x_p(t) = A_p(\omega_p t)$

$$P_{AM}(t) = \frac{1}{R_{ANT}}\left(\underbrace{\left(\frac{A_s}{\sqrt{2}}\right)^2}_{\text{porteuse}} + \underbrace{\left(\frac{1}{2\sqrt{2}} m A_s\right)^2}_{\text{Borne sup}} + \underbrace{\left(\frac{1}{2\sqrt{2}} m A_s\right)^2}_{\text{Borne inf.}}\right)$$

Cas particulier : $m = 1$.

$$R_{ANT} \cdot P_{AM} = \frac{A_s^2}{2} + 2\,\frac{1^2 A_s^2}{8}$$

$$I_{AM} = \frac{A_s^2}{2} + \frac{A_s^2}{4} = \frac{2A^2}{4} + \frac{A_s^2}{4}$$

Porteuse : & $2/3$ (66%) de la conso.

MASP :

$X_m(t)$ modulant $X_p(t)$ porteuse $X_s(t) = X_m(t) + X_p(t)$

Cas particulier :

$X_m(t) = A_m\cos(\omega_m t)$ $X_p(t) = A_m\cos(\omega_p t)$

$$X_s(t) = \underbrace{A_m A_p}_{A_s}\cos(\omega_m t)\cos(\omega_p t)$$

$$X_s(t) = \frac{A_s}{2}\cos((\omega_m+\omega_p)t) + \frac{A_s}{2}\cos((\omega_p-\omega_m)t)$$