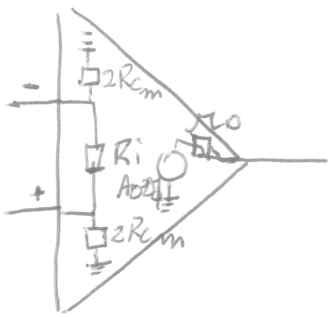
✻ Amp. Op. - Resistências de entrada e de saída

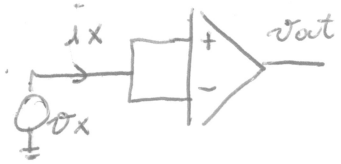
- Malha aberta

r_o - resistência de saída
R_i - resistência diferencial de entrada
R_{CM} - resistência de modo comum

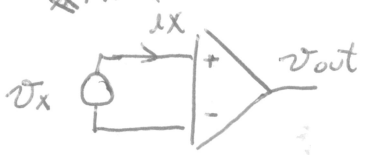


✻ R_{CM}

$$R_{CM} = \frac{v_x}{i_x}$$

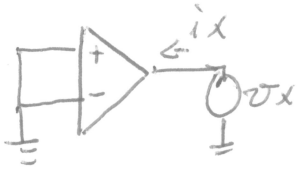


✻ R_i



$$R_i = \frac{v_x}{i_x}$$

✻ R_o



$$R_o = \frac{v_x}{i_x}$$

- Valores típicos

$R_i = 2M\Omega$

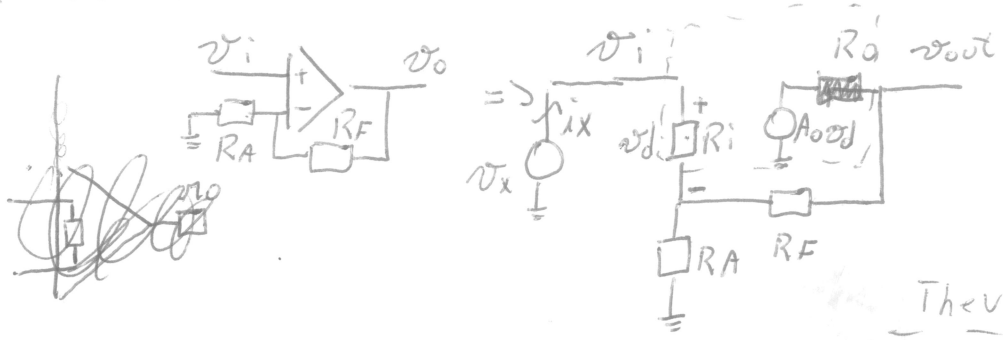
$2R_{CM} = 400M\Omega$

$R_o = 75\Omega$

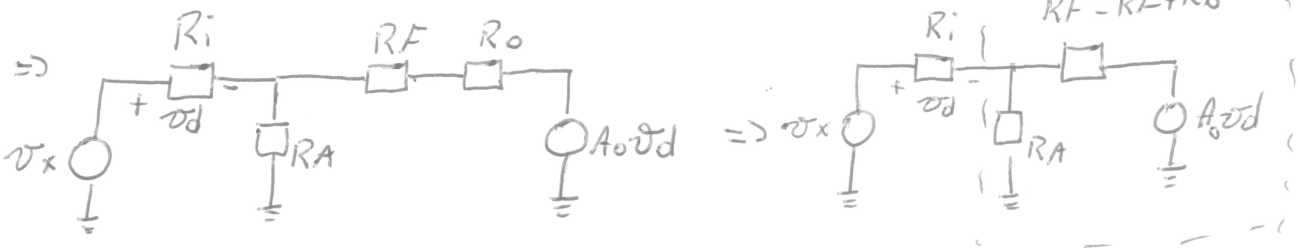
$A_o = 10^5$

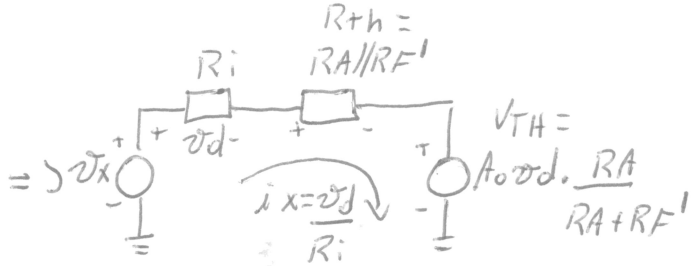
- Malha Fechada - Resistência de entrada
  → como R_{IN} tem valor alto, vamos desconsiderá-lo

