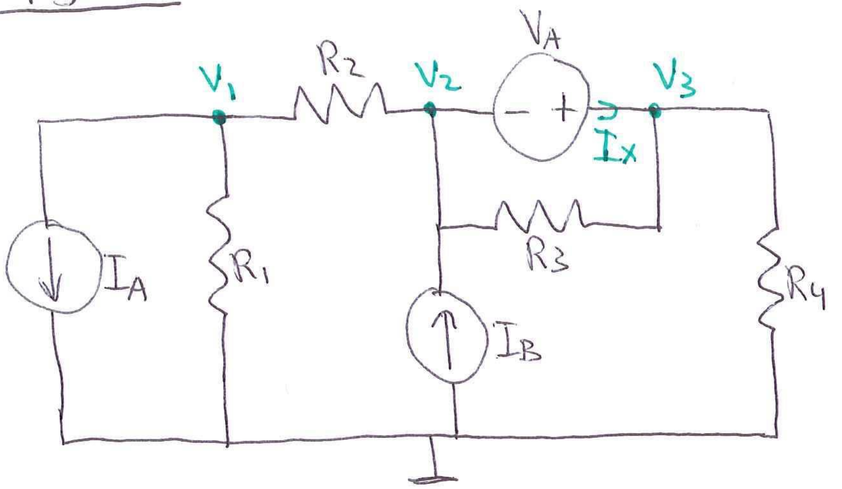
Opgave 1 EE1300-A Tentamen 4-11-2013 M. Pelk 2013



a) * 4 knooppunten, $N-1=3$ onafhankelijke vergelijkingen

b)

KCL V1: $I_A + \frac{V_1}{R_1} + \frac{V_1 - V_2}{R_2} = 0$

$$\boxed{V_1\left(\frac{1}{R_1}+\frac{1}{R_2}\right) - V_2\frac{1}{R_2} = -I_A} \quad (1)$$

V2: $\frac{V_2 - V_1}{R_2} - I_B + \frac{V_2 - V_3}{R_3} + I_x = 0$

$$\boxed{-V_1\frac{1}{R_2} + V_2\left(\frac{1}{R_2}+\frac{1}{R_3}\right) - V_3\frac{1}{R_3} + I_x = I_B} \quad (2)$$

V3: $-I_x + \frac{V_3 - V_2}{R_3} + \frac{V_3}{R_4} = 0$

$$\boxed{-V_2\frac{1}{R_3} + V_3\left(\frac{1}{R_3}+\frac{1}{R_4}\right) - I_x = 0} \quad (3)$$

Randvoorwaarde V_A: $\boxed{V_3 - V_2 = V_A}$ (4)

(2) en (3) optellen:

$$-V_1\frac{1}{R_2} + V_2\frac{1}{R_2} + V_3\frac{1}{R_4} = I_B$$

(1): $$V_1\left(\frac{1}{R_1}+\frac{1}{R_2}\right) - V_2\frac{1}{R_2} = -I_A$$

(4): $$-V_2 + V_3 = V_A$$

Stelsel van 3 vergelijkingen met 3 onbekenden

Of in de vorm van een matrixvergelijking:

$$\begin{bmatrix} -\frac{1}{R_2} & \frac{1}{R_2} & \frac{1}{R_4} \\ \frac{1}{R_1}+\frac{1}{R_2} & -\frac{1}{R_2} & 0 \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} I_B \\ -I_A \\ V_A \end{bmatrix}$$

