# United States Naval Academy
# Electrical and Computer Engineering Department
# EE 221
# Exam 2
# 5 November 2010

1. You must present your work completely and legibly to receive partial credit. You must show sufficient steps to justify intermediate results as well as final answers.
2. Put all your work on the exam. If you need more space than that provided, ask your instructor for paper. Write your answer clearly and use appropriate units. You have 50 minutes to work this examination.
3. **You are not permitted to discuss the contents of this exam until after 6th period today.**

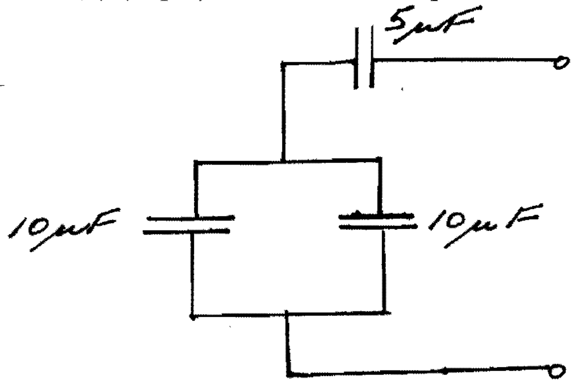
| Page | Value | Score |
|---|---|---|
| 1 | 25 | |
| 2 | 25 | |
| 3 | 25 | |
| 4 | 25 | |
| Total | 100 | |

Name Solution

I have neither given nor received assistance while completing this exam.

Signed and Dated

(1) ( 5 pts) Determine the equivalent capacitance of the capacitor network shown below.




$20\mu F \,//\, 5\mu F$
$= 4\mu F$

CEQ = $4\mu F$

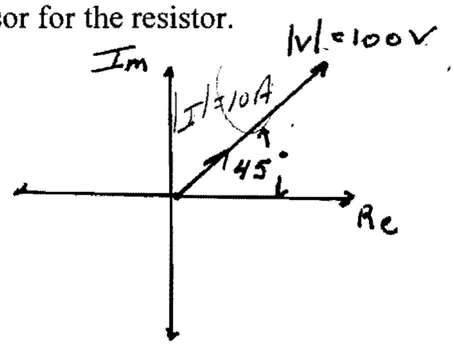
(2) (5 pts) State the i-v characteristic for an inductor.

$v = L \frac{di}{dt}$

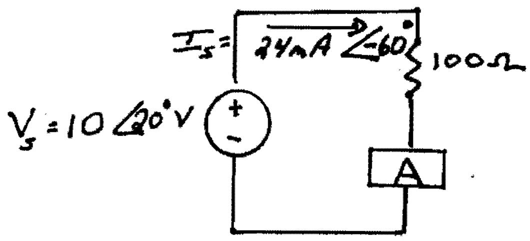
(3) (5 pts) In lab, how might you prevent a DC signal from entering a device while permitting an AC signal to pass through the device?

Put a capacitor before the entrance of the device

(4)(5 pts) Given the voltage phasor for a 10 Ω resistor sketched below on the polar graph, sketch the expected current phasor for the resistor.



