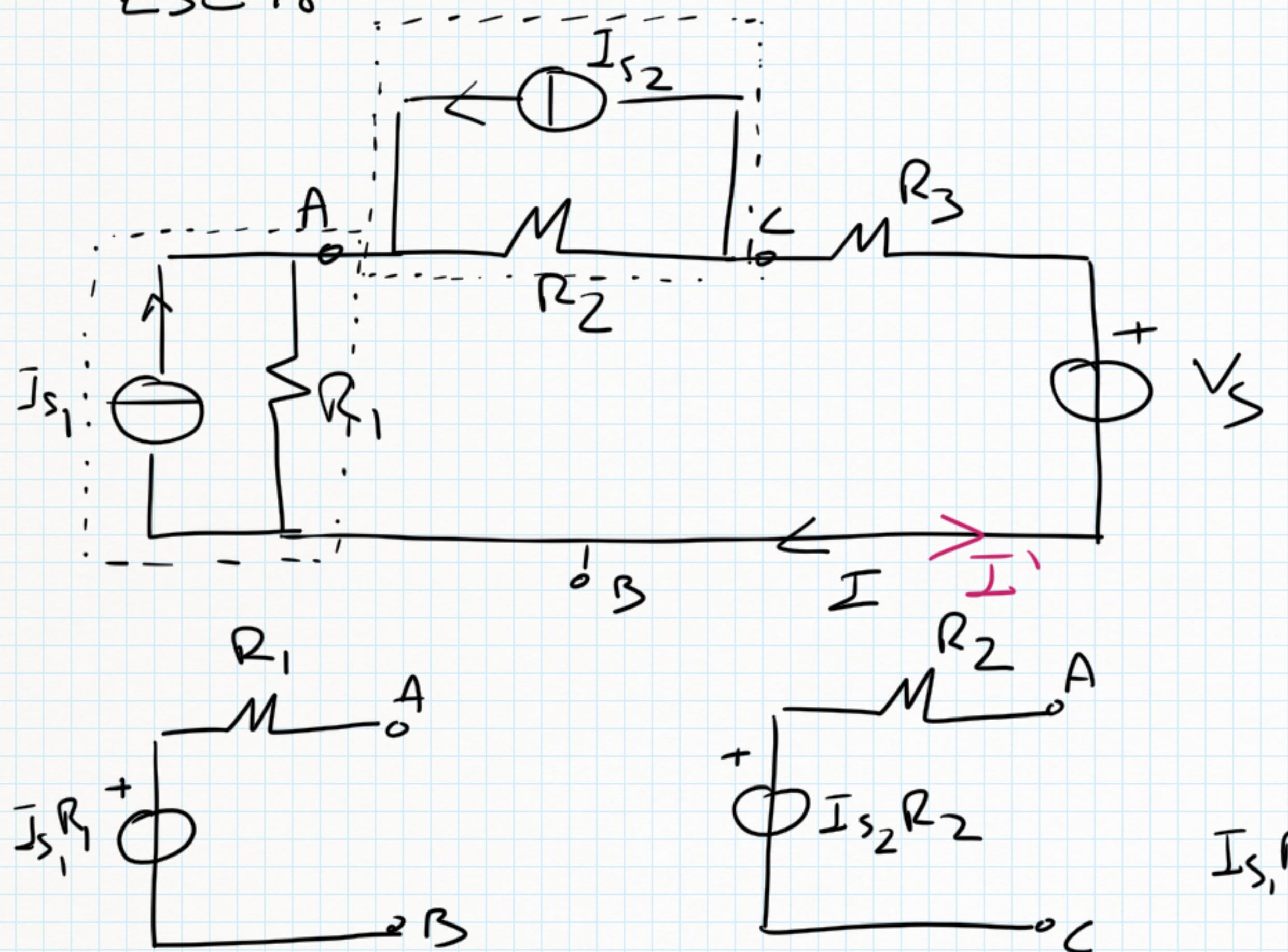


ESE 18



$$V_S = 10 \text{ V}$$

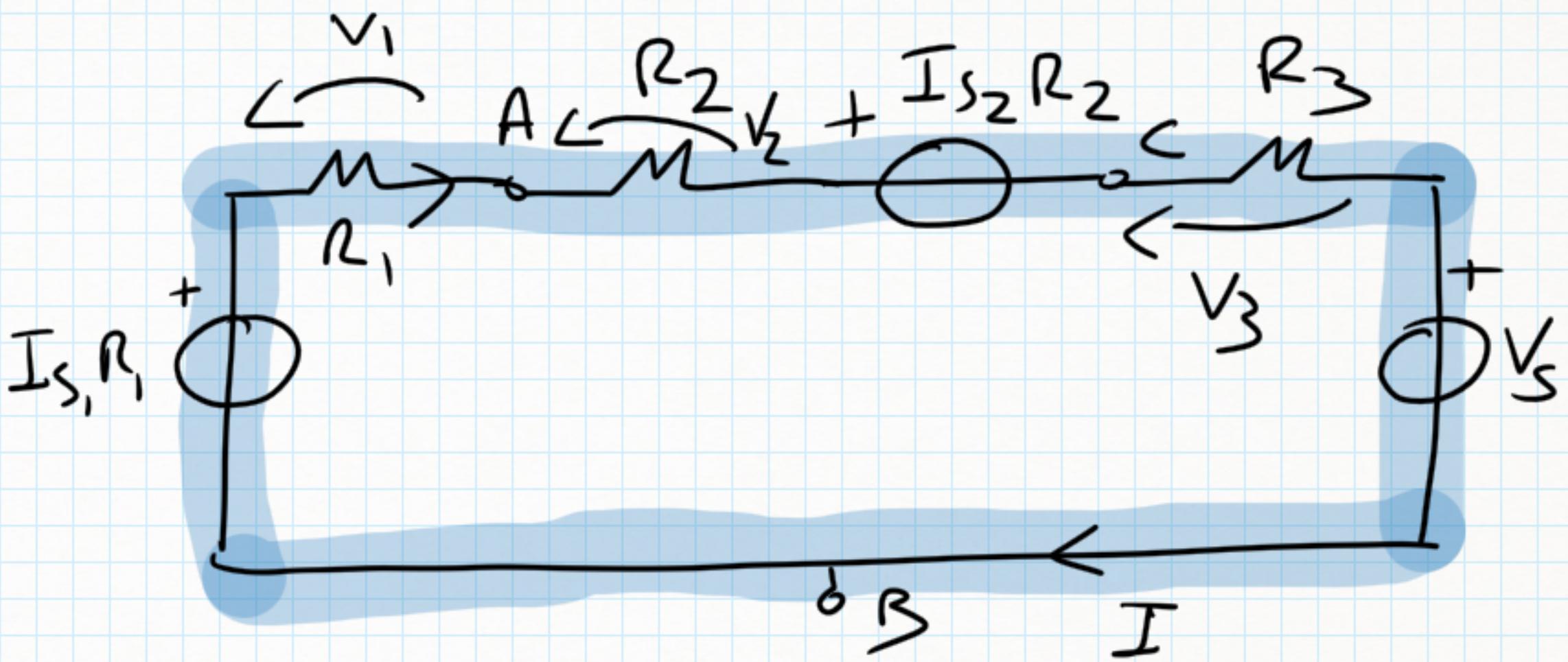
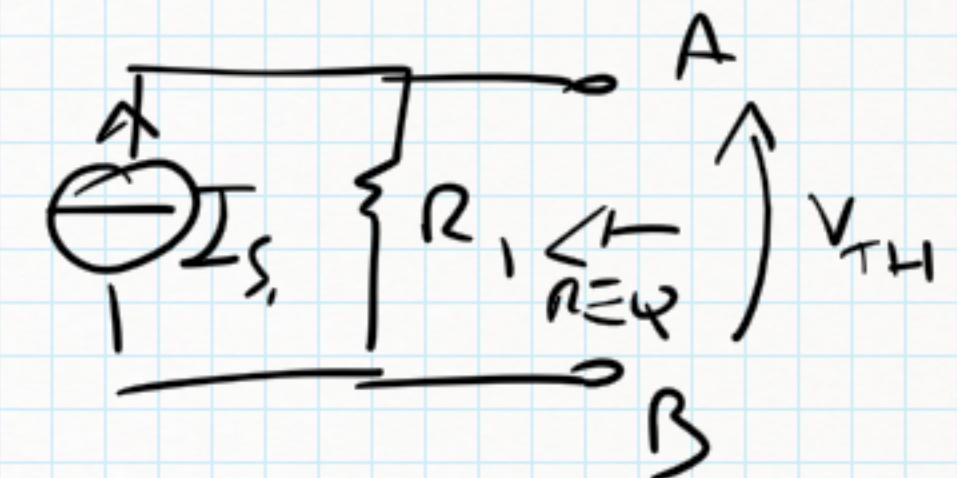
$$I_{S1} = I_{S2} = 2 \text{ A}$$