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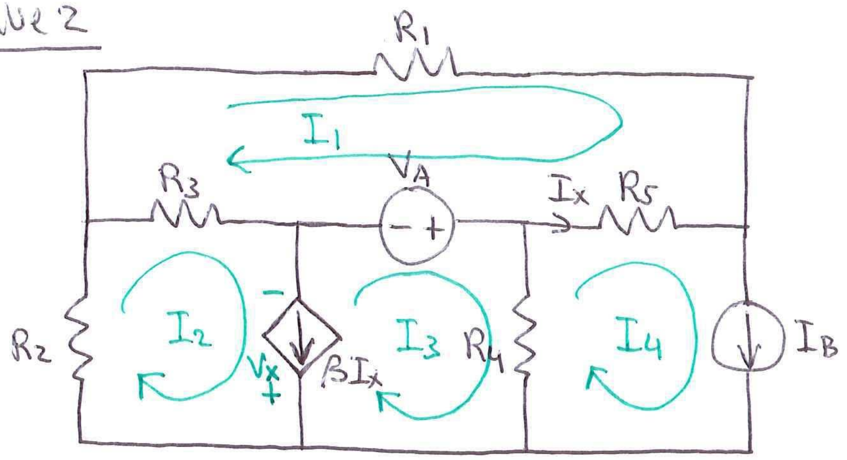
Opgave 2



a) $B - N + 1 = 8 - 5 + 1 = 4$ onafhankelijke mazen.

b) KVL I_1: $I_1 R_1 + (I_1 - I_4) R_5 + V_A + (I_1 - I_2) R_3 = 0$

$$\boxed{I_1(R_1 + R_3 + R_5) - I_2 R_3 - I_4 R_5 = -V_A} \quad 1$$

I_2: $(I_2 - I_1) R_3 - V_x + I_2 R_2 = 0$

$$\boxed{-I_1 R_3 + I_2(R_2 + R_3) - V_x = 0} \quad 2$$

I_3: $-V_A + (I_3 - I_4) R_4 + V_x = 0$

$$\boxed{I_3 R_4 - I_4 R_4 + V_x = V_A} \quad 3$$

I_4: $\boxed{I_4 = I_B}$ 4.

Randvoorwaarde βI_x: $I_2 - I_3 = \beta I_x$, $I_x = I_4 - I_1 = I_B - I_1$

$I_2 - I_3 = \beta I_B - \beta I_1$

$$\boxed{I_1 \beta + I_2 - I_3 = \beta I_B} \quad 5$$

2 + 3 : $-I_1 R_3 + I_2(R_2 + R_3) + I_3 R_4 = V_A + I_B R_4$

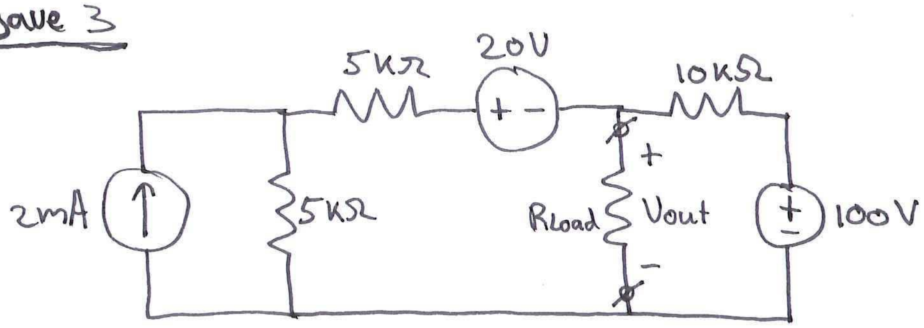
1 : $I_1(R_1 + R_3 + R_5) - I_2 R_3 = -V_A + I_B R_5$

5 : $I_1 \beta + I_2 - I_3 = \beta I_B$

matrix vergelijking:

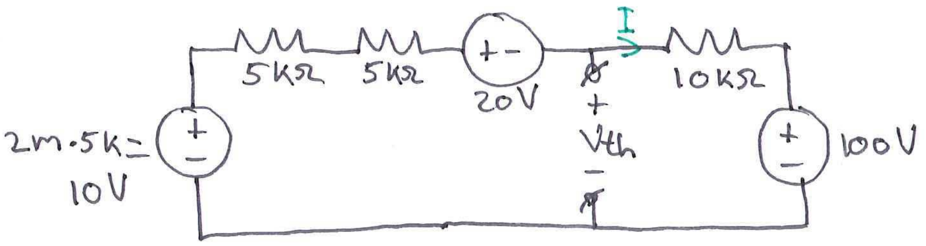
$$\begin{bmatrix} -R_3 & R_2 + R_3 & R_4 \\ R_1 + R_3 + R_5 & -R_3 & 0 \\ \beta & 1 & -1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} V_A + I_B R_4 \\ -V_A + I_B R_5 \\ \beta I_B \end{bmatrix}$$

Opgave 3



a) Thévenin equivalent bepalen:

R_{th}: bronnen "uit" → $R_{th} = (5K+5K)//10K = \boxed{5\,k\Omega}$



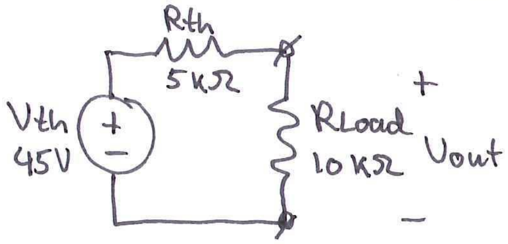
KVL I: $I \cdot 20K + 20 + 100 - 10 = 0$

$I = \frac{10-20-100}{20K}$

$I = -5{,}5\ mA$

$V_{th} = I \cdot 10k + 100 = -55 + 100 = \boxed{45\,V}$

Dus:



$\rightarrow V_{out} = V_{th} \cdot \frac{10}{10+5} = \boxed{30\,V}$

b) Als $\boxed{R_{Load} = R_{th}}$ dan vindt er maximale vermogensoverdracht plaats.

Dus voor $\boxed{R_{Load} = 5\,k\Omega}$

c) Als $R_{Load} = 5k\Omega$ dan is $V_{out} = \frac{V_{th}}{2}$, het vermogen wordt dan dus:

$$P_{L,max} = \frac{\left(\frac{V_{th}}{2}\right)^2}{R_{th}} = \frac{V_{th}^2}{4R_{th}} = \frac{45^2}{4 \cdot 5e3}$$

$$\boxed{P_{L,max} = 101{,}25\ mW}$$

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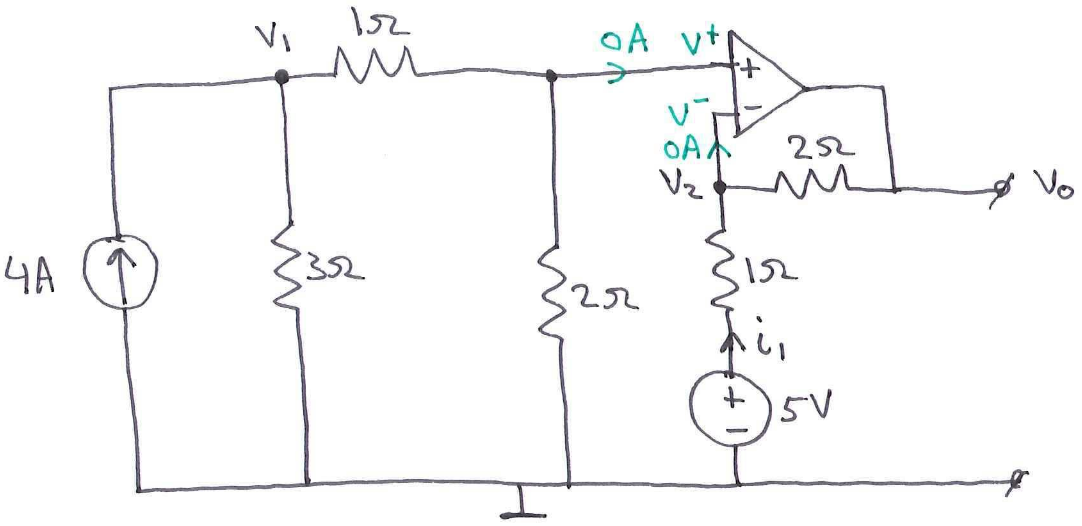
opgave 4