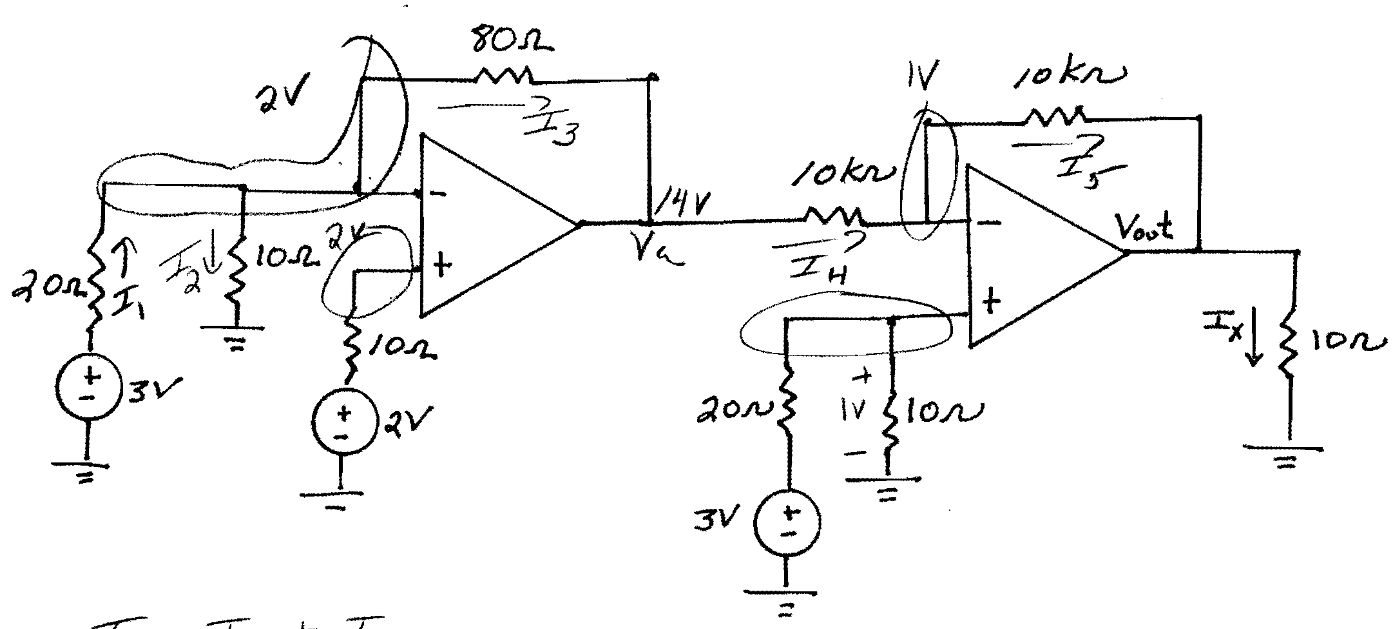

(5)(5pts) What circuit element is element A?




ELI

Inductor

(6) (25 points) Given the circuit shown below, determine the values of Vout and Ix.




$$I_1 = I_2 + I_3$$

$$\frac{3-2}{20} = \frac{2}{10} + \frac{2-V_a}{80}$$

$$\frac{1}{20} = \frac{2}{10} + \frac{2-V_a}{80}$$

$$4 = 16 + 2 - V_a$$

$$-14V = -V_a$$

$$14V = V_a$$

$$I_4 = I_5$$

$$\frac{14-1}{10k} = \frac{1-V_{out}}{10k}$$

$$13 = 1 - V_{out}$$

$$12 = -V_{out}$$

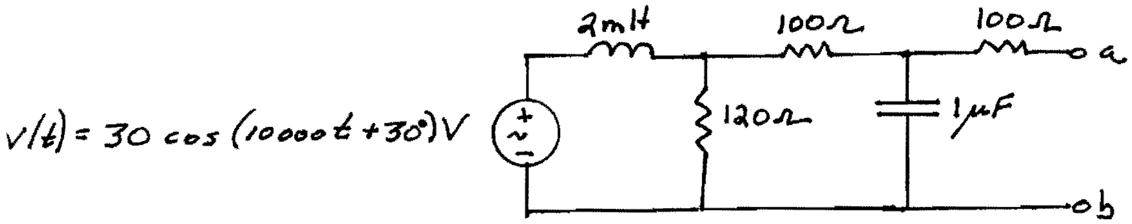
$$-12V = V_{out}$$

$$I_x = \frac{12}{10} = -1.2A$$

Vout = −12 V

Ix = −1.2 A

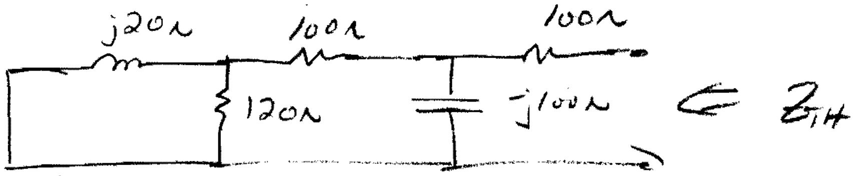
(7) (25 points) Find the Thevenin Equivalent of the circuit shown below from the point of view of terminals a-b. **DRAW THE THEVENIN"S CIRCUIT.**




$$Z_L = j\omega L = j(10000)(2\times10^{-3}) = j20\,\Omega$$

$$Z_C = -j\left(\frac{1}{\omega C}\right) = -j\left(\frac{1}{(10000)(1\times10^{-6})}\right) = -j100\,\Omega$$

