INSTITUT d'OPTIQUE GRADUATE SCHOOL ParisTech

INSTITUT d'OPTIQUE GRADUATE SCHOOL ParisTech | LEnsE Laboratoire d'Enseignement Expérimental

Ingénierie Electronique pour le Traitement de l'Information

TD10

Modéliser un montage transimpédance

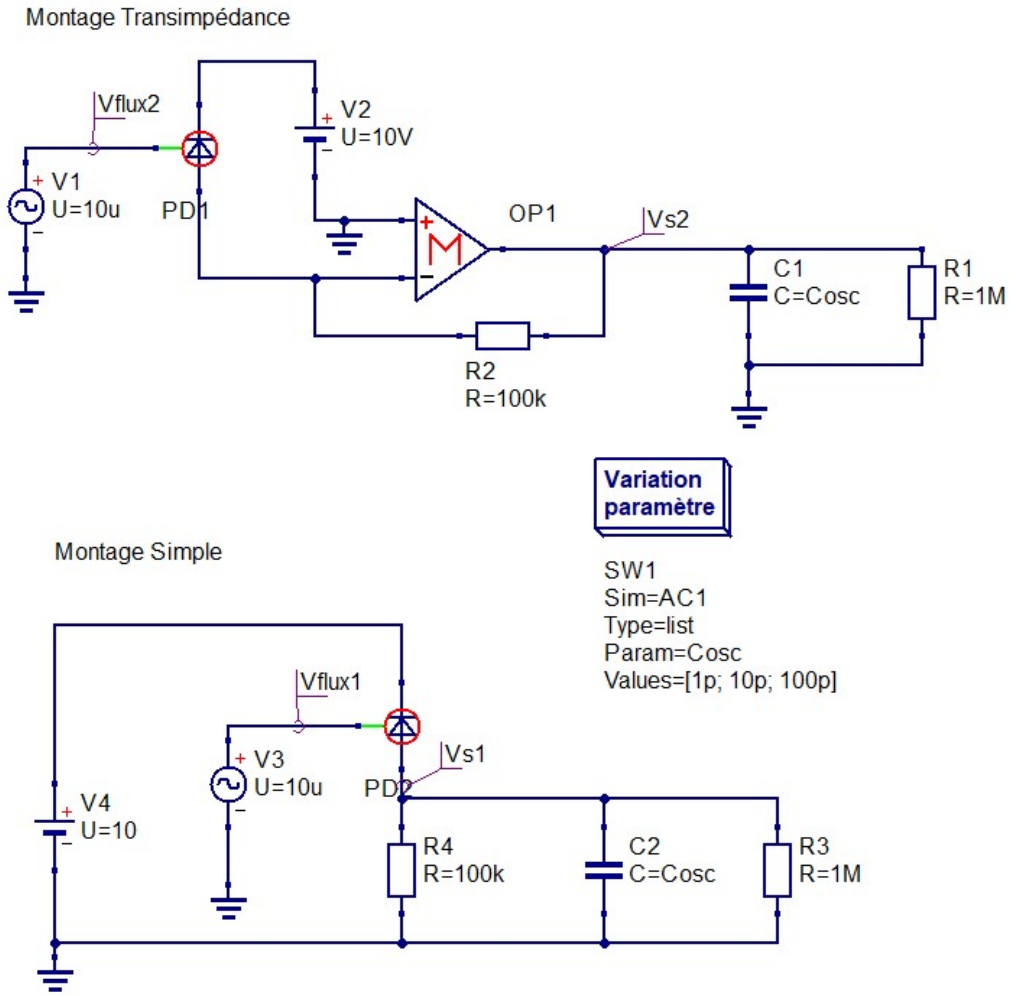
Julien VILLEMEJANE

Paris-Saclay

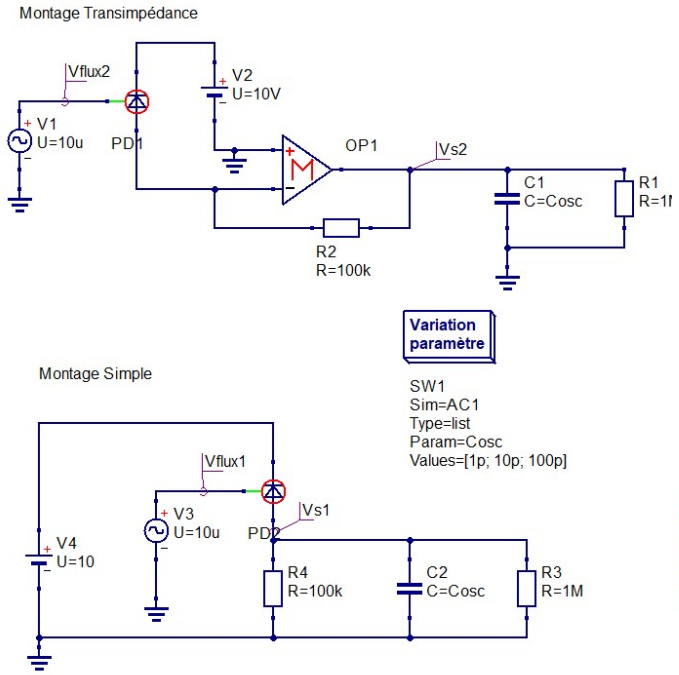
Saint-Étienne

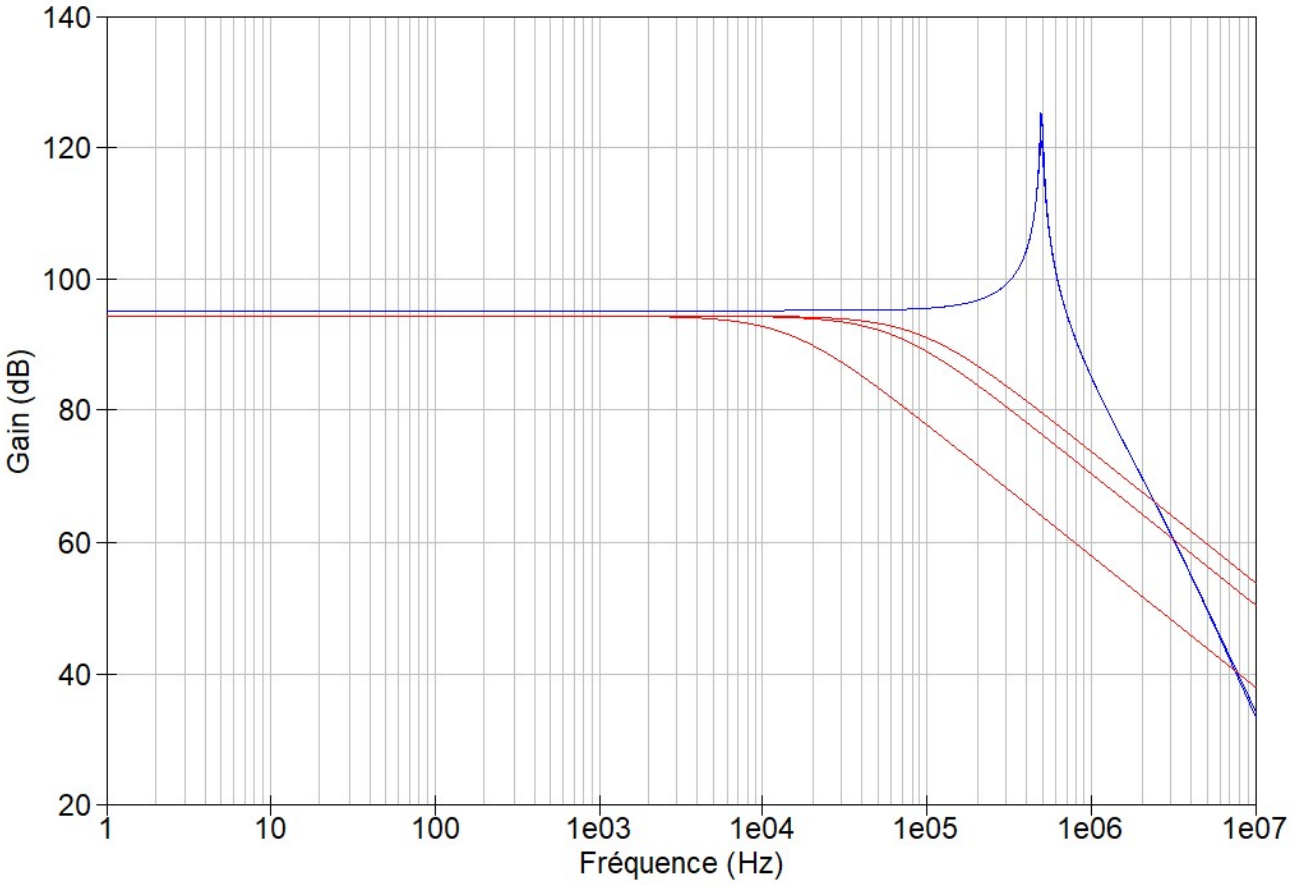
Bordeaux

- **Montage simple vs transimpédance**



- **Montage simple vs transimpédance**



