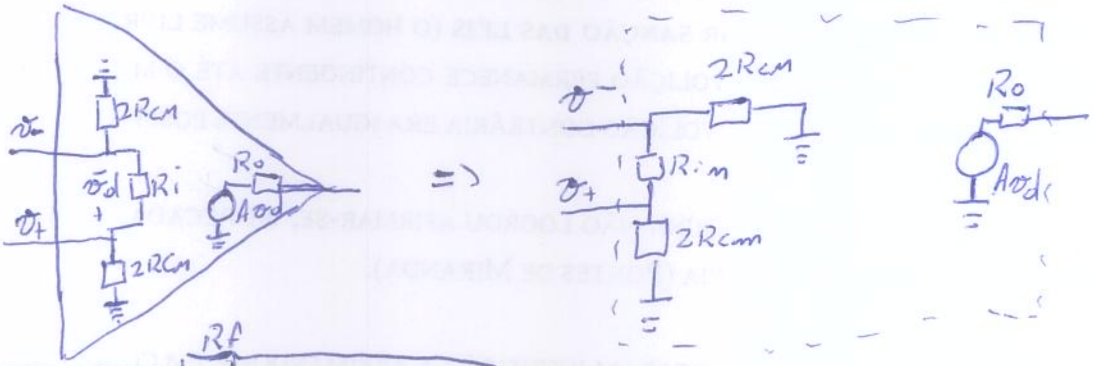
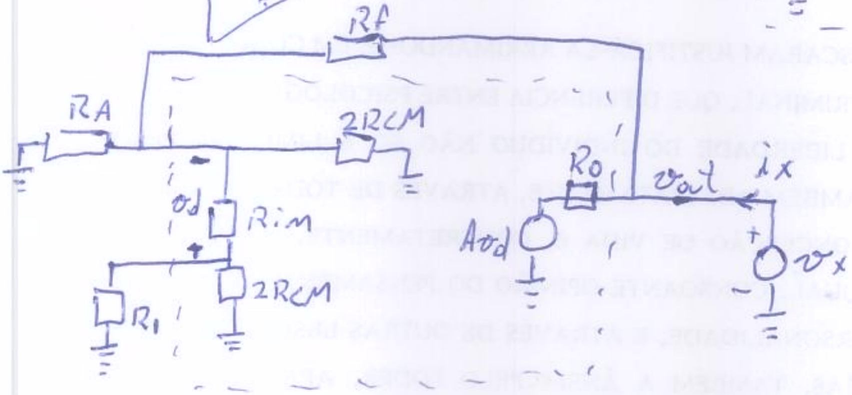
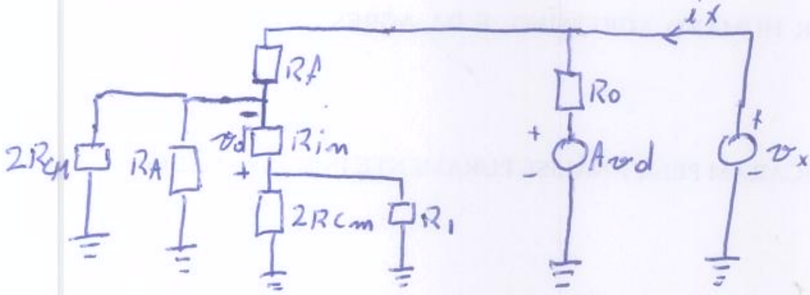
Aula 12C

* Resistência de saída (inversor e não inversor)

→ Valores do 741:
- $R_i = 2\,M\Omega$
- $G = 10^5$
- $2R_{cm} = 400\,M\Omega$
- $R_o = 75\,\Omega$





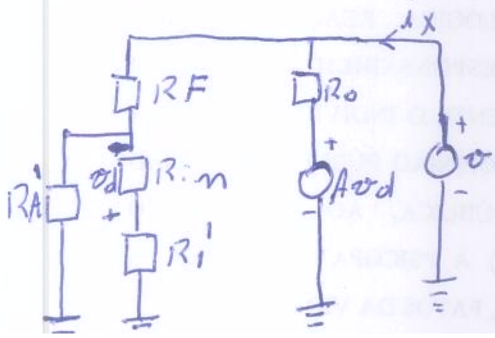


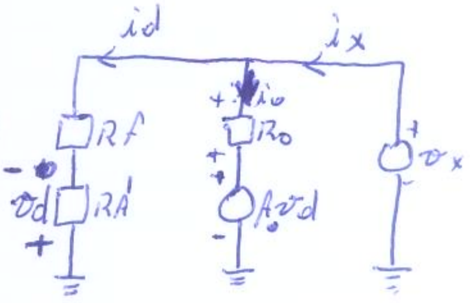
$R_1' = (2R_{CM} // R_1)$

$R_A' = (2R_{CM} // R_A)$

$R_{in} \gg R_1' \Rightarrow \begin{cases} V_{R_1'} \sim 0 \\ V_{R_{in}} \sim v_d \end{cases}$

