Amplificatore Operazionale

Thursday, March 23, 2017 9:38 AM

Amplificatore DIFFERENZIALE a più stadi

→ Caratteristiche IDEALI

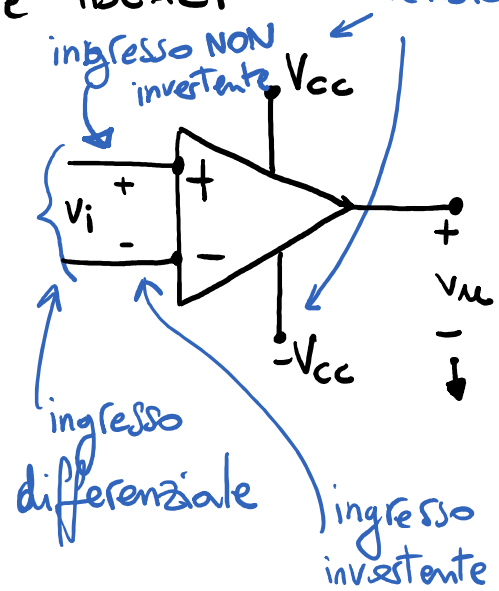
$R_{in} \to \infty$

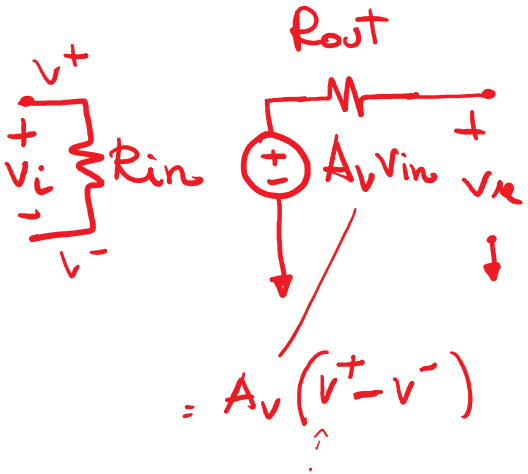
$R_{out} = 0$

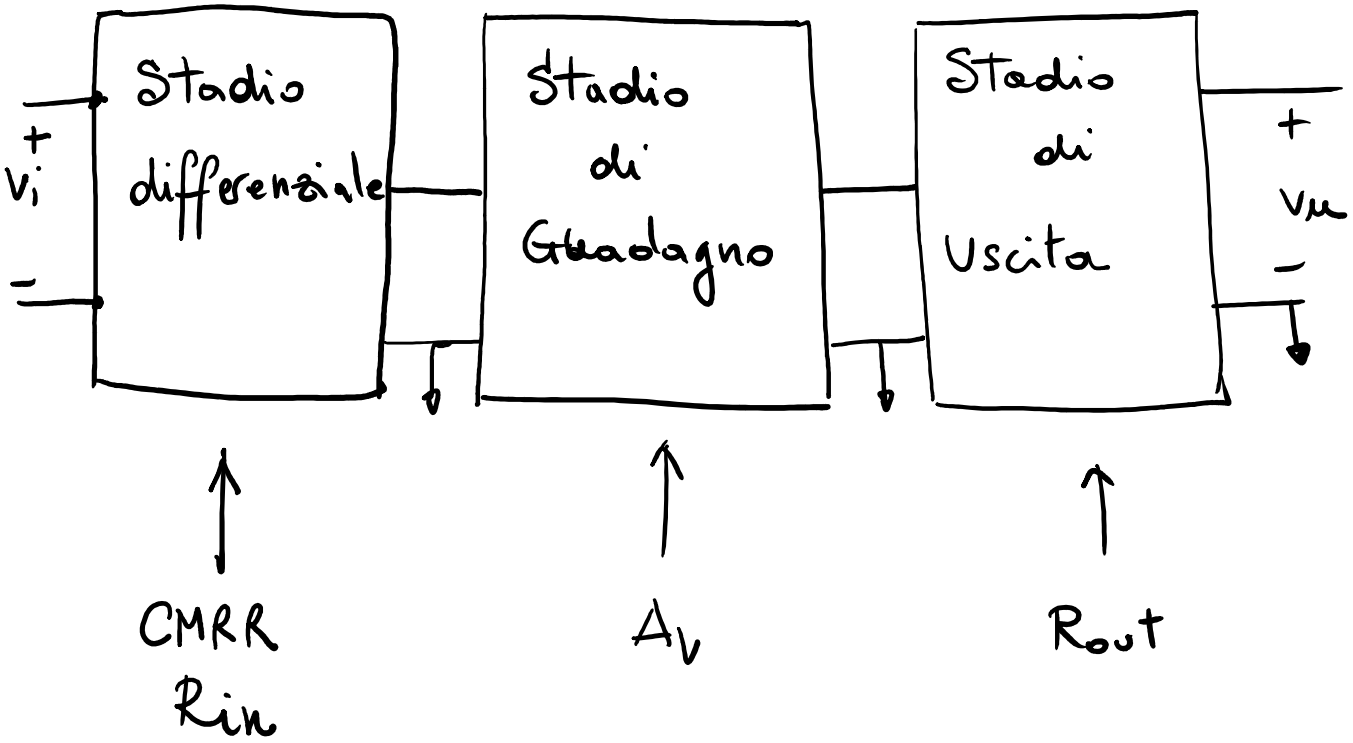
$A_d = A_V \to \infty$

$CMRR \to \infty$

$f_H \to \infty$





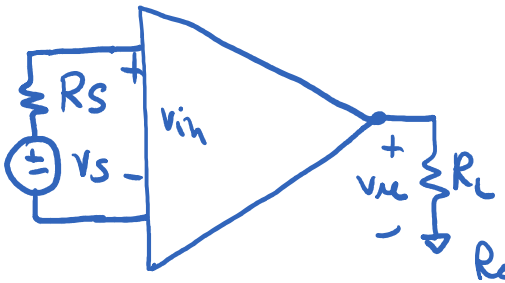

Stadio differenziale
Stadio di Guadagno
Stadio di Uscita
+
V_i
−
+
V_u
−
CMRR
Rin
A_v
Rout

L'Amplificatore operazionale è un

Thursday, March 23, 2017 9:49 AM

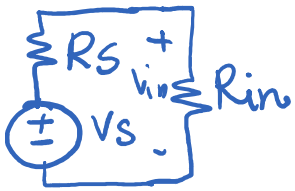
AMPLIFICATORE DIFFERENZIALE DI TENSIONE IDEALE

[l'amplificazione di tensione NON DIPENDE dal carico e dal generatore di ingresso]



$$v_{in} = v_S \frac{R_{in}}{R_{in}+R_S}$$

$$V_u = A_V v_{in} \frac{R_L}{R_L + R_{out}}$$



$$\left|\frac{V_u}{V_S}\right| = A_V \left(\frac{R_L}{R_L + R_{out}}\right)\left(\frac{R_{in}}{R_{in}+R_S}\right) = A_V$$

Amplificatore Operazionale reale

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$R_{in} = 1M\Omega \div 10\ G\Omega$

