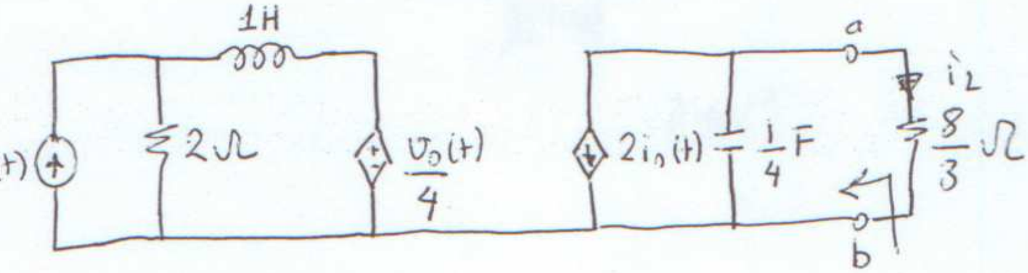
Summer 2006/2007

EE 202

Exam 3

(1)

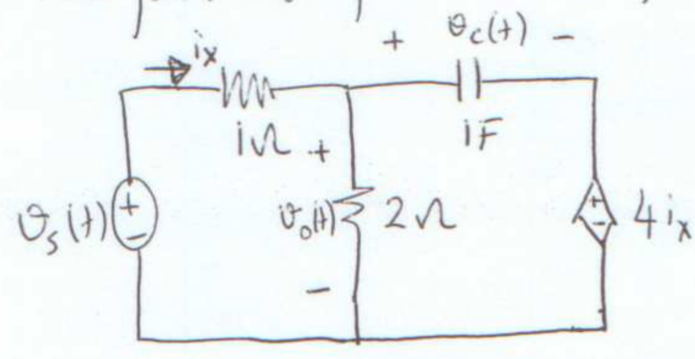


a) Find Thevenin equivalent of the circuit seen from a-b terminals for the steady-state operation with $i_s(t) = \cos(2t)$.

b) Using part a, find $i_L^{s.s}(t)$

c) Find $i_L^{ss}(t)$ when $i_s(t) = 1\,A$.

(2) a) Using Thevenin-Norton equivalent find $V_0(t)$ with Laplace Transform (Laplace Domain) methods.

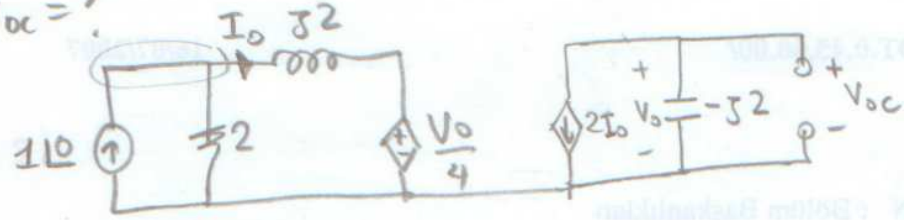


$v_s(t) = 5u(t)$; $v_c(0^-) = 0\,V$

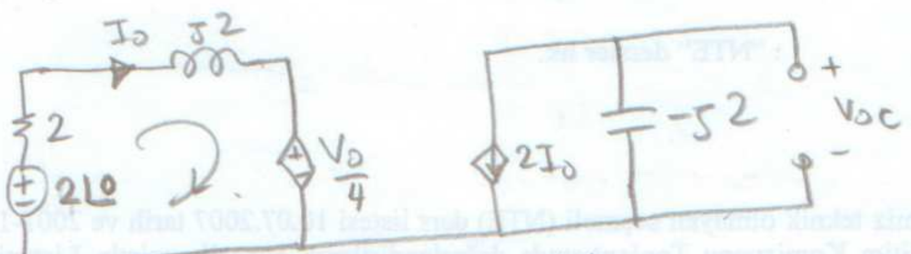
b) Find zero input solution of the circuit given in part a) if $v_c(0^-) = V_0$ Volts, for the circuit variable $v_0(t)$.