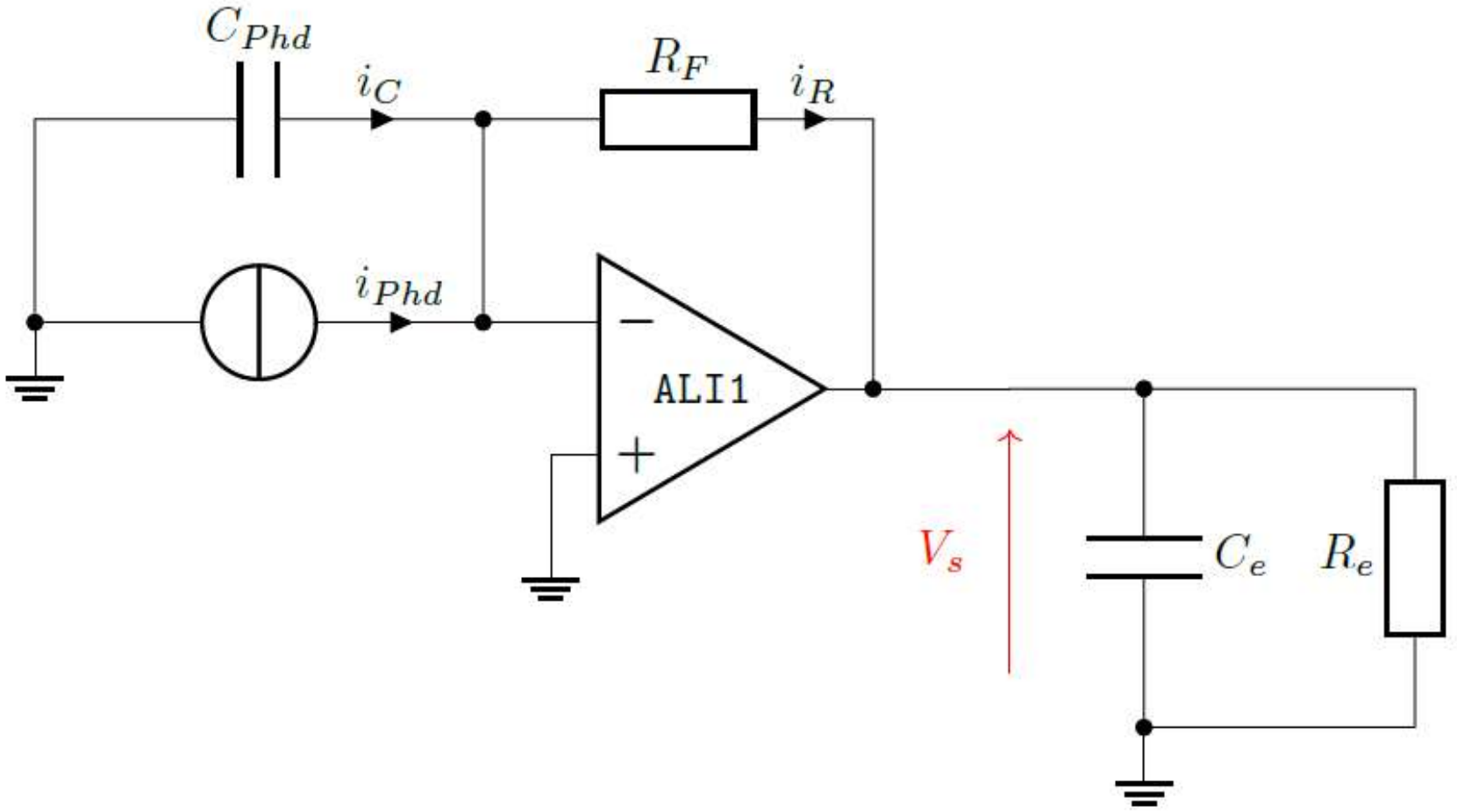


Paris-Saclay

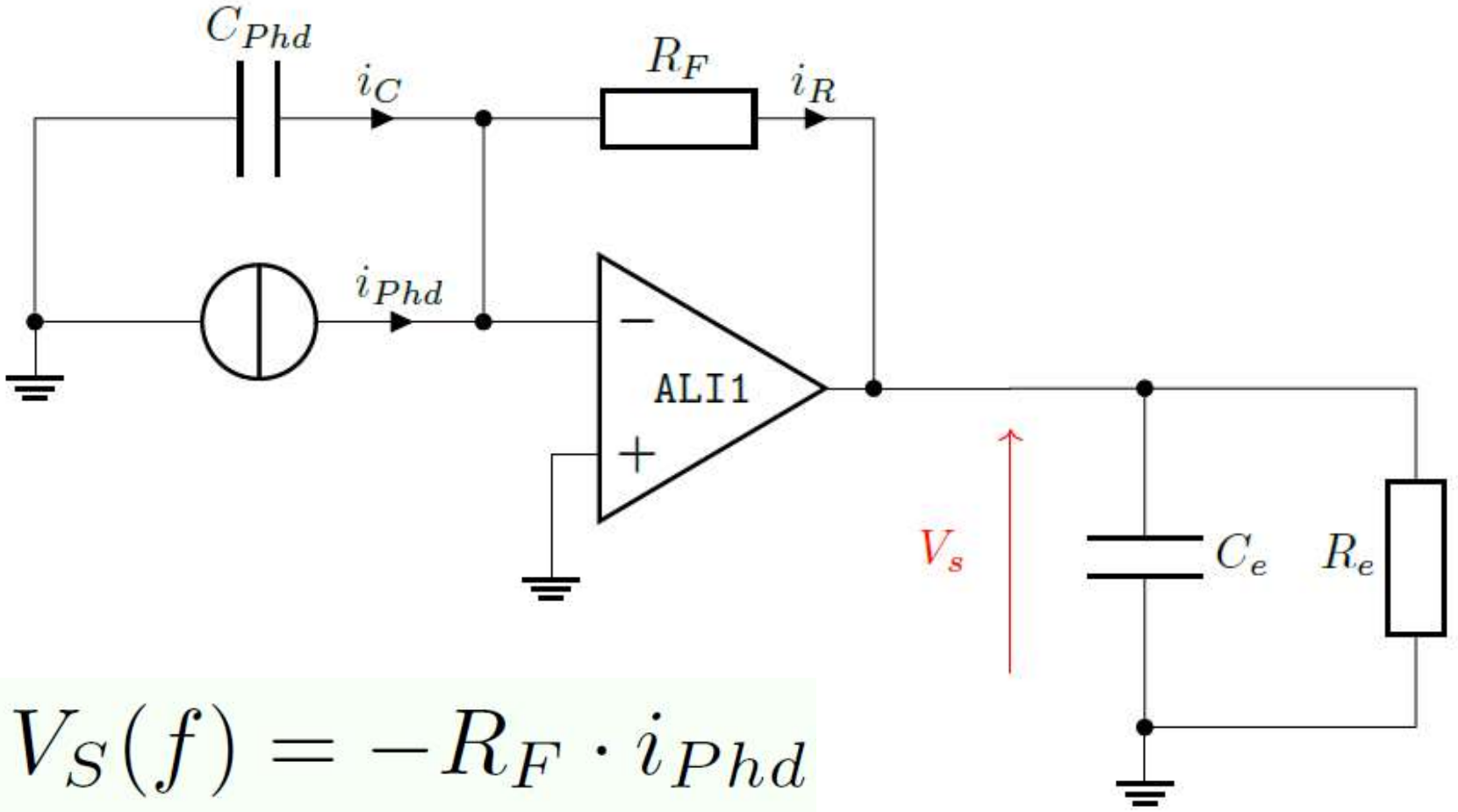
Saint-Étienne

Bordeaux

- **Exercice 1 / Modèle simplifié de l'ALI (mode linéaire)**

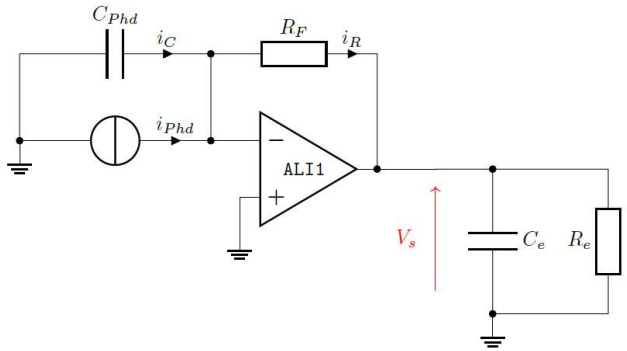


- **Exercice 1 / Modèle simplifié de l'ALI (mode linéaire)**



$$V_S(f) = -R_F \cdot i_{Phd}$$

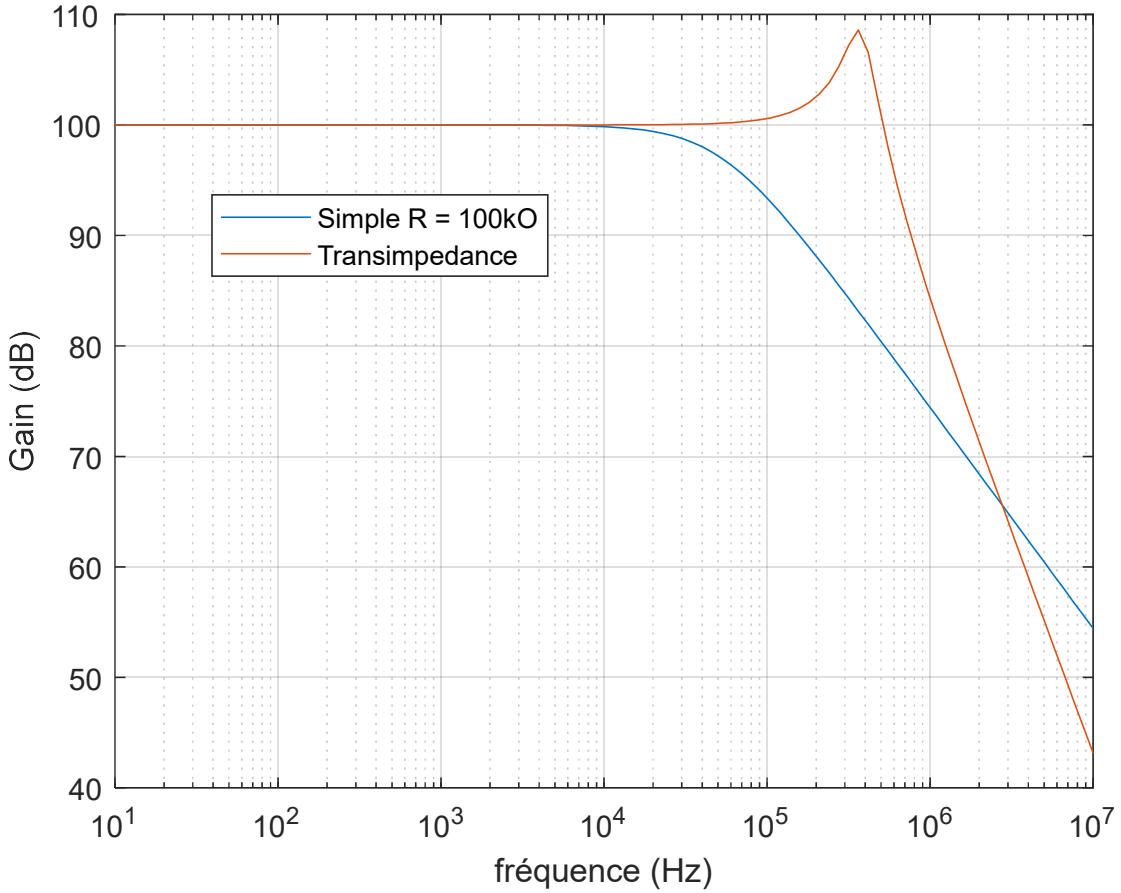
- **Exercice 1 / Modèle simplifié de l'ALI (mode linéaire)**



$$V_S(f) = -R_F \cdot i_{Phd}$$

≠

