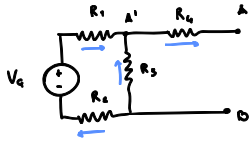
Esercizi Reti Elettriche

1)



R_1, R_2, R_3, R_4, V_G

1) $V_{AB} = ?$

2) I_{AB} (in corto) $= ?$

1) $V_B - V_A = I_3 R_3 + I_4 R_4$ (0 (la presenza in A c'è un aperto ($I=0$))

$= I_3 R_3$

$= V_{A'B}$

$V_{AB} = I_2 R_2 + V_G + I_4 R_4$ (↳ $I_1 = I_2 = I_G$)

$= I_G (R_1 + R_2) + V_G$

$= -\frac{V_{A'B}}{R_3}(R_1 + R_2) + V_G$

$V_B - V_A = V_{A'B}$

$= \frac{V_G}{1 + \frac{R_1 + R_2}{R_3}}$

$= \frac{R_3}{R_1 + R_2 + R_3} V_G$

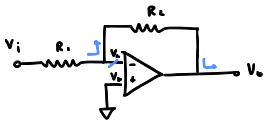
2) V_{AB} (in corto) $= \frac{R_3 /\!/ R_4}{R_1 + R_2 + R_3 /\!/ R_4} V_G$

$I_{AB} = V_{A'B} R_4$

$= \frac{(R_3 /\!/ R_4) R_4}{R_1 + R_2 + R_3 /\!/ R_4} V_G$

Esercizi con Opamp

1)



$A_V = ?$

$V_i - V_- = R_1 I$ (↳ $V_- = V_+ = 0$)

$V_i = R_1 I$

$V_- - V_o = R_2 I$

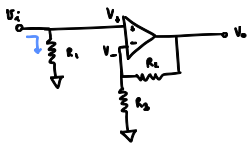
$V_o = -R_2 I$

$A_V = \frac{V_o}{V_i} = \frac{-R_2 I}{R_1 I} = -\frac{R_2}{R_1}$

$R_i = R_1$

$R_o = 0$ (perché ??)

2)



$V_i - 0 = R_1 I_i$ ($= V_+ = V_-$)

$I_- = \frac{V_- - V_o}{R_2} = \frac{0 - V_o}{R_2 + R_3}$

$\frac{V_o}{R_2} - \frac{V_o}{R_2 + R_3} = \frac{V_-}{R_1}$

$V_o \left(\frac{1}{R_2} - \frac{1}{R_2 + R_3}\right) = \frac{V_i}{R_1}$

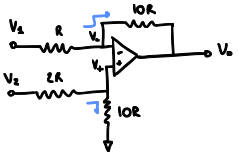
$V_o = \frac{R_2 + R_3}{R_3} V_i$

$A_V = \frac{V_o}{V_i} = \frac{R_2 + R_3}{R_3}$

$R_i = \frac{V_i}{I_i} = R_1$

$R_o = \frac{V_o}{I_o} = \frac{V_o}{\frac{V_- - V_o}{R_2}} = \frac{R_2 V_o}{V_i - V_o}$ (??)

3)



$A_{V_1} = ?$ $A_{V_2} = ?$

$R_{i_1} = ?$ $R_{i_2} = ?$

Guadagno per V_1:

$A_{V_1} = -\frac{10R}{R} = -10$

Guadagno per V_2:

$V_+ = \frac{10R}{12R} V_2 = \frac{5}{6} V_2$

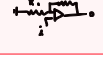
$A_V = \frac{5}{6}\left(1 + \frac{10R}{R}\right) = \frac{55}{6}$

Guadagno invertente

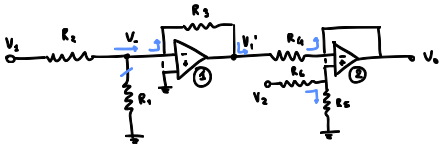
$A_V = -\frac{R_2}{R_1}$

Guadagno non invertente

$A_V = 1 + \frac{R_2}{R_1}$



3)

