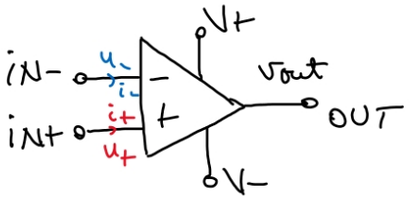
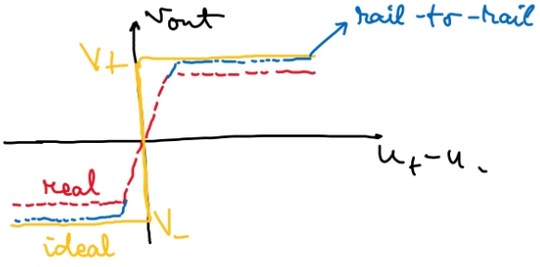
Laborator 6 FTFi:

Amplificatorul operațional: (A.O)

„op-amp".

A.O. - circuit integrat → tranzistori (BJT, FET)
→ rezistori
→ capacități





$$v_{out} = A_d(u_+ - u_-)$$

A_d - factorul de amplificare în buclă deschisă
„open-loop gain"

Caracteristici AO ideal:

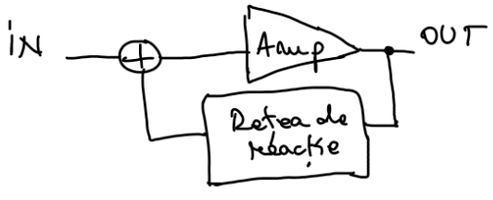
$A_d = \infty$
$z_{in} = \infty$
$z_{out} = 0$
$i_+ = 0$
$i_- = 0$

Caracteristici AO real:

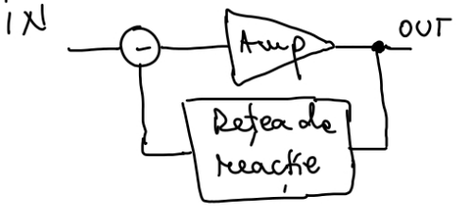
$A_d \geq 10^5$
$z_{in} \geq M\Omega$
$z_{out} \leq 100\,\Omega$
$i_+, i_- \simeq$ mA - pA

•) Reacția:

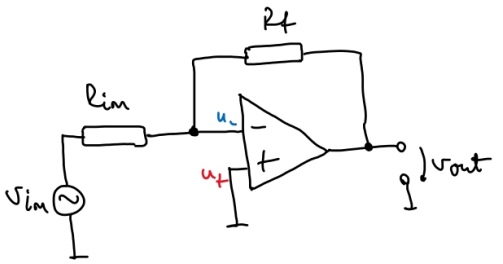
•) reacție pozitivă:



•) reacția negativă



) Conexiunea inversoare:

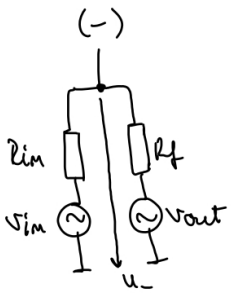


$V_{out} = ? = f(V_{in}, R_{in}, R_f)$

$V_{out} = A_d (u_+ - u_-)$

$u_+ = 0$

Schema echivalentă pt. IN -:



T. lui Millman:

$$u_{ech} = \frac{\frac{V_1}{R_1} + \frac{V_2}{R_2} + \dots + \frac{V_n}{R_n}}{\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}}$$

$$u_- = \frac{\frac{V_{in}}{R_{in}} + \frac{V_{out}}{R_f}}{\frac{1}{R_{in}} + \frac{1}{R_f}} = \frac{\frac{V_{in}R_f + V_{out}R_{in}}{R_{in}R_f}}{\frac{R_f + R_{in}}{R_{in}R_f}}$$

$$u_- = \frac{V_{in}R_f + V_{out}R_{in}}{R_f + R_{in}}$$

$$V_{out} = -A_d \cdot \frac{V_{in}R_f + V_{out}R_{in}}{R_f + R_{in}}$$

$$V_{out}(R_f + R_{in}) = -A_d V_{in} R_f - A_d V_{out} R_{in}$$

$$V_{out}(R_f + R_{in} + A_d R_{in}) = -A_d R_f V_{in}$$

$$V_{out} = \frac{-A_d R_f V_{in}}{R_f + R_{in} + A_d R_{in}}$$

$$V_{out} = \frac{-A_d R_f V_{in}}{A_d\left(\frac{R_f + R_{in}}{A_d} + R_{in}\right)}$$

$\frac{R_f + R_{in}}{A_d} \simeq 0$

$$V_{out} = -\frac{R_f}{R_{in}} \cdot V_{in}$$

$$u_- = \frac{V_{in}R_f + V_{out}R_{in}}{R_f + R_{in}} = \frac{V_{in}R_f - R_{in}\cdot\frac{R_f}{R_{in}}\cdot V_{in}}{R_f + R_{in}}$$

