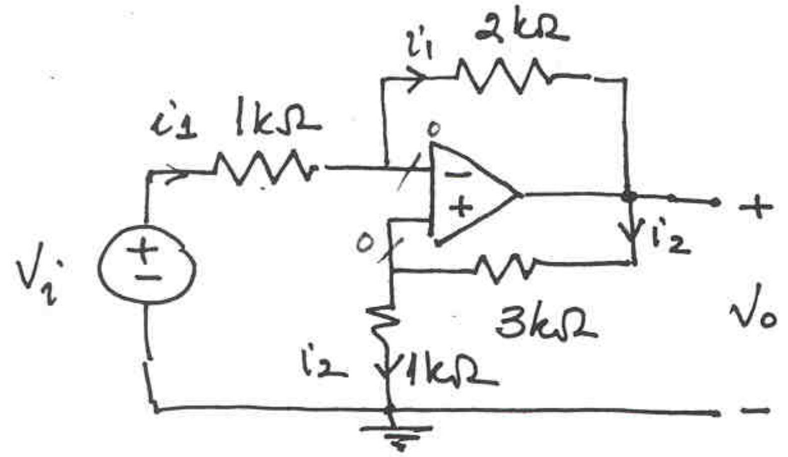
1



$$V_i - 10^3 i_1 - 10^3 i_2 = 0$$

$$V_o - 3\times10^3 i_2 - 10^3 i_2 = 0$$

$$V_i - 10^3 i_1 - 2\times10^3 i_1 - V_o = 0$$

Hence,

$$10^3 i_1 + 10^3 i_2 = V_i$$

$$4\times10^3 i_2 = V_o$$

$$3\times10^3 i_1 + V_o = V_i$$

Since $i_2 = \dfrac{V_o}{4\times10^3}$, then

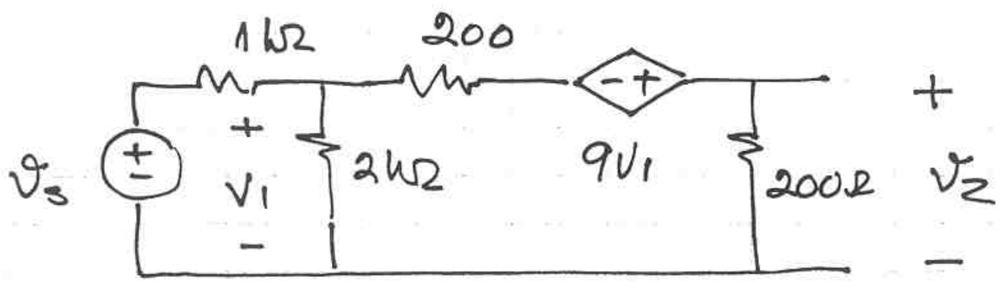
$$i_1 + i_2 = \frac{V_i}{10^3}$$

$$3\times10^3 \cdot i_1 + V_o = V_i \Rightarrow i_1 = \frac{V_i - V_o}{3\times10^3}$$

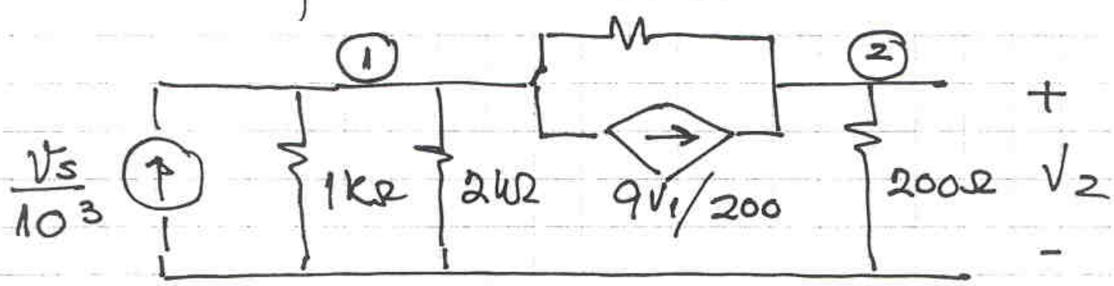
$$\frac{V_i - V_o}{3\times10^3} + \frac{V_o}{4\times10^3} = \frac{V_i}{10^3} \quad /12\times10^3$$

$$4V_i - 4V_o + 3V_o = 12V_i \quad \text{or:} \quad \frac{V_o}{V_i} = -8$$

2



Source transformation:



Nodal equation:

$$\frac{v_1}{10^3} + \frac{v_1}{2\times10^3} + \frac{v_1-v_2}{200} + \frac{9v_1}{200} = \frac{v_s}{10^3} \Big/ \times 2\times10^3$$

$$\frac{v_2}{200} + \frac{v_2-v_1}{200} - \frac{9v_1}{200} = 0$$

Hence, $3v_1 + 10(v_1 - v_2) + 90v_1 = 2v_s$

$$2v_2 - 10v_1 = 0$$

or: $103v_1 - 10v_2 = 2v_s$

$$v_2 = 5v_1$$

$$i = \frac{10^{-3} \cdot v_x}{6 + \frac{1}{5} + \frac{2}{3}}$$

$$i = \frac{15}{103} \times 10^{-3} \cdot v_x$$

Then.

$$i_x = \frac{v_x}{200} + i$$

$$i_x = \frac{v_x}{200} + \frac{15}{103} \times 10^{-3} \cdot v_x$$

$$\frac{v_x}{i_x} = \frac{1}{\frac{1}{200} + \frac{15}{103} \times 10^{-3}}$$

$$R_{Th} = \frac{v_x}{i_x}$$

$$R_{Th} = \frac{10^3}{5 + \frac{15}{103}}$$

$$R_{Th} = \frac{103}{530} \times 10^3 \, \Omega$$

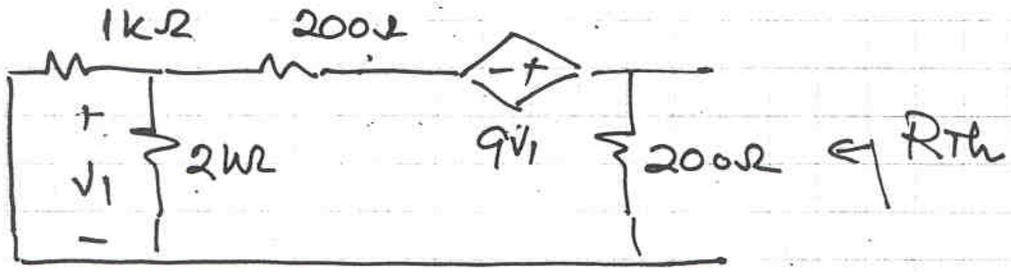
$$R_{Th} = \frac{103}{530} \, k\Omega$$

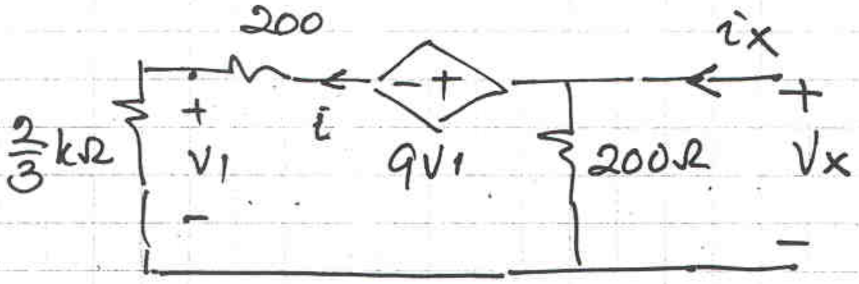
$$103V_1 - 50V_1 = 2V_S$$

$$V_1 = \frac{2}{53}V_S$$

Thevenin equivalent Resistance:

$V_S = 0$; or $i_S = 0$





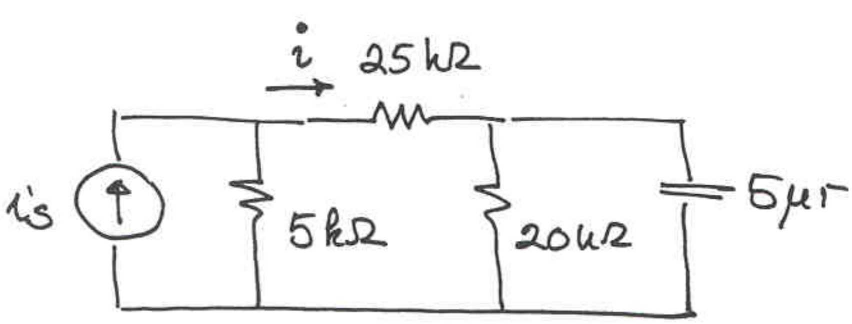
Hence, $V_x - 9V_1 - 200i - \frac{2}{3}\times 10^3 \cdot i = 0$

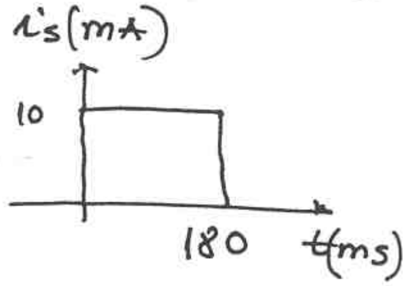
$$V_1 = \frac{2}{3}\times 10^3 \cdot i$$

$$V_x = 9\cdot \frac{2}{3}\times 10^3 i + 200i + \frac{2}{3}\times 10^3 i$$

$$i = \frac{V_x}{6\times 10^3 + 200 + \frac{2}{3}\times 10^3}$$

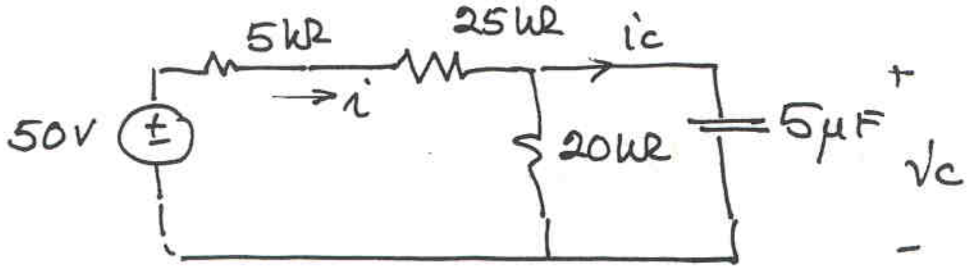
2





for $t<0$ $\quad i(t)=0$

for $0<t<180\,ms$; $i_s = 10\,mA$



$$50 - 30\times10^{3}\cdot i - v_c = 0$$

$$i_c = 5\times10^{-6}\cdot\frac{dv_c}{dt}$$

$$i = i_c + \frac{v_c}{20\times10^{3}}$$

$$30\times10^{3}\cdot i + v_c = 50$$

$$i = 5\times10^{-6}\cdot\frac{dv_c}{dt} + \frac{v_c}{20\times10^{3}}$$

Here, state equal is:

$$30\times10^{3}\cdot\left(5\times10^{-6}\cdot\frac{dv_c}{dt} + \frac{v_c}{20\times10^{3}}\right) + v_c = 50$$

$$30\times10^{3}\cdot\left(5\times10^{-6}\cdot\frac{dV_c}{dt}+\frac{V_c}{20\times10^{3}}\right)+V_c=50$$

$$150\times10^{-3}\cdot\frac{dV_c}{dt}+\frac{3}{2}V_c+V_c=50$$

$$\frac{dV_c}{dt}+\frac{5}{300\times10^{-3}}\cdot V_c=\frac{50}{150\times10^{-3}}$$

