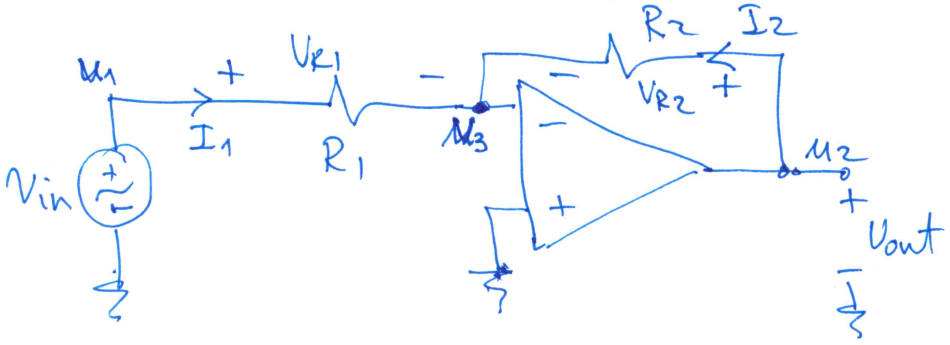
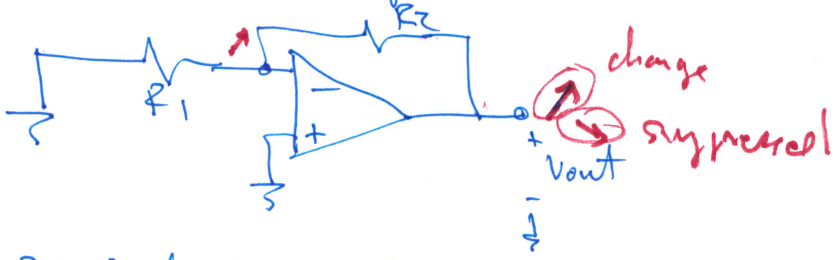
EE16A – Module 2 – Lecture 9

* NFB inspection examples
* Summing amp / Neuron
* Cascading ckt blocks
* Design procedure

Inverting amplifier example:



check for NFB! step 1: Null indep sources



step 2: Disk the output & follow the change in feedback

$u_1 = v_{in}$

$u_2 = v_{out}$

$u_3 = 0$ (b/c NFB ⇒ GR2)

$0 = v^+ = v^- = 0$

(KVL) $v_{R1} = u_1 - u_3 = v_{in}$

(KVL) $v_{R2} = u_2 - u_3 = v_{out}$

$v_{R1} = I_1 R_1$

$v_{R2} = I_2 R_2$

(KCL) $I_1 + I_2 = 0$

⇒ NFB ⇒ GR#2 applies ($v^+ = v^-$)

(R2)

$$I_1 R_1 = v_{in} \Rightarrow I_1 = \frac{v_{in}}{R_1} = \frac{u_1 - u_3}{R_1}$$

$$I_2 R_2 = v_{out} \Rightarrow I_2 = \frac{v_{out}}{R_2} = \frac{u_2 - u_3}{R_2}$$

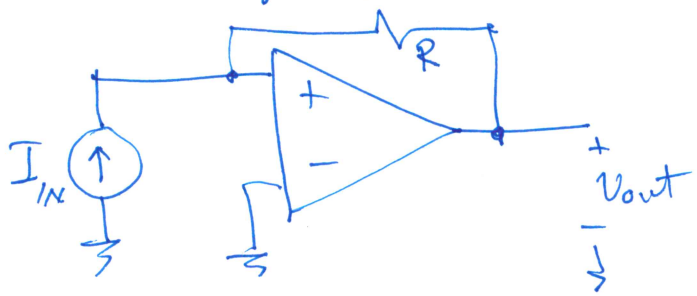
$$I_1 + I_2 = 0$$

$$\frac{v_{in}}{R_1} + \frac{v_{out}}{R_2} = 0 \Rightarrow \frac{v_{out}}{R_2} = -\frac{v_{in}}{R_1}$$

