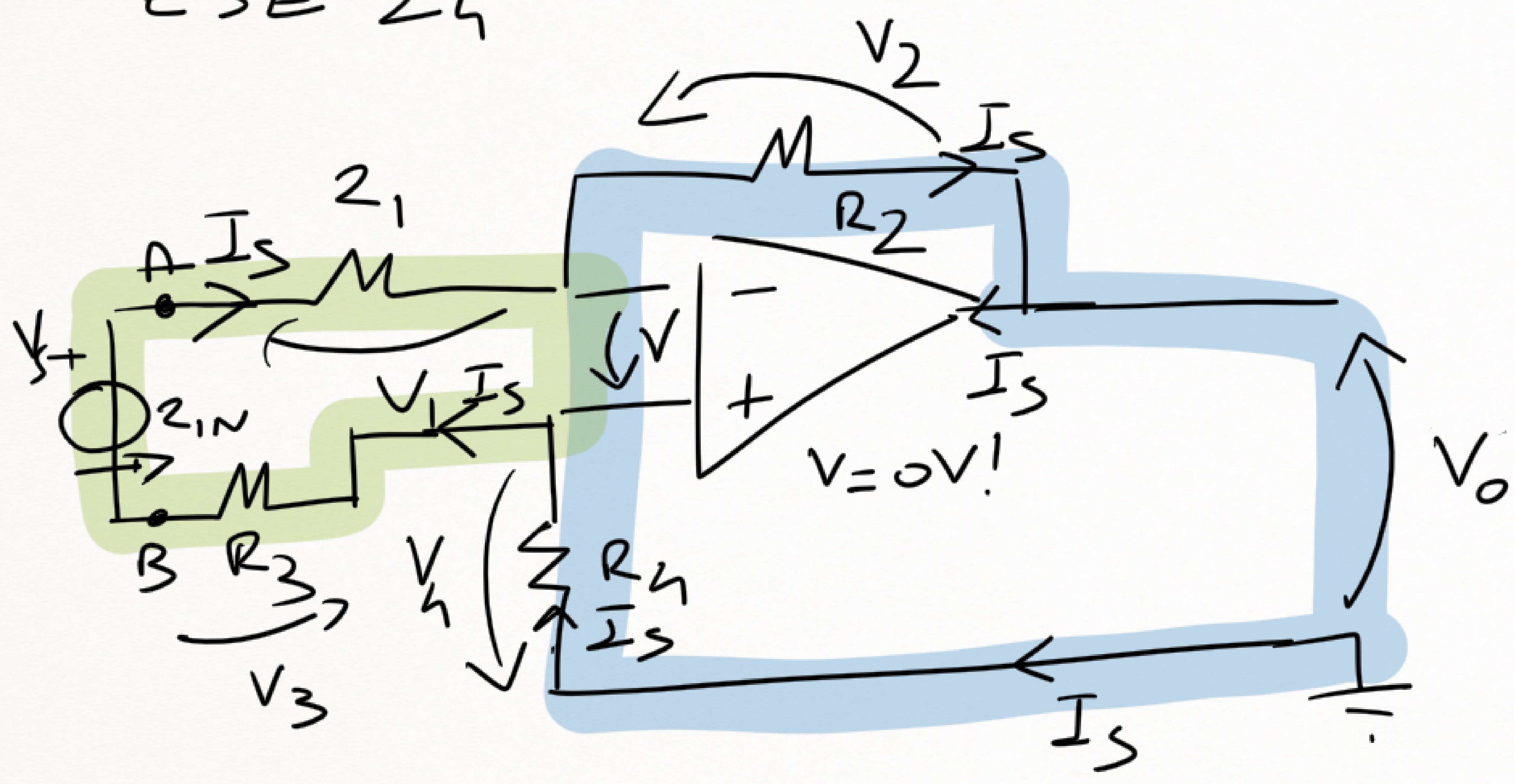
ESE 24




$R_1 = R_2 = R_3 = R_4 = R$

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

$R_{IN} = ?$

$V_s + V = V_1 + V_3 \Rightarrow V_s = V_1 + V_3 = I_s R_1 + I_s R_3 \Rightarrow I_s = \frac{V_s}{R_1 + R_3}$

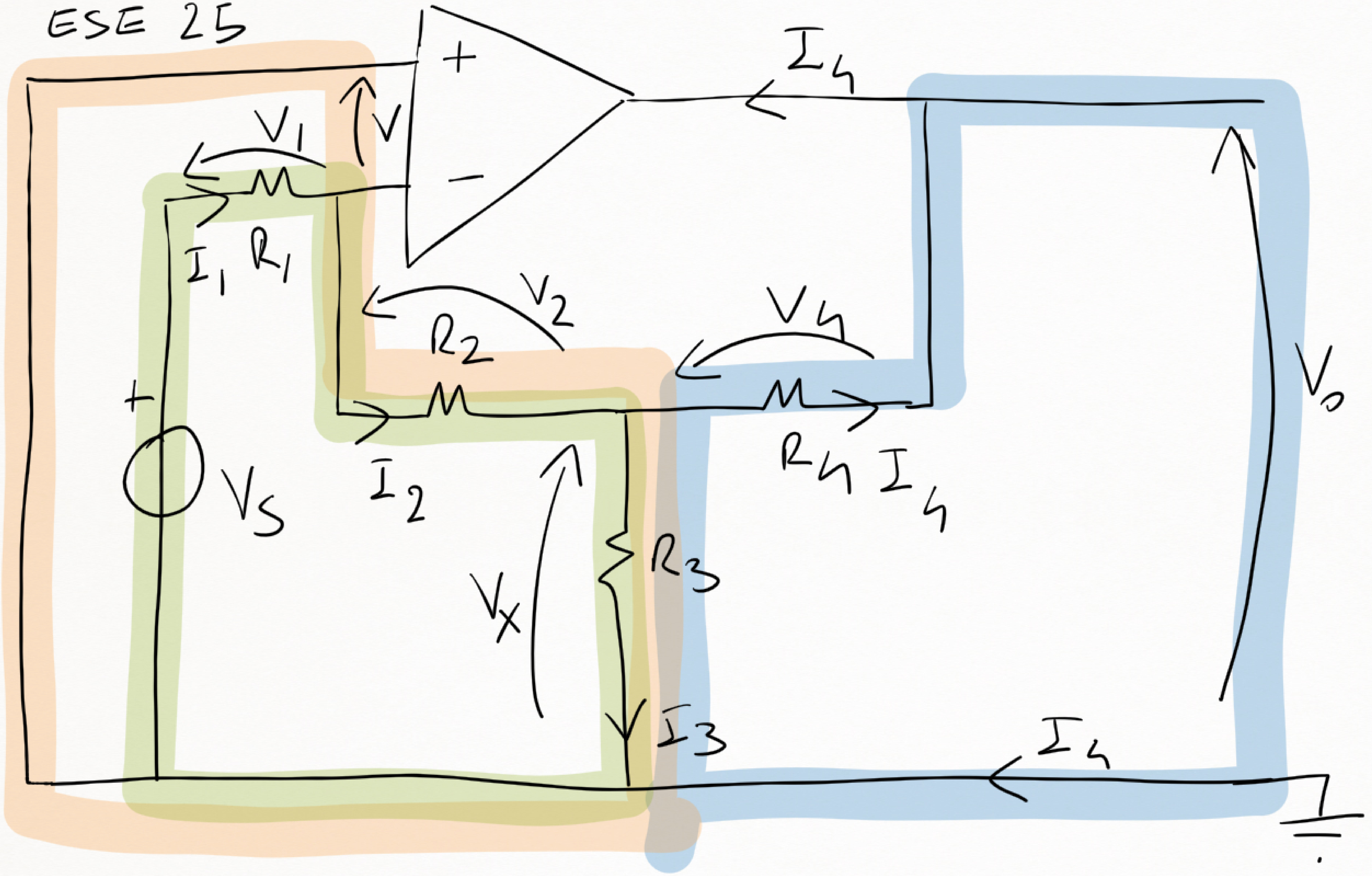
$R_{IN} = \frac{V_s}{I_s} = \frac{I_s (R_1 + R_3)}{I_s} = R_1 + R_3 = 2R$

$V_o + V_2 + V + V_4 = 0 \Rightarrow V_o = -V_2 - V_4 = -I_s R_2 - I_s R_4$

$$V_o = -I_s(R_2 + R_4) = -\frac{V_s}{R_3 + R_1}(R_2 + R_4)$$

$$\frac{V_o}{V_s} = -\frac{R_2 + R_4}{R_1 + R_3} = -1$$

ESE 25




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

$$\frac{V_o}{V_S} = \frac{V_x}{V_S} \cdot \frac{V_o}{V_x}$$

$$I_1 = V_S / R_1 \; ; \; I_2 = I_1$$

$$V_S = V_x + V_2 + V_1$$

$$V_S = V_x + I_1 R_1 + I_2 R_2 = V_x + I_1 (R_1 + R_2) = V_x + \frac{V_S}{R_1}(R_1 + R_2)$$

$$\frac{V_x}{V_S} = -\frac{R_2}{R_1}$$

$$V_x + V_2 + V = 0 \Rightarrow V_2 = -V_x$$

$$V_o + V_4 = V_x \Rightarrow V_o = V_x - V_4 = V_x - I_4 R_4$$

$$I_2 = I_3 + I_4 \Rightarrow I_4 = I_2 - I_3 = \frac{V_2}{R_2} - \frac{V_x}{R_3} = -V_x\left(\frac{1}{R_2} + \frac{1}{R_3}\right) =$$