$R_A' \ll R_{in} + R_1' \Rightarrow V_{R_A'} \sim v_d$





- $i_d = \frac{v_x}{R_A' + R_f}$

- $v_d = -\frac{v_x}{R_A' + R_f} \cdot R_A'$

- $i_o = \frac{v_x - A v_d}{R_o} \Rightarrow i_o = \frac{1}{R_o} \cdot \left[v_x - A \cdot \left(-\frac{v_x}{R_A' + R_f} \cdot R_A' \right) \right]$

$$i_o = \frac{1}{R_o} \cdot \left[v_x + \frac{A\, v_x \cdot R_A'}{R_A' + R_f} \right]$$

$$i_o = \frac{v_x}{R_o} \cdot \left[1 + \frac{A\, R_A'}{R_A' + R_f} \right]$$

---

obs: Normalmente $i_o \gg i_d \Rightarrow i_x \sim i_o$

$$\therefore \boxed{R_{out} = \frac{R_o}{1 + \frac{A R_A'}{R_A' + R_f}}} \rightsquigarrow \text{SAVANT}$$

$$R_{out} = \frac{R_o}{\frac{R_A' + R_f + A R_A'}{R_A' + R_f}} \Rightarrow R_{out} = \frac{R_o (R_A' + R_f)}{R_A'(1+A) + R_f} \xrightarrow{R_A'(1+A) \gg R_f} \boxed{R_{out} = \frac{R_o}{A} \cdot \left(1 + \frac{R_f}{R_A'} \right)}$$

$$\rightarrow R \ll \text{Malto} \Rightarrow \boxed{R_{out} = \frac{R_o}{A} \left(1 + \frac{R_f}{R_A} \right)} \rightsquigarrow \text{SAVANT}$$

$\downarrow$ $R_A' \sim R_A$

↳ A realimentação diminui a resistência de saída.

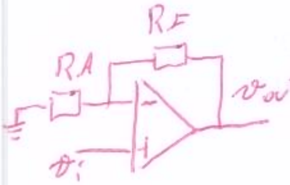
$$i_x = i_d + i_o \Rightarrow i_x = \frac{v_x}{R_A' + R_f} + \frac{v_x}{R_o} \left[1 + \frac{A R_A'}{R_A' + R_f} \right] \Rightarrow i_x = v_x \left[\frac{1}{R_A' + R_f} + \frac{1}{R_o} \left(1 + \frac{A R_A'}{R_A' + R_f} \right) \right]$$

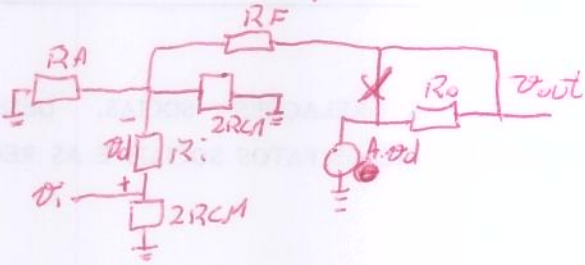
$$i_x = v_x \cdot \left[\frac{R_o + (R_A' + R_f) + A R_A'}{R_o (R_A' + R_f)} \right] \Rightarrow \boxed{R_{out} = \frac{v_x}{i_x} = \frac{R_o (R_A' + R_f)}{R_o + R_A'(1+A) + R_f}}$$

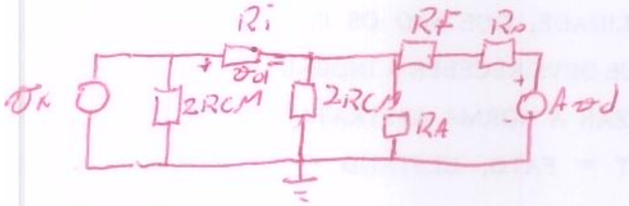
$$(R_A'(1+A)) \gg (R_o + R_f) \Rightarrow \boxed{R_{out} = \frac{R_o}{A} \left(1 + \frac{R_f}{R_A'} \right)} \Rightarrow \boxed{R_{out} = \frac{R_o}{A} \cdot A_{v_i}}$$

