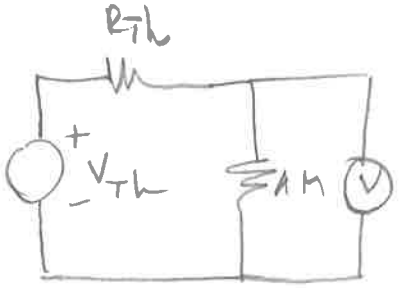
(1)

a) $V_{ca} = 5\,V \Rightarrow V_{Th} = 5\,V$

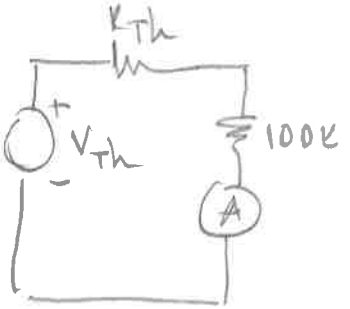
$i_{cc} = 12{,}5\,\mu A \Rightarrow R_{Th} = \frac{V_{ca}}{i_{cc}} = \frac{5}{12{,}5 \times 10^{-6}}\,\Omega = 0{,}4\,M\Omega$

$= 400\,k\Omega$

b)



$V_{med} = \frac{1M}{1M + R_{Th}} \times V_{Th} = 5\,V$



$i_{med} = \frac{V_{Th}}{R_{Th} + 1k\Omega} = 12{,}5\,\mu A$

$$\begin{cases} V_{Th} \times \frac{1M}{1M + R_{Th}} = 5\,V \\ \frac{V_{Th}}{R_{Th} + 1k\Omega} = 12{,}5\,\mu A \end{cases} \qquad \begin{cases} \text{——} \\ V_{Th} = 12{,}5\,\mu A \times (R_{Th} + 1k\Omega) \end{cases}$$

$$\begin{cases} V_{Th} = 5\,V \times \frac{(1M + R_{Th})}{1M} = \frac{5 \times 10^6 + 5R_{Th}}{10^6} = 5\,V + 5 \times 10^{-6} R_{Th} \\ V_{Th} = 12{,}5 \times 10^{-6} \times R_{Th} + 0{,}0125 \end{cases}$$

$$12{,}5 \times 10^{-6} \times R_{Th} + 0{,}0125 = 5 + 5 \times 10^{-6} R_{Th}$$

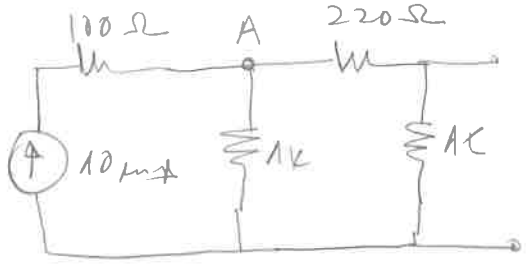
$$R_{Th}(12{,}5 \times 10^{-6} - 5 \times 10^{-6}) = 5 - 0{,}0125$$

$$R_{Th} = \frac{(5 - 0{,}0125)}{12{,}5 \times 10^{-6} - 5 \times 10^{-6}} = \frac{4{,}99}{7{,}5} \times 10^6 \simeq 666\,k\Omega$$

$$V_{Th} = (12{,}5 \times 10^{-6} \times 0{,}666 \times 10^6 + 0{,}0125)\,V = 8.3\,V$$

(2)

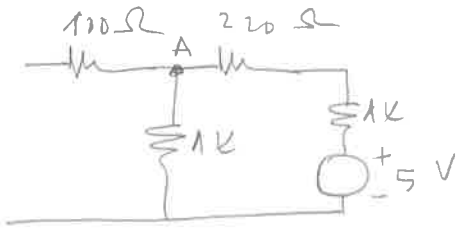
a)



$$(V_A)_1 = 10\,mA \times \left(1K \parallel (220\,\Omega + 1K)\right)$$

$$\frac{1 \times 1.22}{1 + 1.22} \simeq 549\,\Omega$$

$$(V_A)_1 = 10 \times 10^{-3} \times 549\ V \simeq 5{,}5\ V$$



$$(V_A)_2 = \frac{1K}{1K + 220\,\Omega + 1K} \times 5\ V \simeq 2{,}2\ V$$

$$V_A = 5{,}5 + 2{,}2 = 7{,}7\ V$$

b) $$V_S = V_A - V_{R_3} = 7{,}7\ V - V_{R_3}$$

$$V_{R_3} = R_3 \times i \quad ; \quad i = \frac{(V_A - 5)}{R_3 + R_4} = \frac{2{,}7}{1K22}\ A \simeq 2{,}2\ mA$$