$$\frac{dV_c}{dt}+\frac{10^3}{60}V_c=\frac{10^3}{3}$$

Natural frequency: $s=-10^3/60$; $s=-\frac{50}{3}$

$V_c(t)=V_{c_h}(t)+V_{c_p}(t)$

$V_{c_h}(t)=K_1e^{-10^3/60\,t}$

$V_{c_p}(t)=A$; $\frac{10^3}{60}\cdot A=\frac{10^3}{3}$; $A=20$

$V_c(t)=K_1e^{-10^3/60\,t}+20$

$V_c(0-)=0$; $V_c(0+)=0 \Rightarrow K_1+20=0$; $K_1=-20$

$V_c(t)=20\left(1-e^{-50/3\,t}\right)$

At $t=180\text{ms}$: $V_c(180\text{ ms})=20\left(1-e^{-\frac{50}{3}\times180\times10^{-3}}\right)$

$V_c(180\text{ ms})=20\cdot(1-e^{-3})$

Since $e^{-3}=0.05$ $V_c(180\text{ ms})=20\,(1-0.05)$

$V_c(180\text{ ms})=19V$

For $t > 180$ ms

$$\frac{dv_c}{dt} + \frac{10^3}{60} \cdot v_c = 0$$

<The same LHS as before>

$$v_c(t) = k_2 e^{-\frac{10^3}{6} \cdot t}$$

$$v_c(t) = k_2 e^{-\frac{50}{3} t}$$

$$v_c(180^+ ms) = k_2 e^{-\frac{50}{3} \times 180 \times 10^{-3}}$$

$$= k_2 e^{-3}$$

$$v_c(180^+ ms) = v_c(180^- ms)$$

Hence, $k_2 e^{-3} = 20(1 - e^{-3})$

$$k_2 = 20(e^3 - 1) \quad \text{or} \quad k_2 = 20 \cdot (19 - 1)$$

$$k_2 = 380$$

And $v_c(t) = 20(e^3 - 1) e^{-\frac{50}{3} t}$

or

$$v_c(t) = 380\, e^{-\frac{50}{3} t}$$

For $t < 180ms$:

Current $i_{(t)} = C\frac{dv_c}{dt} + \frac{v_c}{20\times10^3}$

$$i(t) = 5\times10^{-6}\cdot\frac{dv_c}{dt} + \frac{v_c}{20\times10^3}$$

Recall that
$$v_c(t) = 20(1-e^{-\frac{50}{3}t})$$

$$i(t) = 5\times10^{-6}\cdot 20\cdot\frac{50}{3}e^{-\frac{50}{3}t} + \frac{20\cdot(1-e^{-\frac{50}{3}t})}{20\times10^3}$$

$$i(t) = \frac{5}{3}\times10^{-3}\times e^{-\frac{50}{3}t} + 1\times10^{-3} - 1\times10^{-3}\times e^{-\frac{50}{3}t}$$

$$i(t) = (1 + \frac{2}{3}e^{-\frac{50}{3}t})\times10^{-3}$$

For $t > 180ms$ $\quad v_c(t) = 20(e^3-1)e^{-\frac{50}{3}t}$

$$i(t) = C\frac{dv_c}{dt} + \frac{v_c}{20\times10^3}$$

$$i_{(t)} = 5\times10^{-6}\times 20(e^3-1)\cdot(-\frac{50}{3}e^{-\frac{50}{3}t}) + \frac{20(e^3-1)e^{-\frac{50}{3}t}}{20\times10^3}$$

$$i(t) = -\frac{5}{3}\times10^{-3}\times(e^3-1)e^{-\frac{50}{3}t} + 10^{-3}(e^3-1)e^{-\frac{50}{3}t}$$

$$i(t) = -\frac{2}{3}(e^3-1)e^{-\frac{50}{3}t}$$

Let $e^3 \simeq 20$

$$i(t) = -\frac{38}{3}e^{-\frac{50}{3}t}$$

Note that:

$$i(0) = 10^{-3} \cdot \left(1 + \frac{2}{3}\right) \quad ; \; i(0) = \frac{5}{3} \times 10^{-3}\ A$$

