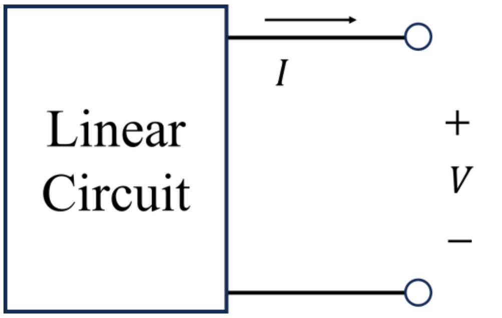
ESc201A: Introduction to Electronics

Quiz 1 Solutions

31 Aug 2023

Question 1

10 marks



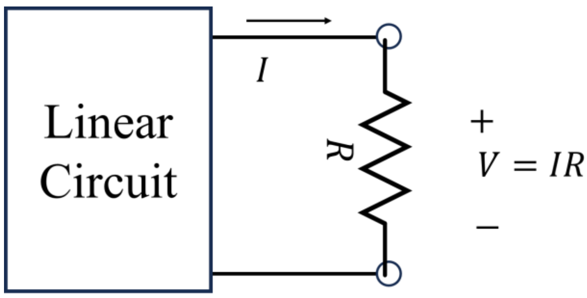
A student is given an unknown linear circuit with two open ports. The student connects the ports with resistance R and measures the voltage across those ports. He observes the following

$\boldsymbol{R}$	$\boldsymbol{V}$
$1\,\Omega$	$5\,V$
$5\,\Omega$	$10\,V$

a) Draw the voltage (V) - current (I) characteristics of this circuit. Write down its relation.
b) Compute the open circuit voltage and short circuit current.
c) Write down the Thevenin equivalent of the circuit.

Solution:

After connecting the resistance circuit will look like

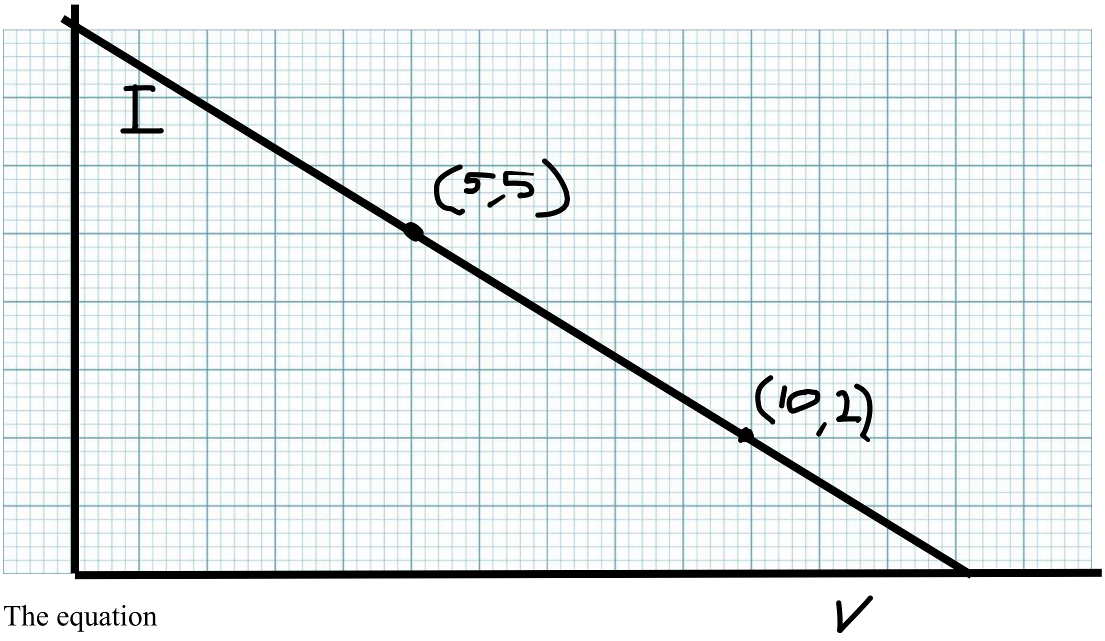


a) Part (a) is of 4 marks

Hence, the current can be computed as $I = V/R$ to give the following table

$\boldsymbol{R}$	$\boldsymbol{V}$	**I**
$1\,\Omega$	$5\,V$	5 A
$5\,\Omega$	$10\,V$	2 A