$$R_1 = 10 \Omega$$

$$R_2 = 5 \Omega$$

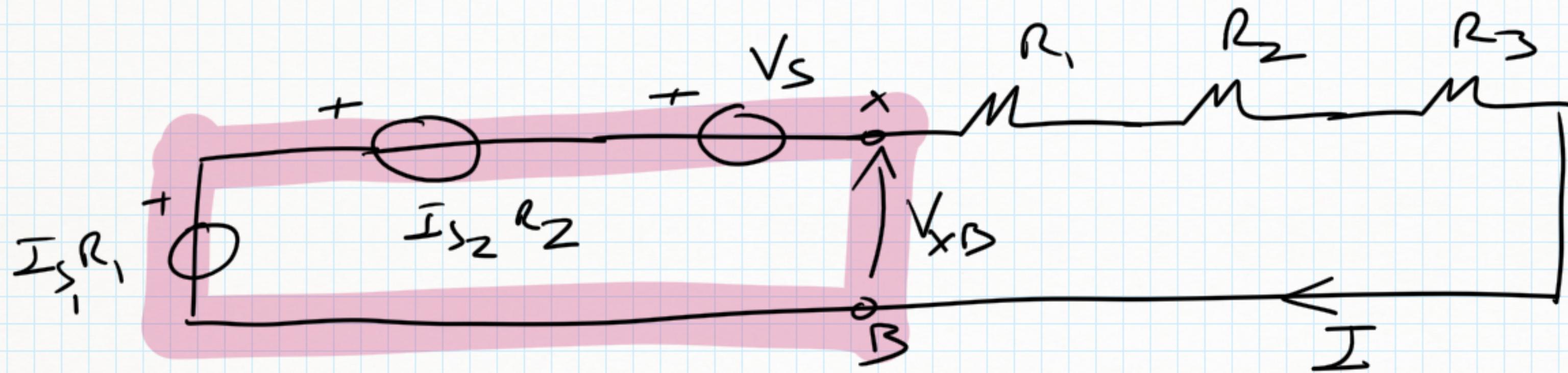
$$R_3 = 25 \Omega$$

$$I = ?$$



$$V_1 + V_2 + V_3 = I (R_1 + R_2 + R_3) = I_{S1} R_1 - I_{S2} R_2 - V_S$$

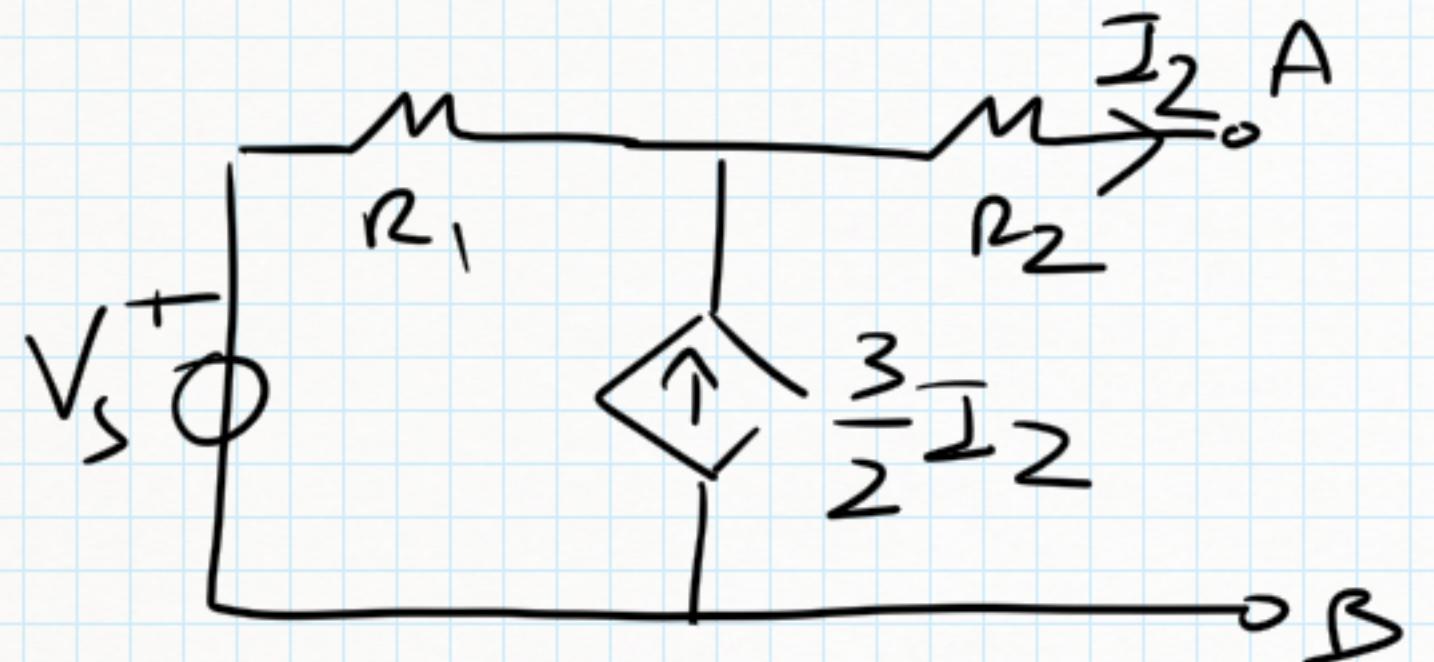
$$I = \frac{I_{S1} R_1 - I_{S2} R_2 - V_S}{R_1 + R_2 + R_3} = -\frac{1}{Z_0} A = -I'$$



$$I = \frac{V_{XB}}{R_1 + R_2 + R_3}$$

$$I_{S1} R_1 = I_{S2} R_2 + V_S + V_{XB} \Rightarrow V_{XB} = I_{S1} R_1 - I_{S2} R_2 - V_S$$