↳ A realimentação diminui R_{out}

* Resistência de entrada - Amp. não inversor

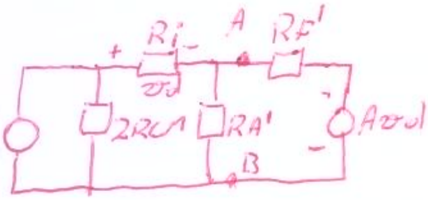




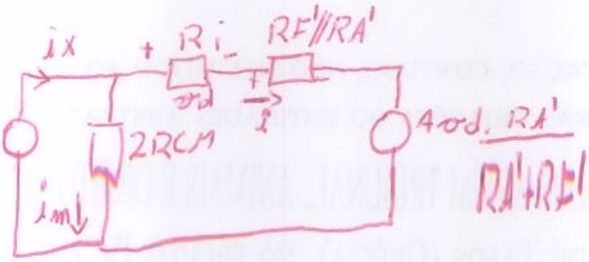


$RA' = 2RCM // RA$

$RF' = RF + R_o$



Thevenin(AB)



$$v_d = v_x - \left(v_{//} + A_{od}\frac{RA'}{RA'+RF'}\right) \Rightarrow v_d = v_x - \left[\underbrace{\frac{v_d}{R_i}}_{i} \cdot (RF'//RA') + A_{od}\frac{RA'}{RA'+RF'}\right]$$

$$v_x = \left(1 + \frac{RF'//RA'}{R_i} + A\frac{RA'}{RF'+RA'}\right) v_d =$$

③

$$\bullet\; i = \frac{v_d}{R_i} = \frac{v_x}{R_i} \cdot \frac{1}{1 + \frac{R_F'//R_A'}{R_i} + \frac{AR_A'}{R_F'+R_A'}} = \frac{v_x}{R_i + R_F'//R_A' + \frac{AR_A' R_i}{(R_F'+R_A')}}$$

$$i = \frac{v_x}{R_i\left(1 + \frac{AR_A'}{R_F'+R_A'}\right) + R_F'//R_A'}$$

$$\bullet\; i_x = i + i_m \Rightarrow i_x = \frac{v_x}{R_i\left(1+\frac{AR_A'}{R_F'+R_A'}\right) + R_F'//R_A'} + \frac{v_x}{2R_{CM}}$$

$$\frac{i_x}{v_x} = R_{in}^{-1} = \frac{1}{R_F'//R_A' + R_i\left(1+\frac{AR_A'}{R_F'+R_A'}\right)} + \frac{1}{2R_{CM}}$$

$$\therefore R_{in} = 2R_{CM} // \left[R_F'//R_A' + R_i\left(1+\frac{AR_A'}{R_F'+R_A'}\right)\right]$$

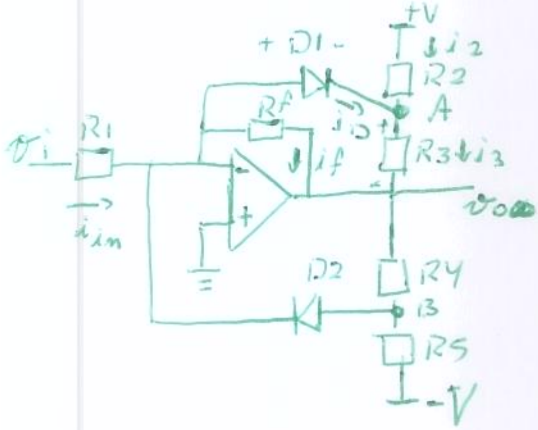
$$R_{out} = 2R_{CM} // \left[\frac{R_F' \cdot R_A' + R_i + R_i A R_A'}{R_F' + R_A'} \right]$$

$$\Downarrow\; R_i A R_A' \gg (R_F' R_A' + R_i)$$

$$R_{out} = 2R_{CM} // \left[\frac{R_i \cdot A \cdot R_A'}{R_F' + R_A'} \right]$$

$$R_{in} = 2R_{CM} // \frac{R_i A}{1 + \frac{R_F'}{R_A'}} \xRightarrow[R_A \ll 2R_{CM}]{R_F \gg R_o} R_{in} \cong 2R_{CM} // \frac{R_i A}{A_{v_f}}$$

