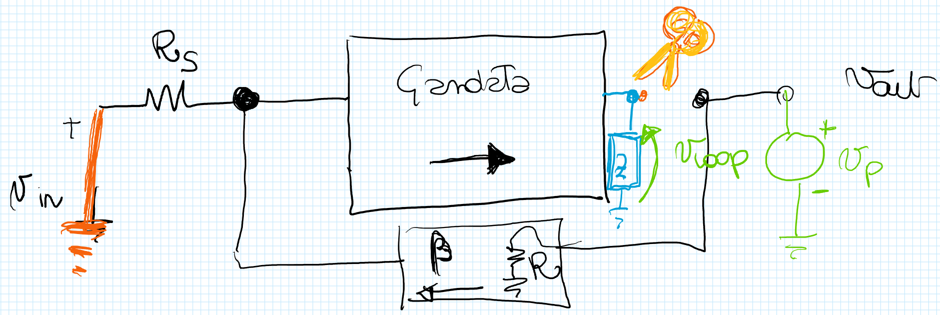
METODO DI CALCOLO DEL GUADAGNO D'ANELLO

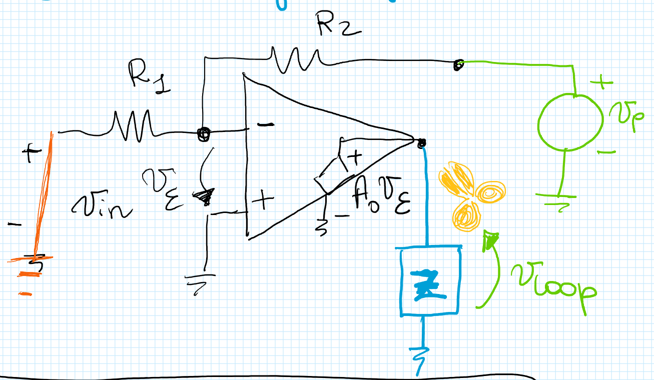


$Z = R$

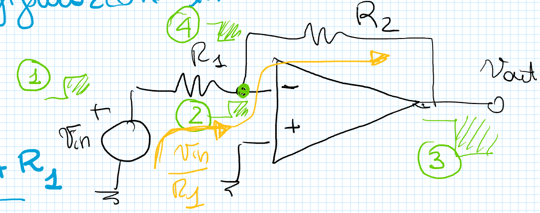
1. spegnere i gen. forzanti
2. Togliere l'anello (in un punto comodo)
3. ripristinare a monte del Taglio l'impedenza vista a valle
4. applicare a valle del Taglio un gen. di prova (v_p) e valutare il relativo segnale una volta percorso l'anello (v_{loop})

$$G_{loop} \triangleq \frac{v_{loop}}{v_p}$$

Calcolo del guadagno d'anello della configurazione invertente



$Z = R_2 + R_1$



$$G_{loop} \triangleq \frac{v_{loop}}{v_p} =$$

$$v^- = \frac{R_1}{R_1+R_2} v_p$$

$$v_\varepsilon = v^+ - v^- = -\frac{R_1}{R_1+R_2} v_p$$

$$v_{loop} = A_0 v_\varepsilon = -A_0 \frac{R_1}{R_1+R_2} v_p$$

$$G_{loop} \triangleq \frac{v_{loop}}{v_p} = -A_0 \frac{R_1}{R_1+R_2}$$

$$G_{reale} = \frac{G_{andata}}{1 - G_{loop}} = \frac{G_{andata}}{1 + G_{andata}\beta} =$$

$$= \left(\frac{1}{\beta}\right) \cdot \frac{G_{andata}}{1 + \frac{1}{G_{andata}\beta}} \frac{1}{G_{andata}} =$$