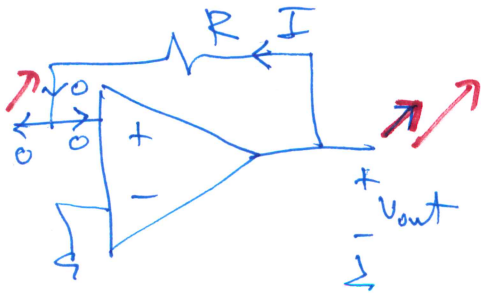
$$v_{out} = -\frac{R_2}{R_1} \cdot v_{in}$$

$$A_v = \frac{v_{out}}{v_{in}} = -\frac{R_2}{R_1}$$

NFB example #3:

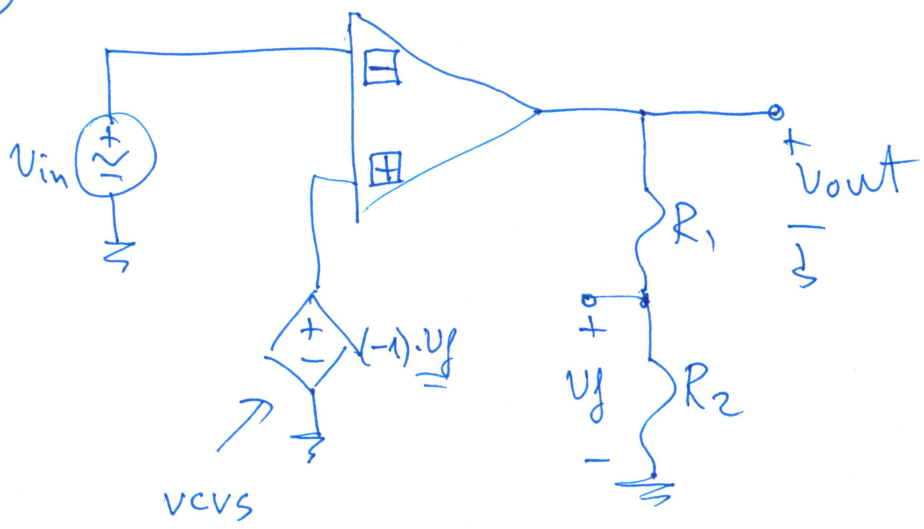


step 1:

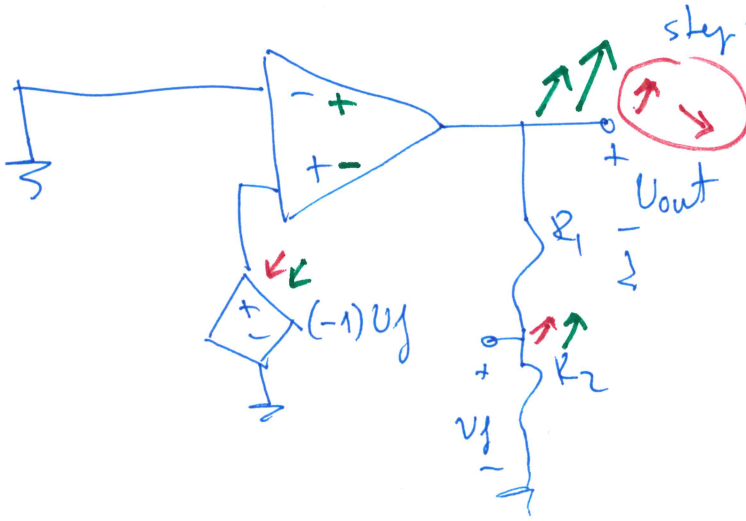


=> not NFB

(3)