— Exam 3 —
— Solutions —

1) a) $V_{oc} = ?$



$$V_o = V_{oc} = (-j2)(-2I_o) = j4I_o \quad (1)$$



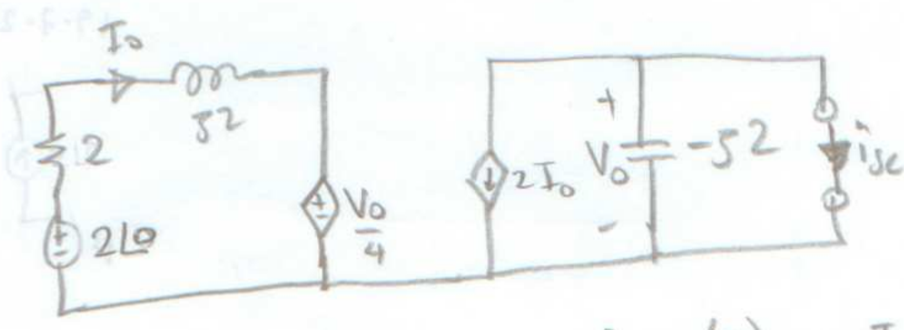
$$-2 + 2I_o + j2I_o + \frac{V_o}{4} = 0 \quad (2)$$

$j4I_o$

$$I_o = \frac{2}{2+j3} = \frac{2}{13}(2-j3)$$

$$V_{oc} = \frac{8}{13}(3+2j) \qquad \text{from (1)}$$

$i_{sc} = ?$



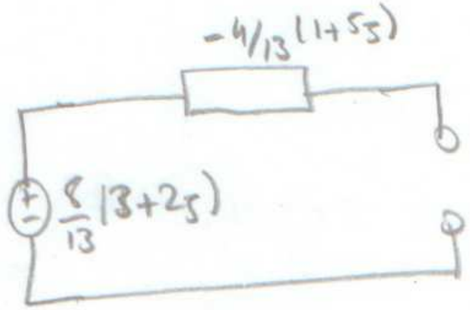
$$i_{sc} = -2I_o \; ; \rightarrow V_o = 0 \rightarrow \text{from (2)} \rightarrow I_o = \frac{2}{2+j2}$$

$$\downarrow$$

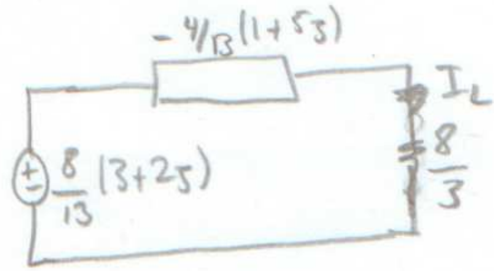
$$i_{sc} = \frac{-2}{1+j} = -(1-j)$$

$$Z_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{8/13\,(3+2j)}{-(1-j)} = -\frac{4}{13}(3+2j)(1+j)$$

$$= -\frac{4}{13}(1+5j)$$



b).



$$I_L = \frac{\frac{8}{13}(3+2j)}{-\frac{4}{13}(1+5j) + \frac{8}{3}} = \frac{24(3+2j)}{-12+104-60j}$$

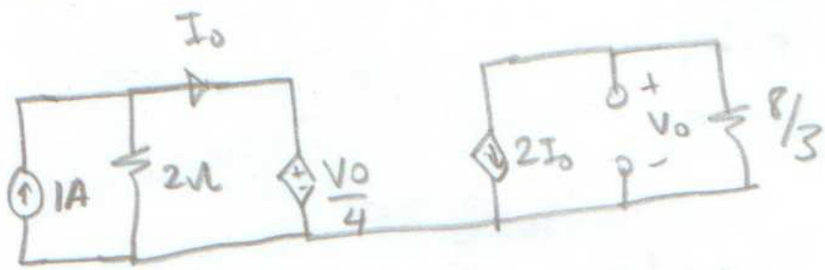
$$I_L = \frac{24}{4}\,\frac{(3+2j)}{(23-15j)}$$

$$= \frac{6}{23^2+15^2}(39+j91)$$

$$= 0{,}31 + j0{,}72 = 0{,}78\angle 66^\circ{,}2$$

$$I_L(t) = 0.78\cos(2t + 66.2^\circ)\,A.$$

c)



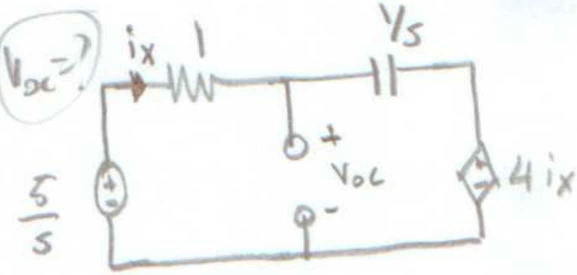
$$V_0 = -\frac{8}{3}\cdot 2I_0 \;;\; I_0 = -\frac{V_0}{8} + 1$$

$$I_0 = \frac{2}{3}I_0 + 1 \rightarrow I_0 = +3\text{ A.}$$

$$V_0 = -16\text{V}$$

$$i_L^{ss}(t) = 3A.$$

2 (a) V_{oc} = ?