$$= -V_x\left(\frac{R_3 + R_2}{R_2 R_3}\right)$$

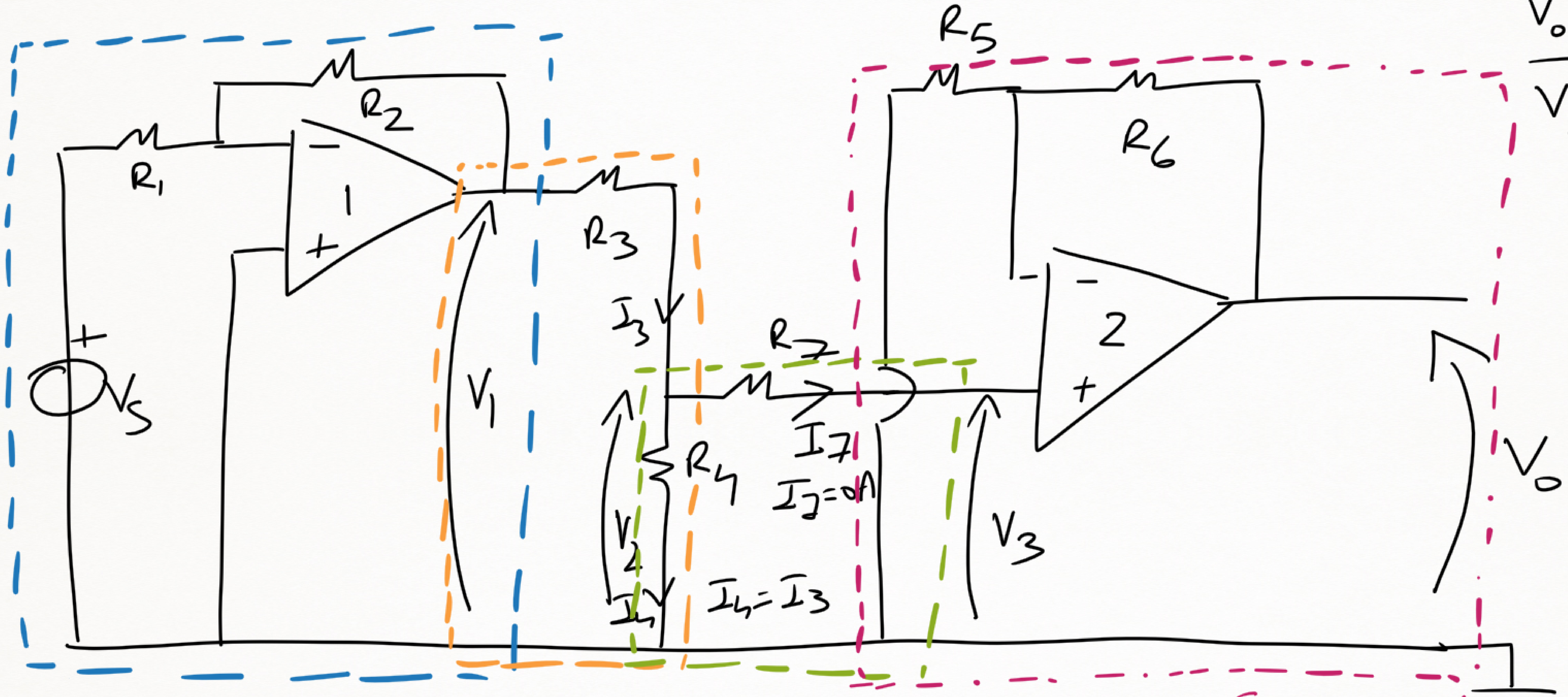
$$V_o = V_x - R_4 \cdot \left(-V_x\left(\frac{R_2 + R_3}{R_2 R_3}\right)\right)$$

$$\frac{V_o}{V_x} = 1 + R_4 \cdot \frac{R_2 + R_3}{R_2 R_3}$$

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

# ESE 26

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




↳ CONF. INV.

$$\frac{V_1}{V_s} = -\frac{R_2}{R_1}$$

PART. TENS.

$$\frac{V_2}{V_1} = \frac{R_4}{R_3 + R_4}$$

$$\frac{V_3}{V_2} = 1$$

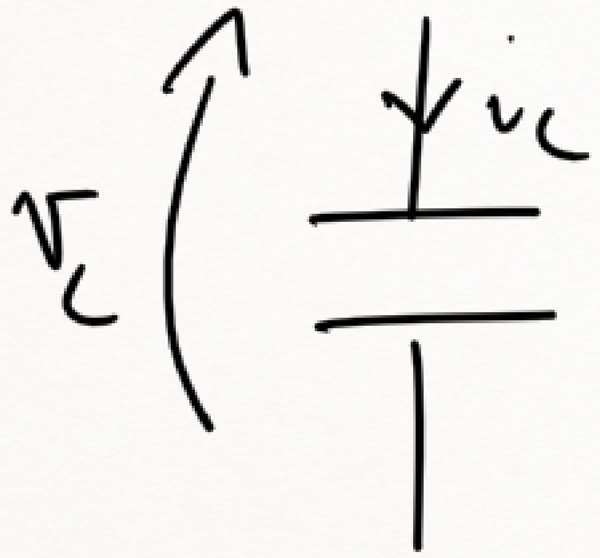
↳ CONF. NON INV.

$$\frac{V_o}{V_3} = 1 + \frac{R_6}{R_5}$$

$$\frac{V_0}{V_s} = \frac{V_1}{V_s} \cdot \frac{V_2}{V_1} \cdot \frac{V_3}{V_2} \cdot \frac{V_0}{V_3} = -\frac{R_2}{R_1} \cdot \frac{R_4}{R_3+R_4} \cdot 1 \cdot \left(1 + \frac{R_6}{R_5}\right)$$

# CIRCUITI A SINGOLA COSTANTE DI TEMPO

## CONDENSATORE




$$i_C = C \frac{dv_C}{dt}$$

$$v_C(t_0^-) = v_C(t_0^+)$$

## INDUTTORE


$$v_L = L \frac{di_L}{dt}$$

$$i_L(t_0^-) = i_L(t_0^+)$$

COND. STAZIONARIE = COND. EQUILIBRIO

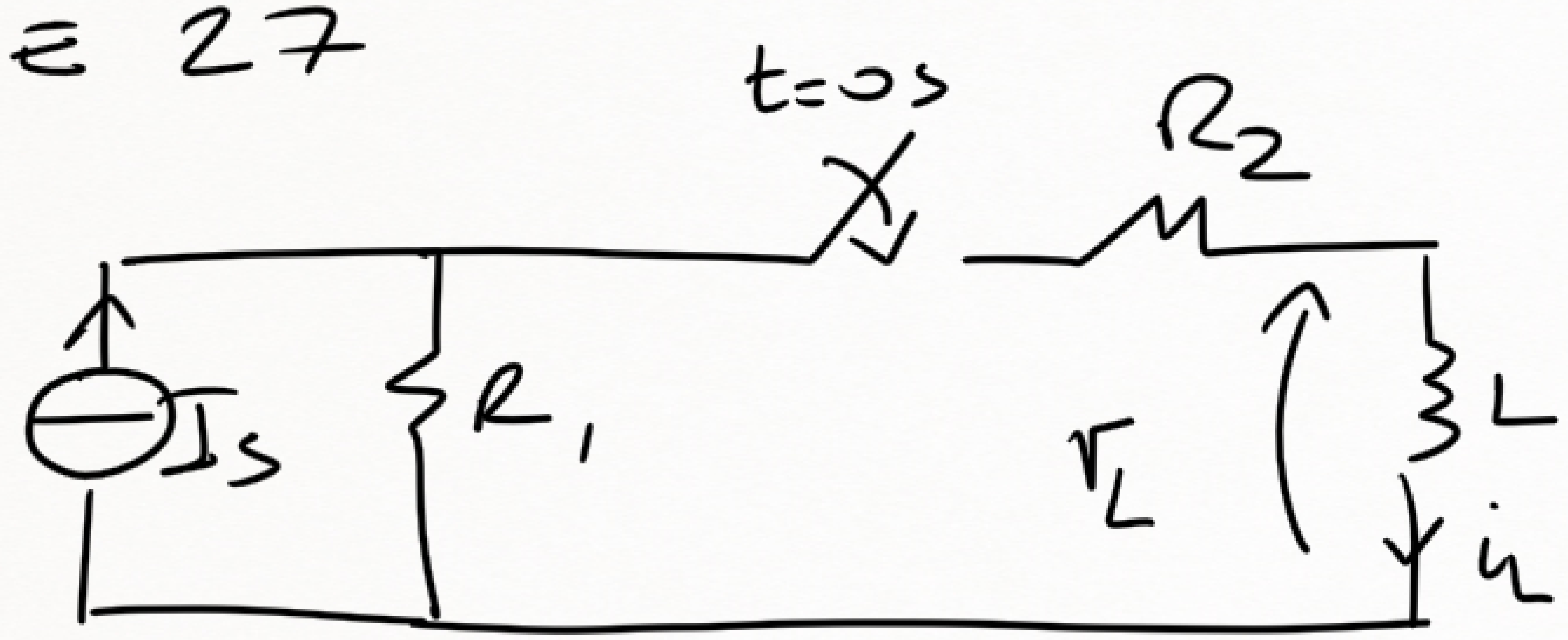
$$\frac{dv_C}{dt} = 0 \Rightarrow i_C = 0A$$

COND. SI COMPORTA COME UN CIRC. APERTO!

$$\frac{di_L}{dt} = 0 \Rightarrow v_L = 0V$$

IND. SI COMPORTA COME UN FILO!