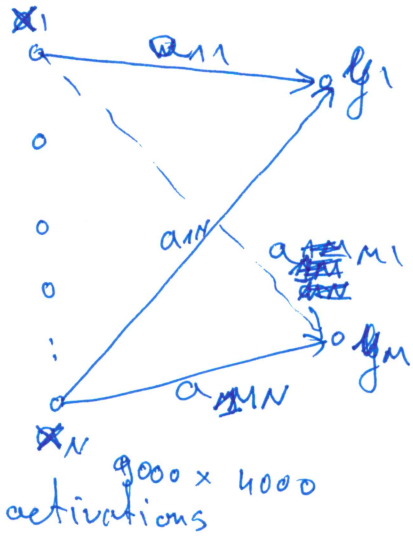

V_{in}
R_1
V_{out}
$(-1).V_f$
V_f
R_2
VCVS

step 1:


step 2:
=> NFB
change is
suppressed
V_{out}
R_1
R_2
$(-1)V_f$
V_f

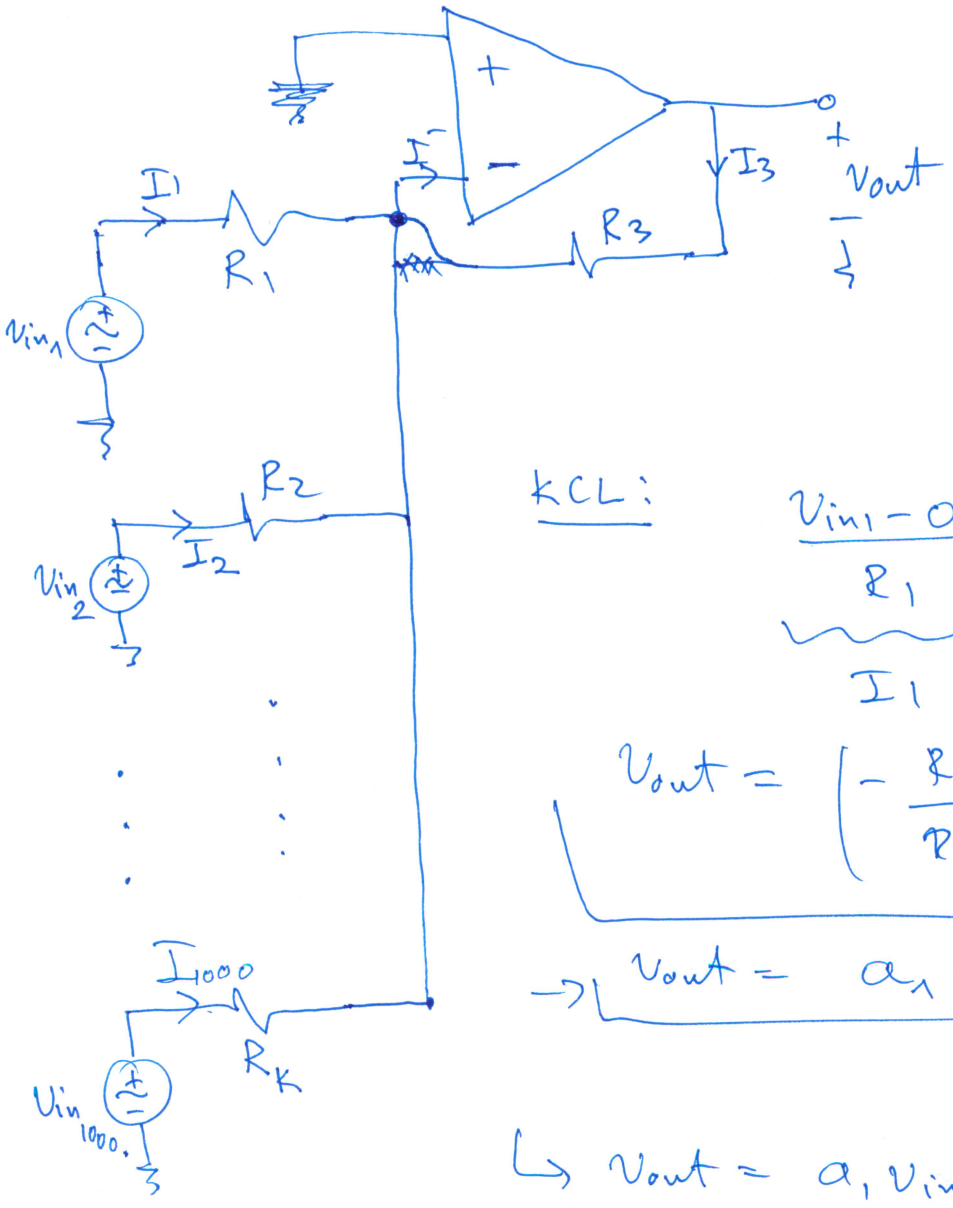
(l4)