$$G_{loop} = -G_{andata}\beta$$

$$= \frac{G_{ideale}}{1 - \frac{1}{G_{loop}}} =$$

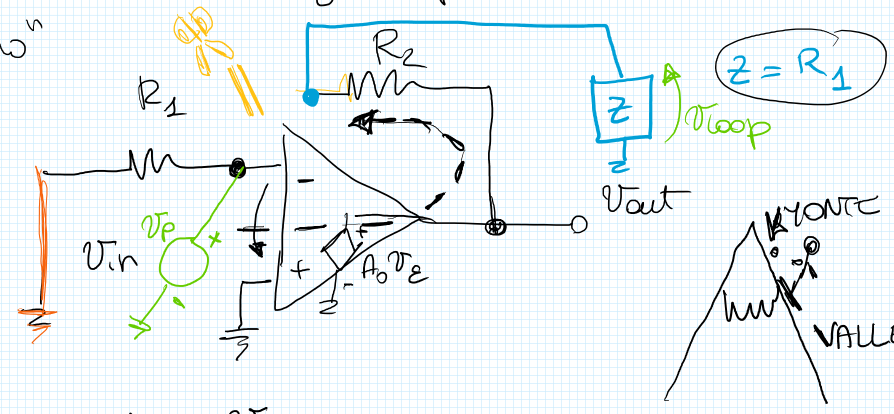
$= -R_2/R_1 \ldots$ 1 ... GUADAGNO REALE

G_{loop}

$$= \frac{-R_2/R_1}{1 + \frac{1}{A_0}\frac{R_1+R_2}{R_1}} = -\frac{R_2}{R_1}\,\frac{1}{1+\frac{1}{A_0}\left(1+\frac{R_2}{R_1}\right)}$$

GUADAGNO REALE CONFIG. INVERTENTE

Calcolo nuovamente il guadagno d'anello tagliando in un punto "scomodo"

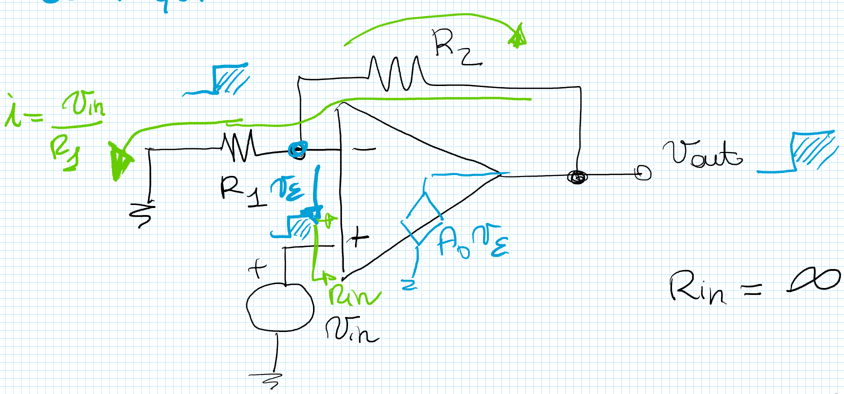


$$v_E = -v_p$$

$$v_{loop} = A_0 v_E \frac{Z}{Z+R_2} = -A_0 \frac{R_1}{R_1+R_2} v_p$$

$$G_{loop} \triangleq \frac{v_{loop}}{v_p} = -A_0 \frac{R_1}{R_1+R_2}$$

CONFIGURAZIONE NON INVERTENTE



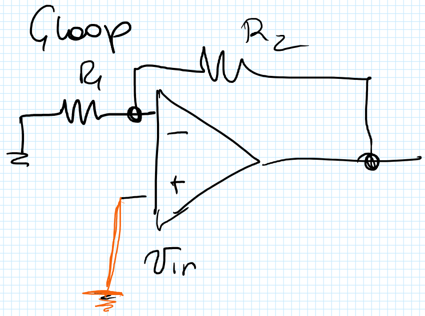
$R_{in} = \infty$!!