a) geen stroom door de opamp dus $V_1 = 4 \cdot 3 // (1+2) = \boxed{6\,V}$

b) $V^+ = V_1 \cdot \frac{2}{2+1} = 4V \rightarrow V^- = V^+ = 4V \rightarrow V_2 = V^- = \boxed{4V}$

c) $i_1 = \frac{5-4}{1} = \boxed{1\,A}$

d) $V_o = V_2 - i_1 \cdot 2 = 4 - 2 = \boxed{2\,V}$

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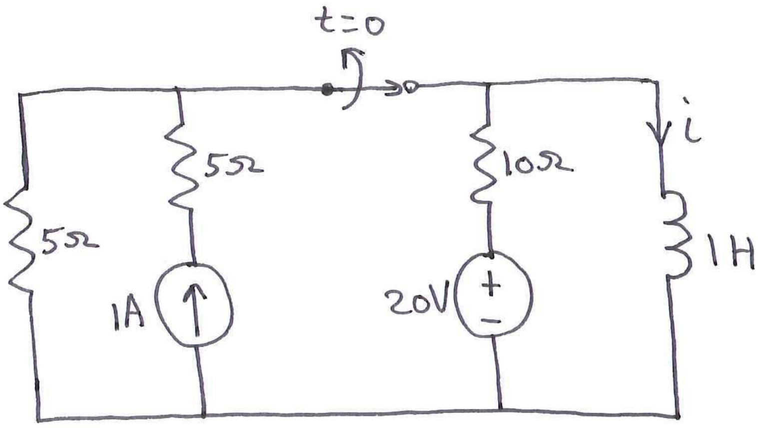
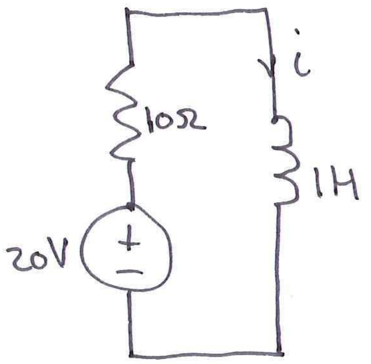
Opgave 5



a) $i(0^-)$: inductantie = kortsluiting → $i(0^-) = 1 + \frac{20}{10} = \boxed{3A}$

$i(0^-) = i(0^+) = i(0) = \boxed{3A}$

b) $t>0$:



$i(\infty) = \frac{20}{10} = \boxed{2A}$

$\tau = \frac{L}{R} = \frac{1}{10} = 0{,}1 \text{ s}$

Dus: $i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau}$

$i(t) = 2 + [3-2]e^{-t/0{,}1}$

$$\boxed{i(t) = 2 + e^{-10t} \quad A}$$

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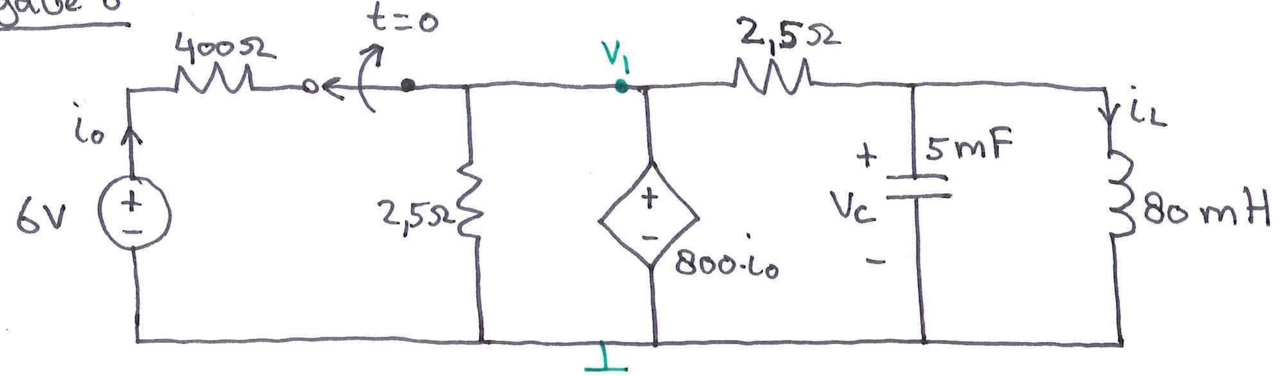
opgave 6