expérimentalement

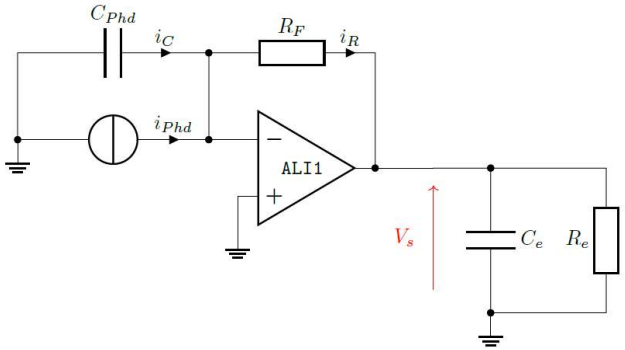


Paris-Saclay

Saint-Étienne

Bordeaux

- **Exercice 1 / Modèle simplifié de l'ALI (mode linéaire)**

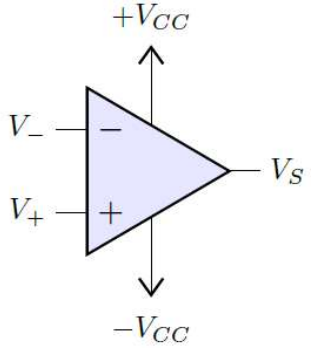


$$V_S(f) = -R_F \cdot i_{Phd}$$

≠

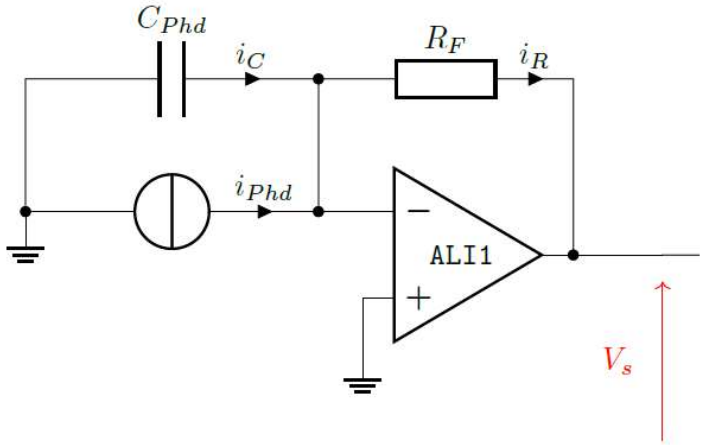
expérimentalement

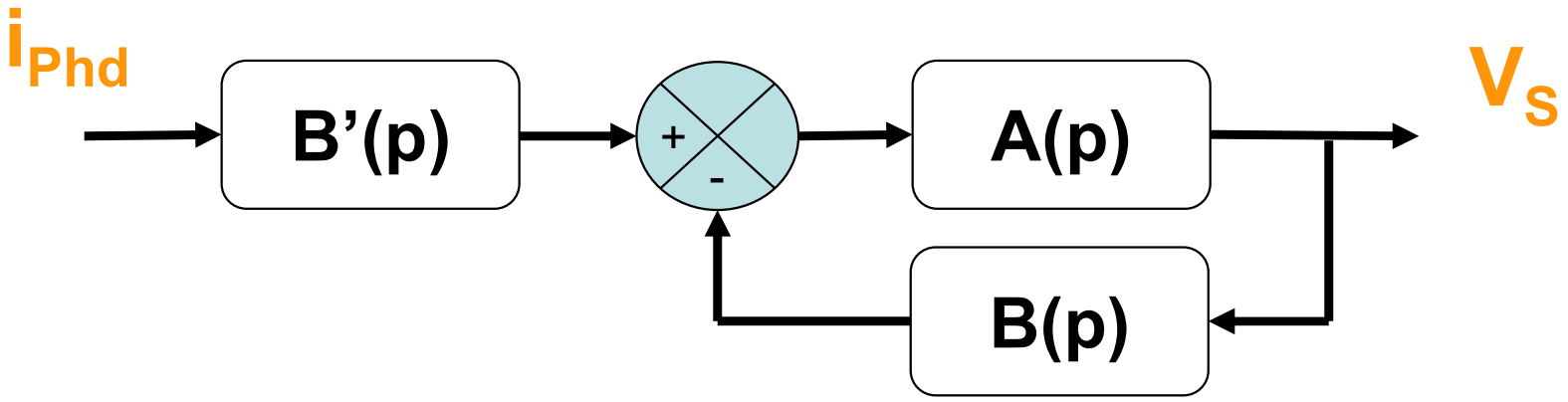
Modèle trop simplifié de l'ALI



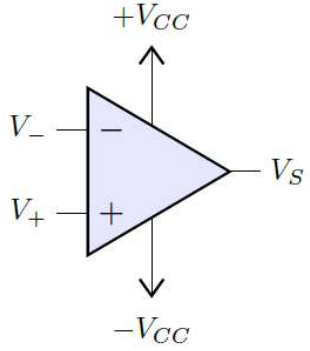
$$A(p) = \frac{V_S(p)}{\varepsilon(p)} = \frac{A_0}{1 + \frac{p}{\omega_c}}$$