$$i(0) = \frac{5}{3}\ mA$$

$$i(180ms^-) = \left(1 + \frac{2}{3} \cdot e^{-\frac{50}{3} \times 180 \times 10^{-3}}\right) \times 10^{-3}$$

$$= \left(1 + \frac{2}{3} \cdot e^{-3}\right) \times 10^{-3}$$

Let $e^{-3} = 0.05$

$$i(180ms^-) = \left(1 + \frac{2}{3} \times 0.05\right) \times 10^{-3}$$

$$= \frac{31}{30}\ mA$$

$$i(180ms^+) = -\frac{2}{3}(e^3 - 1) \times e^{-\frac{50}{3} \times 180 \times 10^{-3}}$$

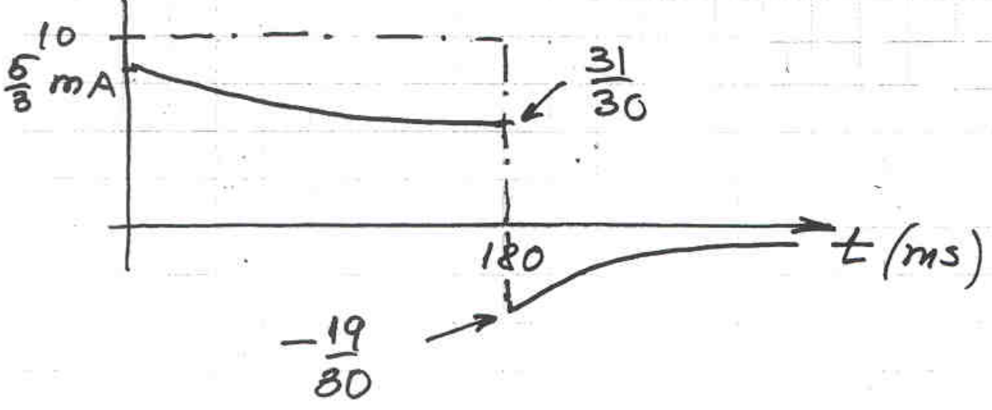
$$= -\frac{2}{3} \cdot (e^3 - 1) \cdot e^{-3}$$