ESE 27




$I_s = 6A$

$R_1 = 2\,\Omega$

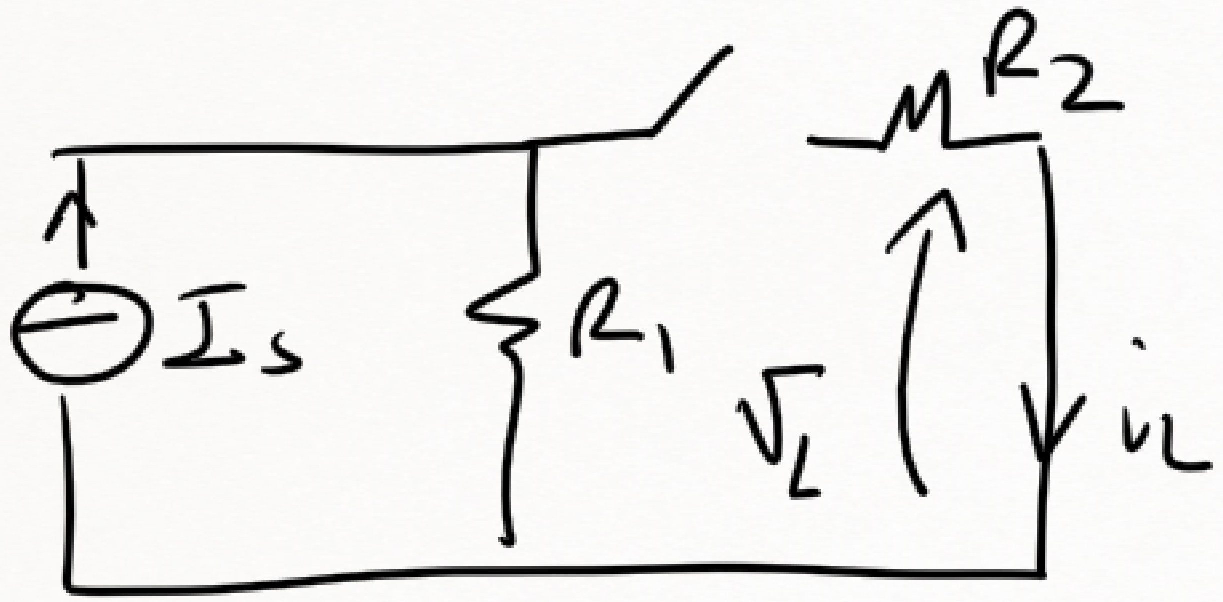
$R_2 = 4\,\Omega$

$L = 3H$

$i_L(t) = ?$

$v_L(t) = ?$

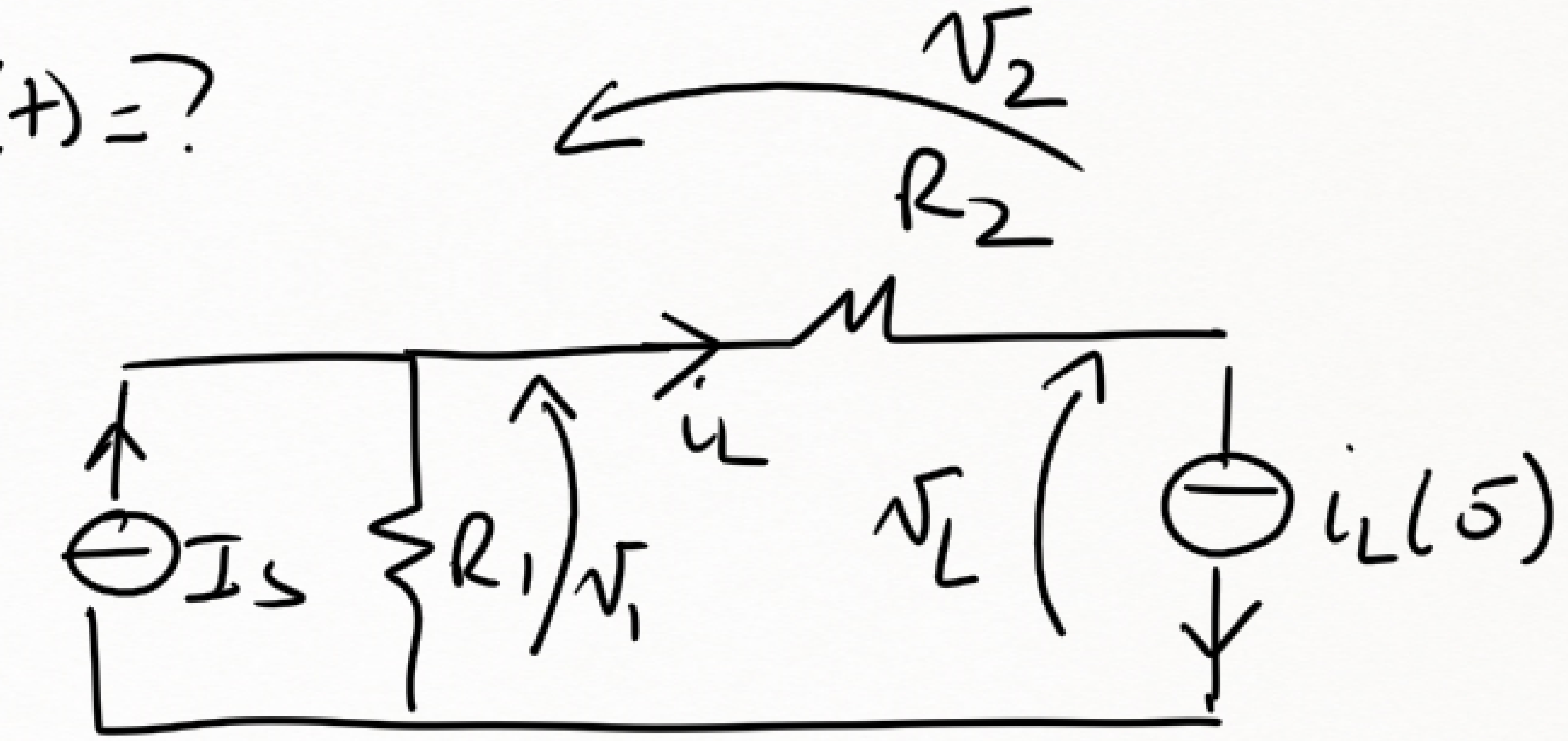
$t = 0^- s$: COND. STAZ.




$i_L(0^-) = 0A$

$v_L(0^-) = 0V$

$t = 0^+ s$:

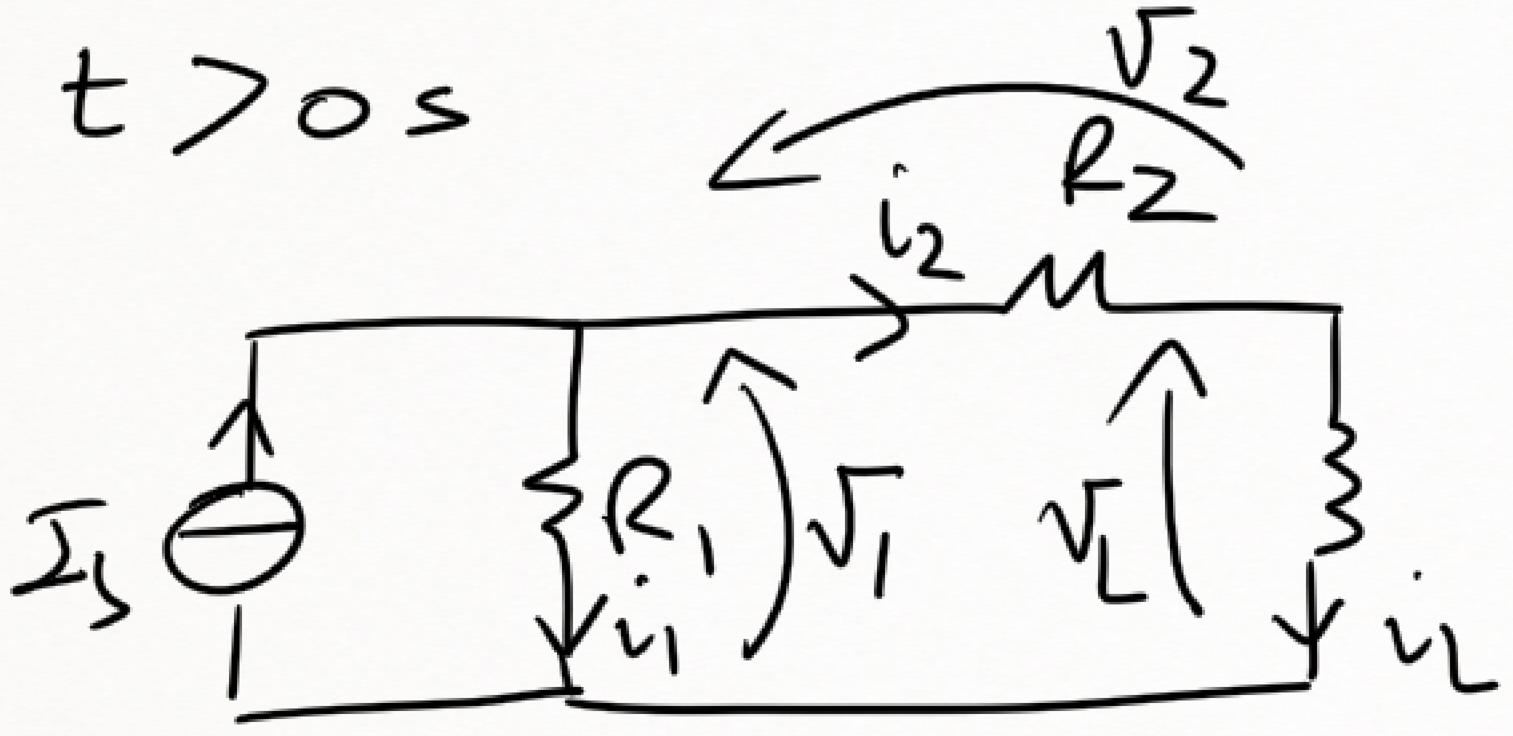



$v_2(0^+) = 0V \Rightarrow v_L(0^+) = v_1(0^+) = I_s R_1 = 12V$

$v_L(0^+) = L \dfrac{di_L(0^+)}{dt} > 0 \Rightarrow i_L(t) \nearrow \Rightarrow v_2(t) \nearrow$

$\Rightarrow v_L(t) \; ?$

$t > 0\,s$




$i_2 = i_L$

$I_s = i_1 + i_L \Rightarrow i_1 = I_s - i_L$

$v_1 = i_1 R_1 = (I_s - i_L) R_1$

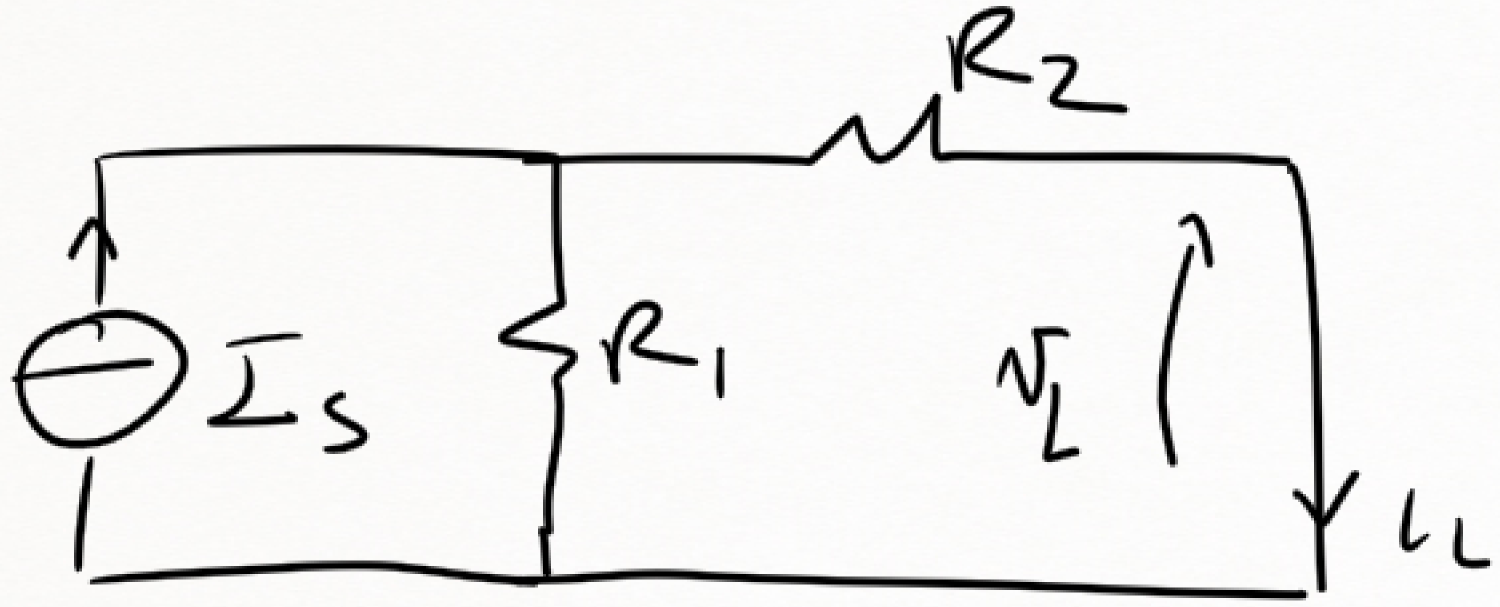
$v_2 = v_1 - v_L$

$$i_L = \frac{v_2}{R_2} = \frac{v_1 - v_L}{R_2}$$

$$\frac{v_L}{R_2} = \frac{v_1}{R_2} - i_L \quad ; \quad v_L = L\frac{di_L}{dt}$$

$$\tau = \frac{L}{R_{EQ}} \Leftarrow \boxed{\frac{L}{R_1+R_2}} \frac{di_L}{dt} + i_L = \boxed{I_s \frac{R_1}{R_1+R_2}} \Rightarrow i_L(+\infty)$$