$Z_{TH}$:




$$Z_{TH} = \{[(j20 \,//\, 120) + 100] \,//\, -j100\} + 100$$

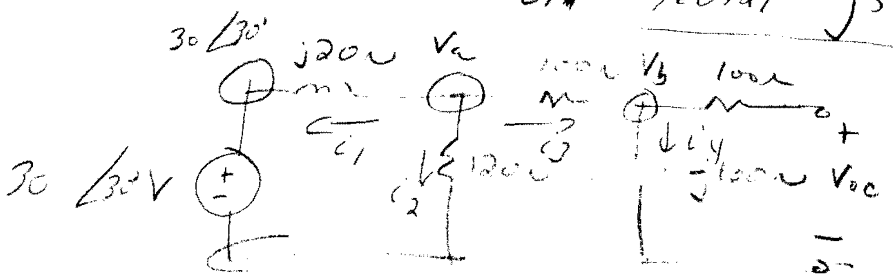
$$Z_{TH} = \{[19.73\angle 80.53° + 100] \,//\, -j100\} + 100$$

$$Z_{TH} = \{(105.06\angle 10.67°) \,//\, -j100\} + 100$$

$$Z_{TH} = (80.23\angle -41.37°) + 100$$

$$Z_{TH} = 168.76\angle -18.3°$$

$$Z_{TH} = 160.21 - j53.02\,\Omega$$



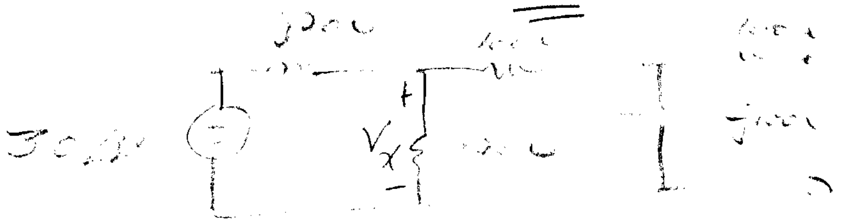
$i_1 + i_2 + i_3 = 0$ $\qquad\qquad i_3 = i_4$

$$\frac{V_a - 30\angle 30^\circ}{20j} + \frac{V_a}{120} + \frac{V_a - V_b}{100} = 0 \qquad \frac{V_a - V_b}{100} = \frac{V_b}{-100j}$$