- **Transimpédance / Schéma bloc**

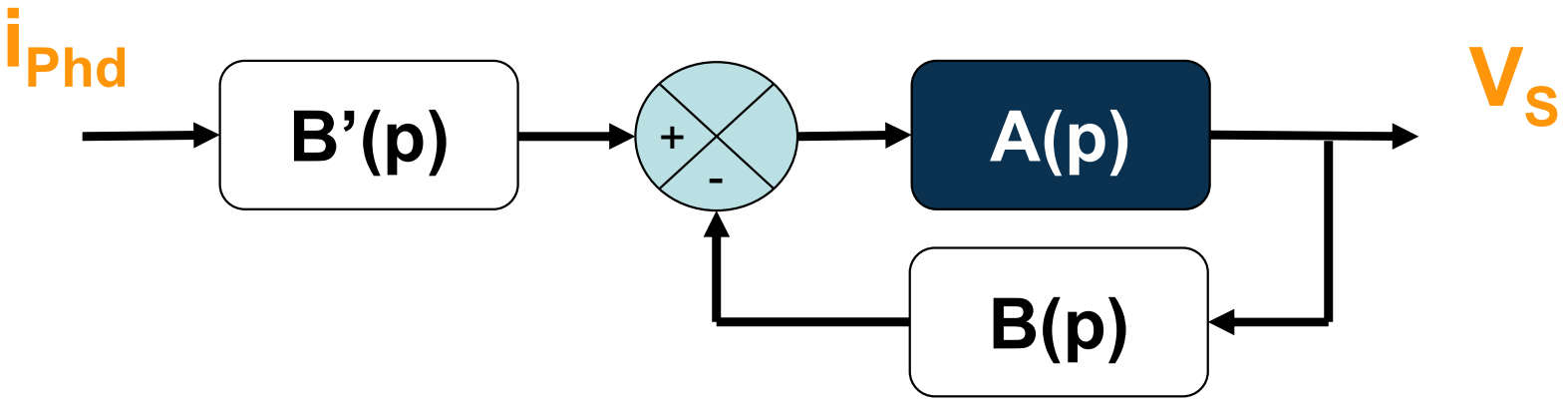




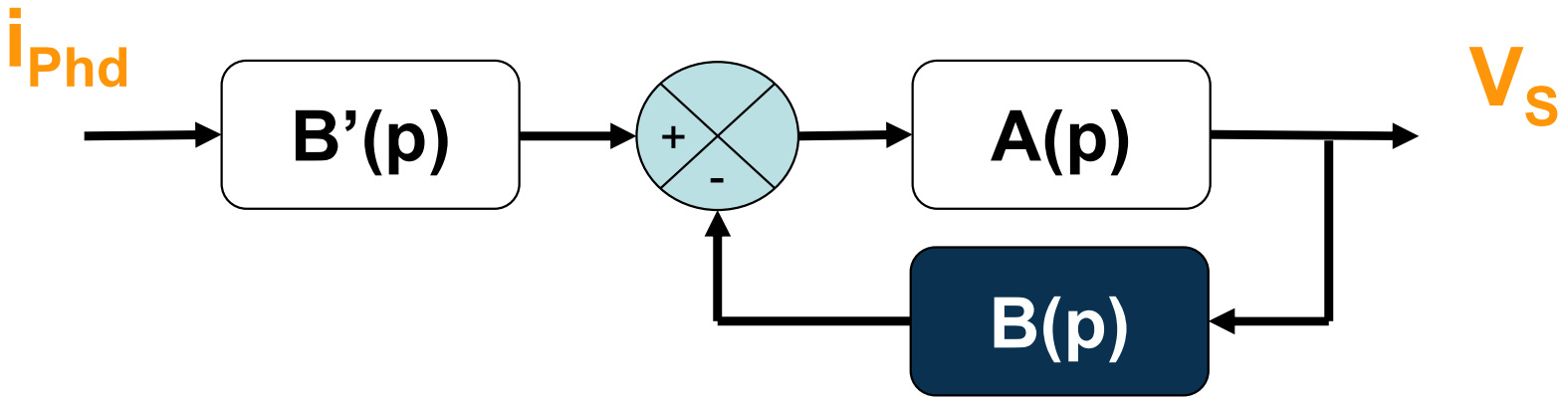
- **Transimpédance / Schéma bloc**



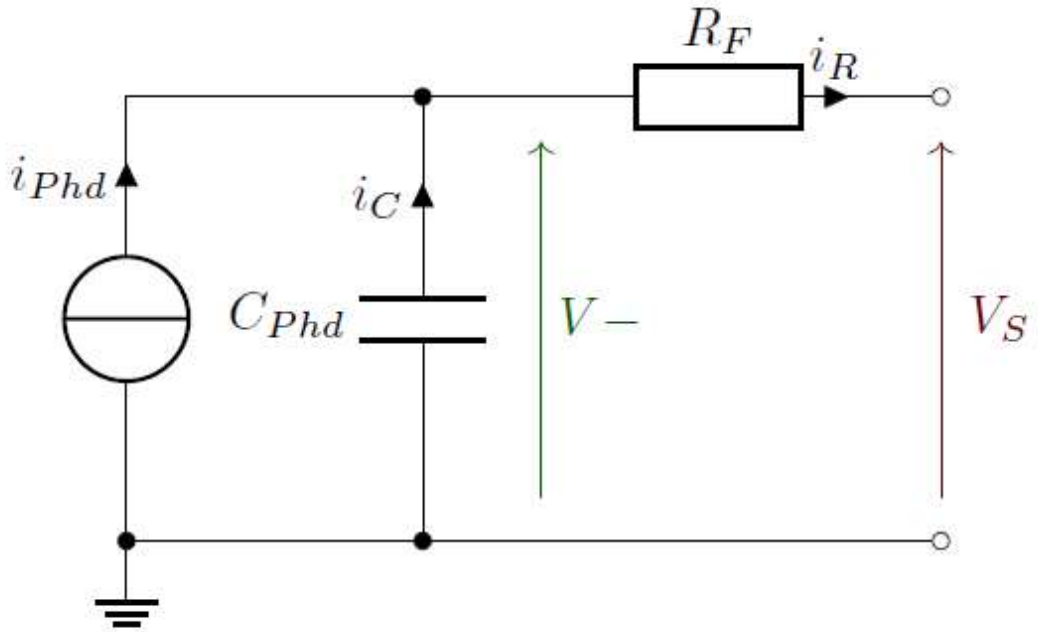
$$A(p) = \frac{V_S(p)}{\varepsilon(p)} = \frac{A_0}{1 + \frac{p}{\omega_c}}$$