$\bar{E} \subseteq 1 \Delta$

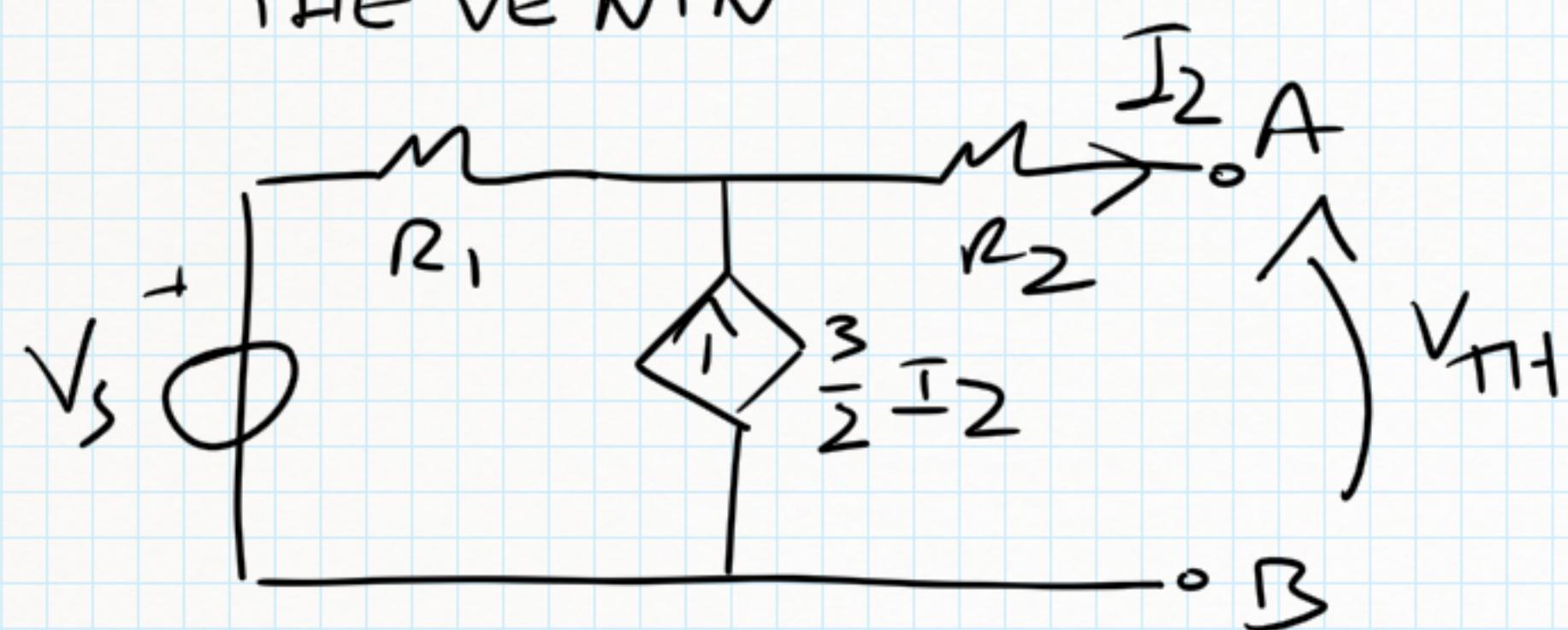


$$R_1 = 5 \Omega$$

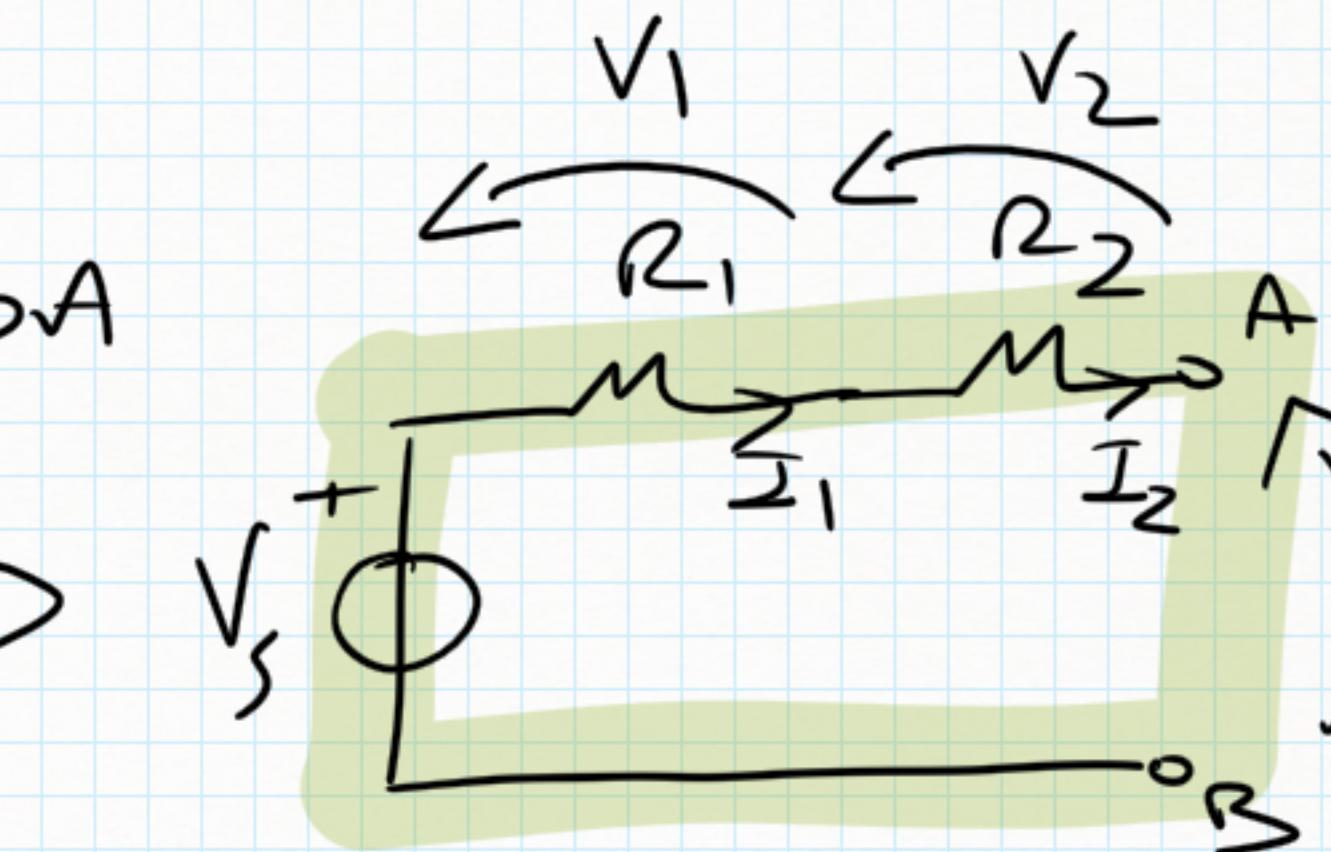
$$R_2 = 3 \Omega$$

$$V_s = 6 V$$

THEVENIN



$$I_2 = 0 A$$



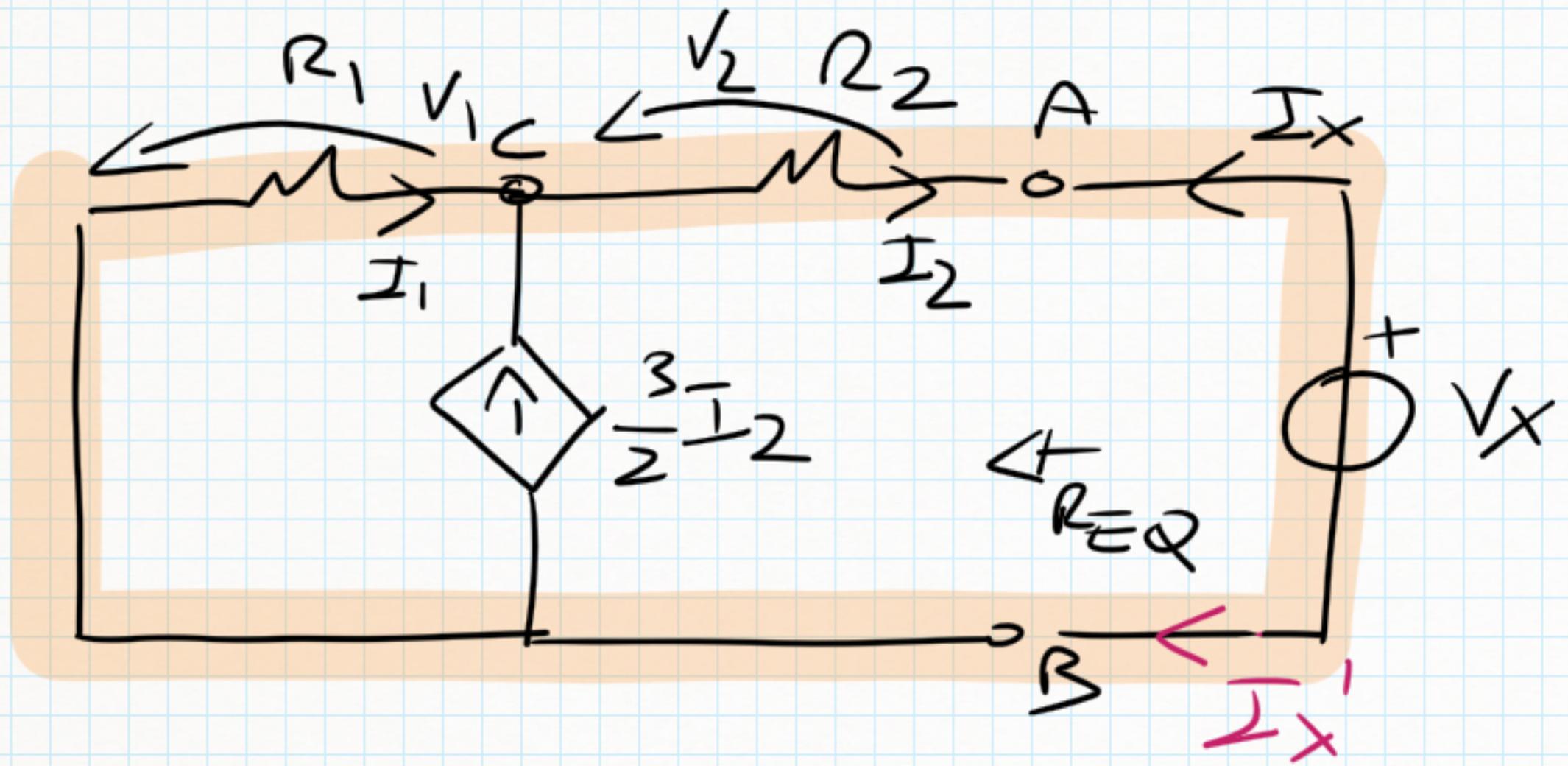
$$I_1 = I_2 = 0 A$$

$$\frac{1}{V}$$

$$V_1 = V_2 = 0 V$$

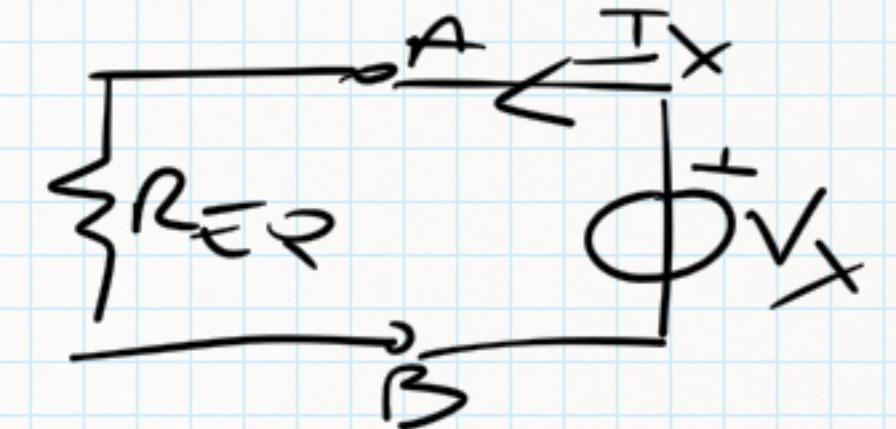
$$V_s = V_1 + V_2 + V_{TH} \Rightarrow$$

$$V_{TH} = V_s$$



$$R_{EQ} = \frac{V_x}{I_x}$$

$$R_{EQ} = -\frac{V_x}{I_x}$$

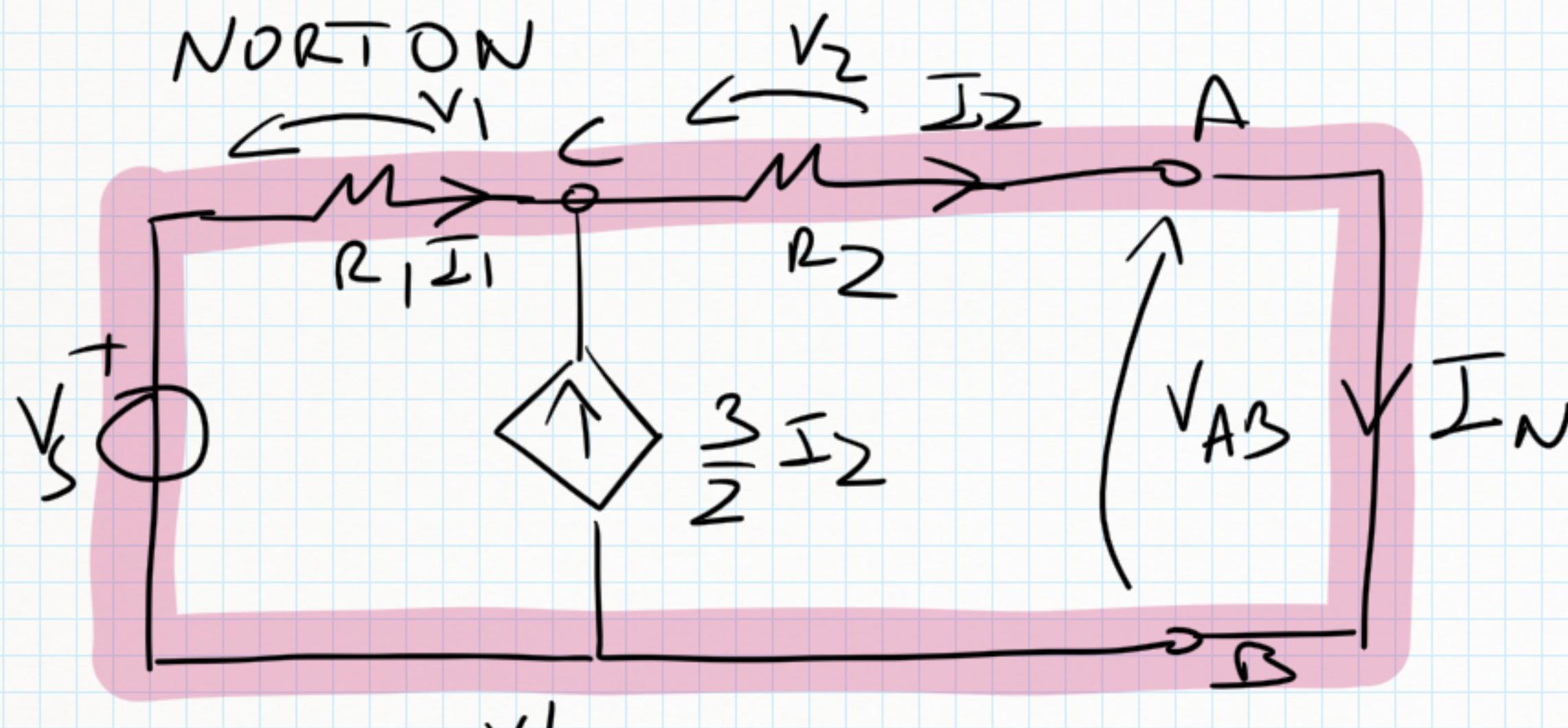
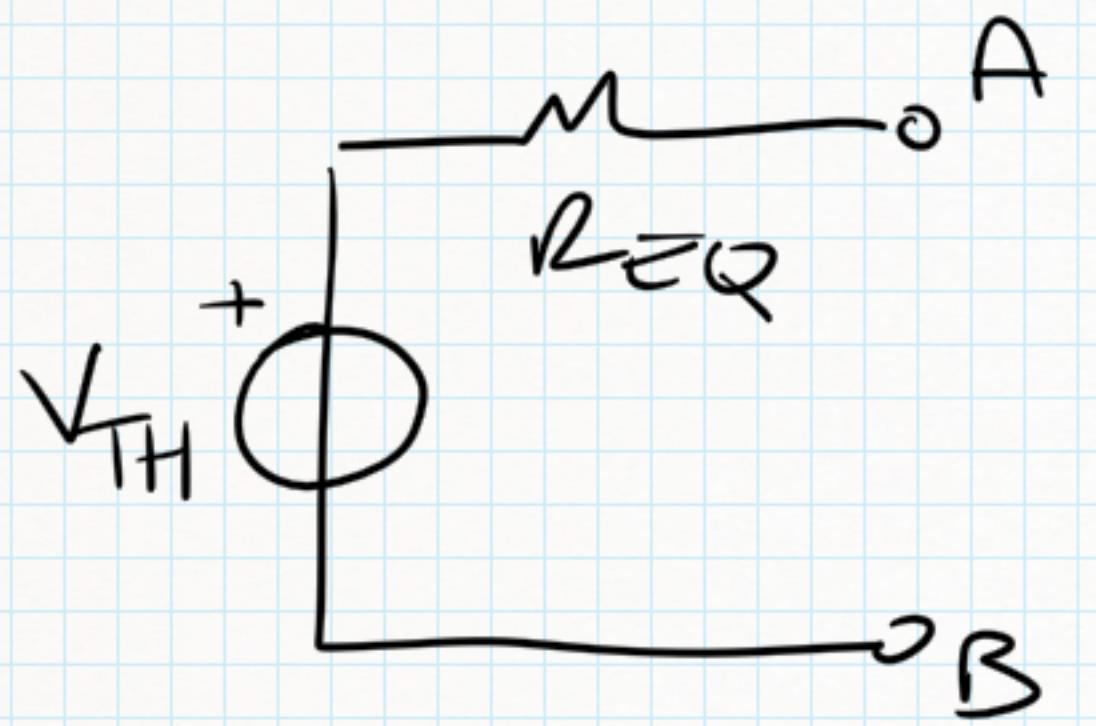


$$I_x = -I_2$$

$$I_1 + \frac{3}{2}I_2 = I_2 \Rightarrow I_1 = I_2 - \frac{3}{2}I_2 = -\frac{I_2}{2} = \frac{I_x}{2}$$

$$V_x + V_1 + V_2 = 0 \Rightarrow V_x = -V_1 - V_2 = -I_1 R_1 - I_2 R_2 \Rightarrow$$

$$V_x = -\frac{I_x}{2} R_1 + I_x R_2 = I_x \left(R_2 - \frac{R_1}{2} \right) \Rightarrow R_{EQ} = \frac{V_x}{I_x} = R_2 - \frac{R_1}{2} = -\frac{1}{2} R_1$$