$$V_S = 7{,}7\ V - 2{,}2 \times 10^{-3} \times 220\,\Omega \simeq 7{,}2\ V$$

c) $$V_{TC} = V_A + V_{R_1} = 7{,}7\ V + 10\,mA \times 100\,\Omega = 8{,}7\ V$$

d) $$V_{Th} = V_S = 7{,}2\ V$$

$$R_{Th} = R_4 \parallel (R_3 + R_2) = 1K \parallel 1K22 = 549\,\Omega$$

e) $$R_N = R_{Th} = 549\,\Omega$$

$$i_N = \frac{V_{Th}}{R_{Th}} = \frac{7{,}2\ V}{549\,\Omega} \simeq 13{,}1\ mA$$

(3) (3)

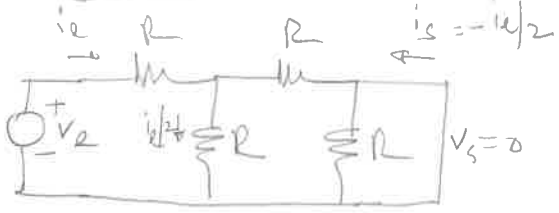
$$\begin{bmatrix} V_e \\ i_s \end{bmatrix} = \begin{bmatrix} h \end{bmatrix} \begin{bmatrix} i_e \\ V_s \end{bmatrix} \quad \begin{cases} V_e = h_{11} i_e + h_{12} V_s \\ i_s = h_{21} i_e + h_{22} V_s \end{cases}$$

$V_s = 0$ $\quad h_{11} = \left.\frac{V_e}{i_e}\right|_{V_s=0}$; $h_{21} = \left.\frac{i_s}{i_e}\right|_{V_s=0}$

$i_e = 0$

$$h_{12} = \left.\frac{V_e}{V_s}\right|_{i_e=0} \quad ; \quad h_{22} = \left.\frac{i_s}{V_s}\right|_{i_e=0}$$

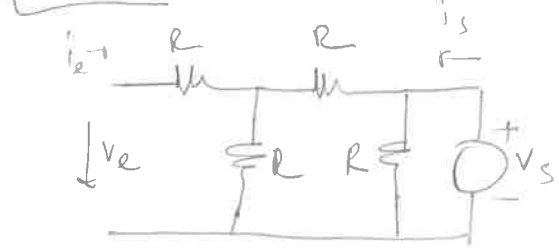
$V_s = 0$



$$h_{11} = R + R \| R = R + \tfrac{1}{2} R = \tfrac{3}{2} R$$

$$h_{21} = \left.\frac{i_s}{i_e}\right|_{V_s=0} \quad i_s = -i_e/2 \Rightarrow h_{21} = -1/2$$