$$= -\frac{2}{3}(1 - e^{-3})$$

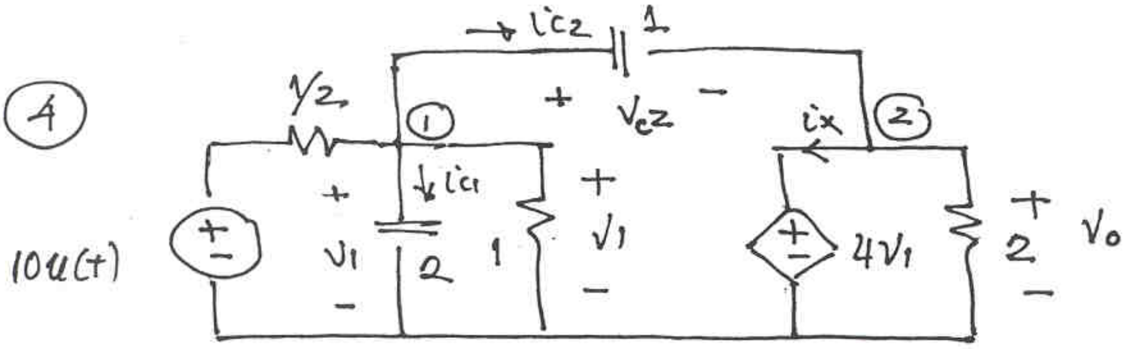
$$= -\frac{2}{3}(1 - 0.05)$$

$$= -\frac{19}{30}\ mA$$

Note:
$i(\infty) \to 0$



4



1 $$\frac{v_1 - 10}{1/2} + i_{c1} + i_{c2} + \frac{V_1}{1} = 0$$

2 $$V_2 = 4V_1$$

2 $$-i_{c2} + i_x + \frac{V_2}{2} = 0$$

$$2(V_1 - 10) + i_{c1} + i_{c2} + V_1 = 0$$

$$V_2 = 4V_1$$

$$i_{c1} = 2\frac{dV_1}{dt}$$

$$i_{c2} = \frac{d(V_1 - V_2)}{dt}$$

$$3V_1 + 2\frac{dV_1}{dt} + \frac{d}{dt}(V_1 - V_2) = 20$$

$$3\frac{dV_1}{dt} - \frac{dV_2}{dt} + 3V_1 = 20$$

$$V_2 = 4V_1$$

$$-\frac{dV_1}{dt} + 3V_1 = 20$$

$-s + 3 = 0 \quad s = \underline{3}$

$$-\frac{dV_1}{dt} + 3V_1 = 20$$

$$V_1 = Ke^{3t} + A$$

$$V_{1p} = A \therefore \quad 3A = 20$$
$$A = \frac{20}{3}$$

$$V_1(0) = 0$$
$$K + A = 0; \quad K = -\frac{20}{3}$$

$$v_1 = \frac{20}{3}(1 - e^{3t}) \quad ; V_{C1} = \frac{20}{3}(1-e^{3t})$$

$$V_2 = 4 \cdot \frac{20}{3}(1 - e^{3t}) \quad ; \quad V_{C2} = -20(1 - e^{3t})$$

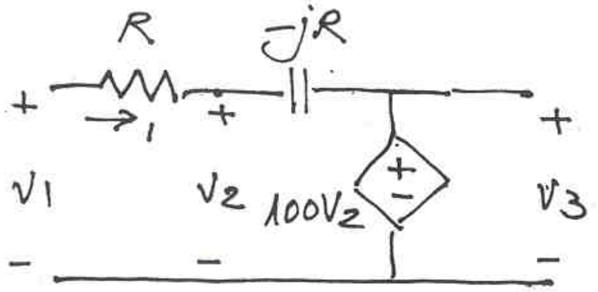
$$V_2 = \frac{80}{3}(1 - e^{3t})$$

It is a first order circuit.

$$V_{C2} = v_2 - v_1$$

$$V_o = 4 \cdot V_1$$
$$V_o = V_2; \quad V_o = \frac{80}{3}(1 - e^{3t})$$

5



$$V_1 - R \cdot i + jR \cdot i - 100 \cdot V_2 = 0$$

$$V_3 = 100 \cdot V_2$$

$$V_1 - R . i - V_2 = 0 \; ; \; V_2 = V_1 - R . i$$

or: $i = \dfrac{V_1 - V_2}{R}$

$$V_1 - R(1-j) \cdot \frac{V_1 - V_2}{R} - 100 V_2 = 0$$

$$V_1 - (1-j)(V_1 - V_2) - 100 V_2 = 0$$

$$V_1 - (1-j)V_1 + (1-j)V_2 - 100 V_2 = 0$$

$$j \cdot V_1 - (99 + j) \cdot V_2 = 0$$

$$V_2 = \frac{j}{99+j} V_1$$

$$\underline{V_3} = \frac{100j}{99+j} \underline{V_1} \qquad \text{or} \quad \underline{V_3} = \frac{100}{1-99j} \cdot \underline{V_1}$$

$$\underline{V_3} = \frac{100}{\sqrt{99^2+1}} \cdot \frac{e^{j \pi/2}}{e^{j \operatorname{arctg} 1/99}} \cdot \underline{V_1} \qquad \underline{V_3} = \frac{100}{\sqrt{99^2+1}} \cdot e^{j \operatorname{arctg} 99} \underline{V_1}$$

$$\underline{A} = \frac{100}{\sqrt{99^2+1}} \cdot e^{j\left(\frac{\pi}{2} - \operatorname{arctg} 1/99\right)}$$

$$|A| = \frac{100}{\sqrt{99^2+1}} \qquad |A| \approx 1$$

$$\arg \underline{A} = \frac{\pi}{2} - \operatorname{arctg} 1/99 \qquad \arg \underline{A} \approx \pi/2$$