- Amp. não inversor



Thevenin





$$v_x - v_d - R_{th}\cdot\frac{v_d}{R_i} - A_o v_d \cdot \frac{R_A}{R_A+R_F'} = 0$$

$$v_x = v_d\left(1 + \frac{R_{th}}{R_i} + \frac{A_o R_A}{R_A+R_F'}\right)$$

($R_{th} = R_A // R_F'$)

$$i_x = \frac{v_d}{R_i} \Rightarrow Z_{in} = \frac{v_x}{i_x} = R_i\left(1 + \frac{R_{th}}{R_i} + \frac{A_o R_A}{R_A+R_F'}\right)$$

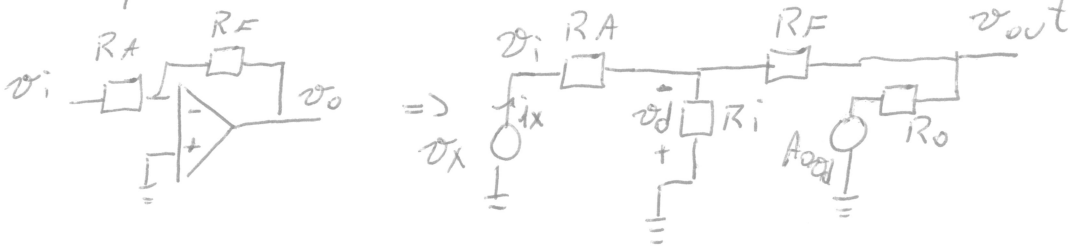
$$\boxed{Z_{in} = R_i + R_A // R_F' + R_i \cdot \frac{A_o R_A}{R_A+R_F'}}$$

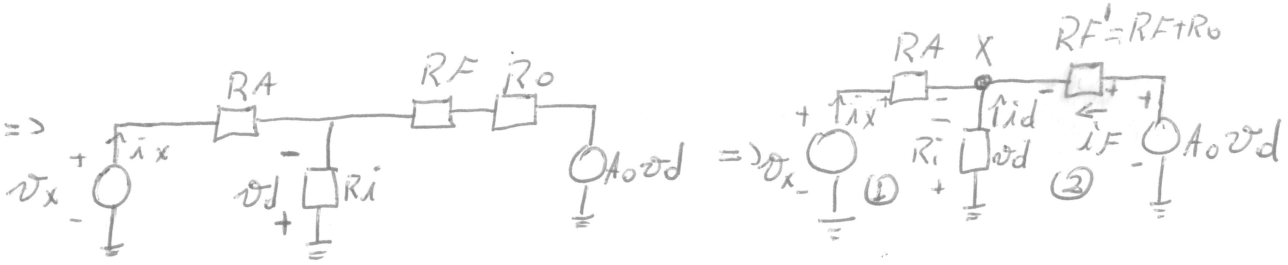
($R_F' = R_F + R_o$)

obs: $R_i \frac{A_o R_A}{R_A+R_F'} >> 1 + R_A // R_F'$ e $R_F >> R_o$

$$\Rightarrow Z_{in} \cong \frac{R_i \cdot A_o}{A_v} \rightsquigarrow 1 + \frac{R_F}{R_A}$$

• Amp. inversor





Malha ②

$$A_o v_d - R_F' I_F + v_d = 0 \Rightarrow I_F = \frac{A_o v_d + v_d}{R_F'}$$

Nó ⓧ

$$i_x + i_d + i_f = 0 \Rightarrow i_x + \frac{v_d}{R_i} + \frac{A_o v_d + v_d}{R_F'} = 0 \Rightarrow i_x = -\frac{v_d}{R_i} - \frac{v_d(A_o+1)}{R_F'}$$

$$i_x = -\frac{v_d R_F' + v_d R_i (A_o+1)}{R_i R_F'} \Rightarrow \boxed{i_x = -\frac{v_d [R_F' + R_i(A_o+1)]}{R_i R_F'}}$$

Malha 1

$$v_x - R_A i_x + v_d = 0 \Rightarrow \boxed{v_x = R_A i_x - v_d}$$

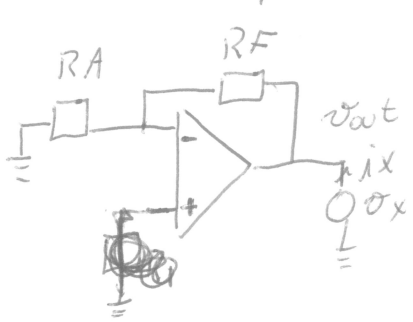
$$\Rightarrow z_{in} = \frac{v_x}{i_x} = R_A + \frac{v_d}{\frac{v_d [R_F' + R_i(A_o+1)]}{R_i \cdot R_F'}} = R_A + \frac{R_i R_F'}{R_F' + R_i'(A_o+1)}$$