$R_{out} = 100 \div 1\ \Omega$

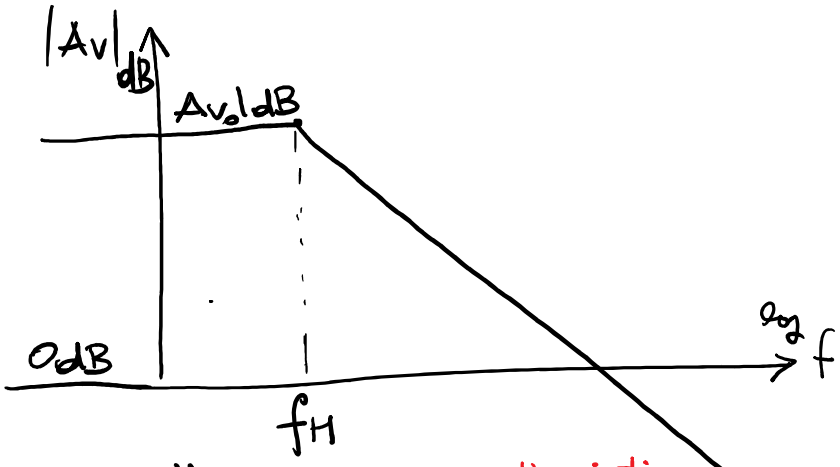
$A_{Vo} = 1000 \div 1M$

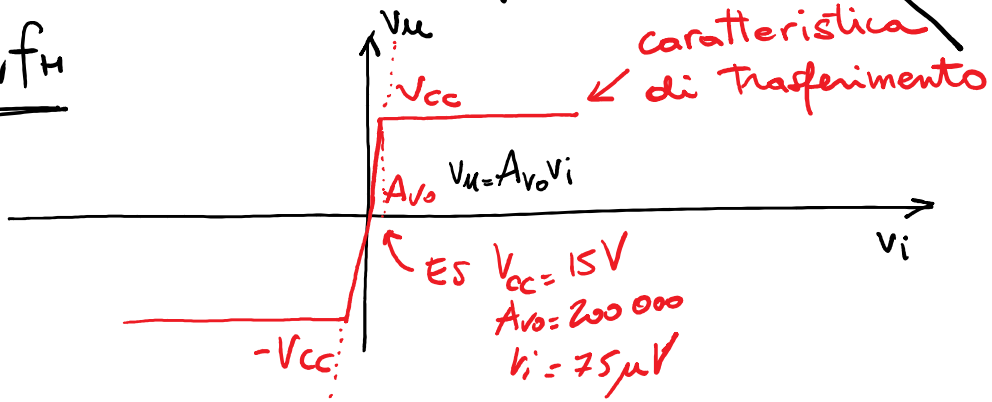
$CMRR = 10^3 \div 10^6$

$f_H = 1\ Hz - 1\ KHz$

$PGB = GBP = A_V f_H$

↑ Gain Bandwidth Product





Amplificatore invertente

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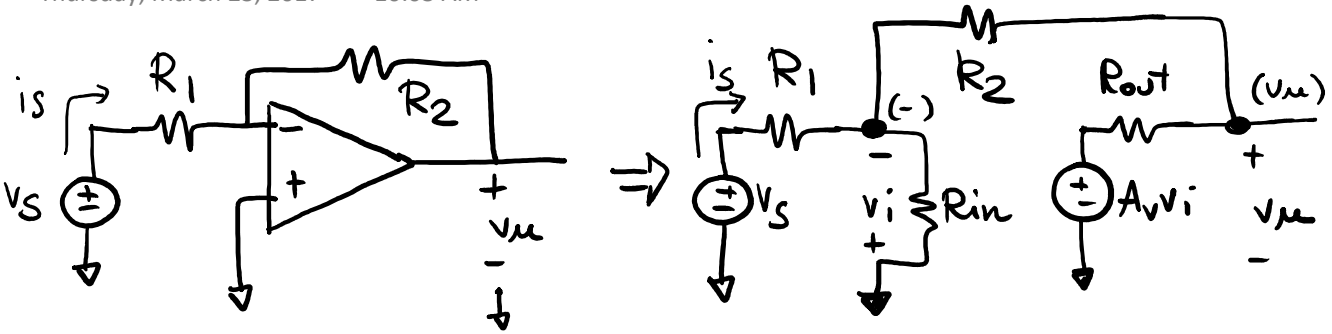


nodo (-)

$$-v_i\left[\frac{1}{R_1}+\frac{1}{R_{in}}+\frac{1}{R_2}\right]-v_S\frac{1}{R_1}-v_u\frac{1}{R_2}=0$$

nodo (v_u)