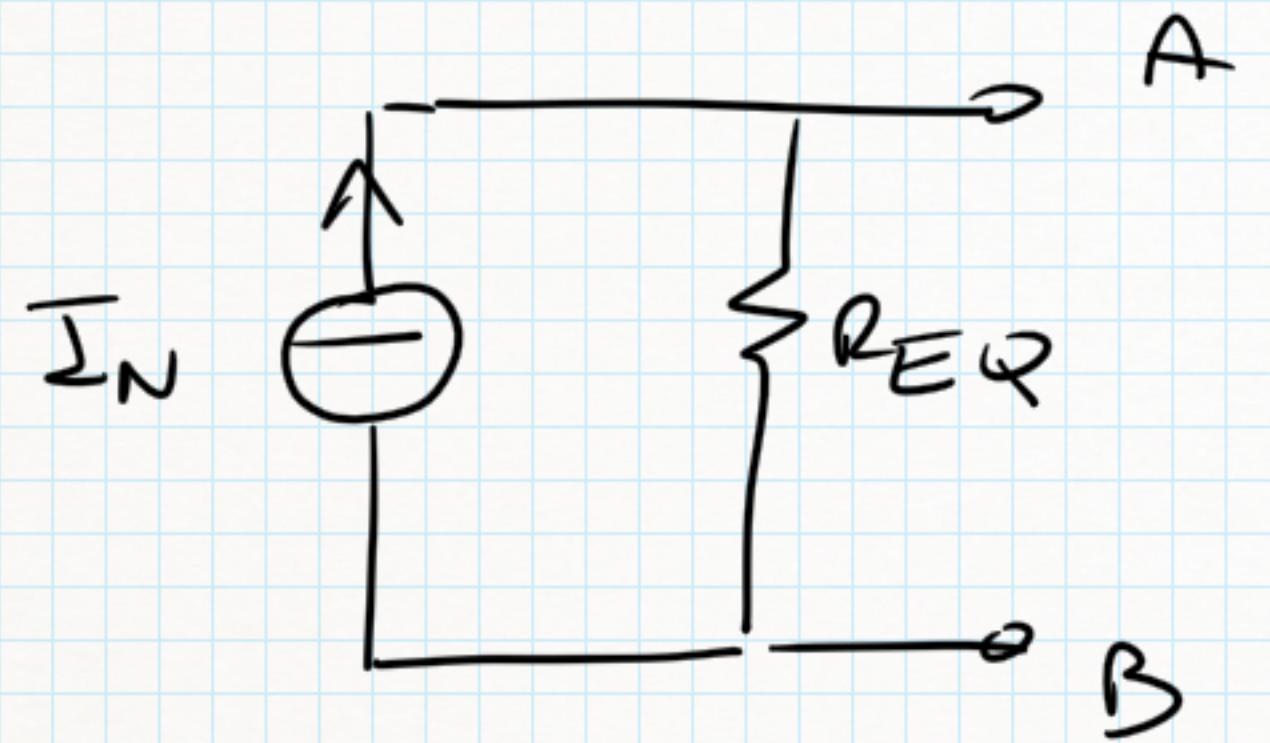
$$V_{AB} = 0V$$

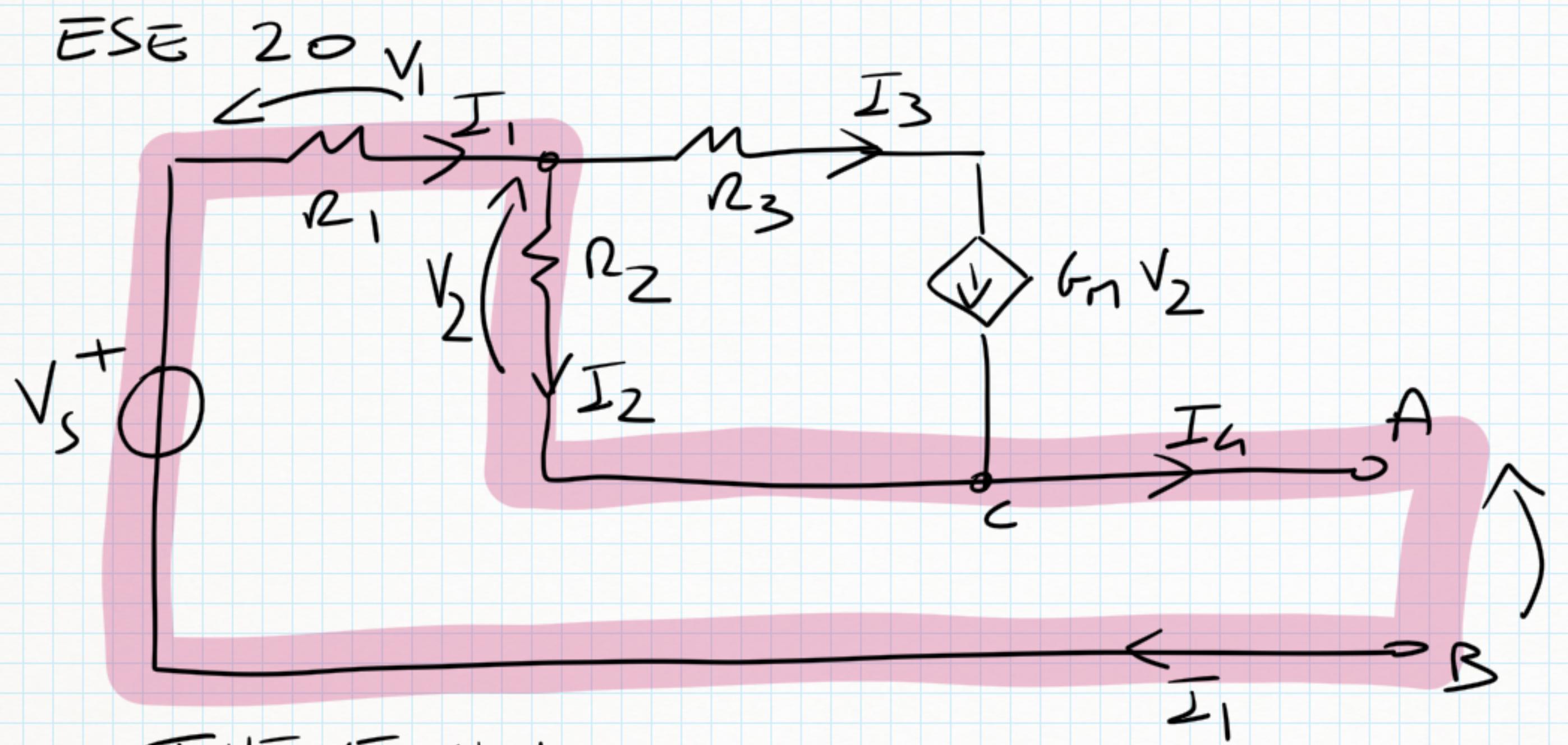
$$V_s = V_1 + V_2 + V_{AB} = V_1 + V_2 = I_1 R_1 + I_2 R_2 = -\frac{I_2}{2} R_1 + I_N R_2$$

$$\bar{I}_N = \bar{I}_2$$

$$I_1 + \frac{3}{2} \bar{I}_2 = \bar{I}_2 \Rightarrow I_1 = \bar{I}_2 - \frac{3}{2} \bar{I}_2 = -\frac{\bar{I}_2}{2} = -\frac{\bar{I}_N}{2}$$

$$I_N = \frac{V_S}{R_2 - \frac{R_1}{2}} = 12 \text{ A}$$





$$R_1 = R_2 = R_3 = 1 \Omega$$

$$V_s = 10 V$$

$$g_m = 1 S$$

$$I_4 = 0 A = I_1$$

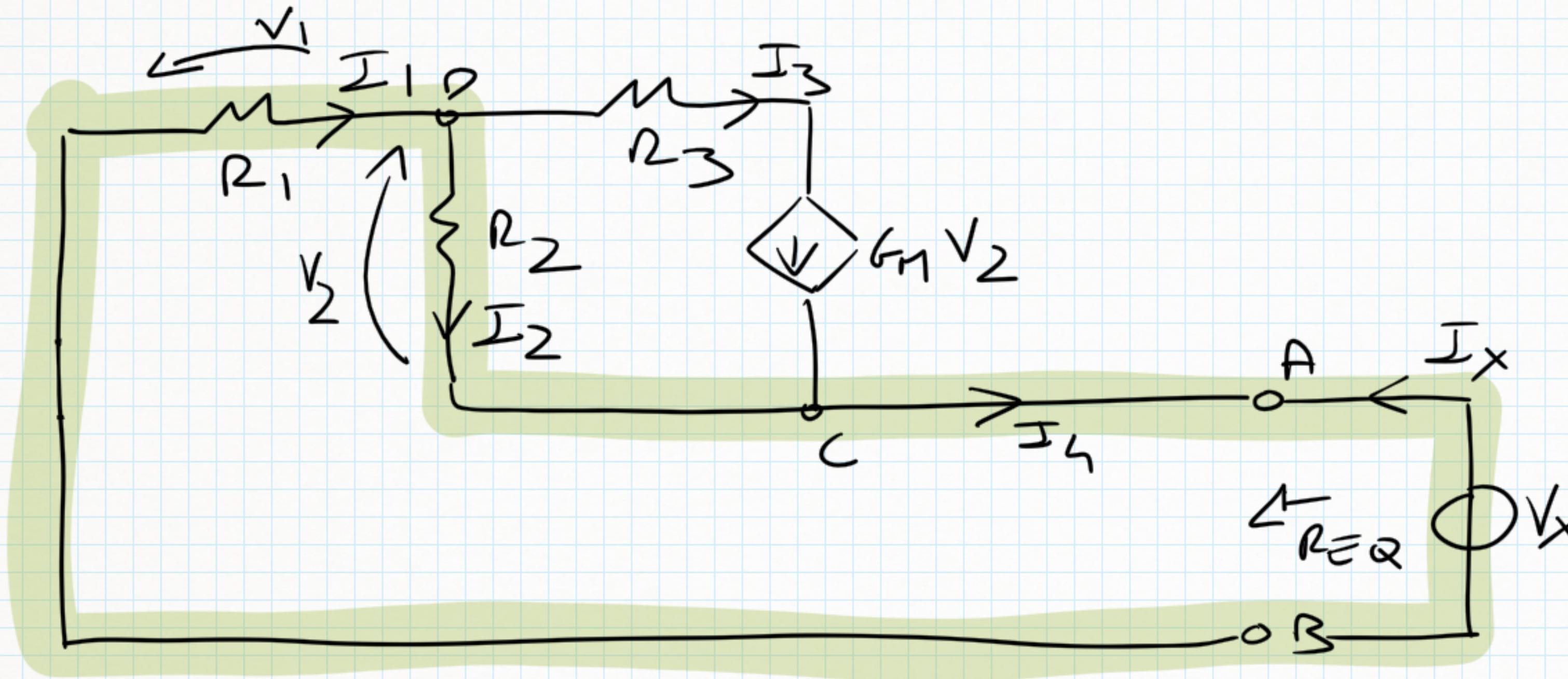
$$I_3 = g_m V_2$$

THEVENIN

$$I_2 + I_3 = I_4 = 0 \Rightarrow I_2 = -I_3 = -g_m V_2 = \frac{V_2}{R_2}$$

$$V_2 \left(\frac{1}{R_2} + g_m \right) = 0 \Rightarrow V_2 = 0 V !! \Rightarrow I_2 = 0 A = I_3$$