FC layer on a DNN

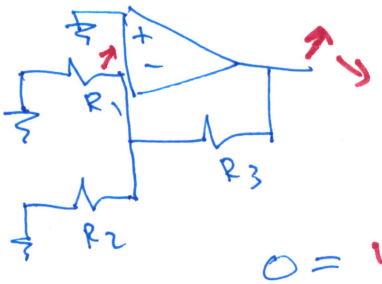


$$\underline{y} = A \cdot \underline{x}$$

$$\begin{bmatrix} y_1 \\ \vdots \\ y_M \end{bmatrix} = \begin{bmatrix} a_{11} & \cdots & a_{1N} \\ a_{M1} & \cdots & a_{MN} \end{bmatrix} \begin{bmatrix} x_1 \\ \vdots \\ x_N \end{bmatrix}$$



① check NFB



NFB ✓

⇓

GR#2

$0 = V^+ = V^-$

KCL:

$$\underbrace{\frac{V_{in1}-0}{R_1}}_{I_1} + \underbrace{\frac{V_{in2}-0}{R_2}}_{I_2} + \underbrace{\frac{V_{out}-0}{R_3}}_{I_3} = \underbrace{I^-}_{0}$$

$$V_{out} = \left(-\frac{R_3}{R_1}\right) V_{in1} + \left(-\frac{R_3}{R_2}\right) \cdot V_{in2}$$

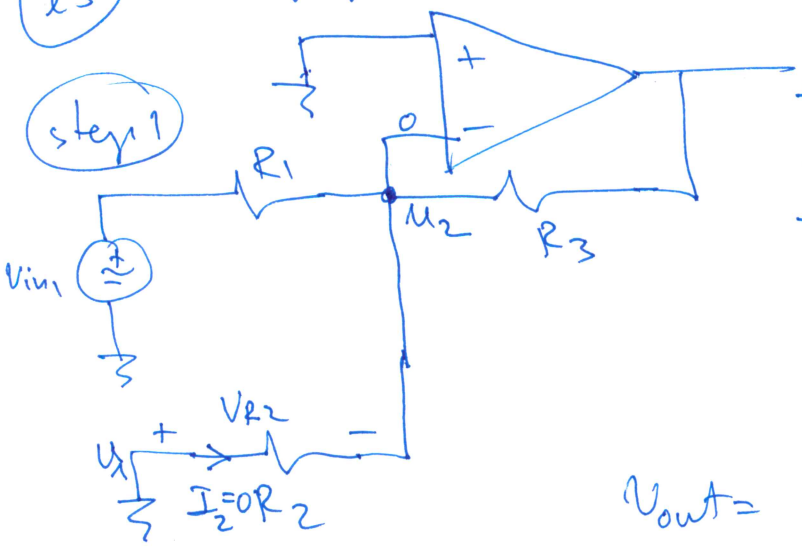
$$\rightarrow V_{out} = a_1 \cdot V_{in1} + a_2 \cdot V_{in2}$$

$$\left(-\frac{R_3}{R_K}\right)$$

$$\hookrightarrow V_{out} = a_1 V_{in1} + a_2 V_{in2} + \cdots + a_k V_{in_{1000}}$$

(15) Superposition

step 1



$$V_{out,1} = -\frac{R_3}{R_1} V_{in1}$$

$$V_{out,2} = -\frac{R_3}{R_2} V_{in2}$$

$$V_{out} = V_{out,1} + V_{out,2} = \left(-\frac{R_3}{R_1}\right) V_{in1} + \left(-\frac{R_3}{R_2}\right) V_{in2}$$