$$v_u\left[\frac{1}{R_2}+\frac{1}{R_{out}}\right]+v_i\frac{1}{R_2}-A_V v_i\frac{1}{R_{out}}=0 \Rightarrow v_i = \frac{\left[\frac{1}{R_2}+\frac{1}{R_{out}}\right]}{\left[\frac{A_V}{R_{out}}-\frac{1}{R_2}\right]}v_u$$

$$\frac{\left[\frac{1}{R_2}+\frac{1}{R_{out}}\right]\left[\frac{1}{R_1}+\frac{1}{R_{in}}+\frac{1}{R_2}\right]}{\left[\frac{A_V}{R_{out}}-\frac{1}{R_2}\right]} V_M + \frac{V_M}{R_2} + \frac{V_S}{R_1} = 0 \quad \rightsquigarrow \frac{V_M}{V_S} = \dots$$

se $A_V \to \infty$ $\rightarrow$ $\frac{V_M}{R_2} + \frac{V_S}{R_1} = 0$ $\Rightarrow$ $\boxed{\frac{V_M}{V_S} = -\frac{R_2}{R_1}}$ $\Leftarrow$ NON DIPENDE DAI PARAMETRI DELL'A.O.

Resistenza di ingresso

$i_S = \frac{V_S + V_i}{R_1}$ se $A_V \to \infty$ $V_i \to 0$ $i_S = \frac{V_S}{R_1}$ $\boxed{R_i = \frac{V_S}{i_S} = R_1}$

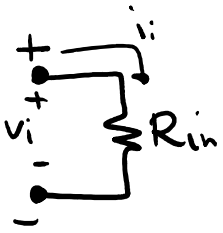
Approssimazione di corto circuito virtuale

Thursday, March 23, 2017 10:16 AM

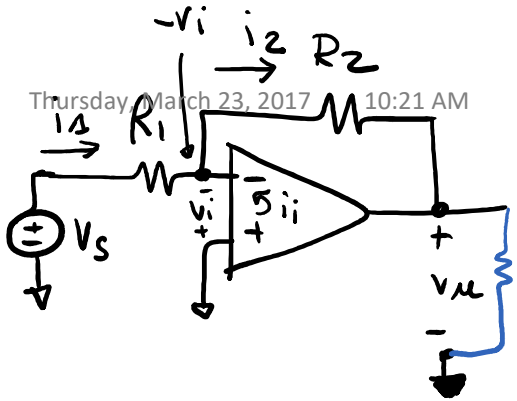
$$\begin{cases} v_i \sim 0 \\ i_i \sim 0 \end{cases}$$

$v_i = \frac{v_u}{A_v} \sim 0$ se A.O. è in zona lineare e $A_v \gg 1$

$i_i = \frac{v_i}{R_{in}} \sim 0$



c.c. virtuale perche $i_i = 0$



$$i_1 = \frac{v_S + v_i}{R_1}$$

CCV $v_i = 0 \rightarrow i_1 = \frac{v_S}{R_1}$

$$i_2 = i_1 + i_i$$

CCV $i_i = 0 \rightarrow i_2 = i_1$

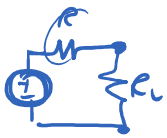
$$v_M = -v_i - R_2 i_2$$

CCV $v_i = 0 \rightarrow v_M = -R_2 i_2 = -R_2 i_1 = -\frac{R_2}{R_1} v_S$

$$\frac{v_M}{v_S} = -\frac{R_2}{R_1}$$

NON DIPENDE DA R_L

$R_{out} = 0$



$$R_i = \frac{v_S}{i_1} = R_1$$

Amplificatore NON invertente

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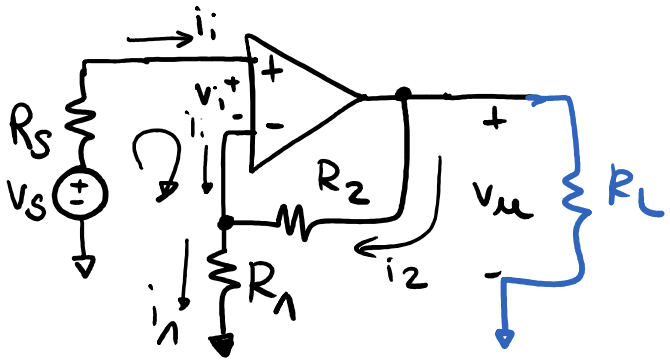