$V_s = V_1 + V_2 + V_{TH} \Rightarrow V_{TH} = V_s$



$$I_4 = -I_X = I_1$$

$$I_3 = g_m V_2$$

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

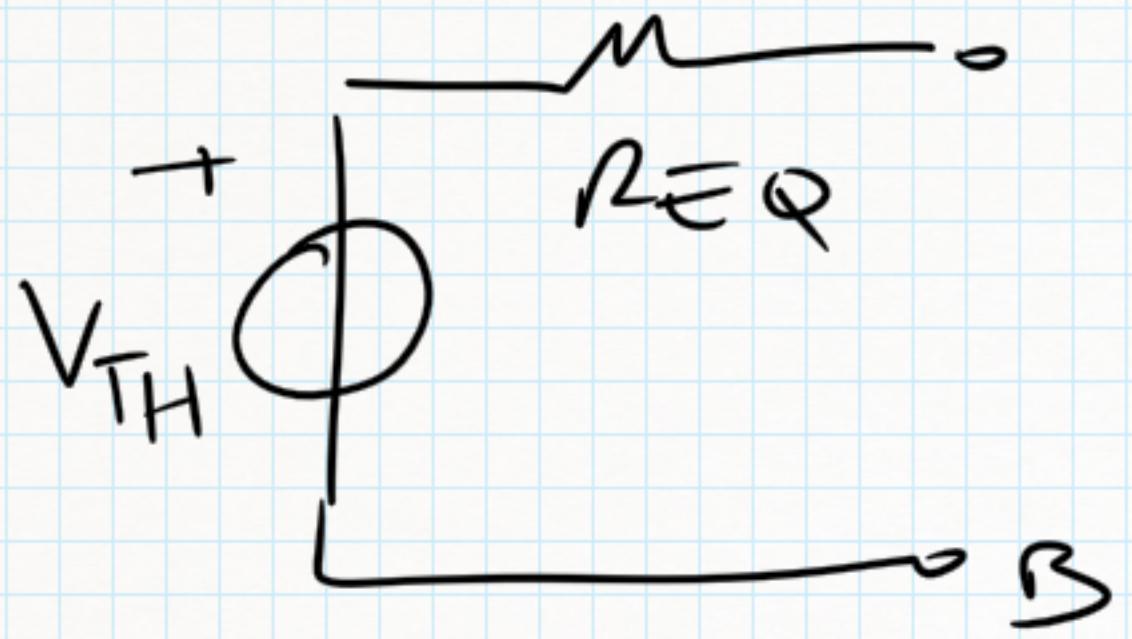
$$I_2 + g_m V_2 + I_X = 0 \Rightarrow I_X = -I_2 - g_m V_2 = -\frac{V_2}{R_2} - g_m V_2 = -V_2 \left(\frac{1}{R_2} + g_m \right)$$

$$V_2 = -\frac{I_X}{\frac{1}{R_2} + g_m}$$

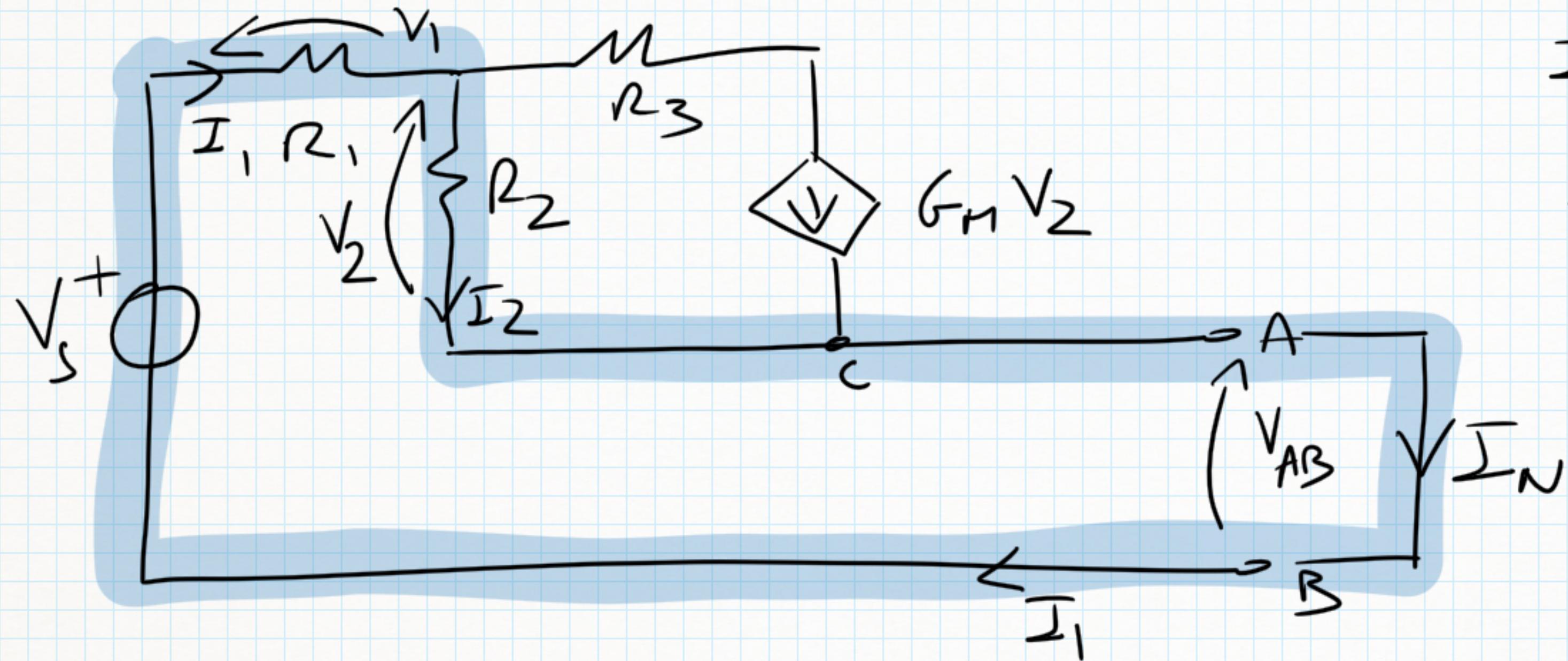
$$V_X + V_1 + V_2 = 0 \Rightarrow V_X = -V_1 - V_2 = I_1 R_1 - \left(-\frac{I_X}{\frac{1}{R_2} + g_m} \right)$$

$$V_1 = + I_x R_1 + \frac{I_x}{\frac{1}{R_L} + G_m} = I_x \left(R_1 + \frac{1}{\frac{1}{R_2} + G_m} \right)$$

$$R_{EQ} = \frac{V_x}{I_x} = R_1 + \frac{R_2}{1 + G_m R_2} = \frac{3}{2} \Omega$$



NORTON



$$I_2 = \frac{V_2}{R_2} ; V_{AB} = 0V!$$

$$I_1 = I_N$$

$$I_2 + G_M V_2 = I_N$$

$$\frac{V_2}{R_2} + G_M V_2 = I_N$$

$$V_2 = \frac{I_N}{\frac{1}{R_2} + G_M} = I_N \frac{R_2}{1 + G_M R_2}$$

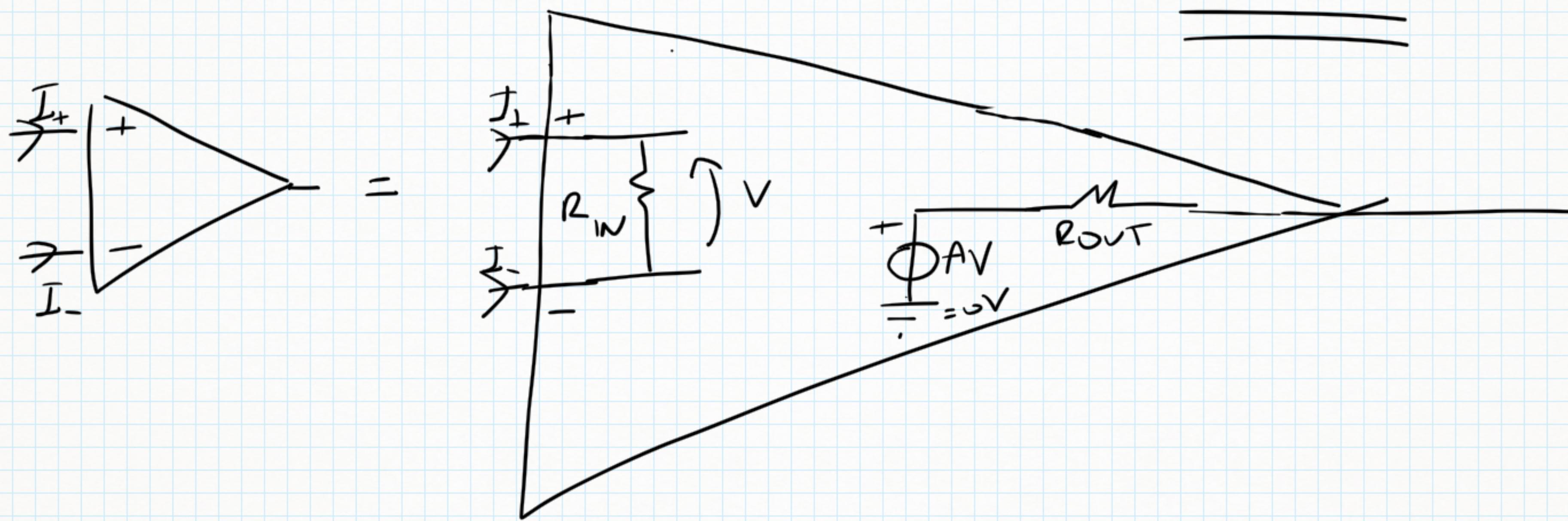
$$V_s = V_1 + V_2 + V_{AB} = V_1 + V_2 = I_1 R_1 + I_N \frac{R_2}{1 + G_M R_2} = I_N \left(R_1 + \frac{R_2}{1 + G_M R_2} \right)$$