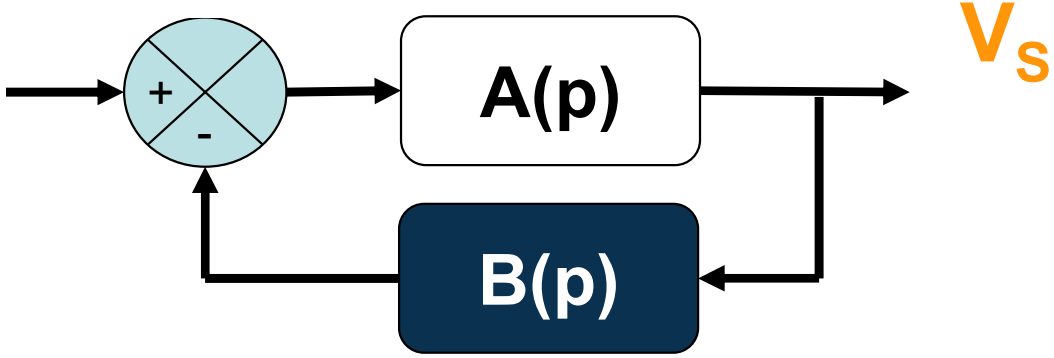


- **Exercice 2 / Contre-réaction**



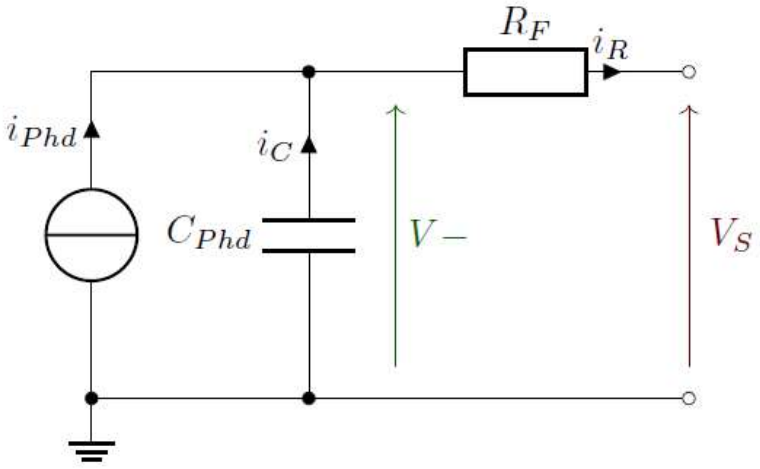
- **Exercice 2 / Contre-réaction**

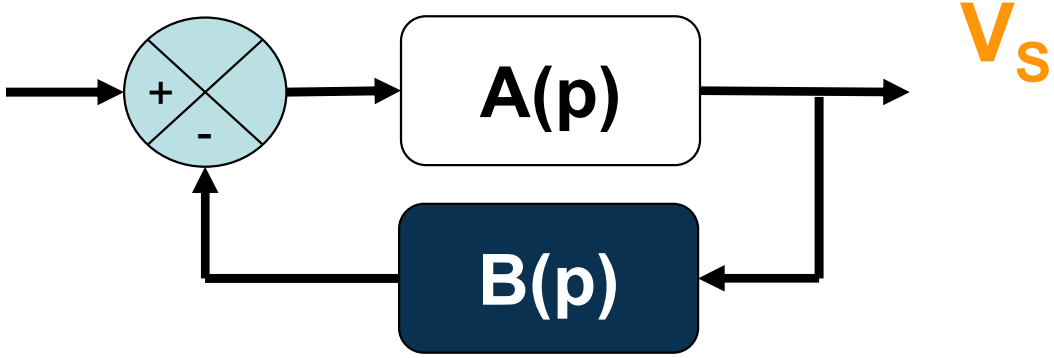




- **Exercice 2 / Contre-réaction**

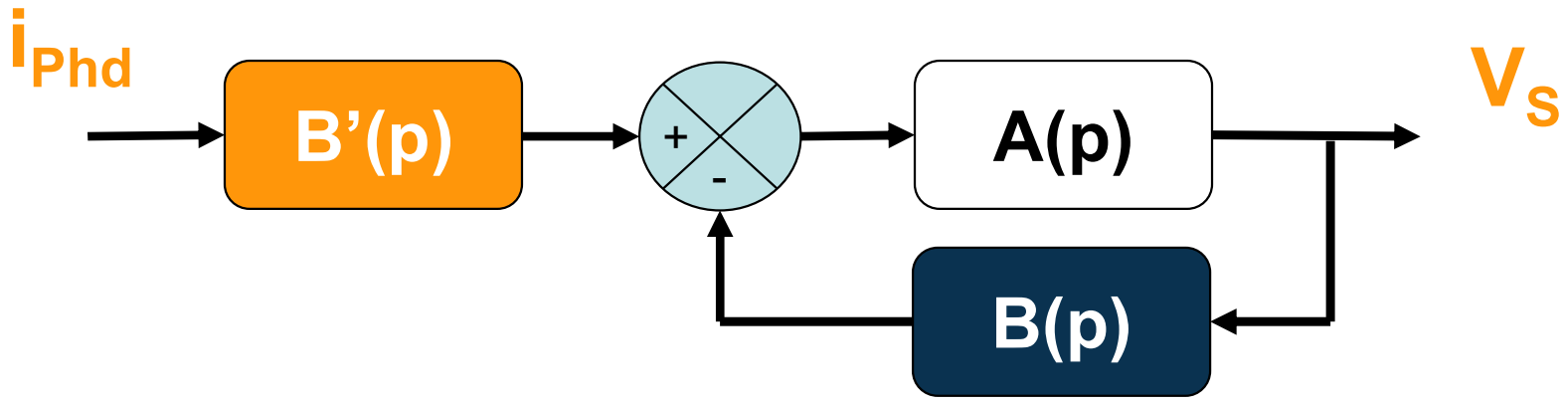
$$V^- = (V_S + R_F \cdot i_{Phd}) \cdot \frac{1}{1 + j \cdot R_F \cdot C_{Phd} \cdot \omega}$$





- **Exercice 2 / Contre-réaction**

$$V^- = (V_S + R_F \cdot i_{Phd}) \cdot \frac{1}{1 + j \cdot R_F \cdot C_{Phd} \cdot \omega}$$



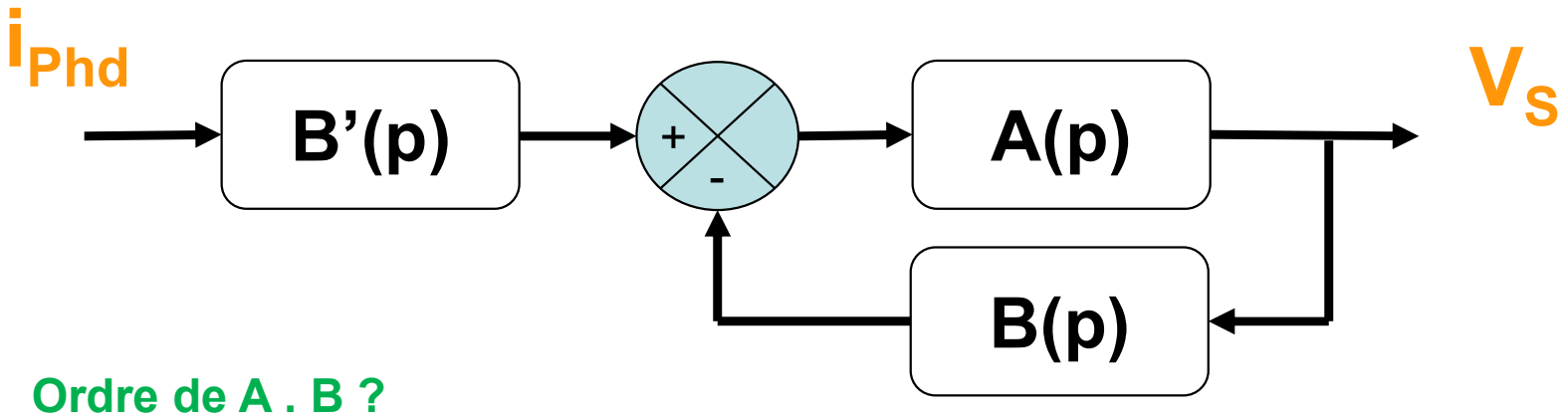
- **Exercice 2 / Contre-réaction**

Ordre de A ?

$$A(p) = \frac{V_S(p)}{\varepsilon(p)} = \frac{A_0}{1 + \frac{p}{\omega_c}}$$

Ordre de B ?

$$V^- = (V_S + R_F \cdot i_{Phd}) \cdot \frac{1}{1 + j \cdot R_F \cdot C_{Phd} \cdot \omega}$$



Ordre de A . B ?

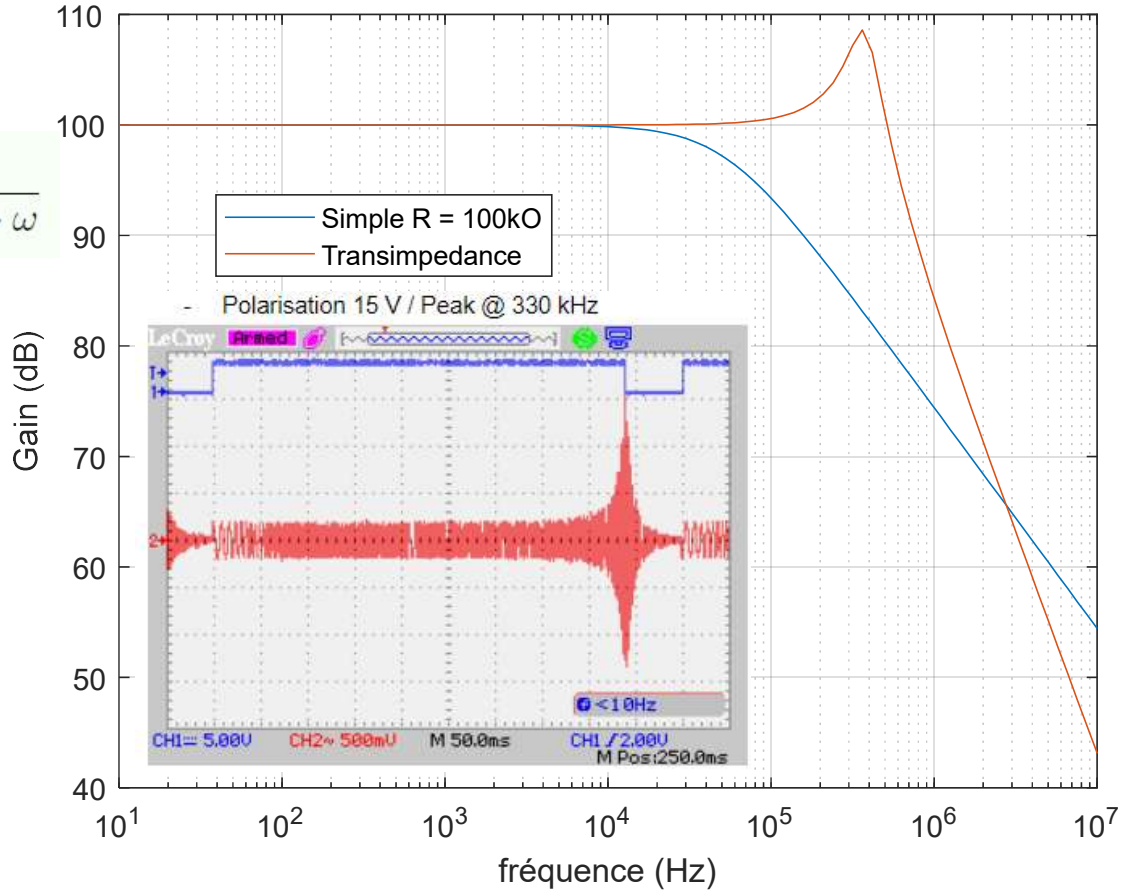
- ## Exercice 2 / Contre-réaction

Ordre de A . B ?