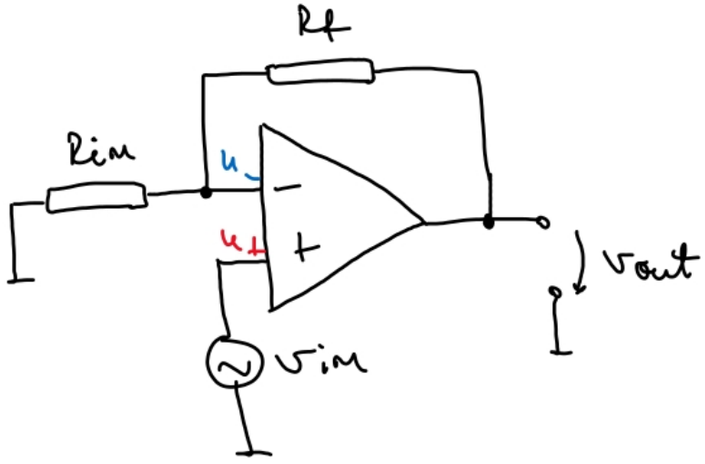
$V_{out} = A_{inv} \cdot V_{in}$

$A_{inv} = -\frac{R_f}{R_{in}}$

$u_- = 0$

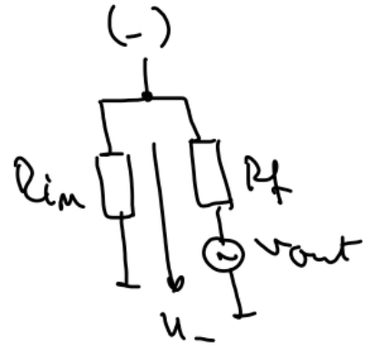
$u_+ \simeq u_-$ → valabilă pt. r. negativă.

Conexiunea neinversoare:



$v_{out} = f(v_{im}, R_f, R_{in})$

$u_+ = v_{im}$



T. lui Millman:

$$u_- = \frac{\frac{0}{R_{in}} + \frac{v_{out}}{R_f}}{\frac{1}{R_{in}} + \frac{1}{R_f}} =$$

$$= \frac{\frac{v_{out}}{R_f}}{\frac{R_{in}+R_f}{R_{in}R_f}} = \frac{v_{out}}{R_{in}+R_f} \cdot R_{in}$$

$$u_- \approx u_+ \Rightarrow \frac{v_{out}}{R_{in}+R_f} R_{in} = v_{in}$$

$$v_{out} = \frac{R_{in}+R_f}{R_{in}} \cdot v_{in}$$

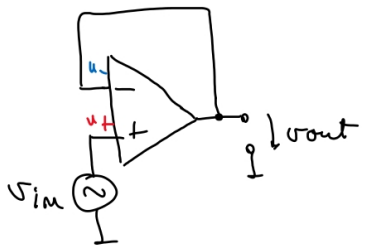
$$\boxed{v_{out} = \left(1 + \frac{R_f}{R_{in}}\right) v_{in}}$$

$v_{out} = A_{neinv} \cdot v_{in}$

$$A_{neinv} = 1 + \frac{R_f}{R_{in}}$$

·) Conexiunea repetoare:

„buffer", „voltage follower"



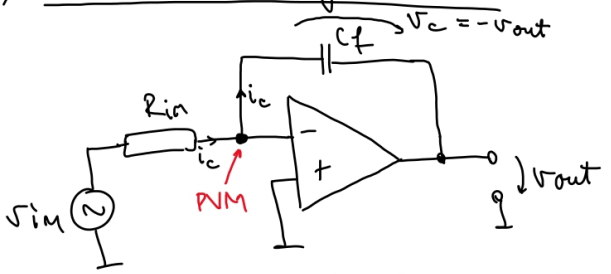
$v_{out} = v_{in}$

$A_{rep} = 1.$

$Z_{in} = \infty$

$Z_{out} = 0$

·) Conexiunea integratoare:



PVM = Punct Virtual de masă

Legea lui ohm pt. capacități:

$$i_C = C_f \frac{dv_C}{dt}$$

$$i_C = \frac{v_{in}}{R_{in}}$$

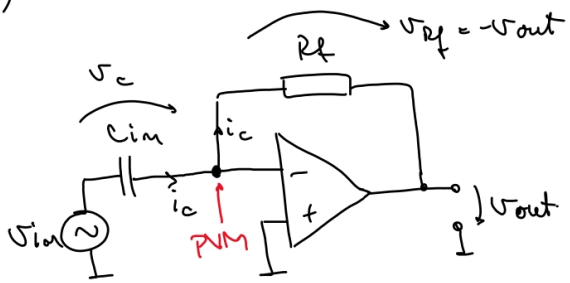
$$\Rightarrow \frac{v_{in}}{R_{in}} = C_f \cdot \frac{dv_C}{dt}$$

$$\frac{v_{in}}{R_{in}} = -C_f \cdot \frac{dv_{out}}{dt}$$

$$dv_{out} = -\frac{1}{C_f R_{in}} \cdot v_{in}\, dt \quad \Big| \int$$

$$v_{out} = -\frac{1}{C_f R_{in}} \int v_{in}\, dt$$

·) Conexiunea derivatoare



$$i_C = C_{in} \cdot \frac{dv_C}{dt}$$

$$-v_{out} = R_f \cdot i_C \qquad // v_{in}$$

$$v_{out} = -R_f \cdot C_{in} \cdot \frac{dv_C}{dt}$$

$$v_{out} = -R_f \cdot C_{in} \cdot \frac{dv_{in}}{dt}$$