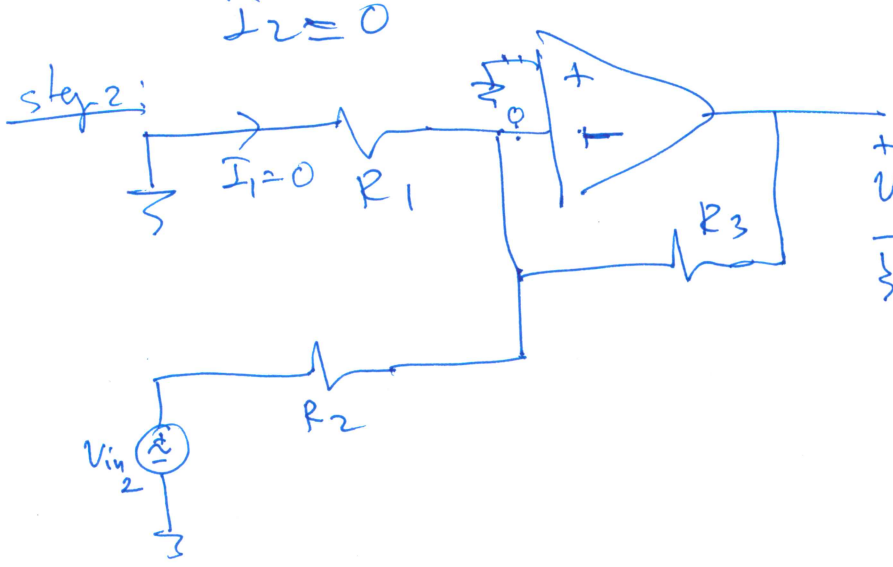
$$I_2 = \frac{V_{R2}}{R_2} \quad \text{(Ohm's law)}$$

$$V_{R2} = u_1 - u_2 = 0$$

$$\Downarrow$$

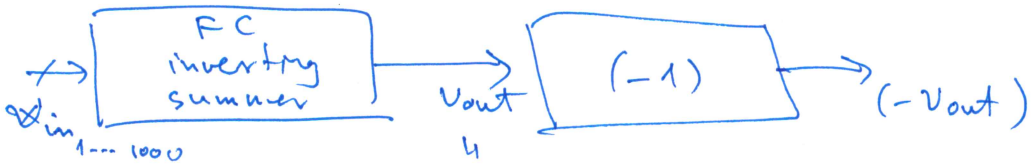
$$I_2 = 0$$

step 2:

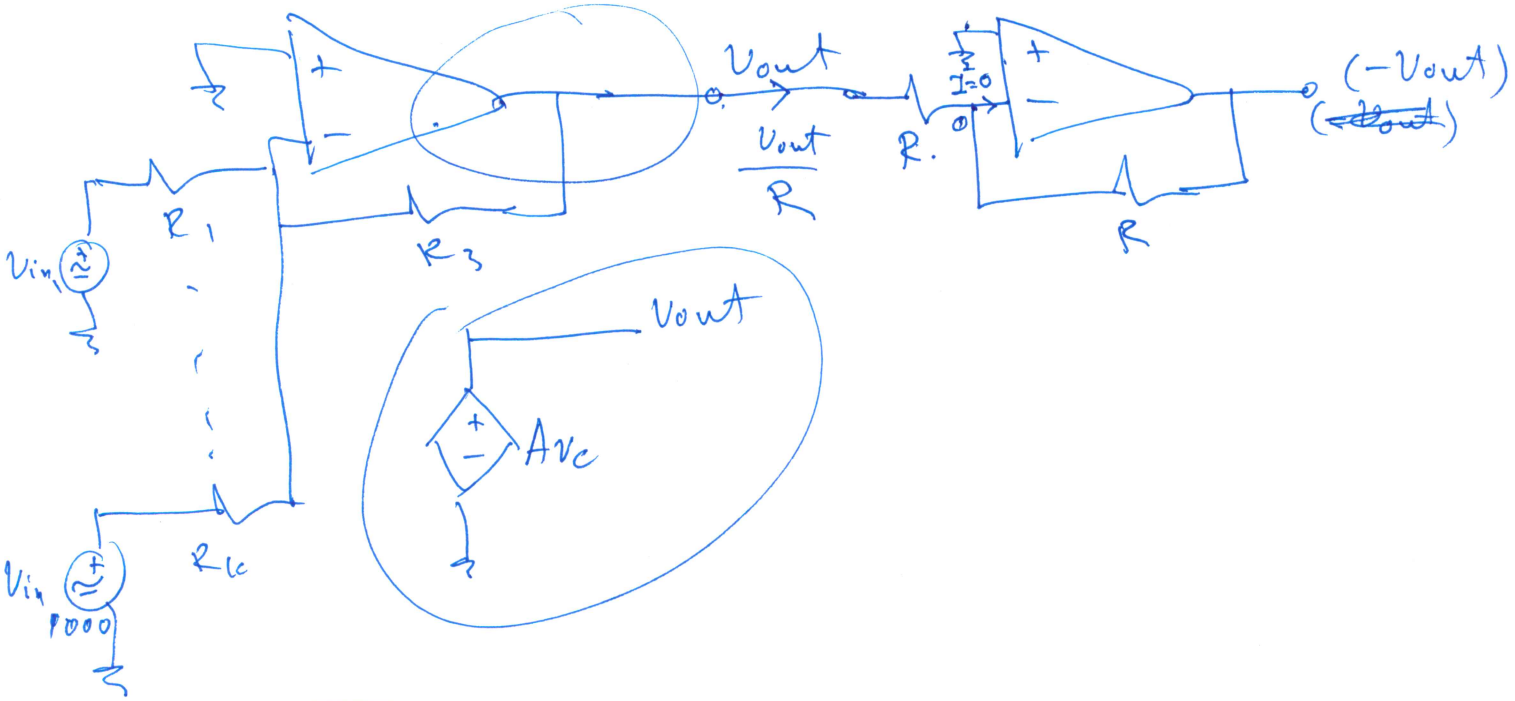


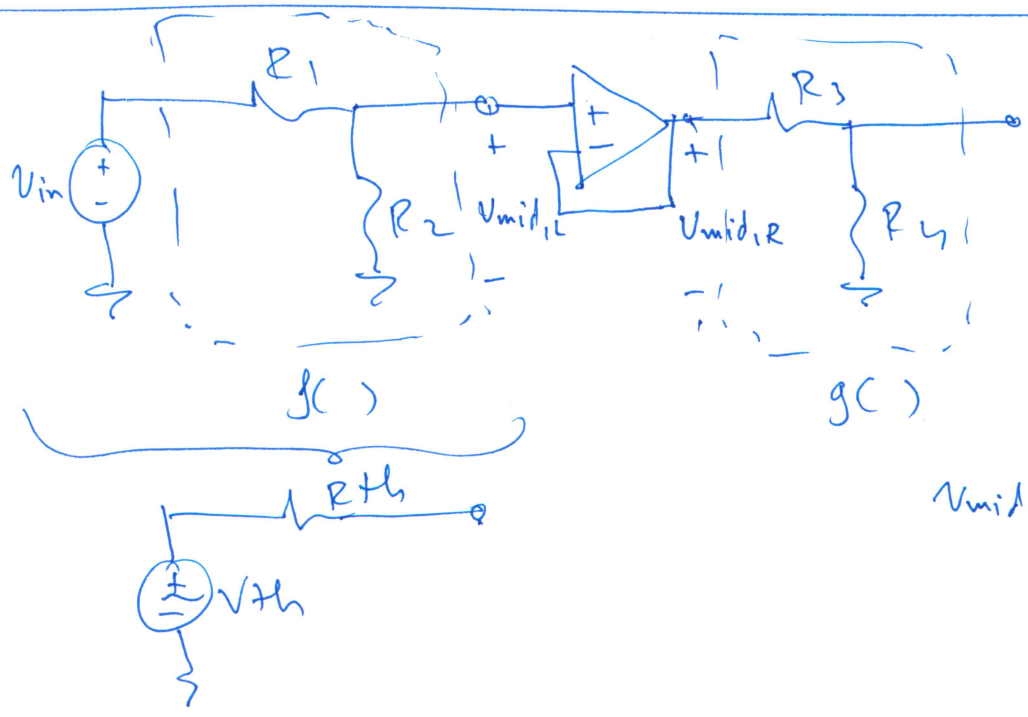
$$V_{out,2} = \left(-\frac{R_3}{R_2}\right) V_{in2}$$