$$A(p) = \frac{V_S(p)}{\varepsilon(p)} = \frac{A_0}{1 + \frac{p}{\omega_c}}$$

$$V^- = (V_S + R_F \cdot i_{Phd}) \cdot \frac{1}{1 + j \cdot R_F \cdot C_{Phd} \cdot \omega}$$

expérimentalement

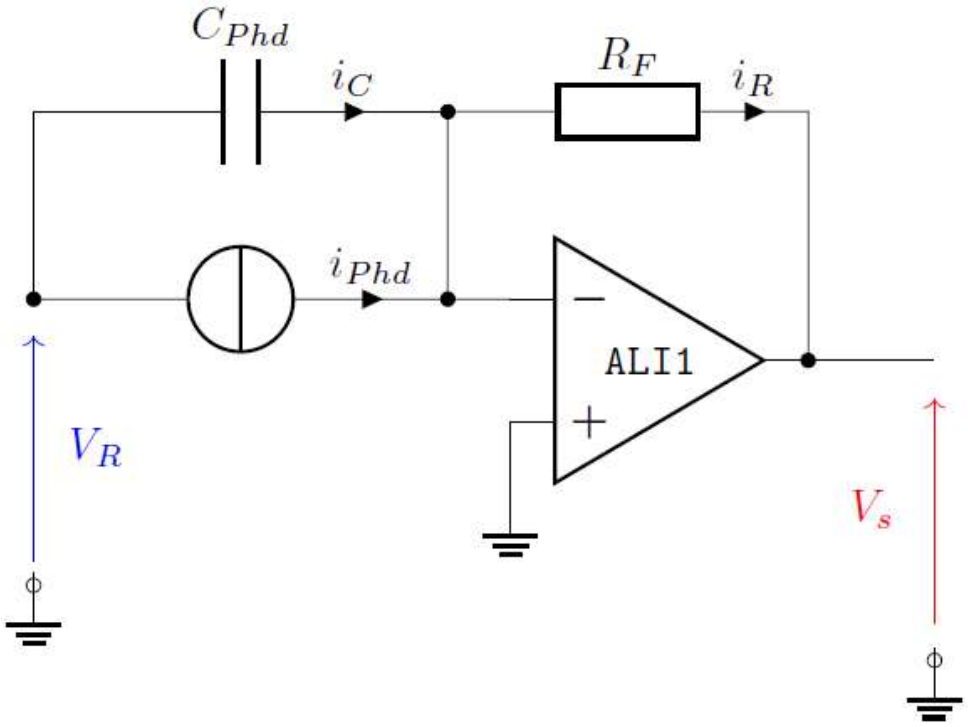


Paris-Saclay

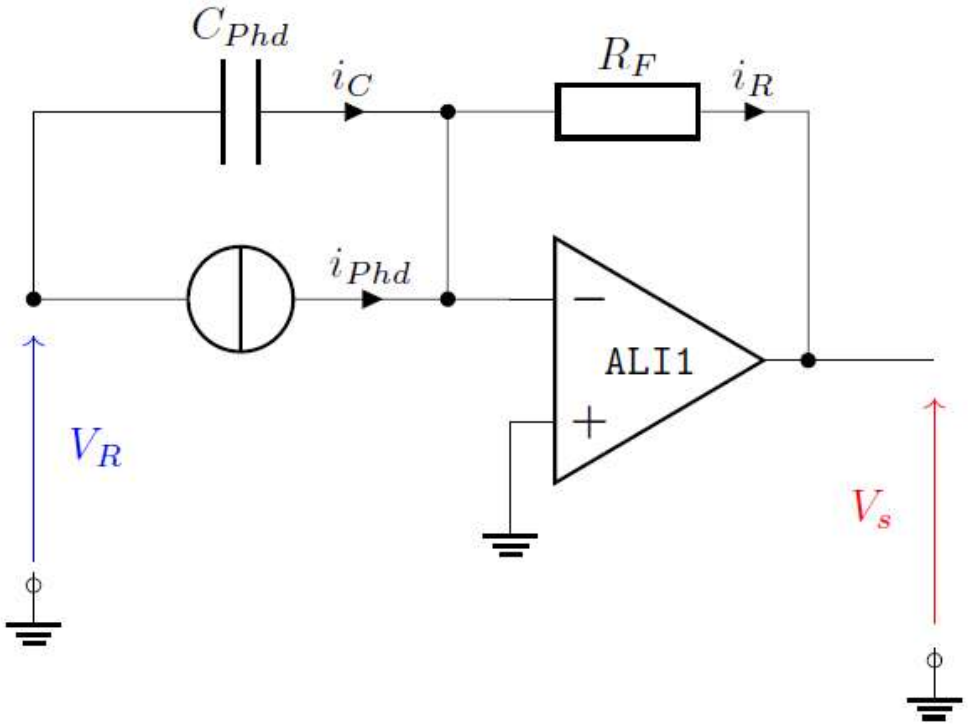
Saint-Étienne

Bordeaux

- **Exercice 3 / Modèle complet**

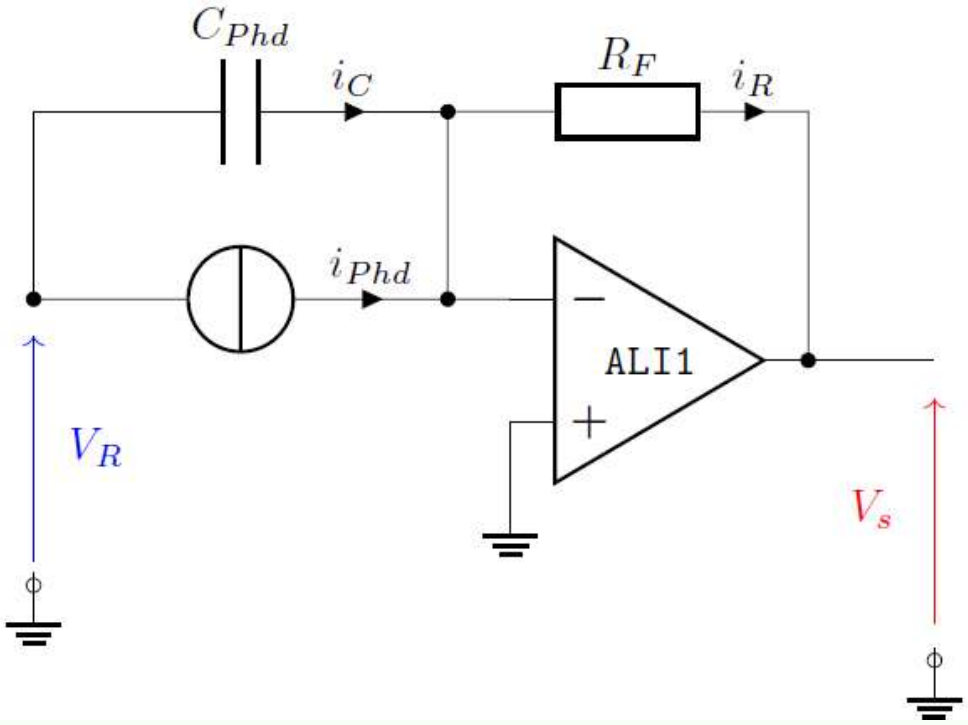


- **Exercice 3 / Modèle complet**



$$V_S = -A(j \cdot \omega) \cdot (V_S + R_F \cdot i_{Phd}) \cdot \frac{1}{1 + j \cdot R_F \cdot C_{Phd} \cdot \omega}$$

- **Exercice 3 / Modèle complet**



$$\omega_c = \frac{1}{R_F \cdot C_{Phd}}$$

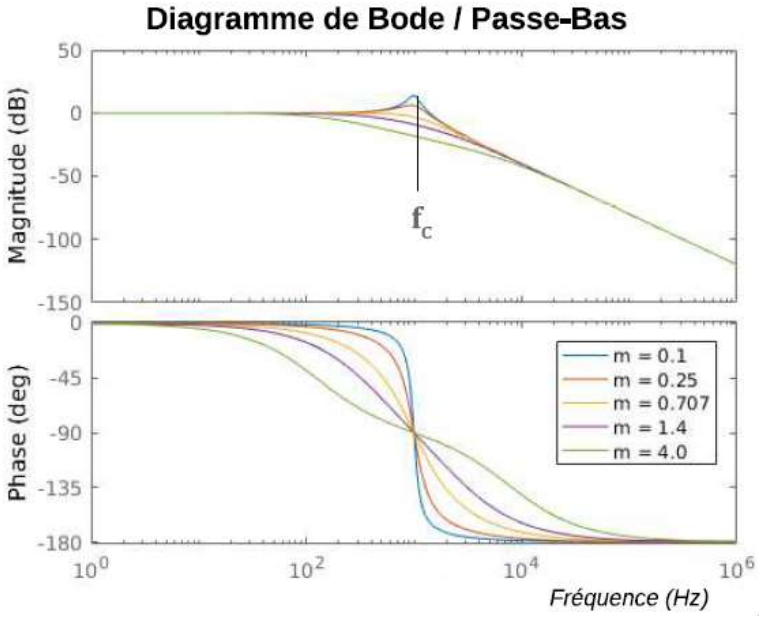
$$K = \frac{A_0}{1+A_0}$$

$$\frac{V_S}{i_{Phd}} = -K \cdot \frac{R_F}{1 + j \cdot \omega \cdot \frac{1}{1+A_0}\left(\frac{\omega_c+\omega_0}{\omega_c \cdot \omega_0}\right) + (j \cdot \omega)^2 \cdot \frac{1}{1+A_0}\frac{1}{\omega_c \cdot \omega_0}}$$

- **Exercice 3 / Modèle complet**

$$\frac{V_S}{i_{Phd}} = -K \cdot \frac{R_F}{1 + j \cdot \omega \cdot \frac{1}{1+A_0}\left(\frac{\omega_c+\omega_0}{\omega_c \cdot \omega_0}\right) + (j \cdot \omega)^2 \cdot \frac{1}{1+A_0}\frac{1}{\omega_c \cdot \omega_0}}$$

$$T_{LP}(j\omega) = \frac{A}{1+2 \cdot m \cdot j\frac{\omega}{\omega_c} + \left(j\frac{\omega}{\omega_c}\right)^2} \qquad \omega_c = \frac{1}{R_F \cdot C_{Phd}} \qquad K = \frac{A_0}{1+A_0}$$



$$G_T = K \cdot R_F$$

$$\omega_T = \sqrt{(1+A_0) \cdot \omega_c \cdot \omega_0}$$

$$m_T = \frac{\omega_T}{(1+A_0) \cdot \omega_c \cdot \omega_0} \cdot \frac{\omega_c + \omega_0}{2}$$