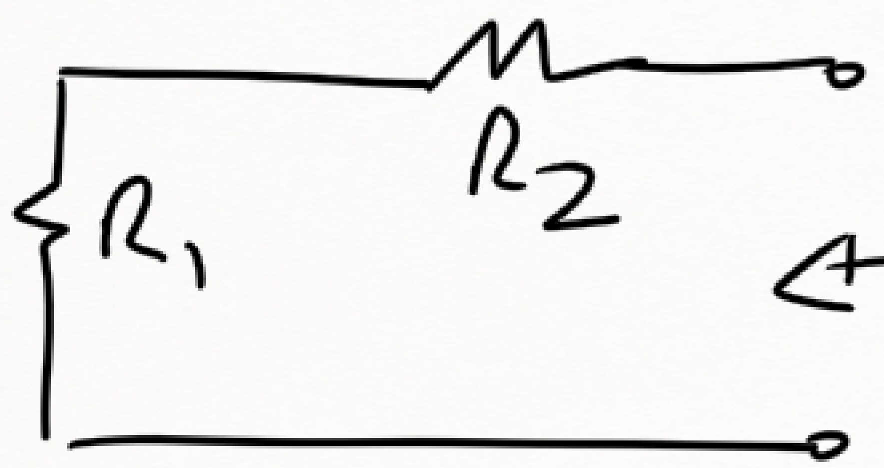
$t = +\infty$ : NUOVE COND. STAZIONARIE




$$i_L(+\infty) = I_S \frac{R_1}{R_1 + R_2} = 2A$$

$$v_L(+\infty) = 0V$$

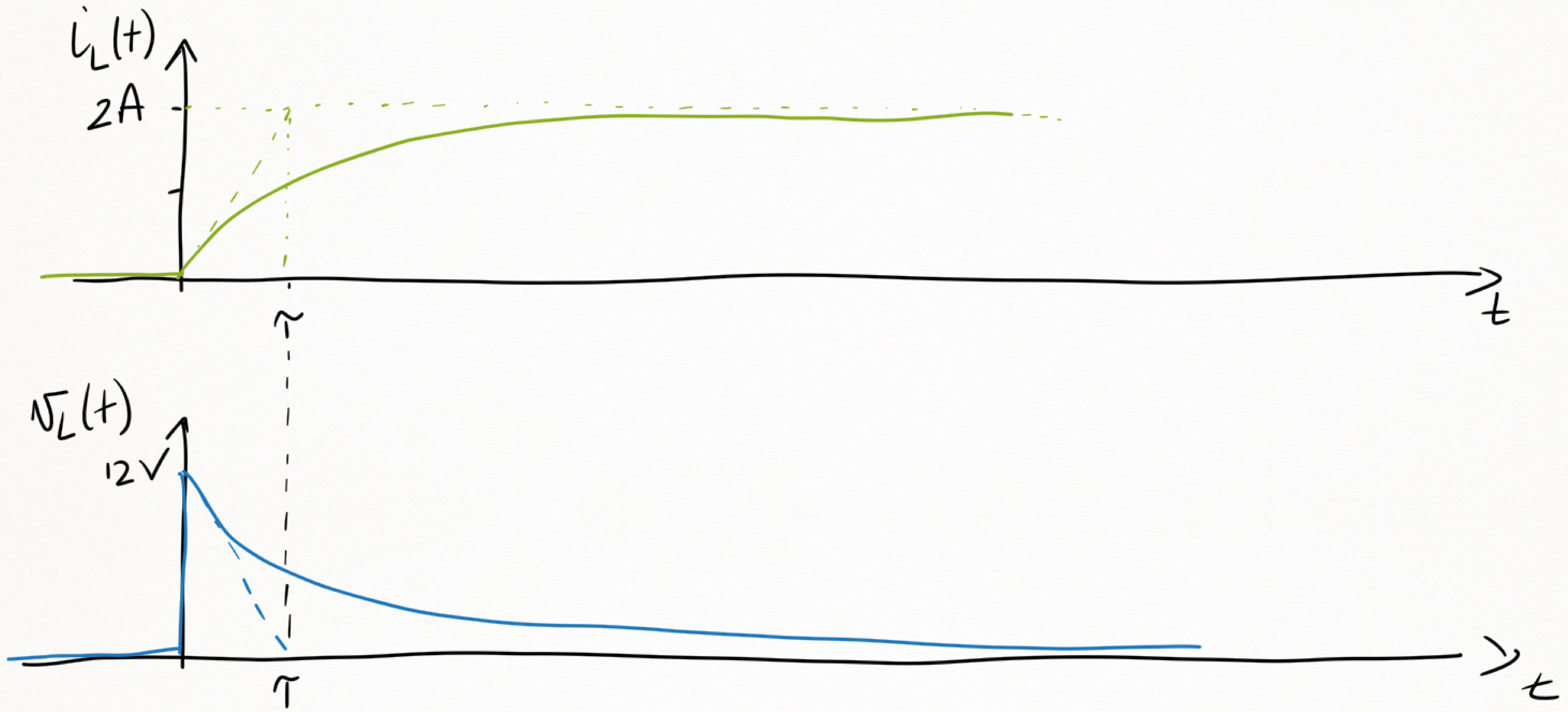
$\tau$ :




$$\leftarrow R_{EQ} = R_1 + R_2 \Rightarrow \tau = \frac{L}{R_{EQ}} = \frac{1}{2} s$$

$$i_L(t) = [i_L(0^+) - i_L(+\infty)] e^{-t/\tau} + i_L(+\infty) = i_L(+\infty)(1 - e^{-t/\tau}) [A]$$

$$v_L(t) = L \frac{di_L}{dt} = [v_L(0^+) - v_L(+\infty)] e^{-t/\tau} + v_L(+\infty) = v_L(0^+) e^{-t/\tau} [V]$$



$i_L(t)$
2A
t
τ
$v_L(t)$
12V
τ
t

RISPOSTA:

$$x(t) = [x(0^+) - x(+\infty)]\, e^{-t/\tau} + x(+\infty) \qquad [x,\ i \text{ OPPURE } v]$$