$$I_N = \frac{V_S}{R_1 + \frac{R_2}{1 + f_M R_2}} = \frac{20}{3} \text{ A}$$

AMPLIFICATORE

OPERAZIONALE

IDEALE

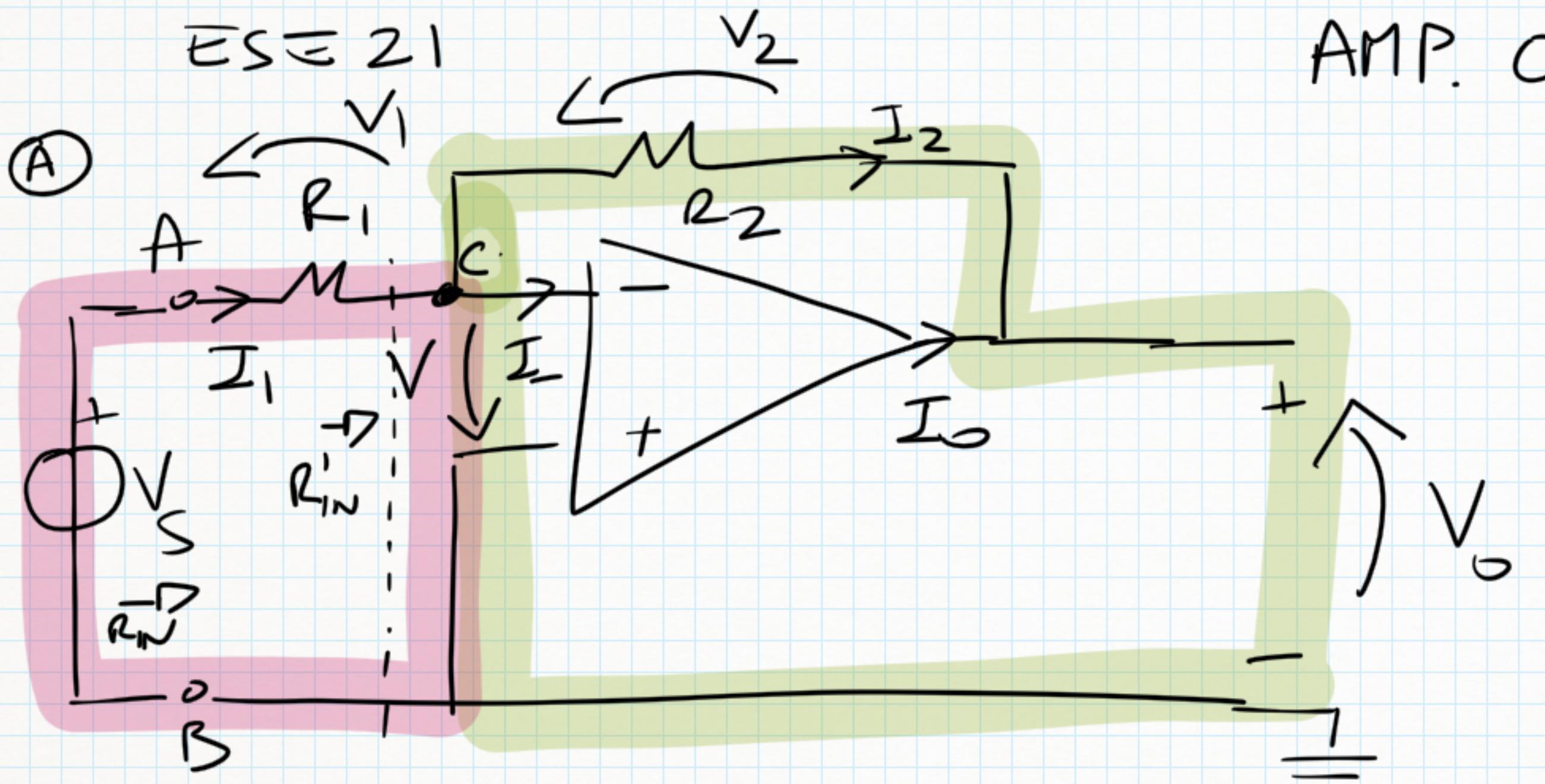


$$R_{IN} = +\infty \Rightarrow I_+ = I_- = 0A$$

$$R_{OUT} = 0\Omega$$

$$A = +\infty \quad (\text{GUADAGNO AD ANELLO APERTO})$$

$$E_S = 2V$$



AMP. OP. IDEALE $\Rightarrow V = 0V$

CORTO CIRCUITO
VIRTUALE

$$R_1 = 10k\Omega$$

$$R_2 = 100k\Omega$$

$$\frac{V_o}{V_s} = ? \quad V_s = 1V$$

$$V_s + V = V_1 \Rightarrow V_s = V_1 \Rightarrow I_1 = \frac{V_1}{R_1} = \frac{V_s}{R_1}$$

$$I_1 = I_- + I_2 \Rightarrow I_1 = I_2$$

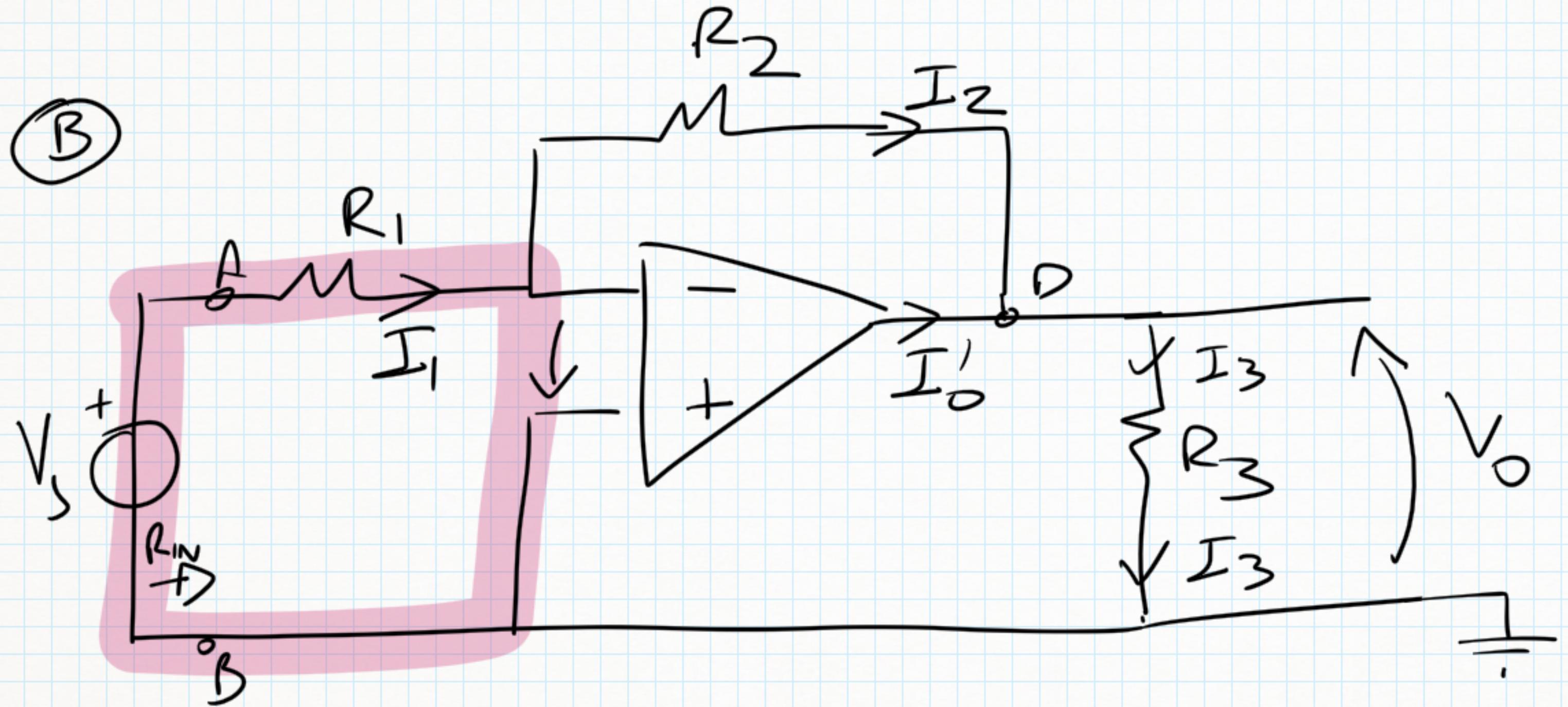
$$V_o + V_2 + V = 0 \Rightarrow V_o = -V_2 = -I_2 R_2 = -\frac{V_s}{R_1} R_2 \Rightarrow \frac{V_o}{V_s} = -\frac{R_2}{R_1} = -10$$

$$R_{IN} = \frac{V_S}{I_1} = \frac{\frac{V_S}{V_S}}{\frac{V_S}{R_1}} = R_1$$

$$R_{IN}^1 = 0 \Omega !$$

$$V_O = -\frac{R_2}{R_1} V_S = -10V$$

$$I_O = -I_2 = -I_1 = -0,1mA$$



$$R_3 = 10 \text{ k}\Omega$$

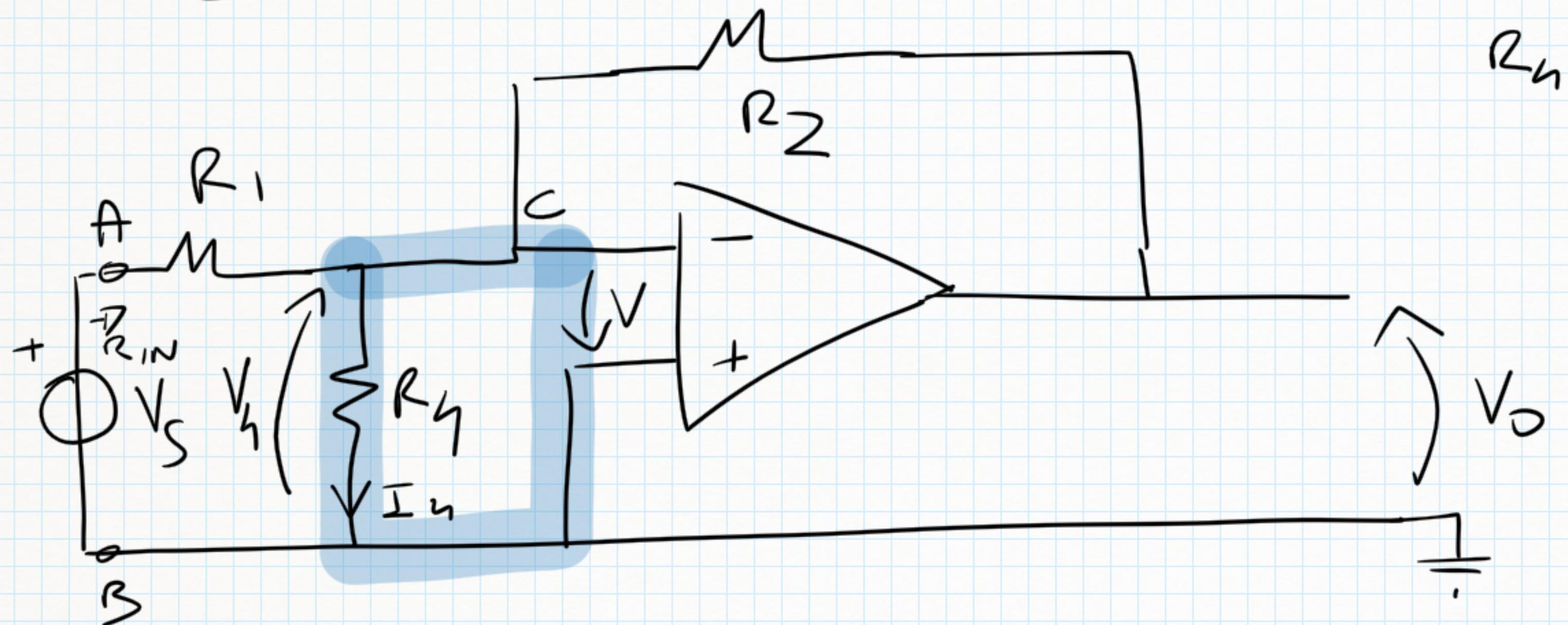
$$\frac{V_o}{V_s} = -\frac{R_2}{R_1} \Rightarrow V_o = -\frac{R_2}{R_1} V_s = -10 \text{ V}$$

$$R_{IN} = R_1$$

$$I_3 = \frac{V_o}{R_3} = -1 \text{ mA}$$

$$I_2 + I_0' = I_3 \Rightarrow I_0' = I_3 - I_2 = -1,1 \text{ mA}$$

c)