Paris-Saclay

Saint-Étienne

Bordeaux

- **Exercice 3 / Modèle complet**

$$\frac{V_S}{i_{Phd}} = -K \cdot \frac{R_F}{1 + j \cdot \omega \cdot \frac{1}{1+A_0}\left(\frac{\omega_c+\omega_0}{\omega_c \cdot \omega_0}\right) + (j \cdot \omega)^2 \cdot \frac{1}{1+A_0}\frac{1}{\omega_c \cdot \omega_0}}$$

$$\omega_c = \frac{1}{R_F \cdot C_{Phd}} \qquad K = \frac{A_0}{1+A_0}$$

$$G_T = K \cdot R_F$$

$$\omega_T = \sqrt{(1 + A_0) \cdot \omega_c \cdot \omega_0}$$

$$m_T = \frac{\omega_T}{(1 + A_0) \cdot \omega_c \cdot \omega_0} \cdot \frac{\omega_c + \omega_0}{2}$$

$A_0 >> 1$

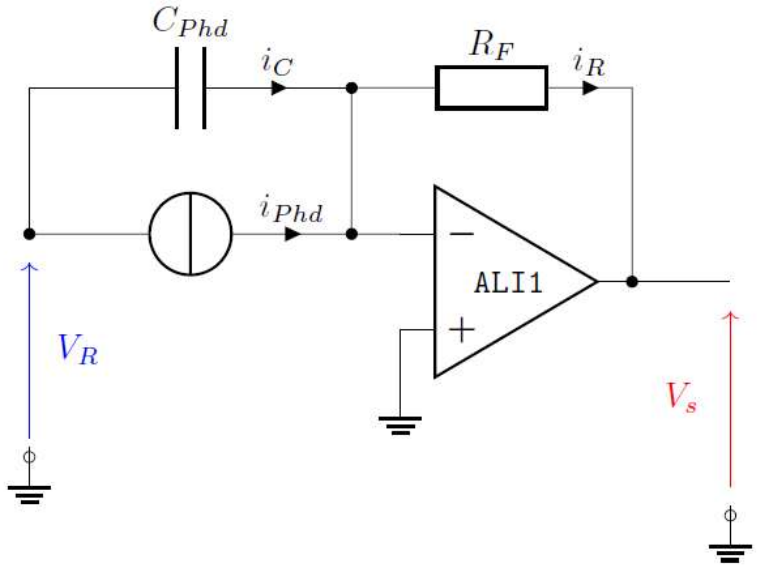
$$K \approx 1$$

$$G_T \approx R_F$$

$$\omega_T \approx \sqrt{\omega_c \cdot A_0 \cdot \omega_0} = \sqrt{\omega_c \cdot \omega_{GBP}}$$

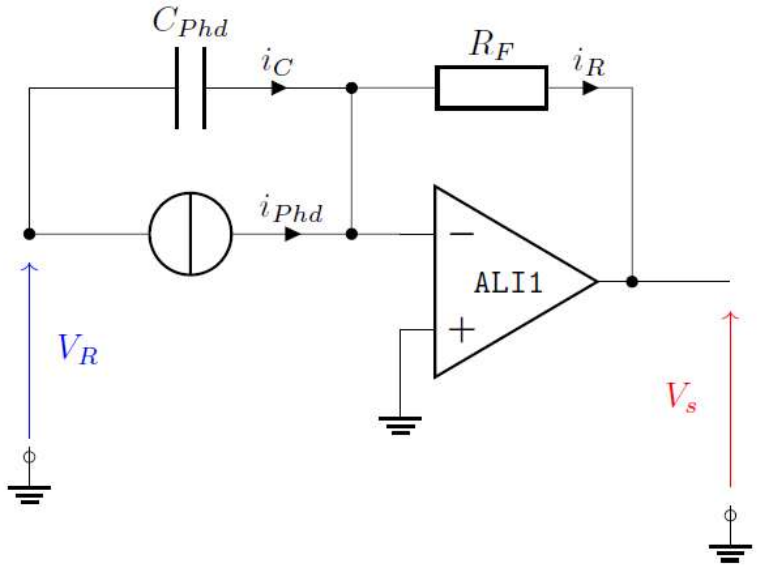
$$m_T = \frac{\omega_c + \omega_0}{2 \cdot \omega_T} \approx \frac{1}{2} \cdot \sqrt{\frac{\omega_c}{\omega_{GBP}}}$$

- **Exercice 3 / Polarisation de la photodiode**

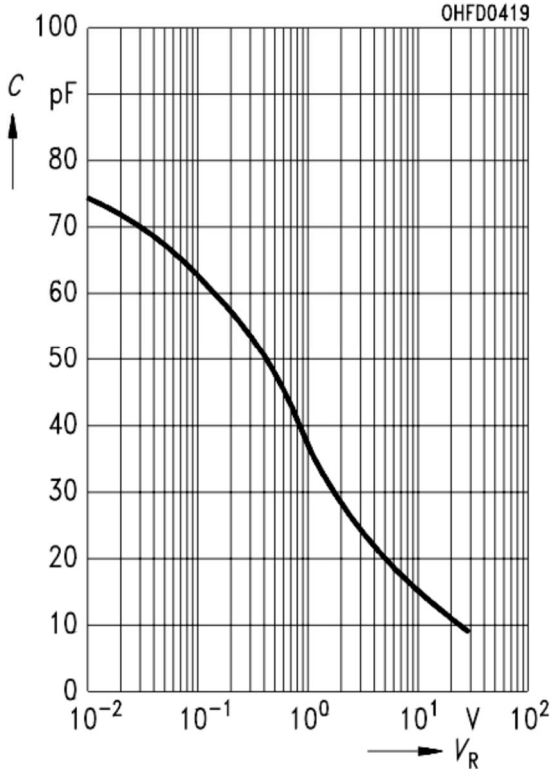


Intérêt de V_R ?

- **Exercice 3 / Polarisation de la photodiode**

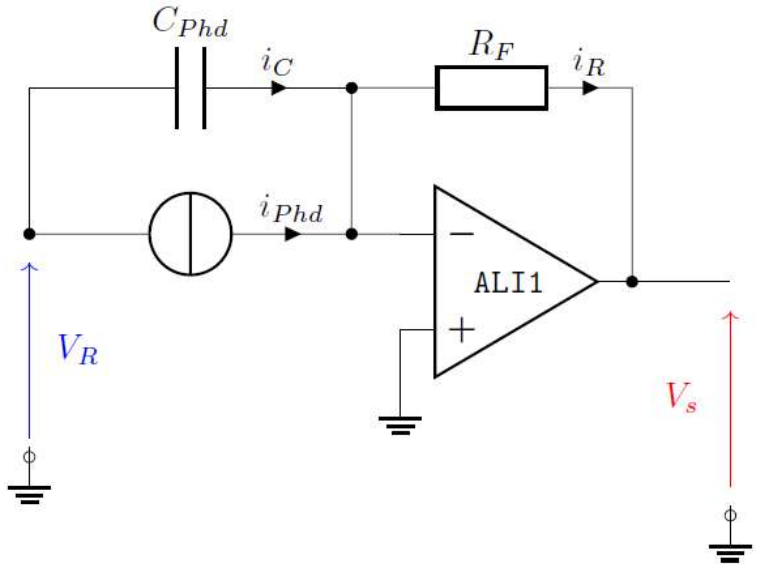


Capacitance



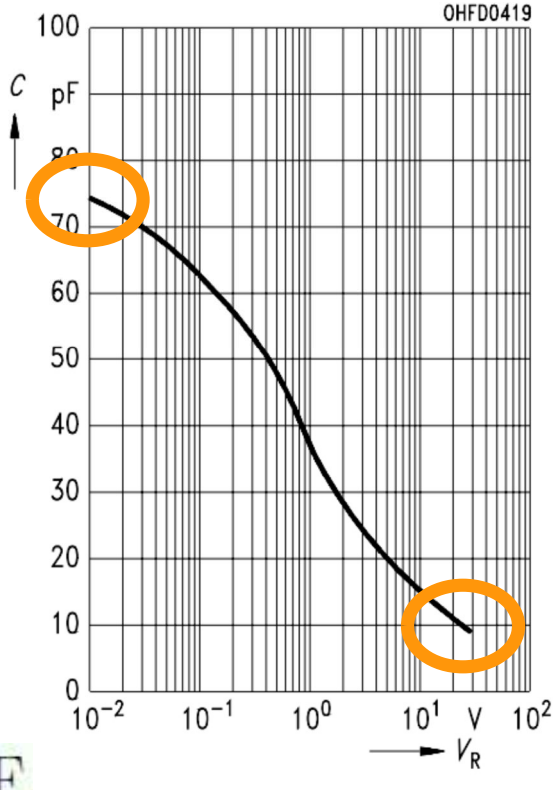
Intérêt de V_R ?