$i_e = 0$



$$h_{12} = \left.\frac{V_e}{V_s}\right|_{i_e=0}$$

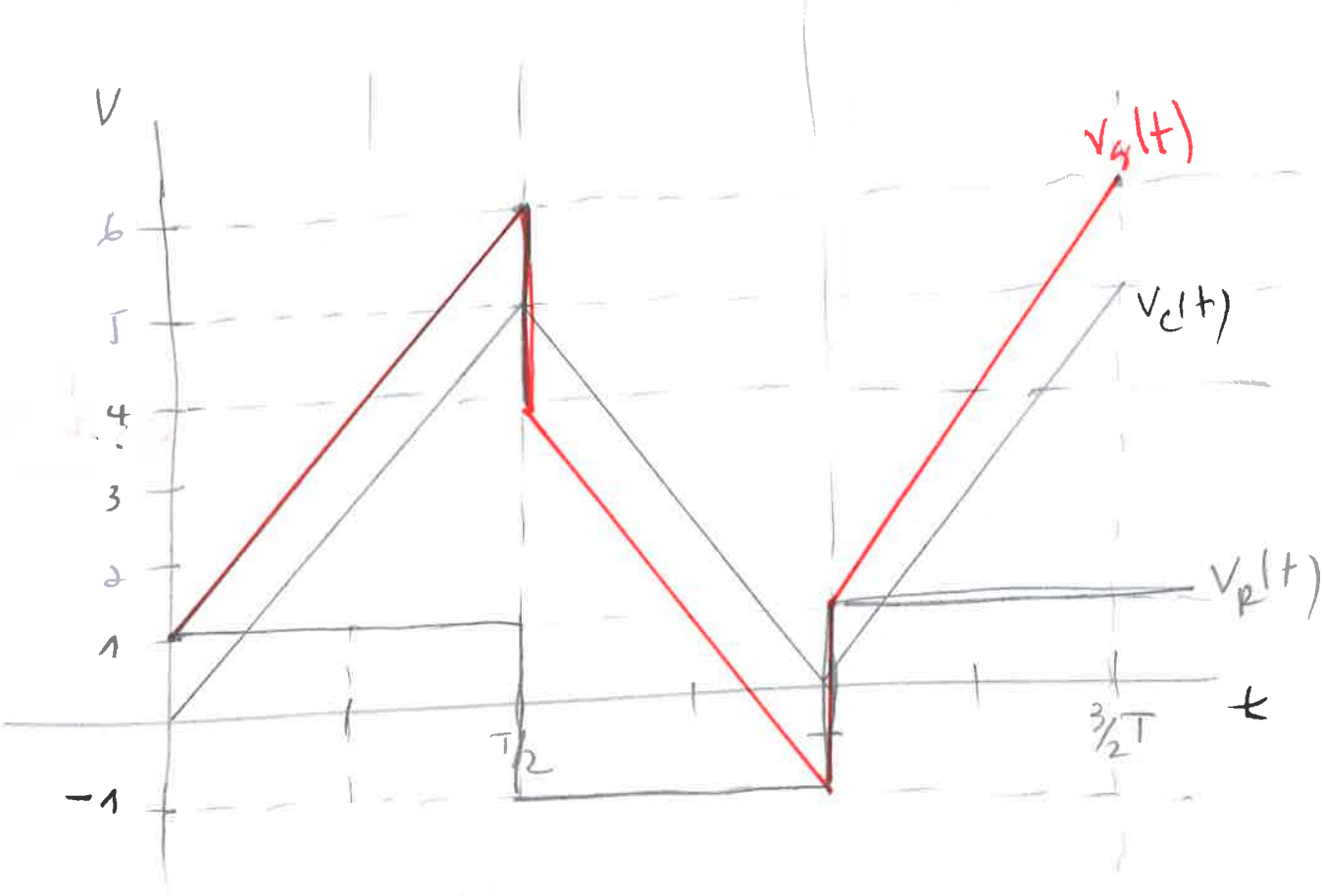
$$V_e = \frac{R}{R+R} V_s = \tfrac{1}{2} V_s \Rightarrow h_{12} = \tfrac{1}{2}$$

$$h_{22} = \frac{1}{R \| 2R} = \frac{R + 2R}{R \times 2R} = \frac{3R}{2R^2} =$$

$$= \frac{3}{2}\left(\frac{1}{R}\right)$$

$$h = \begin{bmatrix} \frac{3}{2} R & \frac{1}{2} \\ -1/2 & \frac{3}{2}\left(\frac{1}{R}\right) \end{bmatrix}$$

(4) $\Delta V_c = \frac{1}{C}\int_0^{0,5\,ms} 10\times10^{-3}\,dt = \frac{0,5\times10^{-3}\times10\times10^{-3}}{10^{-6}} = 5\,V$ (4)



(5) $i(t) = \frac{V_0}{R} e^{-t/RC}$

$RC = 1\,k\Omega \times 1\,\mu F = 10^{3} \times 10 \times 10^{-6} = 1\,ms$

$V_s(t) = V(t) - V_R(t) = V_0 - R\times\frac{V_0}{R} e^{-t/RC} = V_0\left(1 - e^{-t/RC}\right)$

$V_s(t) = 7\,V \Rightarrow 7 = 10\left(1 - e^{-t/RC}\right)$

$0,7 = 1 - e^{-t/RC} \Rightarrow \ln(0,3) = -t/RC$

$t = -RC\,\ln(0,3) = -1\times10^{-3}\times(-1,2) = 1,2\,ms$