Thinking in block diagrams:

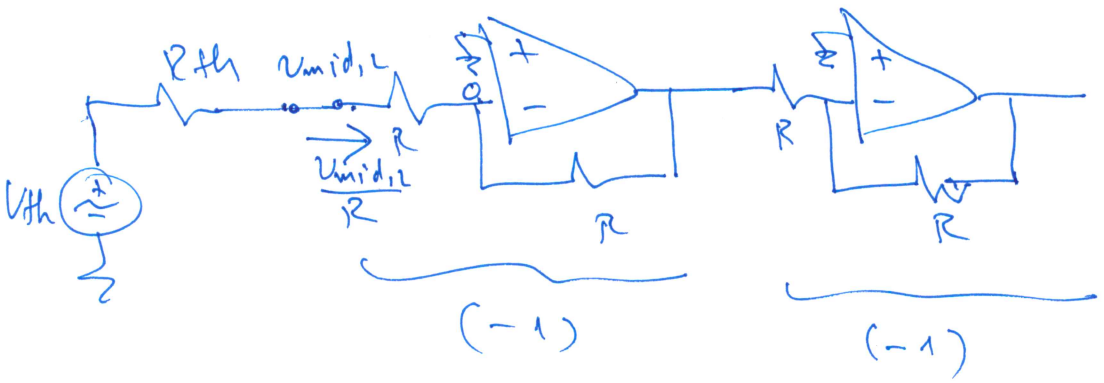


$$\left(-\frac{R_3}{R_1}\right)v_{in,1} + \cdots + \left(-\frac{R_3}{R_k}\right)v_{in,k}$$

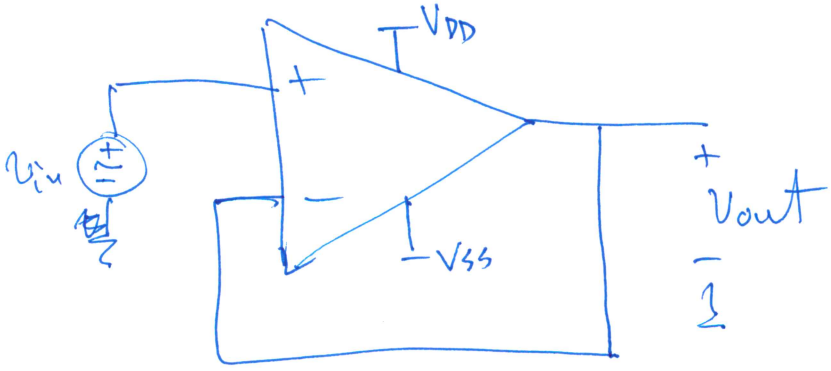


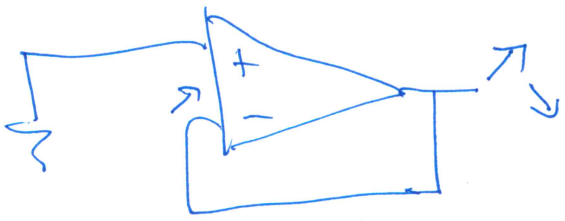


$$v_{mid,L} = v_{mid,R}$$



"Unity gain buffer"





NFB => GR2: $v^+ = v^-$

v_{in} "v_{out}"