Since the circuit is linear, two points are sufficient to draw the V-I line



The equation

$$V - 5 = \frac{(10-5)}{2-5}(I-5)$$

$$3(V-5) = -5(I-5)$$

$$3V + 5I = 25 + 15 = 40$$

$$3V + 5I = 40$$

b) 3 marks

For Open circuit, put $I = 0$ to get $V_{oc} = 40/3$ V

For short circuit, put $V = 0$ to get $I_{SC} = 8$ A

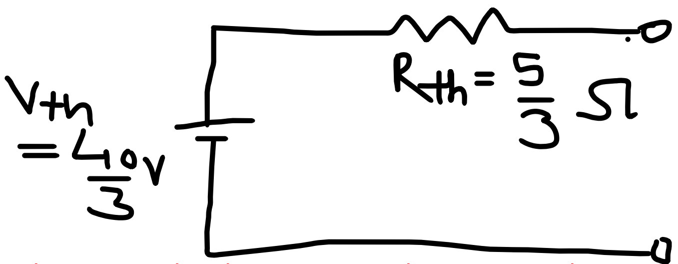
These values can also be obtained from the graph by looking at the intercepts at x and y axis.

c) 3 marks

Thevenin equivalent we require open circuit voltage and Thevenin resistance. open circuit voltage is calculated in previous part, $V_{oc} = 40/3$ V. Thevenin resistance is calculated as

$$R_{th} = \frac{V_{oc}}{I_{SC}} = \frac{40/3}{8} = \frac{5}{3}\Omega$$

Hence, the Thevenin equivalent is

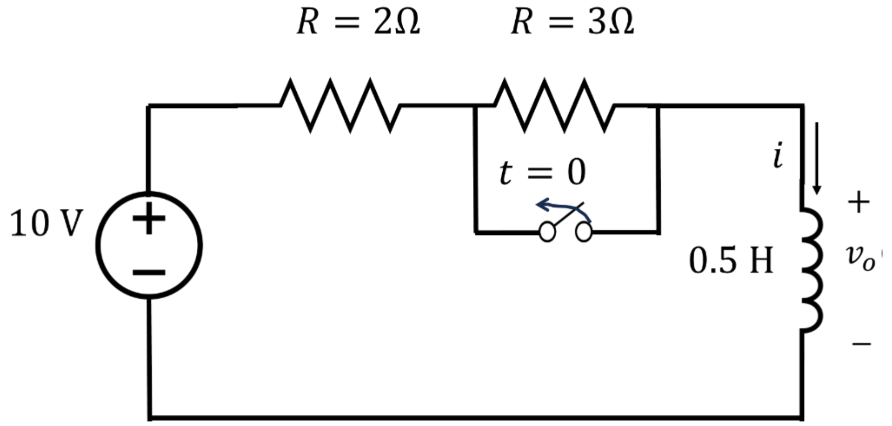


final answer is the Thevenin equivalent circuit only. You must draw the circuit.

Question 2

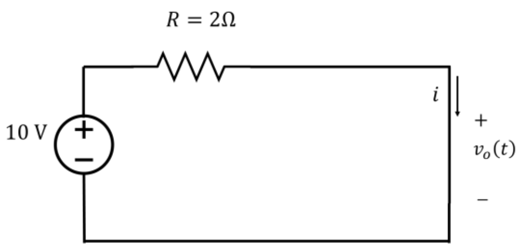
5 marks

Assume that the switch has been closed for a long time in the given circuit. Then the switch is opened at $t = 0$. Compute $i(t)$ and $v_o(t)$ in the circuit for $t > 0$.



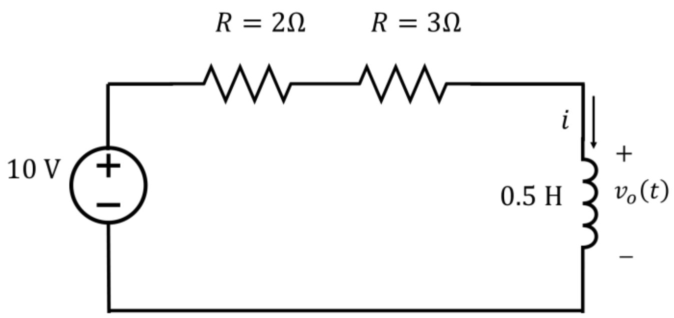
Solution

Before t=0, the switch was closed for a long time. In this case, the steady state has reached and the circuit is as follows