※ Circuito Limitador de amplitude



• $v_i = 0 \Rightarrow v_o = 0 \Rightarrow V_A > 0$ e $V_B < 0 \Rightarrow D_1$ e D_2 abertos

$\therefore v_o = -\frac{R_f}{R_1} v_i$

↳ parte Linear

• $v_o \neq 0$

$$\Rightarrow V_A = V \cdot \frac{R_3}{R_2+R_3} + v_o \cdot \frac{R_2}{R_2+R_3}$$

(Superposição: 1º termo $v_o = 0$
2º termo $V = 0$)

$$\Rightarrow V_B = -V \frac{R_4}{R_4+R_5} + v_o \frac{R_5}{R_4+R_5}$$

• $v_i > 0 \Rightarrow v_o < 0 \Rightarrow v_B < 0 \Rightarrow D_2$ aberto

$\Rightarrow D_1$ conduz quando $V_A = -V_{Don}$

$$-V_{Don} = V \frac{R_3}{R_2+R_3} + v_{oL} \frac{R_2}{R_2+R_3} \Rightarrow -V_{Don}(R_2+R_3) = VR_3 + v_{oL} R_2$$

$$\Rightarrow v_{oL} = -\frac{V_{Don}(R_2+R_3)}{R_2} - \frac{VR_3}{R_2}$$

$$\Rightarrow \boxed{v_{oL} = -V_{Don}\left(1+\frac{R_3}{R_2}\right) - V\frac{R_3}{R_2}}$$

$$\boxed{v_{iL} = +\frac{R_1}{R_f} \cdot \left[+V_{Don}\left(1+\frac{R_3}{R_2}\right) + V\frac{R_3}{R_2}\right]}$$

$\Rightarrow$ Para D_1 conduzindo ($V_A = -V_{Don}$) e ($R_4 + R_5 =$ carga)

$$i_{in} = \frac{v_i}{R_1} \quad \Big| \quad i_{Rf} = \frac{-v_o}{R_f}$$

$$i_2 = \frac{V + V_{Don}}{R_2}$$

$$i_3 = \frac{-v_o - V_{Don}}{R_3}$$

$$i_D = i_3 - i_2 \Rightarrow i_D = -\frac{v_o}{R_3} \overbrace{- \frac{V_{Don}}{R_3} - \frac{V}{R_2} - \frac{V_{Don}}{R_2}}^{-K} \Rightarrow i_D = -\frac{v_o}{R_3} - K$$

$$i_{in} = i_{Rf} + i_D \Rightarrow \underbrace{i_{in}}_{\frac{v_i}{R_1}} = -\frac{v_o}{R_f} - \frac{v_o}{R_3} - K \Rightarrow \frac{v_i}{R_1} = -v_o\left(\frac{1}{R_f} + \frac{1}{R_3}\right) - K$$

$$\frac{v_i}{R_1} = -v_o \frac{R_f + R_3}{R_f R_3} - K \Rightarrow -v_o \cdot \frac{R_f+R_3}{R_f R_3} = \frac{v_i}{R_1} + K \Rightarrow \boxed{v_o = -\frac{R_f \| R_3}{R_1} v_i - R_f \| R_3 \, K}$$

• $v_i < 0 \Rightarrow v_o > 0 \Rightarrow V_A > 0 \Rightarrow D_1$ aberto

→ D_2 conduz quando $V_B = V_{Don}$

$$V_{Don} = -V\frac{R_4}{R_4+R_5} + v_o\frac{R_5}{L+R_4+R_5}$$

$$v_{OL^+} = V_{Don}\left(1+\frac{R_4}{R_5}\right) + V\frac{R_4}{R_5}$$

$$v_{iL^+} = -\frac{R_1}{R_F}\cdot\left[V_{Don}\left(1+\frac{R_4}{R_5}\right) + V\frac{R_4}{R_5}\right]$$

→ Para D_2 conduzindo ($V_B = V_{Don}$) e (R_3 e R_4 = carga)

$$v_o = -\frac{R_f \| R_4}{R_1} v_i - R_f \| R_4\, K'$$