eq. maglia di ingresso

$$v_S = R_S i_i + v_i + R_1 i_1$$

CCV

$$v_S = R_1 i_1$$

$$i_2 = i_1 - i_i = i_1$$

CCV

$$v_u = R_1 i_1 + R_2 i_2 = \frac{R_1 + R_2}{R_1} v_S$$

$$\frac{v_u}{v_S} = \frac{R_1 + R_2}{R_1}$$

NON DIPENDE DA R_L

$R_{out} = 0$

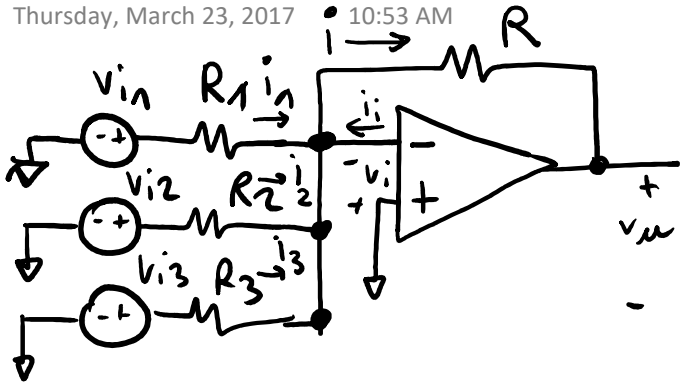
$$R_i = \frac{v_S}{i_i} = \infty$$

NON DIPENDE DA R_S

AMPLIFICATORE DI TENSIONE IDEALE

Sommatore

Thursday, March 23, 2017 10:53 AM



ccv $\quad v_i = 0$

$$i_1 = \frac{v_{in}}{R_1} \qquad i_2 = \frac{v_{i2}}{R_2}$$

$$i_3 = \frac{v_{i3}}{R_3}$$

ccv

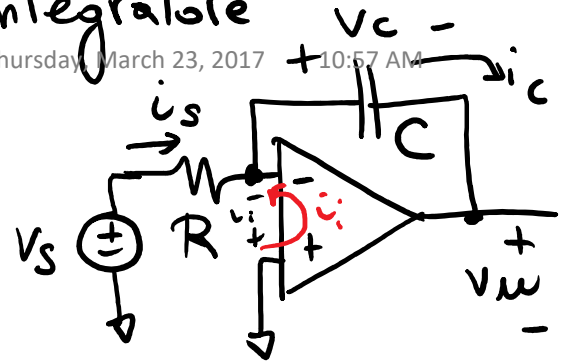
$$i = i_1 + i_2 + i_3 + \cancel{i_i}$$

ccv

$$v_u = \cancel{-v_i} - Ri = \left[\frac{R}{R_1} v_{in} + \frac{R}{R_2} v_{i2} + \frac{R}{R_3} v_{i3}\right]$$

Integratore

Thursday, March 23, 2017 10:57 AM



ccv $v_i = 0$

$$i_s = \frac{V_s}{R}$$

$$i_c = i_s + \cancel{i_i} \quad \text{ccv}$$

$$v_u = -\cancel{v_i} - v_c(t) = -\left[v_c(0) + \int_0^t \frac{i_c(t')dt'}{C}\right] =$$