$v^- = v_{in}$ (per la retroazione o per il cortocircuito virtuale tra i morsetti dell'opamp)

$$v_{out} = v^- + i R_2 = v_{in} + \frac{v_{in}}{R_1} R_2 = v_{in}\left(1+\frac{R_2}{R_1}\right)$$

$$G_{ideale} = \left.\frac{v_{out}}{v_{in}}\right|_{opamp\ ideale} = 1 + R_2/R_1$$

Calcolo Gloop



Gloop è identico al Gloop della config. invertente

$$G_{reale} = \frac{G_{ideale}}{1 - 1/G_{loop}}$$

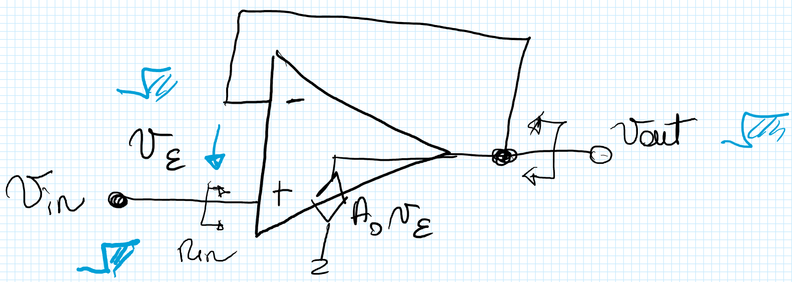
ERRORE STATICO DI GUADAGNO

$$\varepsilon = \left| \frac{G_{ideale}(0) - G_{reale}(0)}{G_{reale}(0)} \right| = \left| \frac{G_{ideale}(0) - \frac{G_{ideale}(0)}{1 - 1/G_{loop}(0)}}{\frac{G_{ideale}(0)}{1 - 1/G_{loop}(0)}} \right|$$

$$= \left| \frac{\frac{1 - 1/G_{loop}(0) - 1}{1 - 1/G_{loop}(0)}}{\frac{1}{1 - 1/G_{loop}(0)}} \right| = \frac{1}{|G_{loop}(0)|}$$

BUFFER DI TENSIONE

$$\begin{cases} G = 1 \\ R_{in} \to \infty \\ R_{out} \to 0 \end{cases}$$



$v^- = v^+ = v_{in}$

$v_{out} = v^- = v^+ = v_{in}$

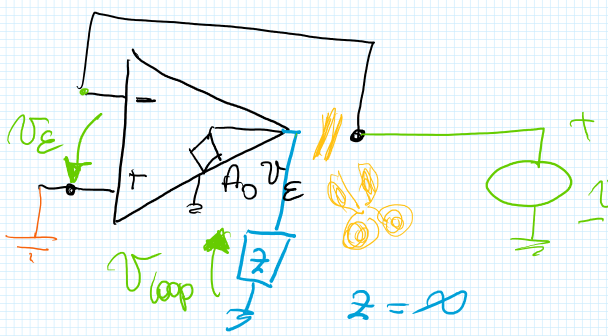
$$G_{ideale} \triangleq \frac{v_{out}}{v_{in}} = 1$$