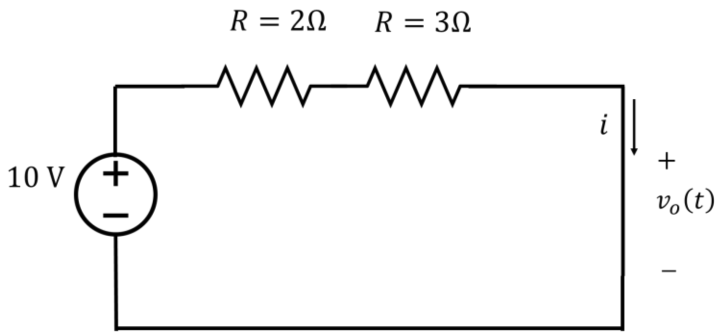
Current through inductor is $i = \frac{10}{2} = 5A$. The voltage is $v_o = 0$.

After the circuit is closed, the circuit looks like this. Immediately the current through inductor is $i(0^+) = 5A$.



Time constant for this circuit is $\tau = \frac{L}{R} = \frac{0.5}{5} = 0.1\ s.$

After the steady state is reached, the circuit will be like this.



Here, the final current will be

$$i(t = \infty) = \frac{10}{5} = 2A.$$

Hence, the current through the inductor is

$$i(t) = i(\infty) + \left(i(0^+) - i(\infty)\right)e^{-t/\tau}$$

Substituting the values we get

$i(t) = 2 + (5 - 2)e^{-t/\tau} = 2 + 3e^{-10t}$ A

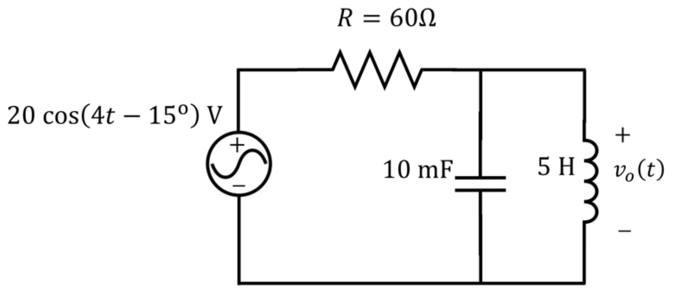
The voltage is

$$v_o(t) = L\frac{di}{dt} = 0.5(3)(-10)e^{-10t} = -15e^{-10t} \text{ V}$$

Question 3

5 marks

Determine the impedance model of the given circuit. Compute $v_o(t)$.



Solution

Part a) 2.5 marks

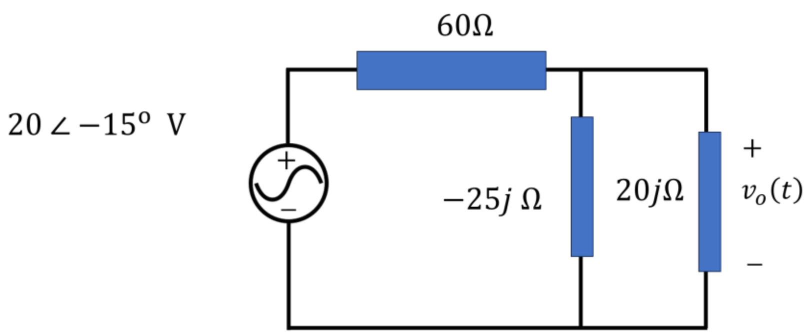
In this circuit, $\omega = 4$.

Hence, impedance of the capacitor is $\frac{1}{j\omega C} = -j\frac{1}{4 \cdot 10.10^{-3}} = -j\ 25\ \Omega$.

Hence, impedance of the inductor is $j\omega L = j4 \cdot 5\ = j\ 20\ \Omega$.

Input voltage is $20\angle - 15\ V$

The impedance model will be



Part b) 2.5 marks

The two parallel impedances are equivalent to an impedance of

$$\frac{1}{\frac{1}{-25j} + \frac{1}{20j}} = \frac{-25j \times 20j}{-25j + 20j} = 100j\Omega$$

Hence the voltage across this impedance will be

$$V_o = V_i \times \frac{100j}{100j + 60} = 20\angle - 15 \times \frac{10}{\sqrt{136}} \times 1\angle 30.966$$

$$V_o = 17.15\angle 15.966\ V$$

Hence the output is

$$v_o(t) = 17.15\cos(4t + 15.966^o)\ \text{V}$$

If the sinusoid form is not written, marks will be deducted