$$V_a = 31.08 + 7.46j$$

$$V_b = 19.27 - j11.81 = 22.6 \angle -31.5^\circ \text{ V}$$

OR

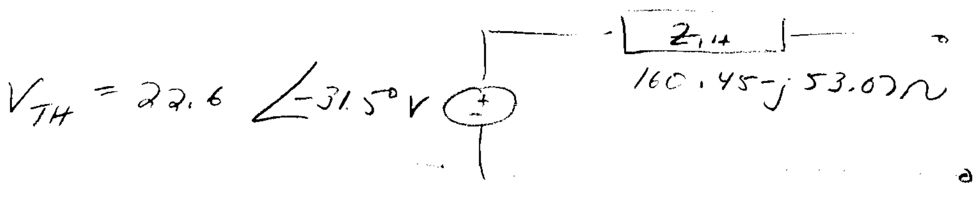


$Z_{eq1} = 120 \parallel (100 - j100)$

$V_x = \left(\frac{Z_{eq1}}{j20 + Z_{eq1}}\right) 30\angle 30^\circ$

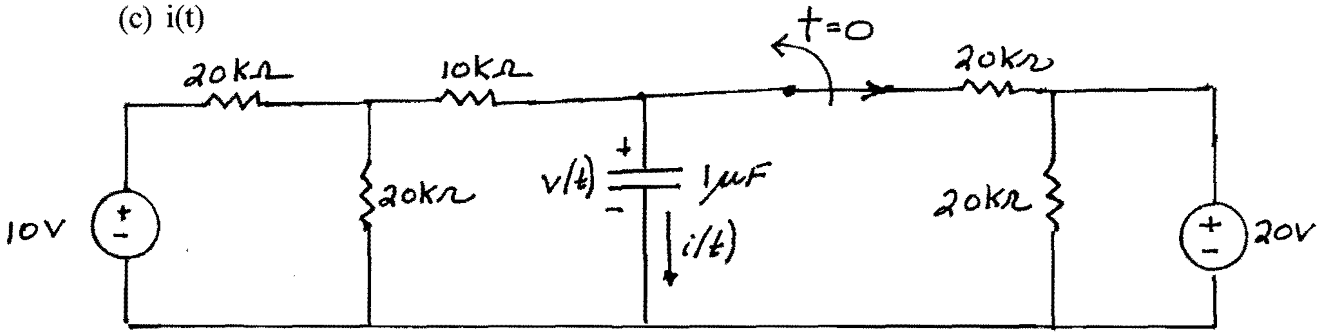
$V_{oc} = \left(\frac{-j100}{100 - j100}\right) V_x$

$V_{TH} = 22.6 \angle -31.5^\circ \text{ V}$

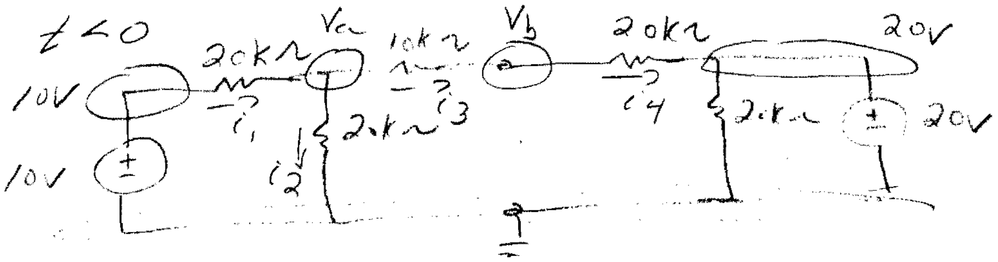


(8) (25 points)The switch in the circuit below has been closed for a long time. At t=0 the switch opens. Find the following for t>0.

(a) v(t)
**(b) Sketch V(t)**
(c) i(t)




(a)




$i_1 = i_2 + i_3$ $\qquad$ $i_3 = i_4$

$\frac{10 - V_a}{20k} = \frac{V_a}{20k} + \frac{V_a - V_b}{10k}$ $\qquad$ $\frac{V_a - V_b}{10k} = \frac{V_b - 20}{20k}$

$V_a = 8.75$ V

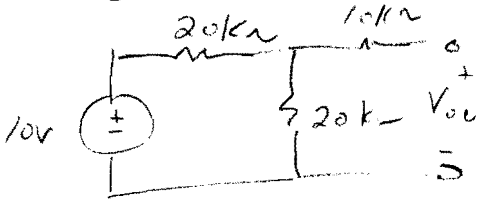
$V_b = 12.5$ V

(c) $i = C\frac{dv}{dt}$

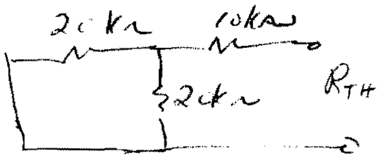
$i = (1\mu)(-50)(7.5)e^{-50t}$

$i = -375e^{-50t}$ μA

t>0

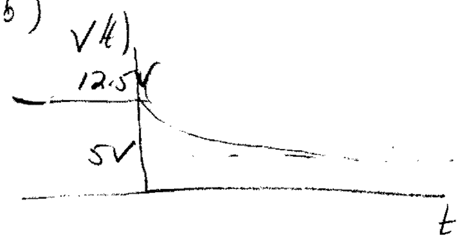



$V_{oc} = \left(\frac{20k}{(20+20k)}\right)10V = 5V$




$R_{TH} = (20k \| 20k) + 10k = 20k\Omega$

(b)




$\tau = RC = (20k)(1\mu) = 20ms$

$\frac{1}{\tau} = 50$

v(t) = $5 + (12.5 - 5)e^{-50t}$ V

i(t) = $-375e^{-50t}$ μA