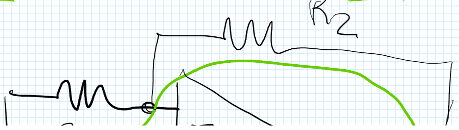
Gloop

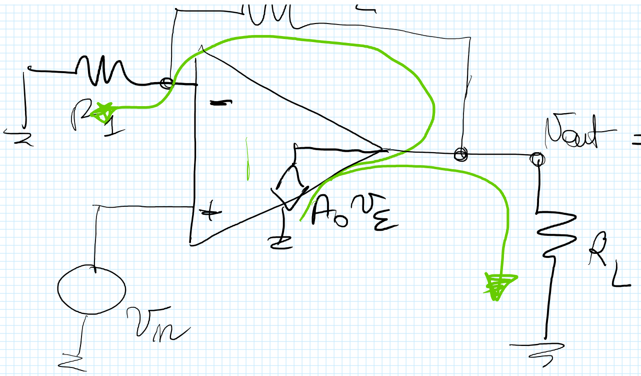
$v_\varepsilon = -v_p$

$v_{loop} = A_0 v_\varepsilon = -A_0 v_p$

$$\boxed{G_{loop} = \frac{v_{loop}}{v_p} = -A_0}$$

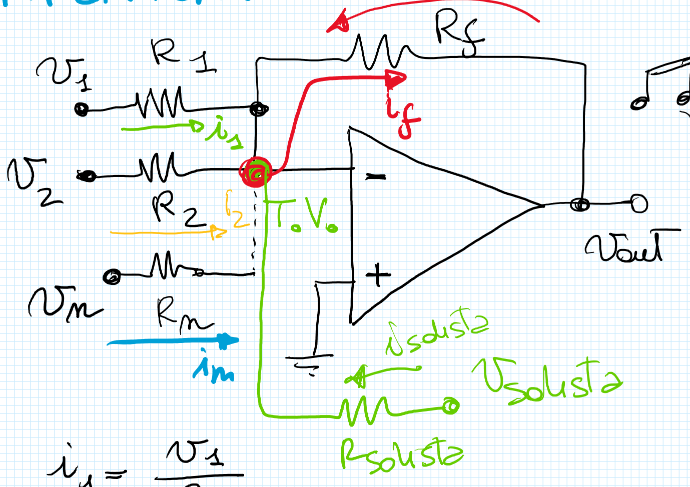


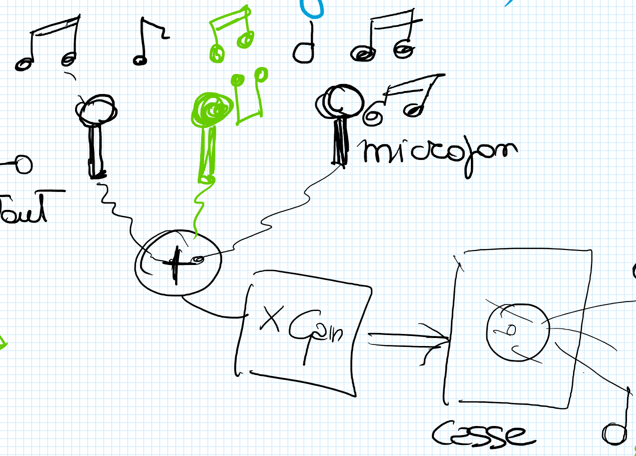




$$v_{out} = \left(1 + \frac{R_2}{R_1}\right) v_{in}$$

AMPLIFICATORE SOMMATORE (Voltage adder summing inverter)





$$i_1 = \frac{v_1}{R_1}$$

$$i_2 = \frac{v_2}{R_2}$$

$$\vdots$$

$$i_n = \frac{v_n}{R_n}$$

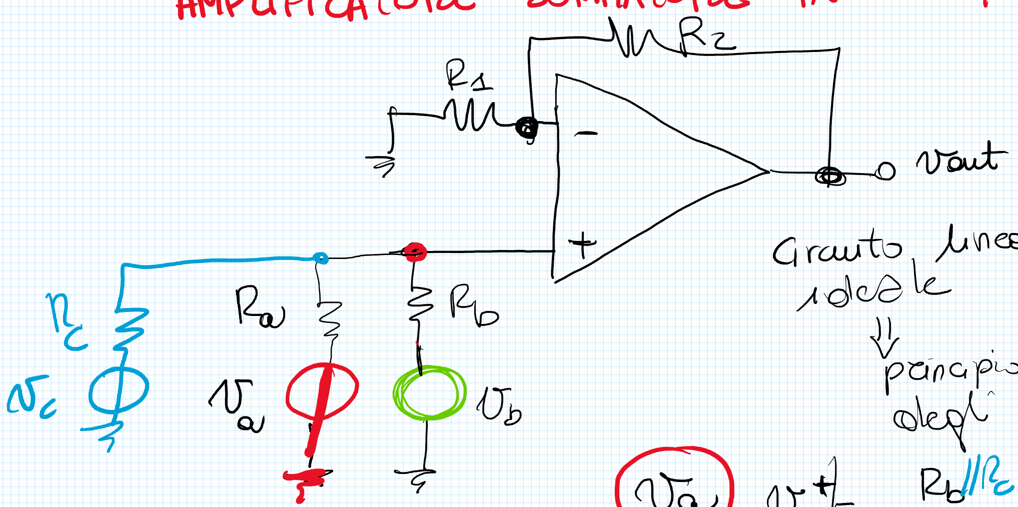
$$i_f = i_1 + i_2 + \dots\ i_n + i_{solista}$$