$$R_h = 10 \text{ k}\Omega$$

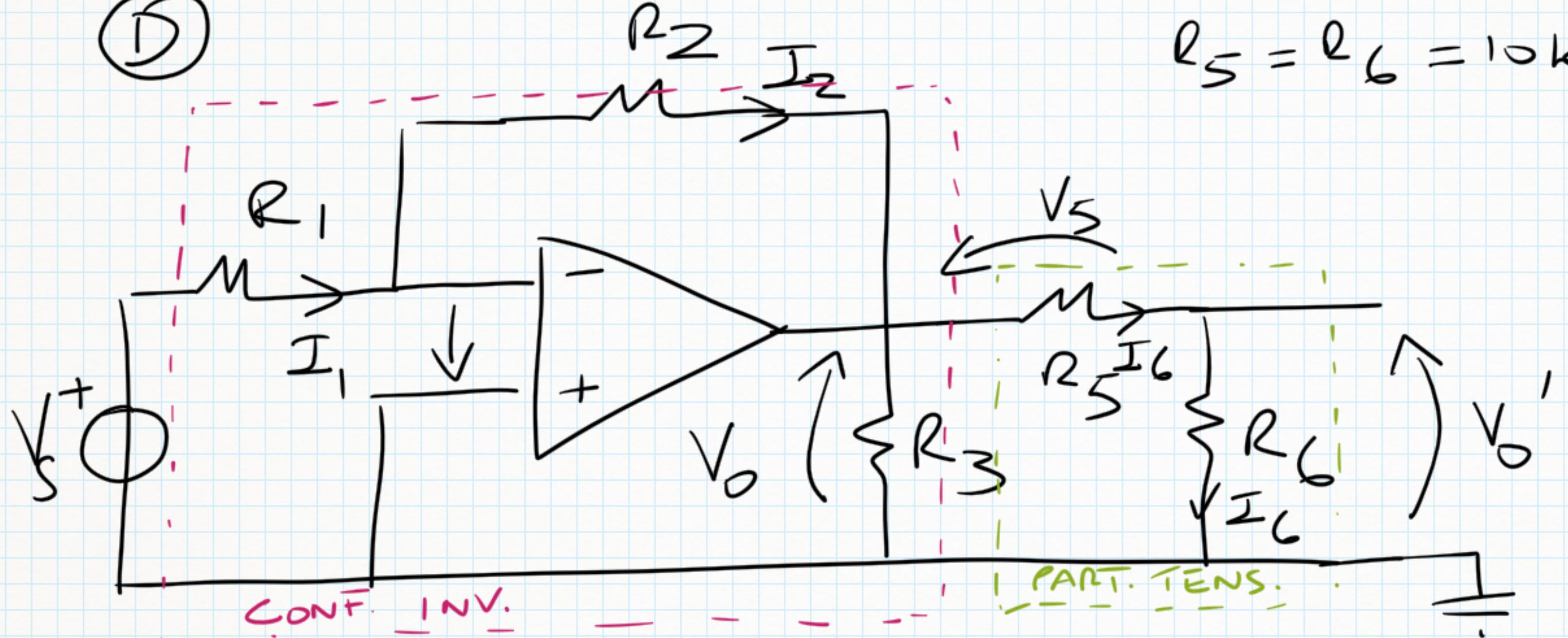
$$\frac{V_o}{V_s} = -\frac{R_2}{R_1}$$

$$V_o = -10 \text{ V}$$

$V_h + V = 0 \Rightarrow V_h = -V = 0 \text{ V}$

$$R_{IN} = R_1$$

⑤



$$R_5 = R_6 = 10\text{k}\Omega$$

$$\frac{V_o}{V_s} = ?$$
$$\frac{V_o'}{V_s} = ?$$

$$\frac{V_o}{V_s} = - \frac{R_2}{R_1}$$

$$\frac{V_o'}{V_o} = ?$$

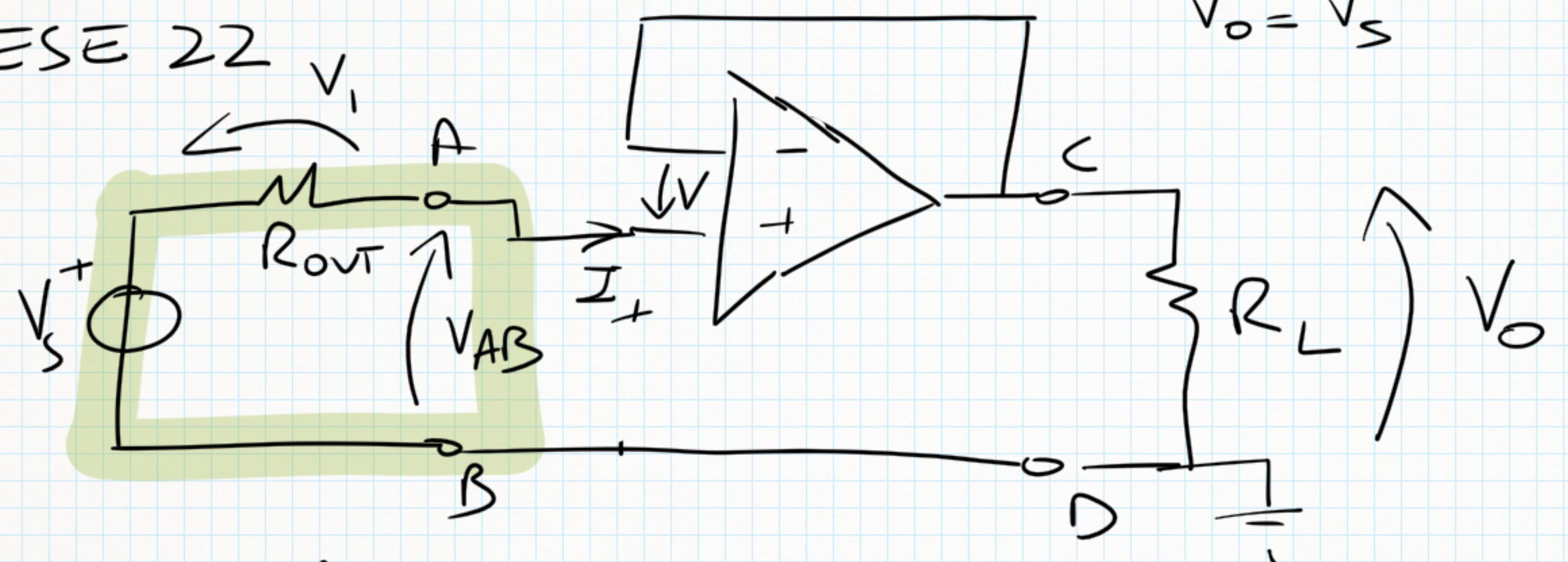
$$V_o' = V_o \frac{R_6}{R_5 + R_6} \Rightarrow$$

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

$$\frac{V_o'}{V_s} = \frac{V_o'}{V_o} \cdot \frac{V_o}{V_s} = -\frac{R_2}{R_1} \cdot \frac{R_6}{R_5 + R_6} = -5$$