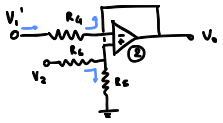


$V_-^{(1)} = V_+^{(1)} = 0$

$I_1 = \frac{V_s - 0}{R_1}$

$= 0$

$V_1' = -\frac{R_3}{R_2} V_s$



$V_1' - V_o = R_4 I_4$

$I_4 = \frac{V_o}{R_4}$

$-\frac{R_3}{R_2} V_1 - V_o = \frac{R_3}{R_2} V_s$

$V_o = -\frac{R_3 + R_4}{R_2} V_s$

$A_V^{(1)} = -\frac{R_3 + R_4}{R_2}$

$V_o^{(2)} = \frac{R_5}{R_5 + R_6} V_2$

$A_V^{(2)} = \frac{R_5}{R_5 + R_6} \left(1 + \frac{0}{R_4}\right)$

$= \frac{R_5}{R_5 + R_6}$

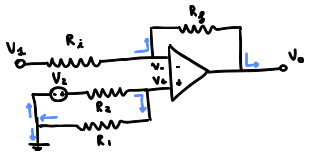
$R_{in}^{(1)} = R_2$

$R_{in}^{(2)} = \frac{V_o^{(2)}}{I_6^{(2)}} = \frac{\frac{R_5}{R_5+R_6} V_2}{\frac{V_2}{R_5+R_6}}$

$= R_5$

Es PDF Amogus

1)



$A_1 = -\frac{R_2}{R_1}$

$V_o - 0 = R_2 I_2$

$V_o = R_2 I_2$ *

$V_2 = I_2 (R_1 + R_2)$

$I_2 = \frac{V_2}{R_1 + R_2}$

* $V_o = \frac{R_2}{R_1 + R_2} V_2 \quad (= V_-)$

$A_2 = \frac{R_1}{R_1 + R_2} \left(1 + \frac{R_2}{R_1}\right)$

$AJ = \frac{A_2 - A_1}{2}$

$A_{com} = A_2 + A_1$

$CMRR = 20 \log \left| \frac{AJ}{A_{com}} \right|$

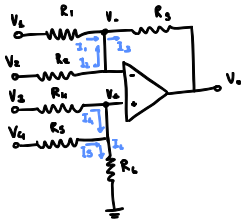
$I_o = \frac{V_o}{R_2}$

$AJ = \frac{A_2 - A_1}{2}$

$A_{com} = A_2 + A_1$

$CMRR = 20 \log \left| \frac{AJ}{A_{com}} \right|$

2)



$I_3 = I_1 + I_2$

$I_6 = I_4 + I_5$

$V_o = I_6 R_6$

$= R_6 (I_4 + I_5)$

$= R_6 \left(\frac{V_4 - V_+}{R_4} + \frac{V_5 - V_+}{R_5} \right)$

$V_+ = \frac{R_6}{R_4} V_3 - \frac{R_6}{R_4} V_4 + \frac{R_6}{R_5} V_4 - \frac{R_6}{R_5} V_+$

$V_+ \left(1 + \frac{R_6}{R_4} + \frac{R_6}{R_5}\right) = \frac{R_6}{R_4} V_3 + \frac{R_6}{R_5} V_4$

$V_+ = \frac{\frac{R_6}{R_4} V_3 + \frac{R_6}{R_5} V_4}{1 + \frac{R_6}{R_4} + \frac{R_6}{R_5}}$

$V_o = V_-$

$V_- - V_o = I_3 R_3$

$V_o = V_- - (I_1 + I_2) R_3$

$I_1 = \frac{V_1 - V_-}{R_1}$

$I_2 = \frac{V_2 - V_-}{R_2}$

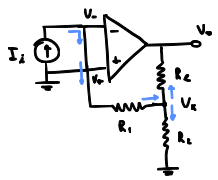
$V_o = V_- - \frac{R_3}{R_1} (V_1 - V_-) - \frac{R_3}{R_2} (V_2 - V_-)$

$= A_1 V_1 + A_2 V_2 + A_3 V_3 + A_4 V_4$

$A_1 = -\frac{R_3}{R_1}$ $\quad A_3 = \frac{R_3 R_6}{R_4 R_5 + R_5 R_6 + R_4 R_6} \left(1 + \frac{R_4}{R_1} + \frac{R_5}{R_6}\right)$

$A_2 = -\frac{R_3}{R_2}$ $\quad A_4 = \frac{R_4 R_6}{R_4 R_5 + R_5 R_6 + R_4 R_6} \left(1 + \frac{R_3}{R_1} + \frac{R_5}{R_6}\right)$