a) op $t=0^-$: $V_c(0^-)=0$ (steady state, kortgesloten door L)

$V_1 = 800\, i_0$, $\quad i_0 = \dfrac{6-V_1}{400} \quad \rightarrow \quad V_1 = 800 \cdot \dfrac{6-V_1}{400} = 12 - 2V_1$

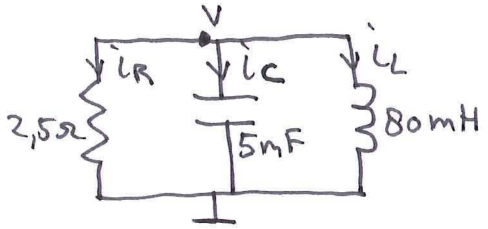
$3V_1 = 12 \rightarrow \boxed{V_1 = 4\,V}$

Dus: $i_L(0^-) = \dfrac{V_1}{2{,}5} = 1{,}6\,A$

$\boxed{V_c(0^+) = V_c(0^-) = 0\,V}$

$\boxed{i_L(0^+) = i_L(0^-) = 1{,}6\,A}$

$t=0^+$: $i_0 = 0 \rightarrow$ gestuurde bron $= 0\,V$ (Kortsluiting)



$i_C(0^+) = C \left.\dfrac{dV}{dt}\right|_{t=0^+} = -i_L(0^+)$

dus: $\left.\dfrac{dV}{dt}\right|_{t=0^+} = \dfrac{-1{,}6}{5e\text{-}3} = \boxed{-320\ V/s}$

b) KCL V:

$$\frac{V}{2{,}5} + C\frac{dV}{dt} + i_L(0) + \frac{1}{L}\int_0^t V(x)\,dx = 0 \qquad (1)$$

$$\frac{d^2V}{dt^2} + \frac{1}{5e\text{-}3 \cdot 2{,}5}\frac{dV}{dt} + \frac{1}{80e\text{-}3 \cdot 5e\text{-}3} = 0$$

Karakteristieke vergelijking: $s^2 + 80s + 2500 = 0 \rightarrow s = \dfrac{-80 \pm \sqrt{6400 - 10000}}{2}$

$\boxed{s = -40 \pm j30}$

$\boxed{\text{ondergedempt}}$

Oplossing:

$V(t) = e^{-40t}\left[A\cdot\cos(30t) + B\sin(30t)\right]$

$V(0) = \boxed{0 = A}$

$\dfrac{dV(t)}{dt} = e^{-40t}\left[-30A\sin(30t) + 30B\cos(30t)\right] - 40e^{-40t}\left[A\cdot\cos(30t) + B\sin(30t)\right]$

$\left.\dfrac{dV(t)}{dt}\right|_{t=0} = 30B - 40A = 30B = -320 \rightarrow \boxed{B = -10{,}67}$

dus: $\boxed{V(t) = -10{,}67 \cdot e^{-40t} \cdot \sin(30t)\ V}$

c) Vermogen in R: $P_R = V^2/R$

$P_R = \dfrac{\left[-10{,}67 e^{-40t}\sin(30t)\right]^2}{2{,}5}$

$\boxed{P_R(t) = 45{,}54 \cdot e^{-80t} \cdot \sin^2(30t)\ W}$