$x(0^+) = ?$

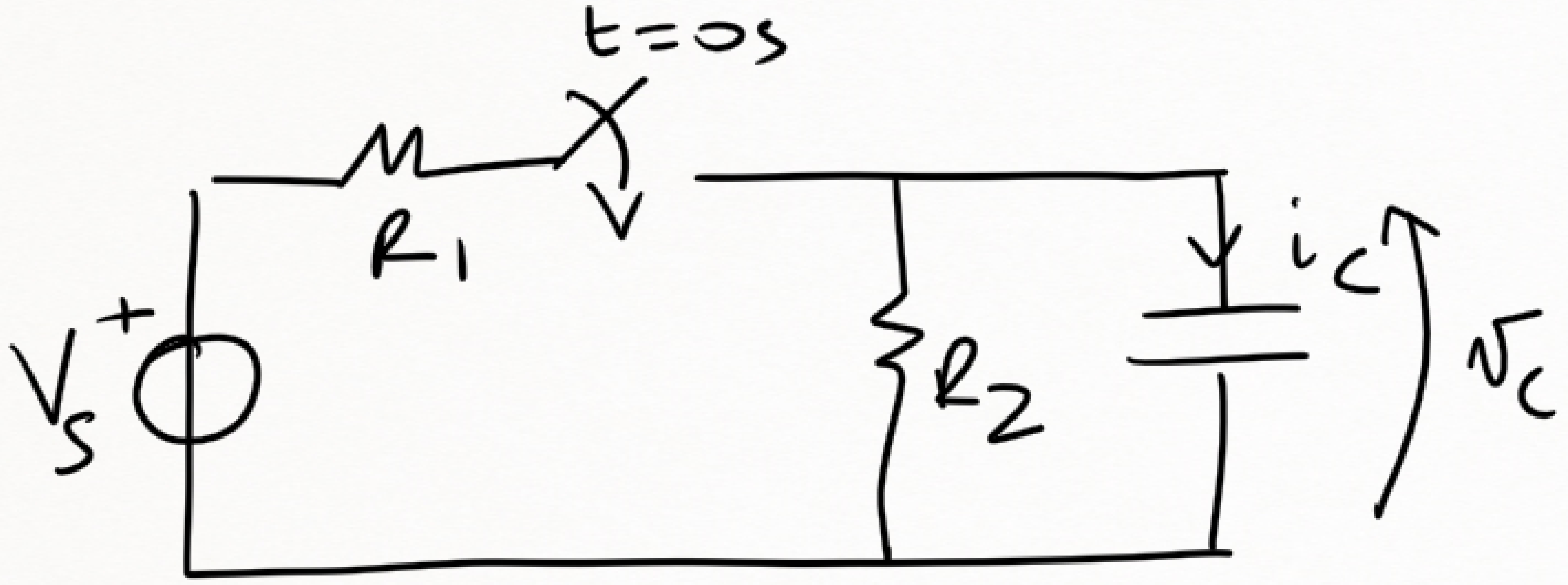
$x(+\infty) = ?$

$\tau = ?$

$\tau$ L: $\tau = \dfrac{L}{R_{EQ}}$

C: $\tau = C \cdot R_{EQ}$

ESE 28




$V_s = 12\,V$

$R_1 = 3\,\Omega$

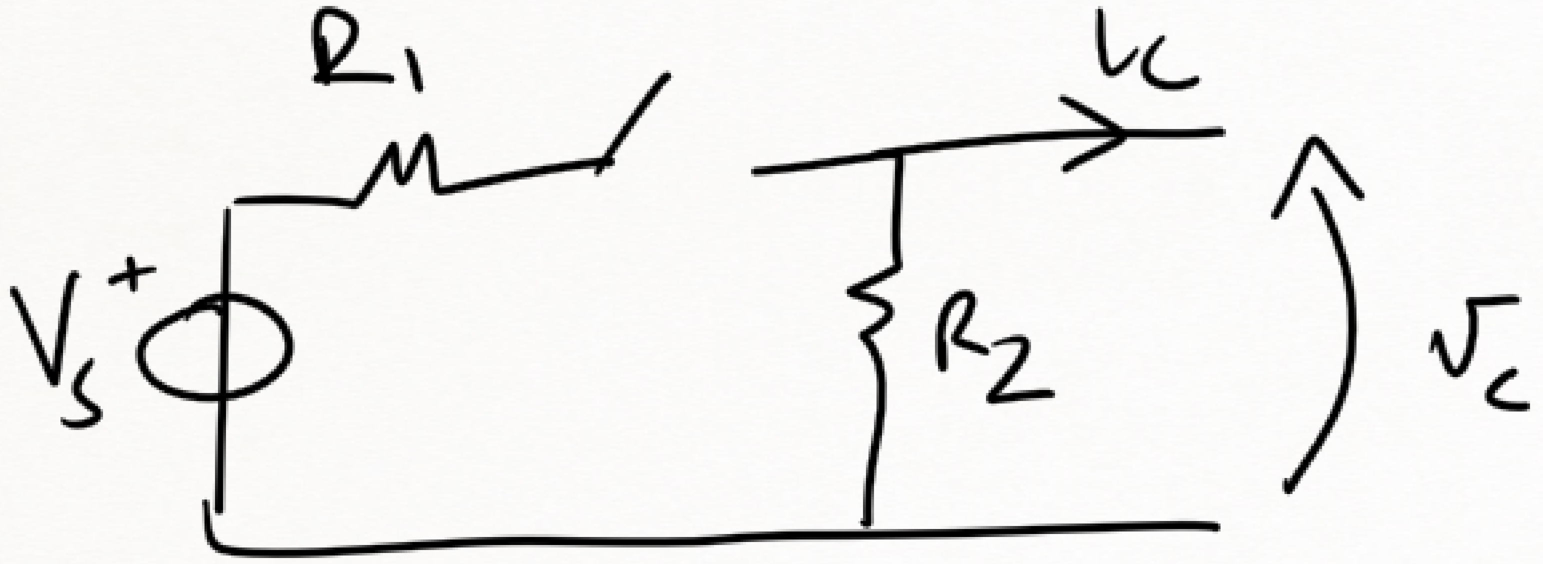
$R_2 = 6\,\Omega$

$C = \frac{1}{2}\,F$

$i_C(t) = ?$

$v_C(t) = ?$

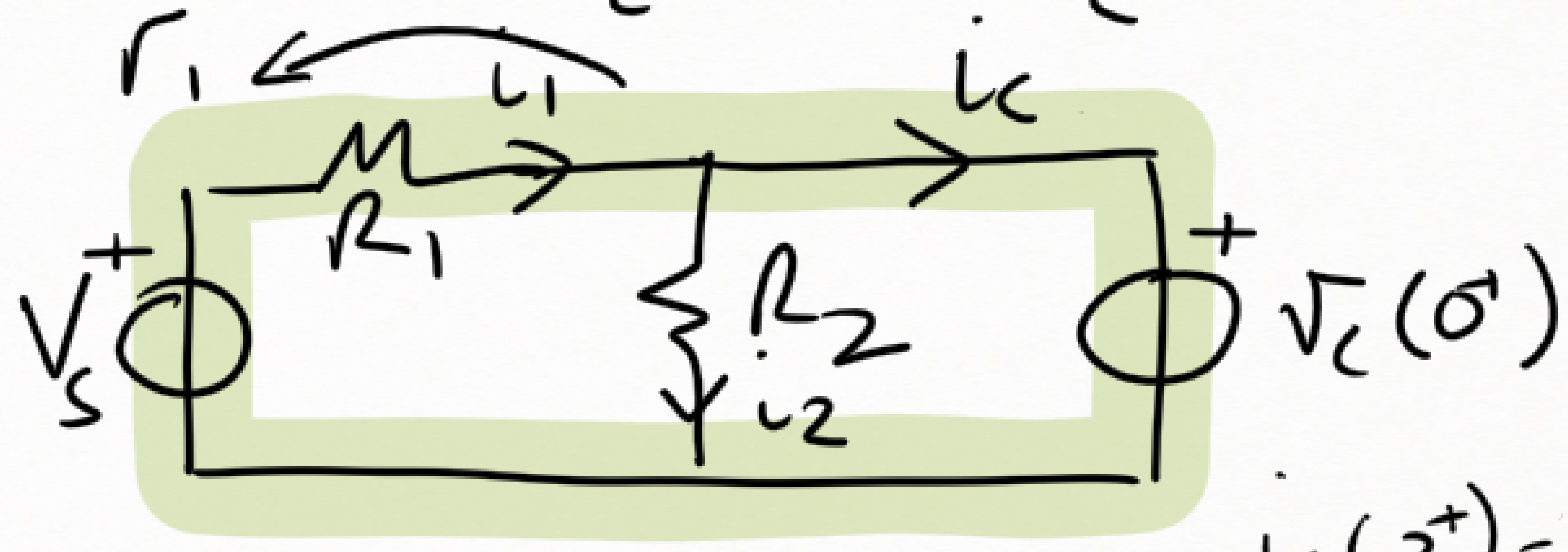
$t = 0^-\,s$:




$i_C(0^-) = 0\,A$

$v_C(0^-) = 0\,V$

$t = 0^+\,s$: $v_C(0^+) = v_C(0^-) = 0\,V \Rightarrow i_2(0^+) = 0\,A$

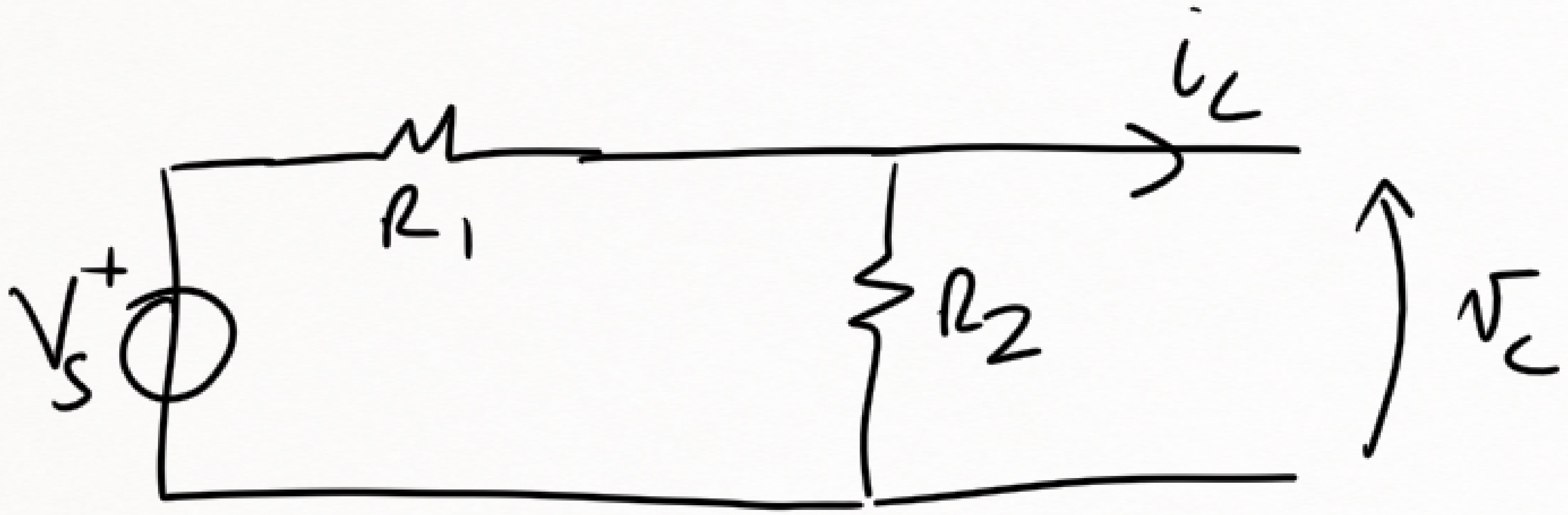



$V_s = v_C + v_1 = v_1$

$i_1(0^+) = i_2(0^+) + i_C(0^+)$

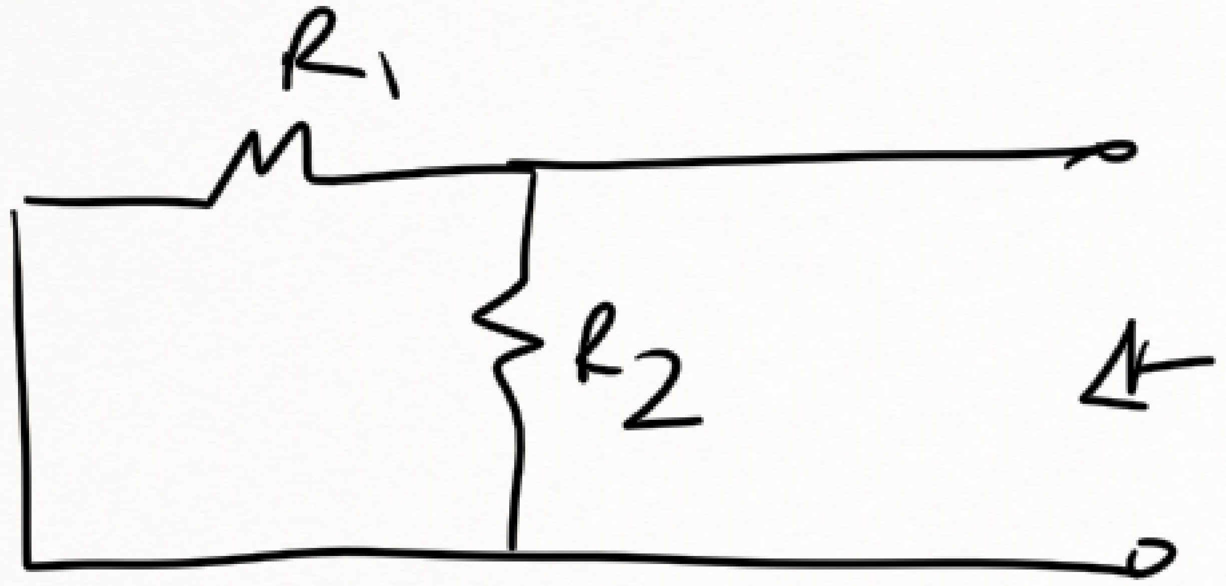
$i_C(0^+) = i_1(0^+) = \frac{V_s}{R_1} = 4\,A$