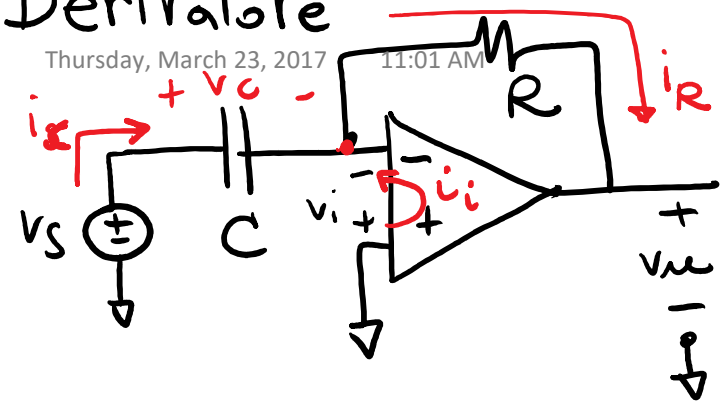
ccv

$$v_u(t) = -v_c(0) - \frac{1}{RC}\int_0^t v_s(t')dt'$$

$$V_u(s) = \frac{-1}{RCs} V_s(s)$$

Derivatore

Thursday, March 23, 2017 11:01 AM



$v_i = 0$ ccv

$v_c = v_s + \cancel{v_i}$

$i_c = C\frac{dv_c}{dt} = C\frac{dv_s}{dt}$

$i_R = i_c + \cancel{i_i}$ ccv

$v_u = -\cancel{v_i} - R i_R = -RC\frac{dv_s}{dt}$

ccv

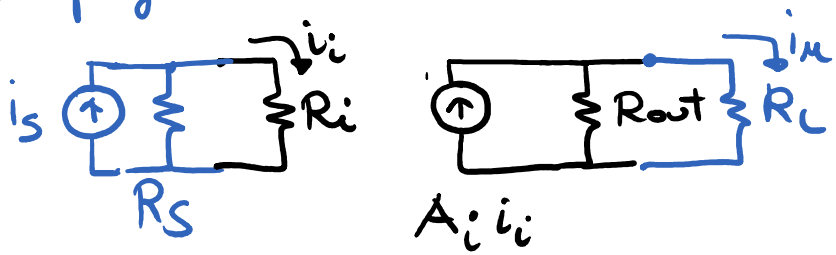
$V_u(s) = RCs\, V_s(s)$

Classificazione degli amplificatori di Tensione

Thursday, March 23, 2017 11:06 AM

(ideali)	R_{in}	R_{out}	fdt indipendente da carico e gen. di ingresso
Amplificatore di TENSIONE	∞	0	$A_v = \frac{v_u}{v_s}$
Amplificatore di CORRENTE	0	∞	$A_i = \frac{i_u}{i_s}$
Amplificatore TRANSRESISTIVO	0	0	$R = \frac{v_u}{i_s}$
Amplificatore TRANSCONDUTTIVO	∞	∞	$G = \frac{i_u}{v_s}$

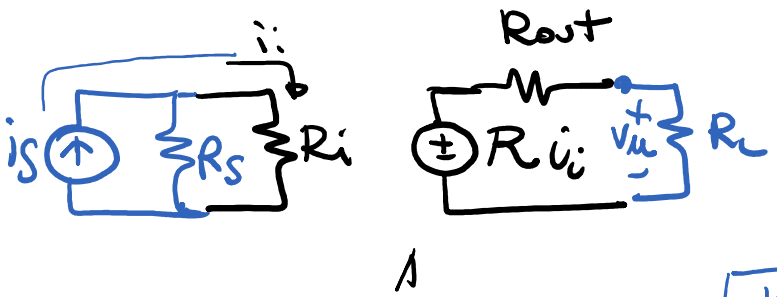
Amplif. di corrente



$$i_i = i_s \frac{R_S}{R_S + R_i}$$

$$i_u = A_i i_i \frac{R_{out}}{R_{out} + R_L}$$

$$\frac{i_u}{i_s} = A_i \left(\frac{R_{out}}{R_{out}+R_L}\right)\left(\frac{R_S}{R_S+R_i}\right) = \begin{matrix} \text{se } R_i = 0 \\ R_{out} \to \infty \end{matrix} = A_i$$