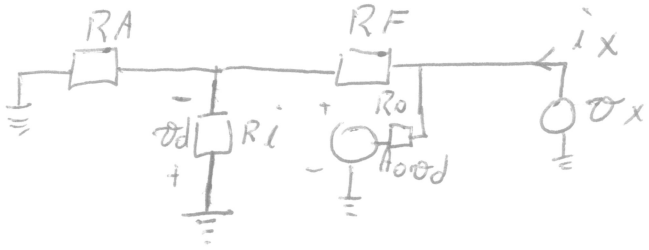
$$\boxed{z_{in} = R_A + \frac{R_i \circ R_F'}{R_F' + R_i(A_o+1)}}$$

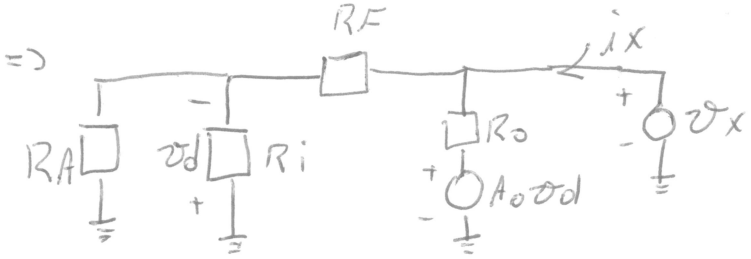
$\hookrightarrow R_F + R_o$

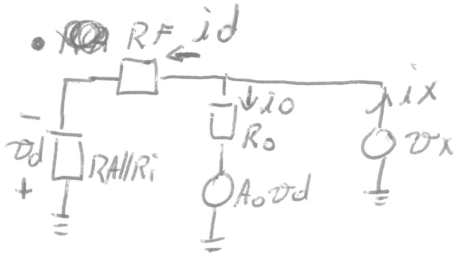
• Malha Fechada - Resistência de saída

$v_{im} = \phi$









• $id = \frac{v_x}{R_F + R_A // R_i}$ • $i_o = \frac{v_x - A_o v_d}{R_o}$

• $i_x = i_d + i_o = \boxed{\frac{v_x}{R_F + R_A // R_i} + \frac{v_x}{R_o} - \frac{A_o v_d}{R_o}}$ (1)

• $v_d = -R_A // R_i \cdot i_d = -R_A // R_i \cdot \frac{v_x}{R_F + R_A // R_i} \Rightarrow \boxed{v_x = -v_d \left(\frac{R_F + R_A // R_i}{R_A // R_i} \right)}$ (2)

• (2) → (1) $\Rightarrow i_x = -v_d \cdot \left(\frac{R_F + R_A // R_i}{R_A // R_i} \right) \cdot \frac{1}{(R_F + R_A // R_i)} - \frac{v_d (R_F + R_A // R_i)}{R_A // R_i} \cdot \frac{1}{R_o} - \frac{A_o v_d}{R_o}$

$$i_x = -v_d \cdot \left(\frac{1}{(R_A // R_i)} + \frac{1}{R_o} \cdot \frac{R_F + R_A // R_i}{R_A // R_i} + \frac{A_o}{R_o} \right)$$

$$Z_{out} = \frac{v_x}{i_x} \quad i_x = -v_d \left(\frac{R_o + R_F + R_A // R_i + A_o R_A // R_i}{R_o \cdot R_A // R_i} \right)$$

$$z_{out} = \frac{v_x}{i_x} = \frac{R_F + R_A // R_i}{R_A // R_i} \cdot \frac{R_o \cdot R_A // R_i}{R_o + R_F + R_A // R_i + A_o R_A // R_i}$$

$$\boxed{z_{out} = \frac{R_o \cdot (R_F + R_A // R_i)}{R_o + R_F + R_A // R_i (1 + A_o)}}$$

→ A realimentação diminui R_{out}

↳ obs: P/ $R_A << R_i$ e $R_A // R_i (1 + A_o) >> R_F$

$$z_{out} = \frac{R_o R_F + R_A}{R_A \cdot A_o} = \frac{R_o}{A_o} \left(1 + \frac{R_F}{R_A} \right)$$