$$v_{out} = -i_f R_f = -R_f \left[\frac{v_1}{R_1} + \frac{v_2}{R_2} + \dots \frac{v_n}{R_n}\right.$$

$$= -\frac{R_f}{R_1} v_1 - \frac{R_f}{R_2} v_2 \dots - \frac{R_f}{R_n} v_n -$$

$$- \frac{R_f}{R_{solista}} v_{solista}$$

AMPLIFICATORE SOMMATORE IN CONFIGURAZIONE NON INVERTENTE



Circuito lineare (assumendo opamp ideale)

⇓

principio di sovrapposizione degli effetti

(v_a) $\quad v^+\Big|_{v_a} = \frac{R_b /\!/ R_c}{R_a + R_b /\!/ R_c} v_a$

$\dots \left(1 + \frac{R_2}{\dots}\right) v^+ \dots$

$$v_{out}\Big|_{v_a} = \left(1+\frac{R_2}{R_1}\right) v^+\Big|_{v_a}$$

$$= \left(1+\frac{R_2}{R_1}\right) \frac{R_b // R_c}{R_a + R_b // R_c} v_a$$

v_b

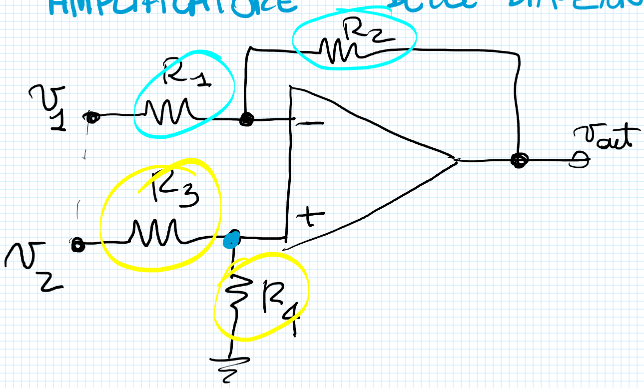
$$v^+\Big|_{v_b} = \frac{R_a}{R_a+R_b} v_b$$

$$v_{out}\Big|_{v_b} = \left(1+\frac{R_2}{R_1}\right) v^+\Big|_{v_b} =$$

$$= \left(1+\frac{R_2}{R_1}\right) \frac{R_a}{R_b+R_a} v_b$$

$$v_{out} = v_{out}\Big|_{v_a} + v_{out}\Big|_{v_b} = \left(1+\frac{R_2}{R_1}\right)\left[\frac{R_a v_b}{R_a+R_b} + \frac{R_b v_a}{R_a+R_b}\right]$$

AMPLIFICATORE DELLE DIFFERENZE



4° LABORATORIO
20 e 27 maggio

$$\begin{cases} v_{cm} = \dfrac{v_1+v_2}{2} \\ v_d = v_2 - v_1 \end{cases}$$

$$v_1 = v_{cm} - v_d/2$$

$$v_2 = v_{cm} + v_d/2$$

Applico il princ. di sovrapposizione degli effetti al circuito che è lineare

$$v_{out}\Big|_{v_1} = -\frac{R_2}{R_1} v_1$$

$$v_{out}\Big|_{v_2} = \overbrace{\frac{R_4}{R_3+R_4} v_2}^{v^+|_{v_2}} \left(1+\frac{R_2}{R_1}\right)$$

$$v_{out} = v_{out}\Big|_{v_1} + v_{out}\Big|_{v_2} = -\frac{R_2}{R_1} v_1 + \frac{R_4}{R_4+R_3}\left(1+\frac{R_2}{R_1}\right) v_2$$