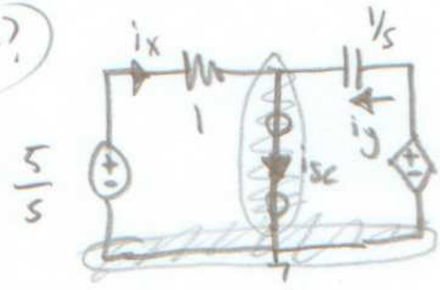


$$i_x = \frac{5/s}{1 + 1/s + 4} = \frac{5}{5s+1}$$

$$V_{oc} = 4 i_x + \frac{1}{s} i_x = \left(\frac{4s+1}{s}\right) i_x$$

$$\boxed{V_{oc} = \frac{5}{s}\,\frac{4s+1}{5s+1}}$$

i_{sc} = ?



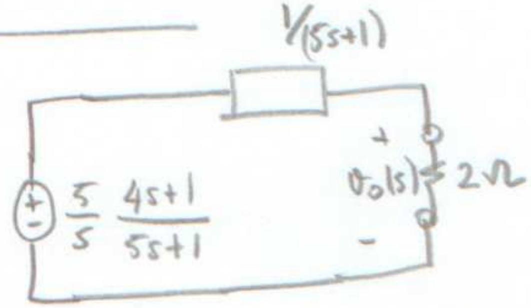
$$i_x = 5/s$$

$$i_y = \frac{4 i_x}{1/s} = 20$$

$$i_{sc} = i_x + i_y = \frac{5}{s} + 20$$

$$\boxed{i_{sc} = \frac{5}{s}(1+4s)}$$

$$R_{Th}(s) = \frac{\frac{5}{s}\frac{(1+4s)}{(5s+1)}}{\frac{5}{s}(1+4s)} = \frac{1}{5s+1}$$



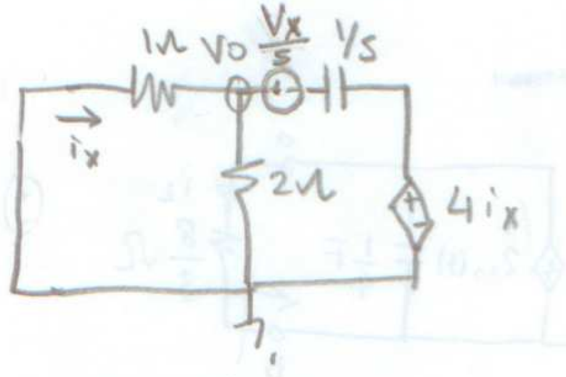
$$v_o(s) = \frac{5}{s}\,\frac{4s+1}{5s+1} \cdot \frac{2}{2 + \frac{1}{5s+1}} =$$

$$= \frac{5}{s}\,\frac{4s+1}{5s+1} \cdot \frac{2}{\frac{10s+3}{5s+1}} = \frac{10}{s}\,\frac{4s+1}{10s+3} = \frac{4(s+1/4)}{s(s+0.3)}$$

$$v_o(s) = \frac{A}{s} + \frac{B}{s+0.3} = \frac{1/0.3}{s} + \frac{\frac{4}{+0.3}\cdot 0.05}{s+0.3} = \frac{3.\overline{3}}{s} + \frac{0.\overline{6}}{s+0.3}$$

$$v_o(t) = \left(3.\overline{3} + 0.\overline{6}\, e^{-0.3t}\right) u(t)$$

b).



$V_c(0^-) = V_x$

$-V_o(s)$.

$$\frac{V_o(s)}{2} + \frac{V_o(s)}{1} + \frac{V_o(s) - V_x/s - 4i_x}{1/s} = 0$$

$$V_o(s)\left[\frac{3}{2} + s5\right] = V_x$$

$$V_o(s) = \frac{V_x}{\frac{3}{2} + s5} = \frac{V_x/5}{s + 0.3}$$

$$V_o(t) = \frac{V_x}{5} e^{-0.3t}\, u(t)$$

$V_c(0^-)$