$t = +\infty$:




$$v_C(+\infty) = V_S \frac{R_2}{R_1 + R_2} = 8V$$

$$i_C(+\infty) = 0A$$

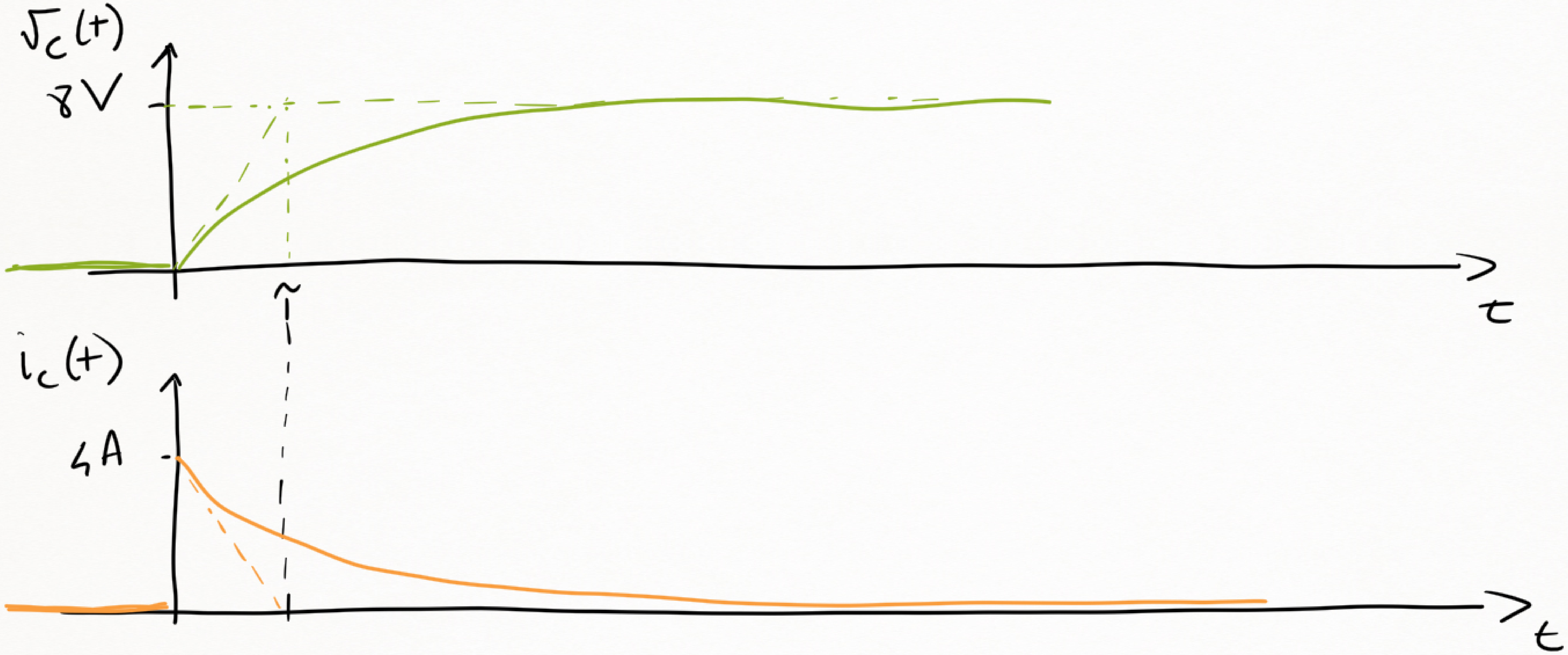



$$R_{EQ} = R_1 // R_2 = \frac{R_1 R_2}{R_1 + R_2} = 2\,\Omega$$

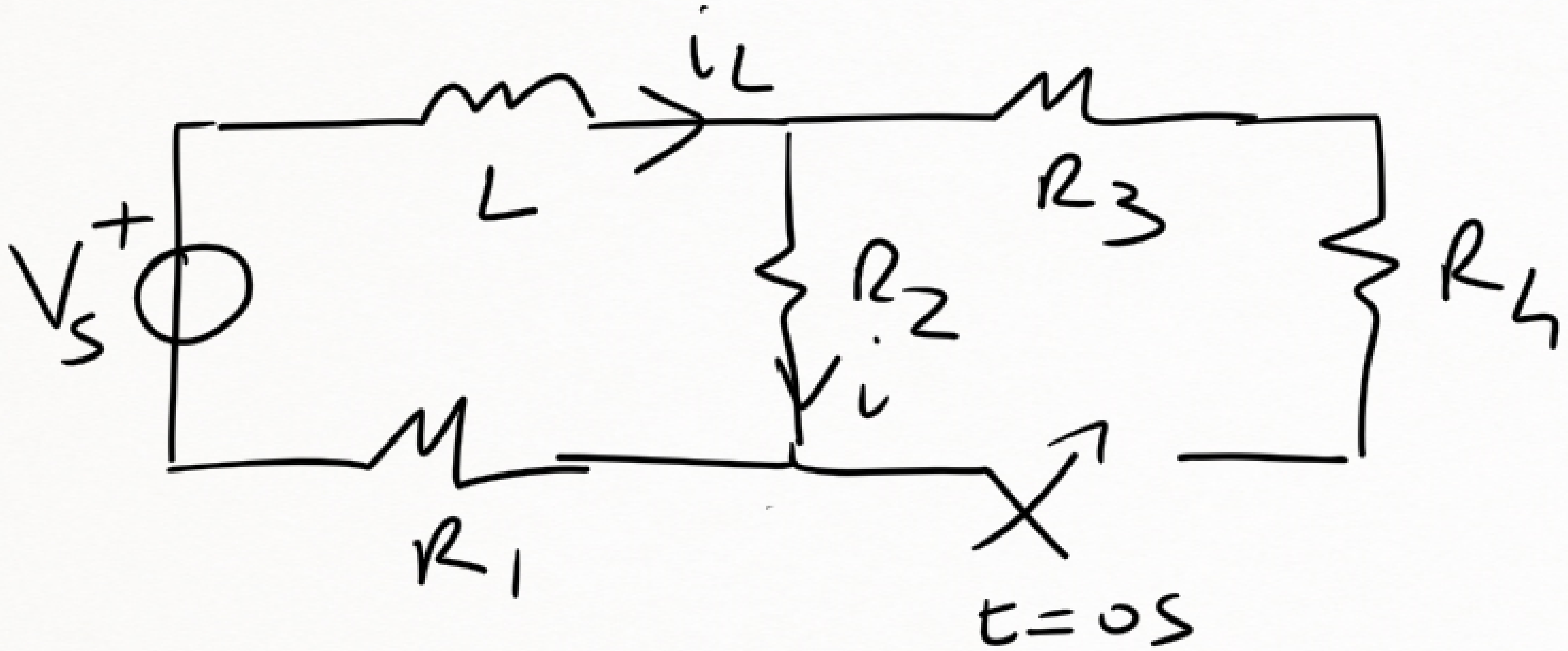
$$\tau = C R_{EQ} = 1\,s$$

$$v_C(t) = [v_C(0^+) - v_C(+\infty)]\, e^{-t/\tau} + v_C(+\infty) = v_C(+\infty)\left[1 - e^{-t/\tau}\right] \; [V]$$

$$i_C(t) = C\,\frac{dv_C}{dt} = i_C(0^+)\, e^{-t/\tau} = [i_C(0^+) - i_C(+\infty)]\, e^{-t/\tau} + i_C(+\infty) \; [A]$$