$$I_6 = \frac{V_o}{R_5 + R_6} = -\frac{10}{20} \text{ mA}$$

ESE 22



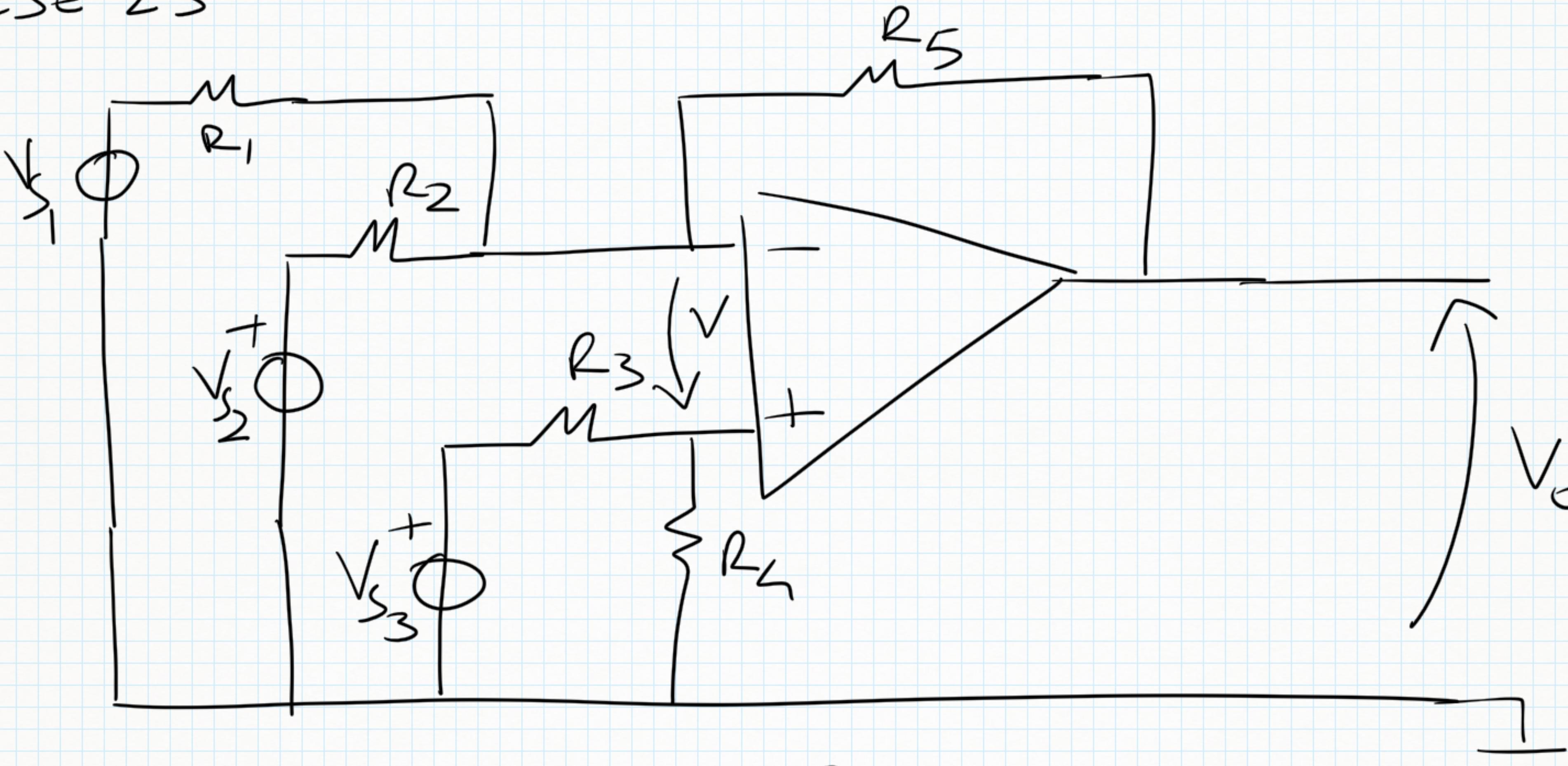
$$V_o = V_s$$

$$\frac{V_o}{V_{AB}} = 1$$

$$I_+ = 0A \Rightarrow V_I = 0V$$

$$V_s = V_{AB} + V_I \Rightarrow \frac{V_s}{V_{AB}} = 1 \Rightarrow V_o = V_s$$

ESE 23



$$V_o = f(V_{S_1}, V_{S_2}, V_{S_3})$$

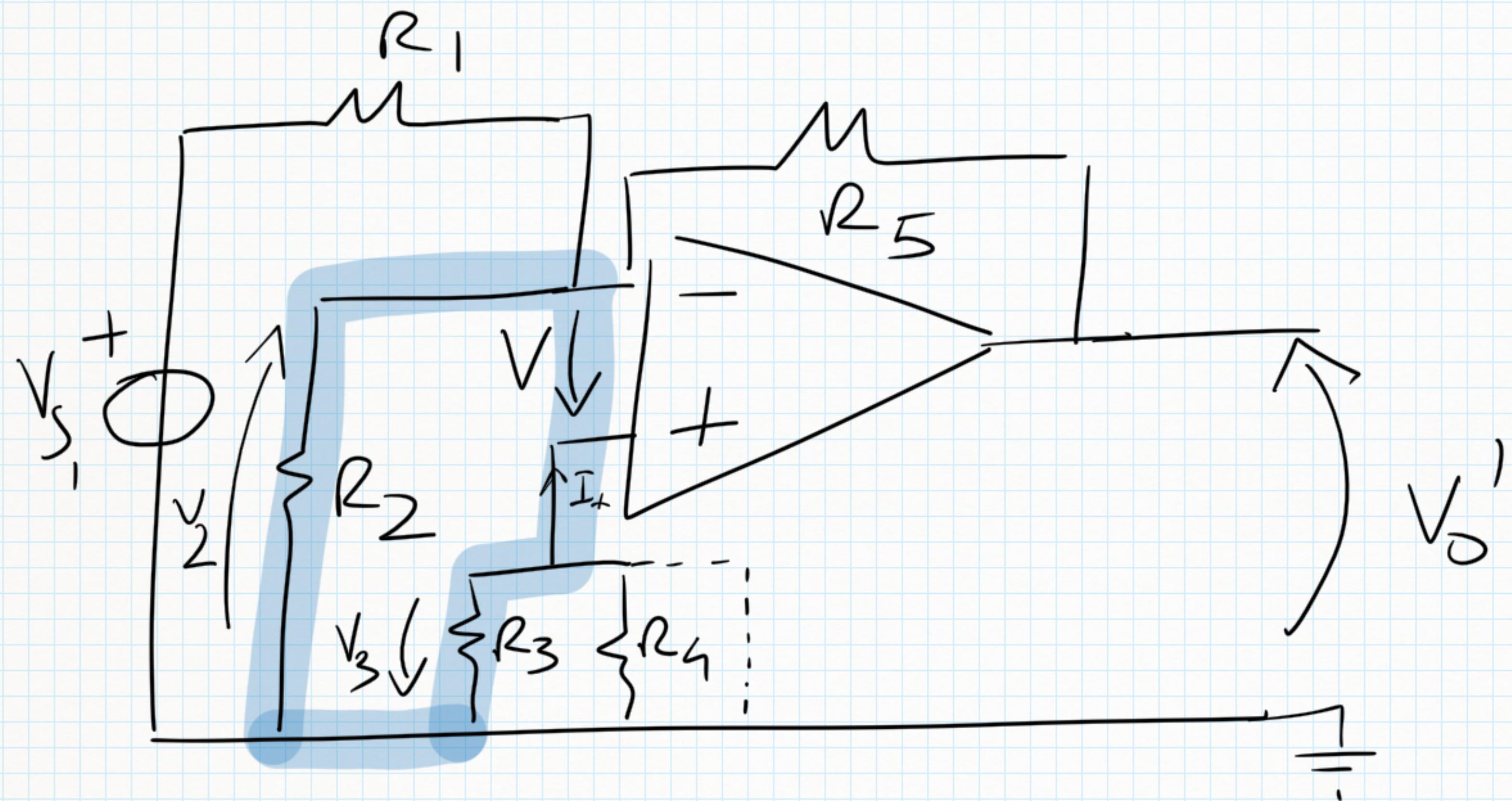
$$R_1 = R_2 = R_3 = R_4 = R_5 = R$$

CASO 1

V_{S_1} ON

V_{S_2} OFF

V_{S_3}



$$I_1 = 0 \text{ A} \Rightarrow V_3 = 0 \text{ V!}$$

$$V_2 + V + V_3 = 0 \Rightarrow V_2 = 0 \text{ V!}$$

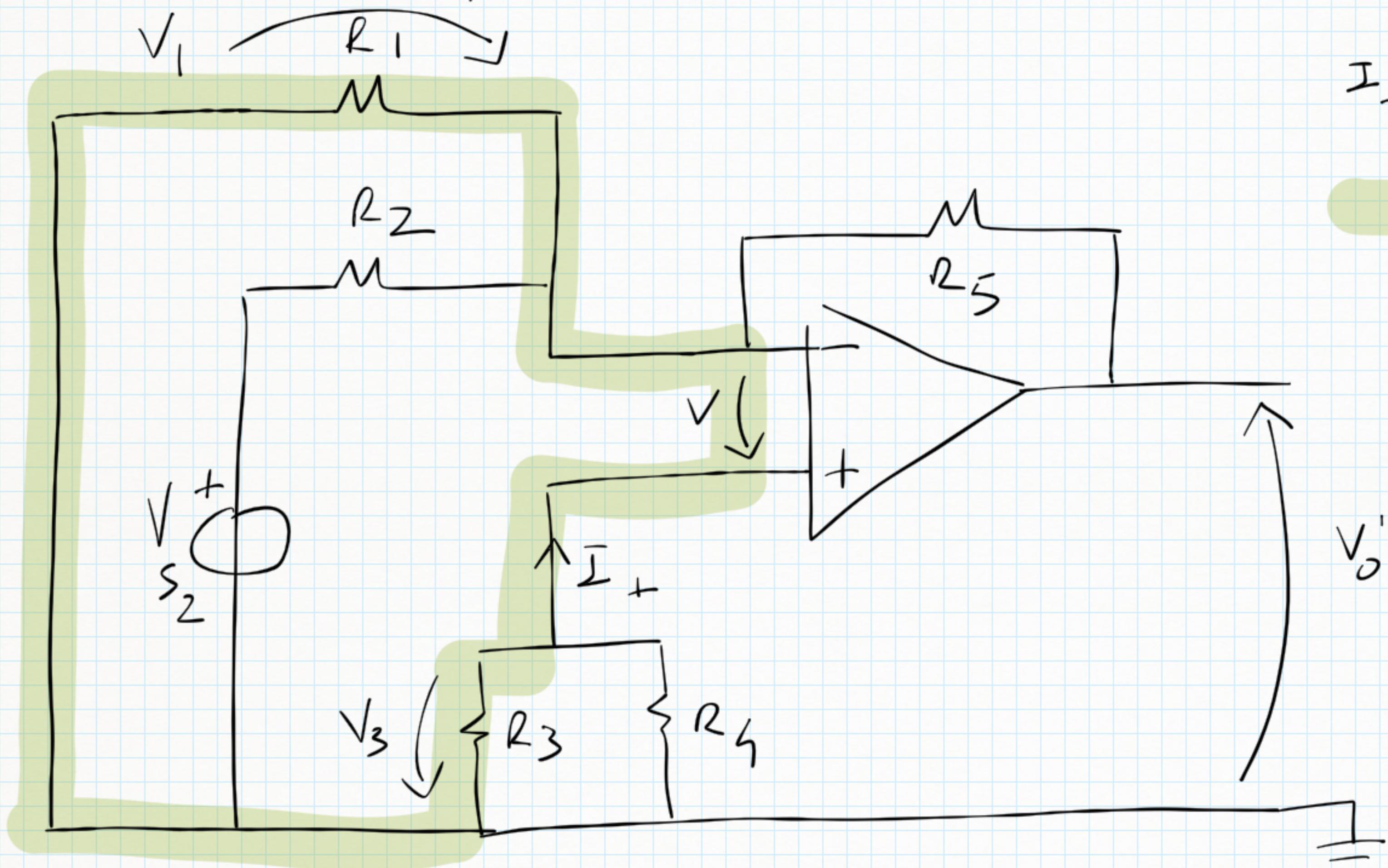
$$V'_0 = - \frac{R_5}{R_1} V_{S_1} = - V_{S_1}$$

CASO 2

V_{S_1} OFF

V_{S_2} ON

V_{S_3} OFF



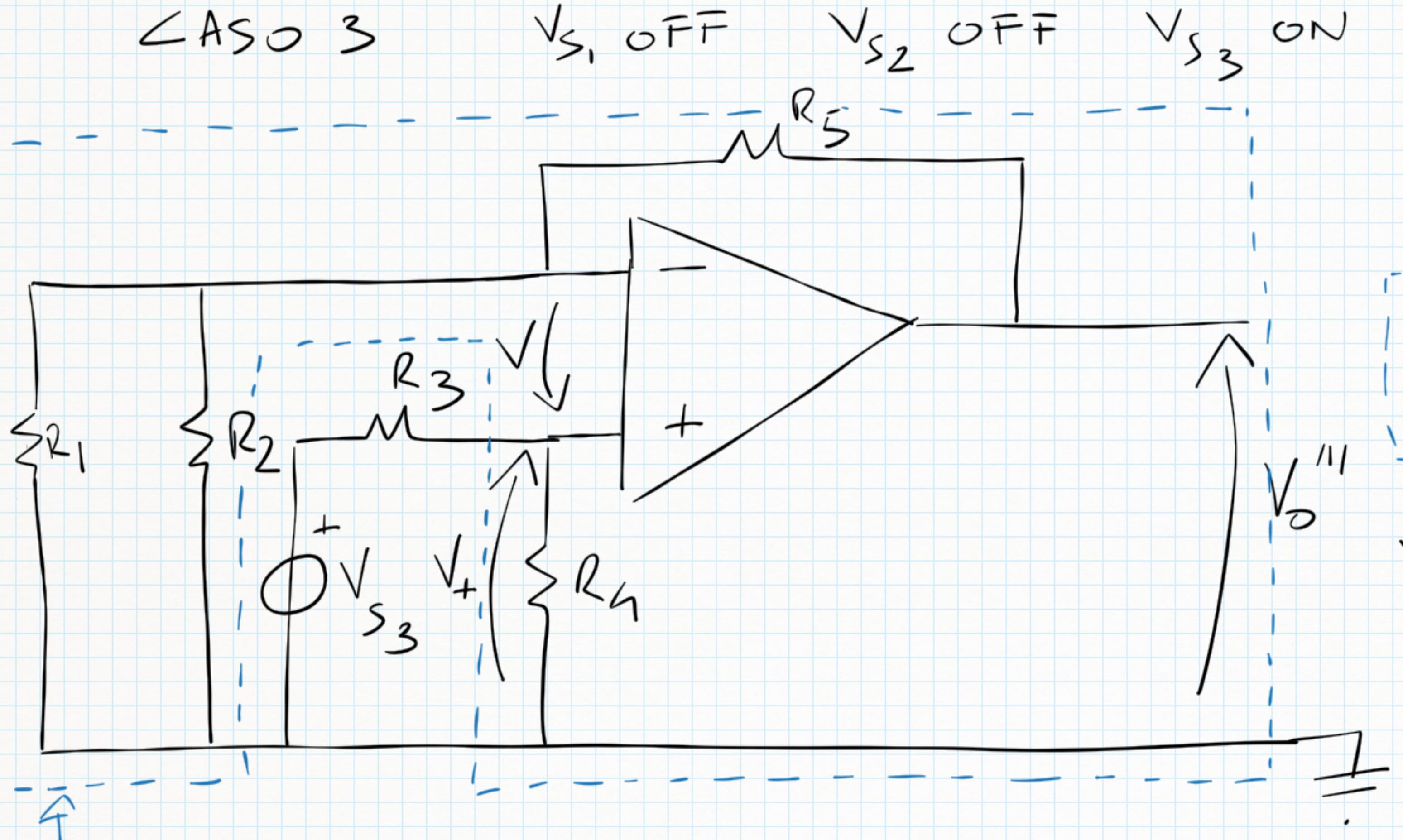
$$I_+ = 0 \text{ A} \Rightarrow V_3 = 0V!$$

$$V_1 + V + V_3 = 0$$

$$V_1 = 0V!$$

$$V_o'' = - \frac{R_5}{R_2} V_{S_2} = - V_{S_2}$$

CASO 3



$$V_+ = V_{S_3} \frac{R_4}{R_3 + R_4} = \frac{V_{S_3}}{2}$$

$$\frac{V_o'''}{V_+} = 1 + \frac{R_5}{R_1 || R_2} = 3$$

$$V_o''' = \left(1 + \frac{R_5}{R_1 || R_2}\right) V_+ = \frac{3}{2} V_{S_3}$$

CONFIG.

NON INVERTENTE!

QUINDI: $V_o = V'_+ + V''_+ + V'''_+ = \frac{3}{2} V_{S_3} - V_{S_2} - V_{S_1}$