3)



a) $\frac{I_c}{I_i} = ?$

b) $\frac{V_o}{I_i} = ?$

a)

$V_x = I_c R_c = I_i R_c$

$V_x - V_- = R_2 I_c$

$I_2 + I_c = \frac{V_x}{R_2} = \frac{R_c}{R_2} I_i$

$I_c = \left(1 + \frac{R_1}{R_2}\right) I_i$

$\frac{I_c}{I_i} = 1 + \frac{R_1}{R_2}$

b)

$I_i R_1 - V_o = R_c I_c$

$\downarrow$ $I_c = I_i - I_2$

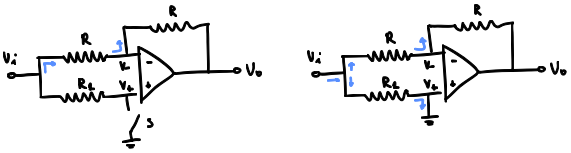
$= R_c \left(I_i - \frac{R_1}{R_2} I_i\right)$

$= R_c I_i \left(1 - \frac{R_1}{R_2}\right)$

$I_i \left(R_1 - R_c \left(1 - \frac{R_1}{R_2}\right)\right) = V_o$

$\frac{V_o}{I_i} = R_1 - R_c \left(1 - \frac{R_1}{R_2}\right)$

4)



a) S aperto:

$A_1 = -\frac{R}{R} = -1$

$A_2 = 1 + \frac{R}{R} = 2$

$V_o = A_1 V_i + A_2 V_i = V_i$

$A = 1$

b)

$V_i = I_1 R_1$

$I_1 = \frac{V_i}{R_1}$

$V_i - V_o = I(R + R)$

$V_- = V_+ = 0 \rightarrow RI = R_1 I_1$

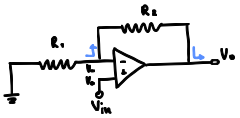
$I = \frac{R_1}{R} I_1 = \frac{R_1}{R} \frac{V_i}{R_1} = \frac{V_i}{R}$

$V_i - V_o = \frac{V_i}{R} 2R = 2V_i$

$V_o = -V_i$

$A = -1$

5)



R_1

A_V

P_0

$V_{in} = ?$

$A_V = 1 + \frac{R_2}{R_1} \rightarrow R_2 = R_1 (A_V - 1)$

$P_0 = V_o I_o$

$= A_V V_{in} I_o$

$= A_V \frac{V_{in}^2}{R_1}$

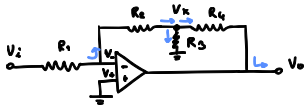
$V_{in} = \sqrt{\frac{P_0 R_1}{A_V}}$

$V_- = V_{in}$

$V_o - V_- = R_2 I_o$

$I_o = \frac{A_V V_{in} - V_{in}}{R_1 (A_V - 1)} = \frac{V_{in} (A_V - 1)}{R_1 (A_V - 1)} = \frac{V_{in}}{R_1}$

6)



$I_1 = \frac{V_i}{R_1} = I_2 = I_3 + I_4$

$-V_x = R_2 I_2 \rightarrow V_x = -\frac{R_2}{R_1} V_i$

$I_3 = \frac{V_x}{R_3}$

$I_4 = \frac{V_x - V_o}{R_4}$

$\frac{V_i}{R_1} = \frac{V_x}{R_3} + \frac{V_x - V_o}{R_4}$

$= -\frac{R_2}{R_1 R_3} V_i - \frac{R_2}{R_1 R_4} V_i - \frac{V_o}{R_4}$

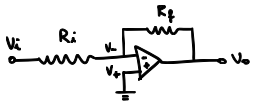
$V_o = -\frac{R_4}{R_2} \left(1 + \frac{R_2}{R_3} + \frac{R_2}{R_4}\right) V_i$

$A_V = -\frac{R_4}{R_1} \left(1 + \frac{R_2}{R_3} + \frac{R_2}{R_4}\right)$

fisso A_V a -120 e vedo per quale R_3 l'equazione è soddisfatta o ci si avvicina di più

7)

a)

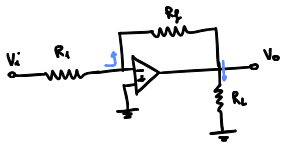


$A_V = -\frac{R_f}{R_i}$

$R_{in} = \frac{V_{in}}{I_{in}} = \frac{V_i}{\frac{V_i}{R_i}} = R_i$

$R_{out} = \frac{V_{out}}{I_{out}} = \frac{-V_o}{-\frac{V_o}{R_f}} = R_f$

b)