se $R_i = 0$

$i_i = i_s$

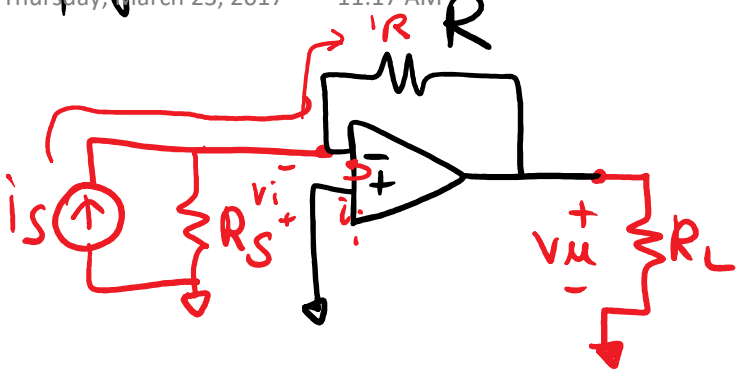
se R_{out}

$v_u = R i_i = R i_s$

$$\frac{v_u}{i_s} = R$$ indipendente da R_S e R_L

Amplificatore transresistivo

Thursday, March 23, 2017 11:17 AM



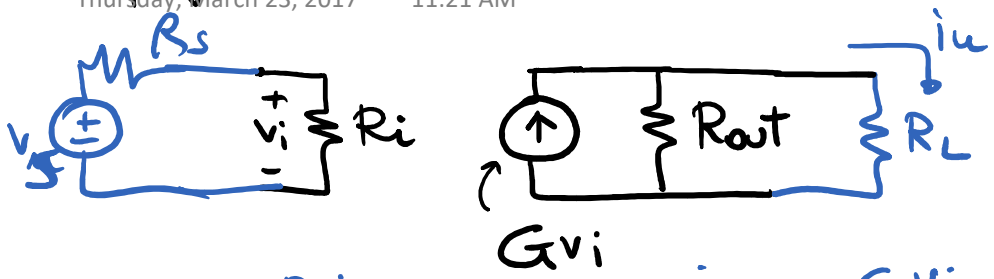
ccv $v_i = 0$

$$i_R = i_S - \frac{v_i}{R_S} + i_i = i_S$$

$$v_u = -\cancel{v_i} - R i_S$$

Amplificatore transconduttivo

Thursday, March 23, 2017 11:21 AM



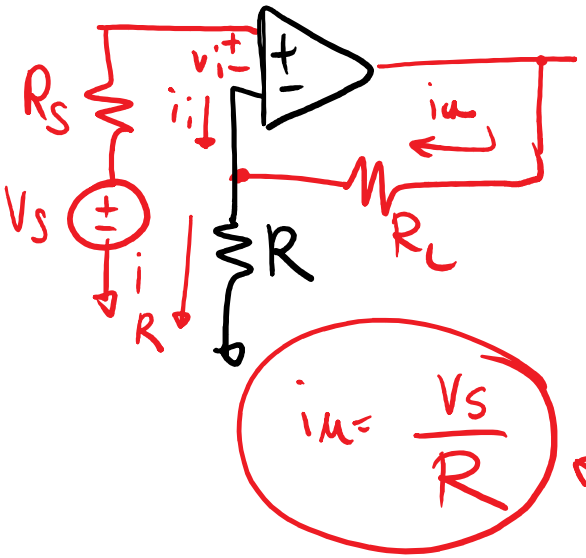
!

$$v_i = \frac{R_i}{R_i + R_S} v_S \qquad i_u = \frac{G v_i R_{out}}{R_{out} + R_L}$$

$$\frac{i_u}{v_S} = G\left(\frac{R_{out}}{R_{out}+R_L}\right)\left(\frac{R_i}{R_i+R_S}\right) = G \quad \begin{pmatrix} \text{se } R_{out} \to \infty \\ R_i \to \infty \end{pmatrix}$$

Amplificatore Transconduttivo

Thursday, March 23, 2017 11:24 AM



$i_R = \cancel{i_i} + i_m$

CCV

$V_S = R_S \cancel{i_i} + \cancel{v_i} + R i_m$

CCV CCV

$i_m = \frac{V_S}{R}$ ← NON DIPENDE DA R_S e bA R_L