per avere un amplificatore "delle differenze"

$$+\frac{R_2}{R_1} = \frac{R_4}{R_4+R_3}\left(\frac{R_1+R_2}{R_1}\right)$$

$R_2 = R_4$
$R_3 = R_1$

$$\frac{R_2}{R_2+R_1} \cdot \left(1+\frac{R_2}{R_1}\right)$$

$$R_2 (R_4+R_3) = R_4 (R_1+R_2)$$

$$R_2 (R_4 + R_3) = R_4 (R_1 + R_2)$$

$$\cancel{R_2 R_4} + R_2 R_3 = R_4 R_1 + \cancel{R_4 R_2}$$

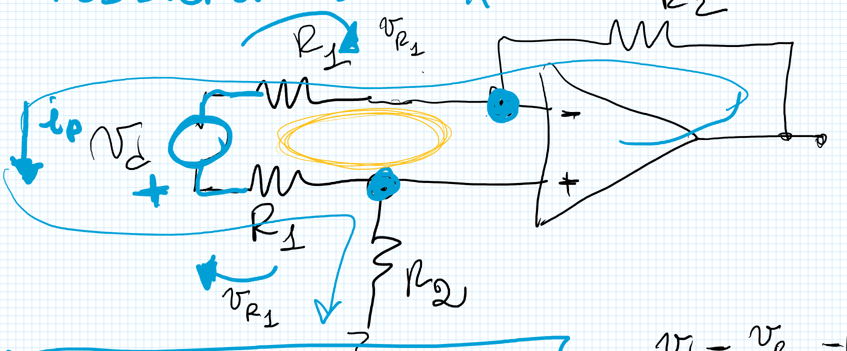
$$R_2 R_3 = R_4 R_1$$

$$\frac{R_2}{R_1} = \frac{R_4}{R_3}$$

$$\frac{R_2}{R_2 + R_1} \cdot \left(1 + \frac{R_2}{R_1}\right) = \frac{R_2}{\cancel{R_2 + R_1}} \cdot \frac{\cancel{(R_1 + R_2)}}{R_1} = \frac{R_2}{R_1}$$

$$\boxed{\begin{aligned} R_2 &= R_4 \\ R_3 &= R_1 \end{aligned}} \Rightarrow \boxed{v_{out} = -\frac{R_2}{R_1} v_1 + \frac{R_2}{R_1} v_2 = \frac{R_2}{R_1}(v_2 - v_1)}$$

RESISTENZA DI INGRESSO

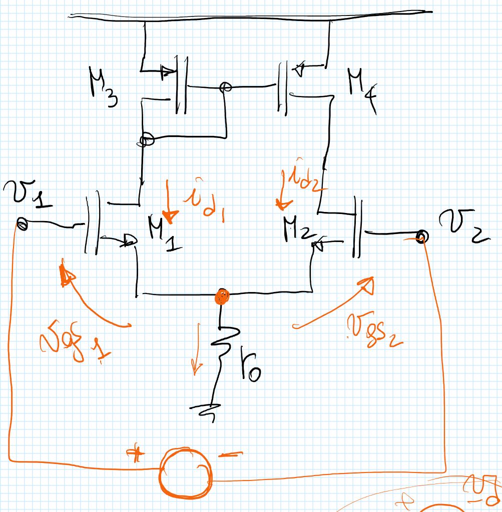


$$\boxed{R_{eq} = \frac{v_d}{i_p} = 2 R_1}$$

$$v_d - v_{R_1} - \underbrace{(v^+ - v^-)}_{\text{per il cortocirc. virtuale tra i morsetti opamp}} - v_{R_1} = 0$$