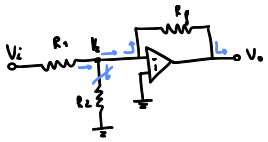
$A_V = -\frac{R_f}{R_1}$ $\left(I = \frac{-V_o}{R_f} = \frac{V_i}{R_1} \rightarrow V_o = -\frac{R_f}{R_1} V_i\right)$

la R_L non cambia il guadagno

$R_{in} = \frac{V_{in}}{I_{in}} = \frac{V_i}{\frac{V_i}{R_1}} = R_1$

$R_{out} = \frac{V_{out}}{I_{out}} = \frac{-V_o}{-\frac{V_o}{R_f}} = R_f$

c)



$V_i = R_1 I_1$

$I_2 = \frac{V_2}{R_2}$ $(V_+ = V_- = V_+ = 0)$

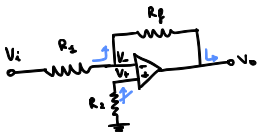
$= 0$

$A_V = -\frac{R_f}{R_1}$

$R_{in} = \frac{V_{in}}{I_{in}} = \frac{V_i}{\frac{V_i}{R_1}} = R_1$

$R_{out} = \frac{V_{out}}{R_{out}} = \frac{-V_o}{-\frac{V_o}{R_f}} = R_f$

d)



$V_o = I_1 R_2$ $(I_1 = 0)$

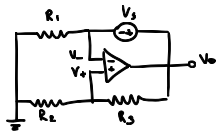
$= 0$

$A_V = -\frac{R_f}{R_1}$

$R_{in} = R_1$

$R_{out} = R_f$

8)



$$V_o = \frac{R_2}{R_2+R_3} V_o$$

$$V_o - V_- = V_s$$

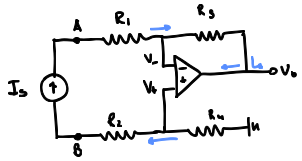
$$V_o \left(1 - \frac{R_2}{R_2+R_3}\right) = V_s$$

$$V_o = \frac{R_2+R_3}{R_3} V_s$$

$$V_- = V_+ = V_o - V_s$$
$$= \left(\frac{R_2+R_3}{R_3} - 1\right) V_s$$
$$= \frac{R_2}{R_3} V_s$$

$$P_s = V_s I_s = -\frac{V_s V_-}{R_1}$$

9)



$$I_1 = I_2 = I_3 = I_4 = I_s$$

$$\frac{V_A - V_-}{R_1} = \frac{V_+ - V_B}{R_2} = \frac{V_- - V_o}{R_3} = \frac{-V_o}{R_4} = I_s$$

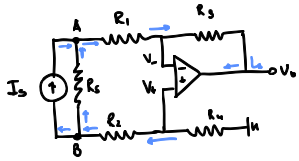
$$V_o = -R_4 I_s$$

$$(V_+ = V_-)$$

$$V_o = V_- - R_3 I_s$$
$$= -(R_3+R_4) I_s$$

$$V_A = V_- + R_1 I_s$$
$$= (R_1 - R_4) I_s$$

$$V_B = V_+ - R_2 I_s$$
$$= -(R_2+R_4) I_s$$



$$I_{Rc} = I_s + \frac{V_B - V_A}{R_s}$$

$$\frac{V_A - V_-}{R_1} = \frac{V_+ - V_B}{R_2} = \frac{V_- - V_o}{R_3} = \frac{-V_o}{R_4} = I_{Rc}$$

$$\begin{cases} \frac{V_o - V_B}{R_2} = I_s + \frac{V_B - V_A}{R_s} \\ -\frac{V_o}{R_4} = I_s + \frac{V_B - V_A}{R_s} \\ \frac{V_A - V_-}{R_1} = I_s + \frac{V_B - V_A}{R_s} \end{cases}$$ → 3 eq. avec 3 inc. ($V_o = V_-$; V_A, V_B)

$V_+ = V_- = \dots$

$V_A = \dots$

$V_B = \dots$

$$V_o = -(R_3+R_4)\left(I_s + \frac{V_B - V_A}{R_s}\right)$$