ESE 29




$V_s = 10V$

$R_1 = R_4 = 3\Omega$

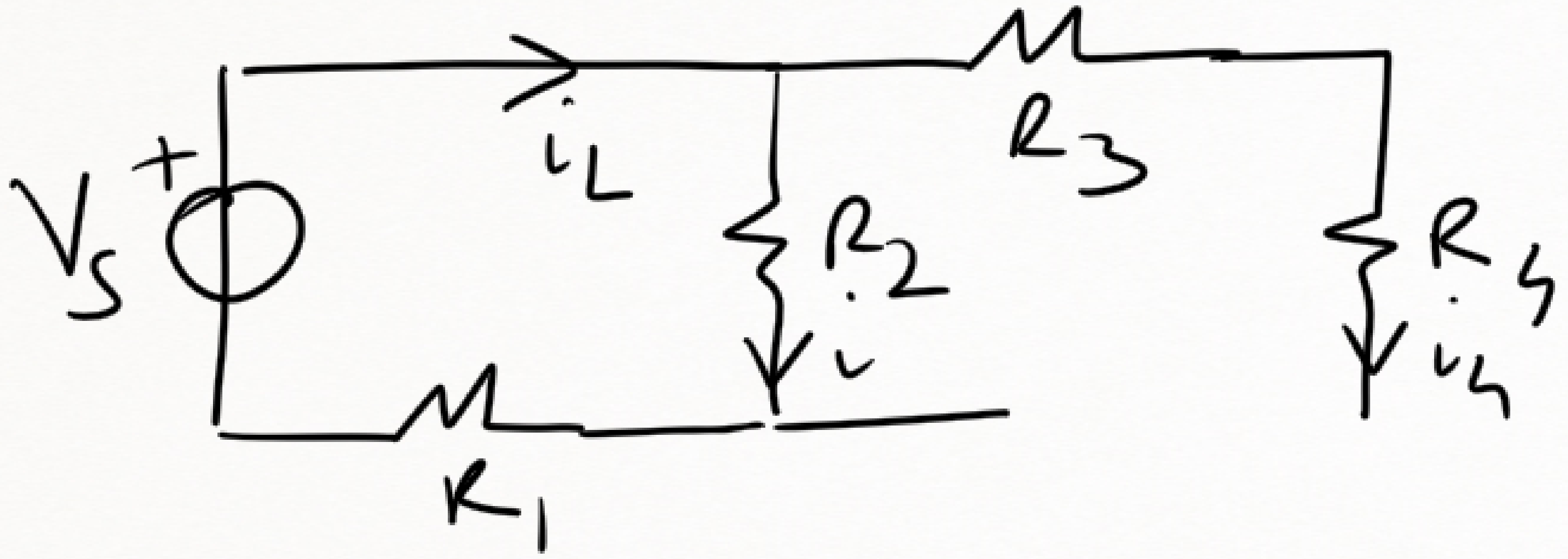
$R_2 = 1\Omega$

$R_3 = 2\Omega$

$L = 1H$

$i(t) = ?$

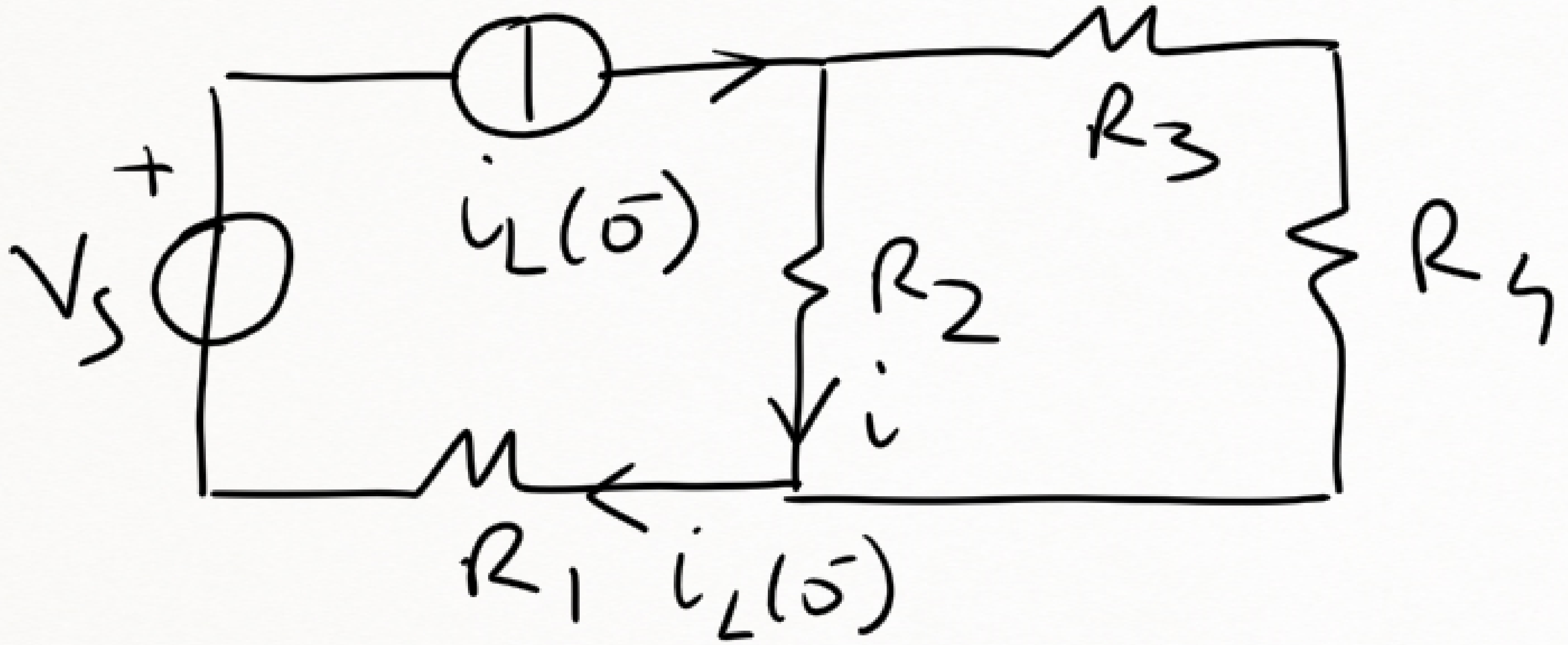
$t = 0^- s$:




$i_4(0^-) = 0A$

$i_L(0^-) = i(0^-) = \dfrac{V_s}{R_1 + R_2} = \dfrac{5}{2}\ A$

$t = 0^+ s$:

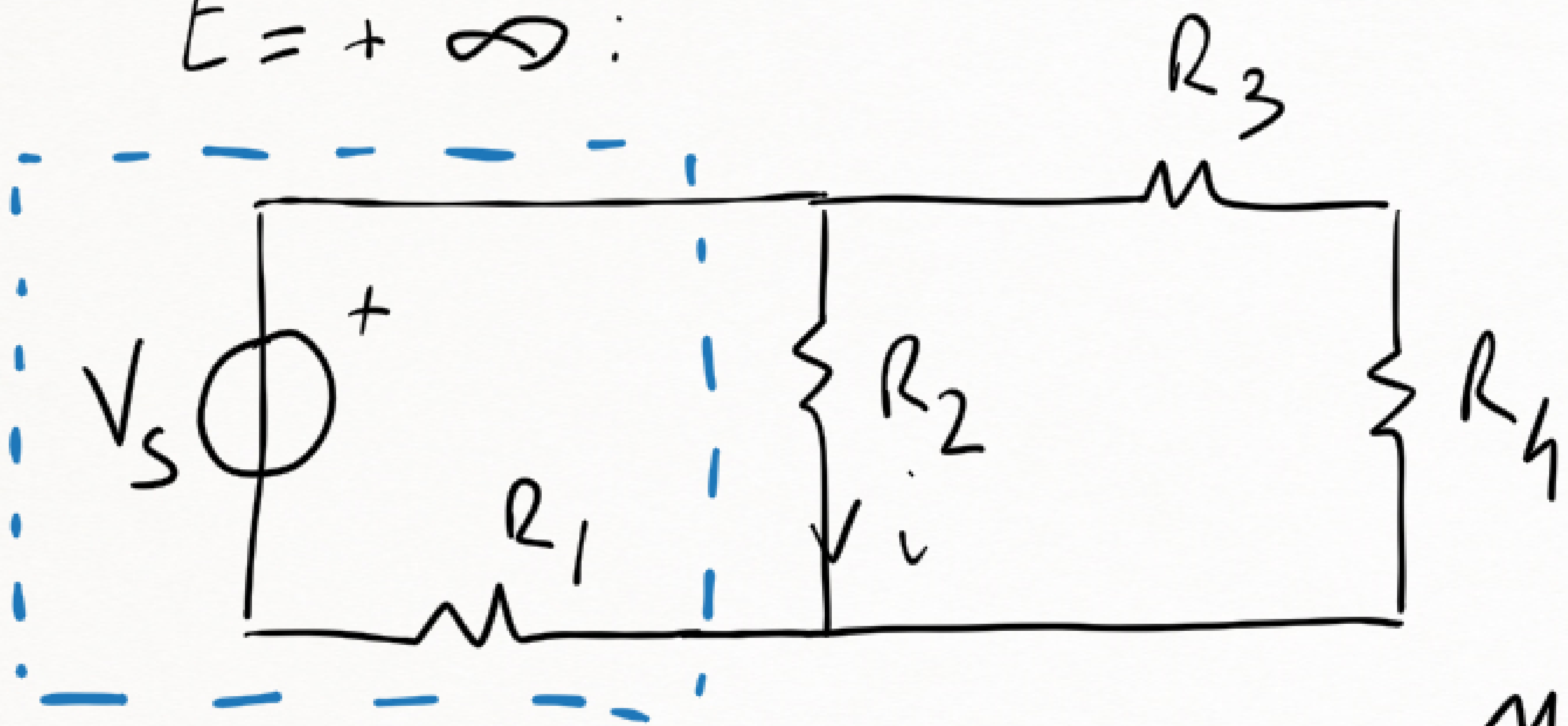


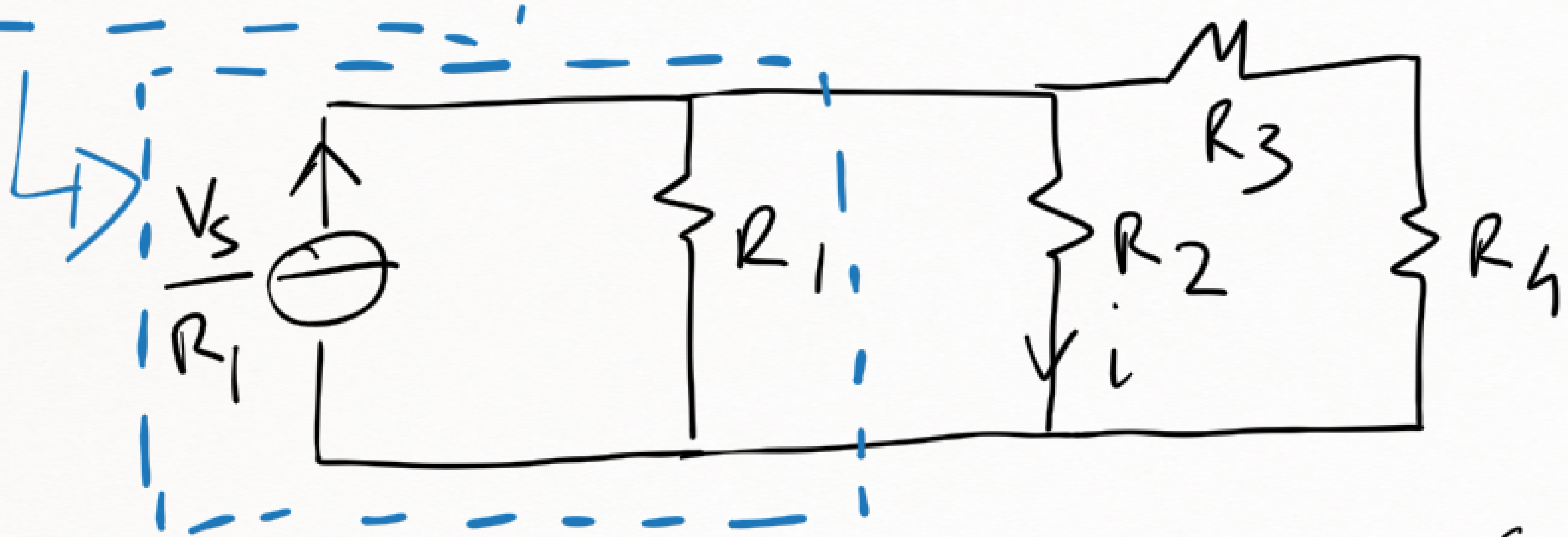

$$G_2 = \frac{1}{R_2} = 1\,S$$

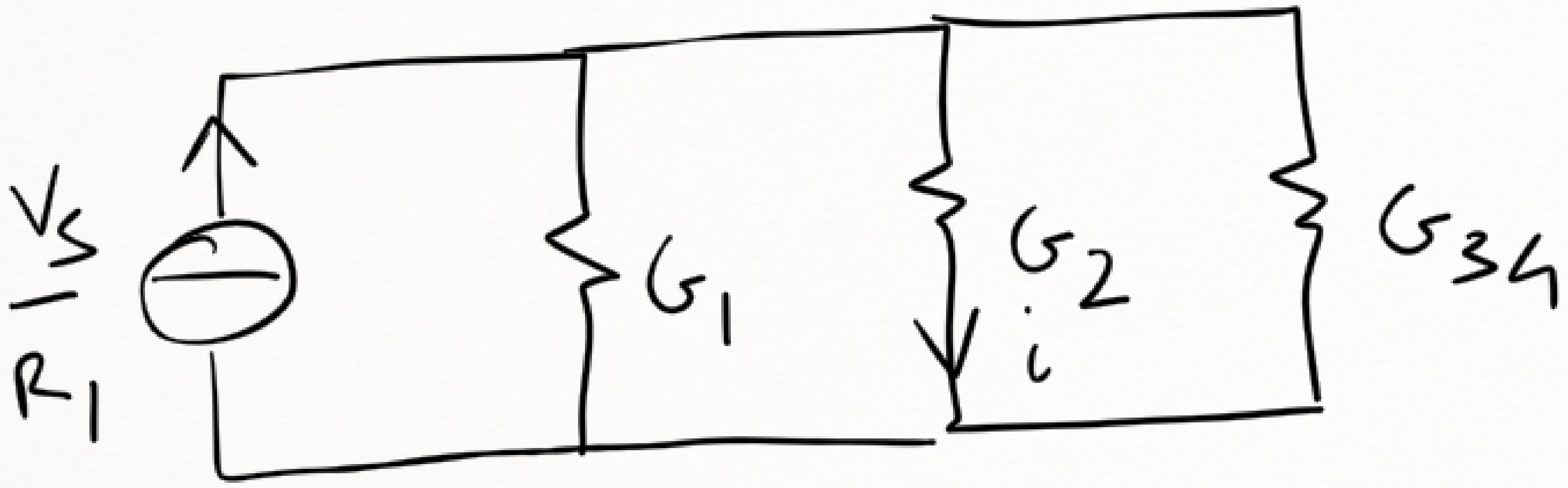
$$G_{34} = \frac{1}{R_3 + R_4} = \frac{1}{5}\,S$$

$$i(0^+) = i_L(0^-) \cdot \frac{R_3 + R_4}{R_2 + R_3 + R_4} = \frac{G_2}{G_2 + G_{34}}\, i_L(0^-) = \frac{25}{12}\,A$$

$t = +\infty$:



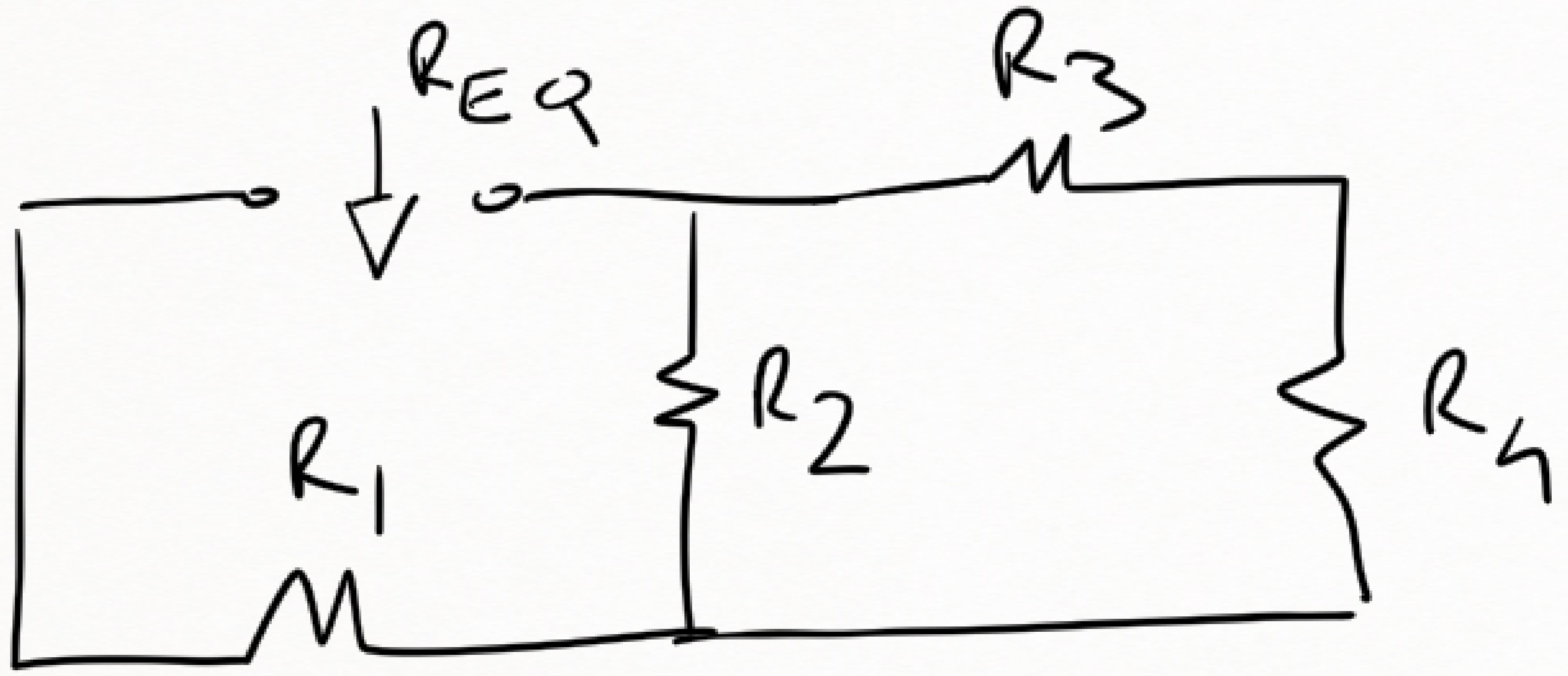

$$G_1 = \frac{1}{R_1} = \frac{1}{3}\,S$$

$$G_2 = \frac{1}{R_2} = 1\,S$$

$$G_{34} = \frac{1}{R_3 + R_4} = \frac{1}{5}\,S$$

$$i(+\infty) = \frac{V_s}{R_1}\frac{G_2}{G_1 + G_2 + G_{34}} = \frac{V_s}{R_1} \cdot \frac{R_1 // (R_3 + R_4)}{R_2 + R_1 // (R_3 + R_4)} = \frac{50}{23}\ A$$

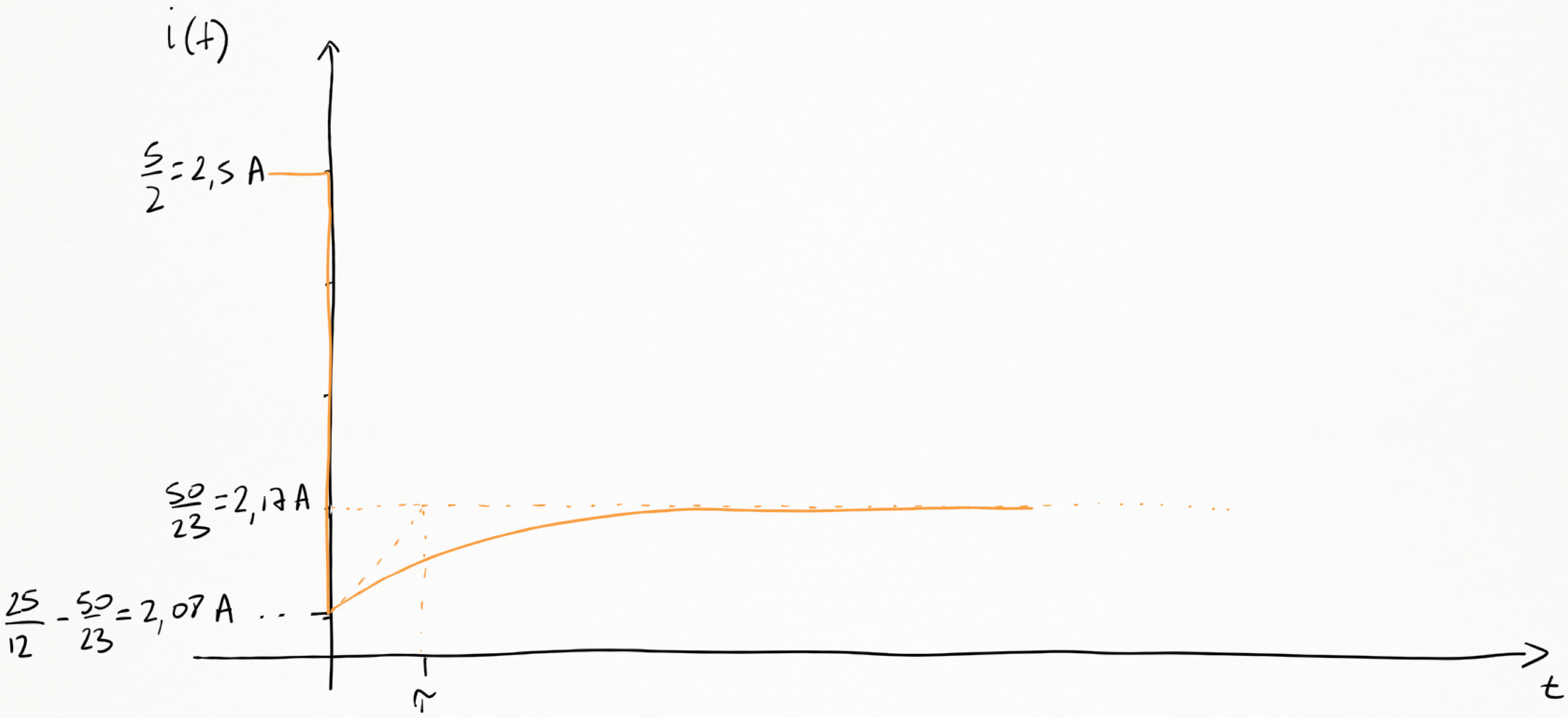
$\tau$:




$$R_{EQ} = R_1 + R_2 // (R_3 + R_4) = \frac{23}{6}\ \Omega$$

$$\tau = \frac{L}{R_{EQ}} = \frac{6}{23}\ s$$

$$i(t) = \left[i(0^+) - i(+\infty)\right] e^{-t/\tau} + i(+\infty) = \left[\frac{25}{12} - \frac{50}{23}\right] e^{-t/\tau} + \frac{50}{23}\ A$$


i(t)
5/2 = 2,5 A
50/23 = 2,17 A
25/12 - 50/23 = 2,07 A
τ
t