- **Exercice 3 / Polarisation de la photodiode**



$$V_R = 0\,\text{V}$$
$$C_{Phd} = 75\,\text{pF}$$

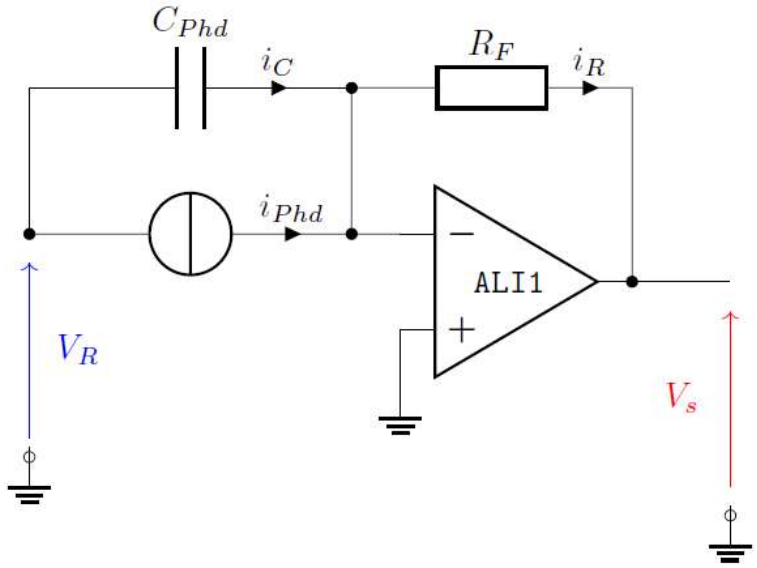
Capacitance



Impact sur la fonction de transfert ?

$$V_R = 30\,\text{V}$$
$$C_{Phd} = 10\,\text{pF}$$

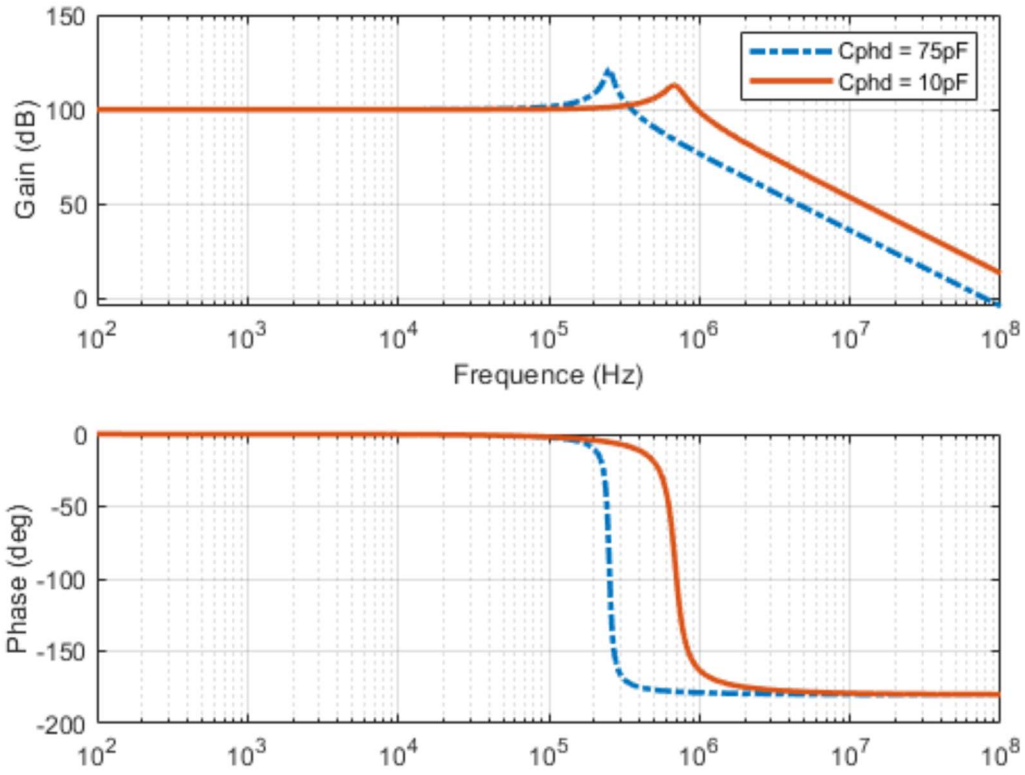
- **Exercice 3 / Polarisation de la photodiode**



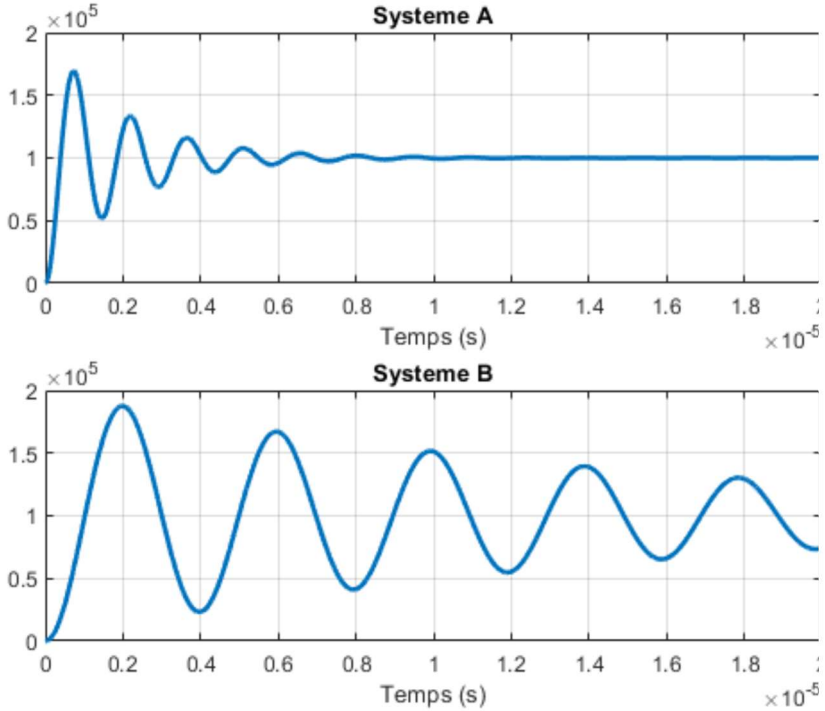
$V_R = 0\,\mathrm{V}$ $C_{Phd} = 75\,\mathrm{pF}$

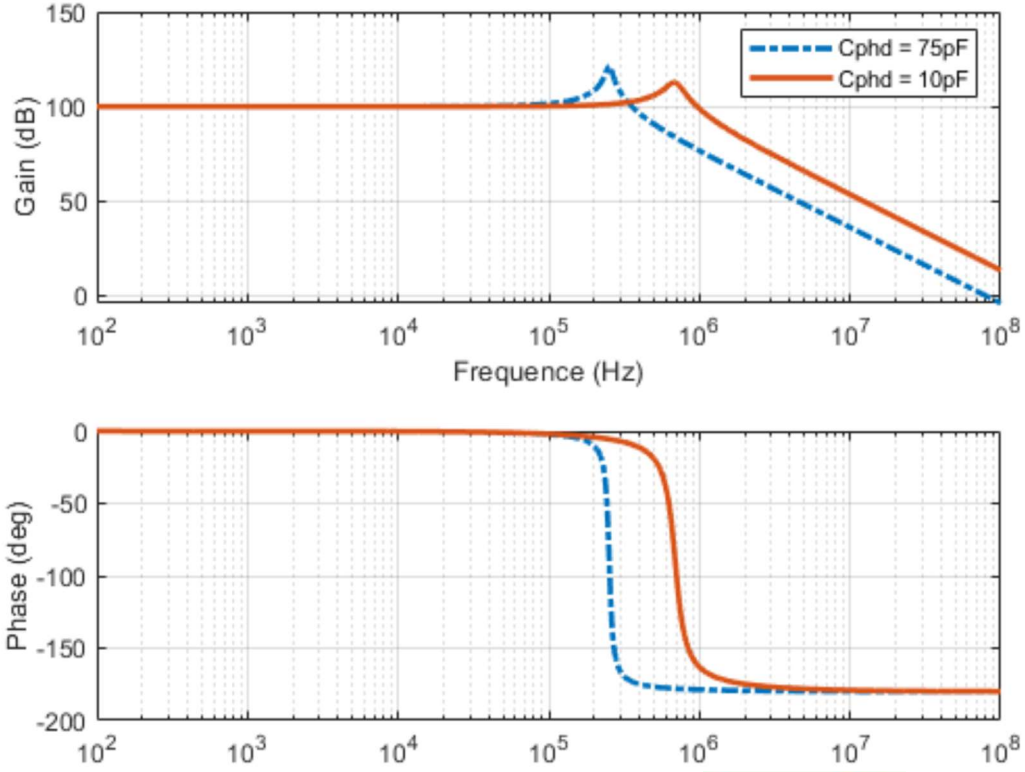
$V_R = 30\,\mathrm{V}$ $C_{Phd} = 10\,\mathrm{pF}$

Bande passante



- **Exercice 3 / Polarisation de la photodiode**





$V_R = 0\,\mathrm{V}$ $C_{Phd} = 75\,\mathrm{pF}$

$V_R = 30\,\mathrm{V}$ $C_{Phd} = 10\,\mathrm{pF}$.