(con $v^+ - v^- = 0$)

$$v_d = 2 v_{R_1} = 2 i R_1$$



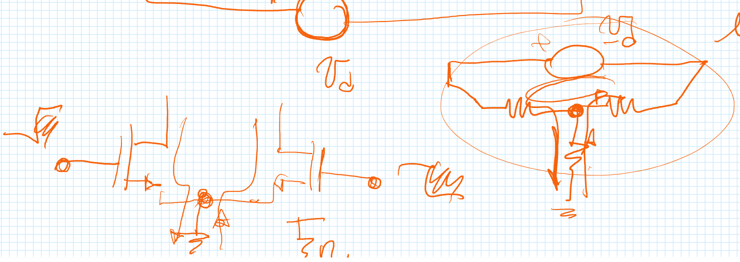
$$v_1 - v_2 = v_d = v_{g_1} - v_{g_2}$$

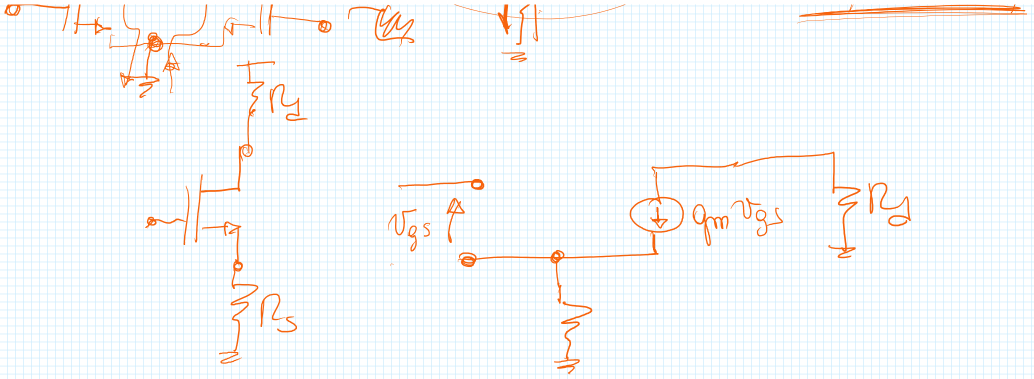
$$v_d = v_{gs_1} - v_{gs_2} \Rightarrow v_{gs_1} = v_d + v_{gs_2}$$

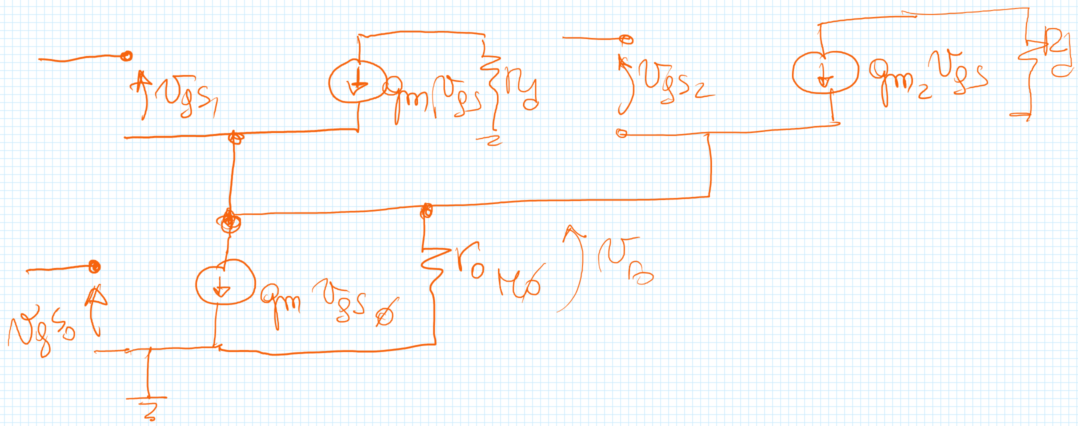
$$i_{d_1} = g_m v_{gs_1}$$

$$i_{d_2} = g_m v_{gs_2}$$

$$i_{r_0} = i_{d_1} + i_{d_2} = g_m v_{gs_1} + g_m v_{gs_2}$$




Rd
Rs
vgs
gm vgs
Rd


vgs1
gm1 vgs
Rd
vgs2
gm2 vgs
Rd
gm vgs0
r0 M0
vD
vgs0