University of Diyala

College of Engineering

Department of Power and Electrical Machines Engineering

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Second Year – Bachelor (BSc) – EPE 204

Spring Semester

EPE 204 Electric Circuits Analysis II

Lecture 2 and 3 Tutorial

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Tutorial of Lectures 2 and 3

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Example 1: For the circuit shown in **Fig.1** let the $v_c(0) = 15V$, Find v_c, v_x and i_x for $t > 0$.

We have the 8Ω and 12Ω resistors are connected in series and can be combined as $(8 + 12 = 20\Omega)$. This new 20Ω is connected in parallel with the 5Ω resistor, so that the equivalent resistor will be (20Ω || 5Ω):

$R_{eq} = \frac{20 \times 5}{20+5} = 4\Omega$ and this can be seen in Fig.2

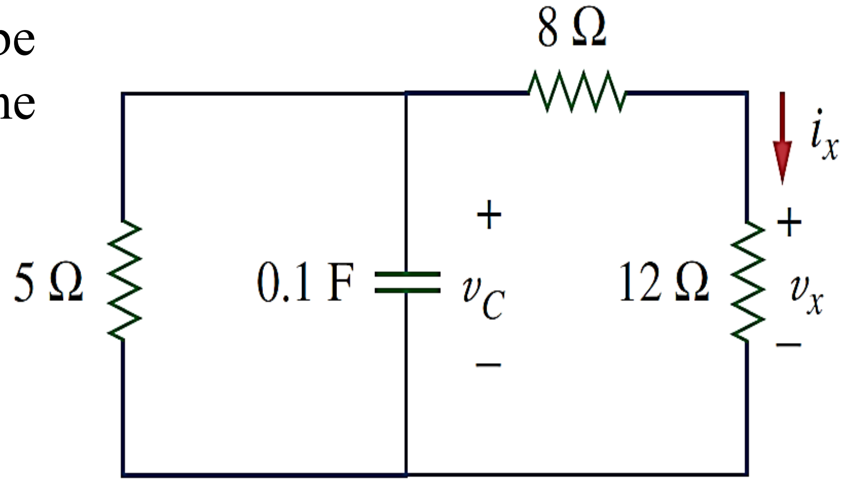

Fig.1

$$\tau = R_{eq}C = 4(0.1) = 0.4 \text{ s}$$

$$v = v(0)e^{-t/\tau} = 15e^{-t/0.4} \text{ V}, \qquad v_C = v = 15e^{-2.5t} \text{ V}$$

Now, using to voltage divider rule to find v_x

$$v_x = \frac{12}{12 + 8}v = 0.6(15e^{-2.5t}) = 9e^{-2.5t} \text{ V}$$

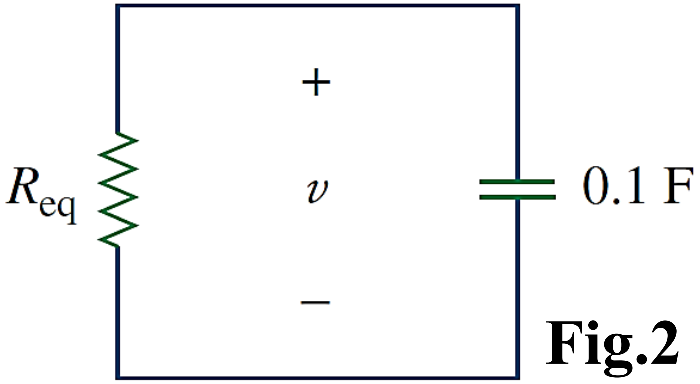

Fig.2

Finally, applying Ohm's law to get i_x

$$i_x = \frac{v_x}{12} = 0.75e^{-2.5t} \text{ A}$$

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Example 2: The switch in the circuit of **Fig.1** has been closed for a long time, and it is opened at $t=0$ Find v(t) for $t \geq 0$. Calculate the initial energy stored in the capacitor.

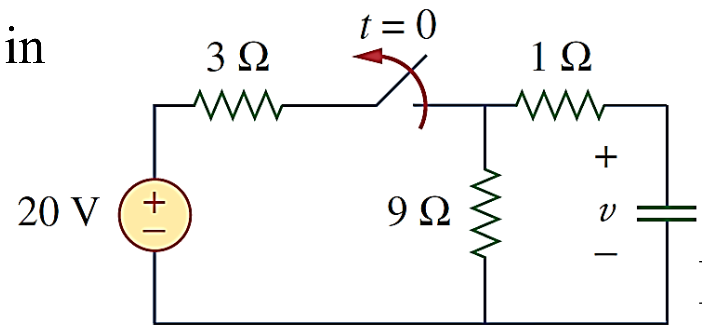


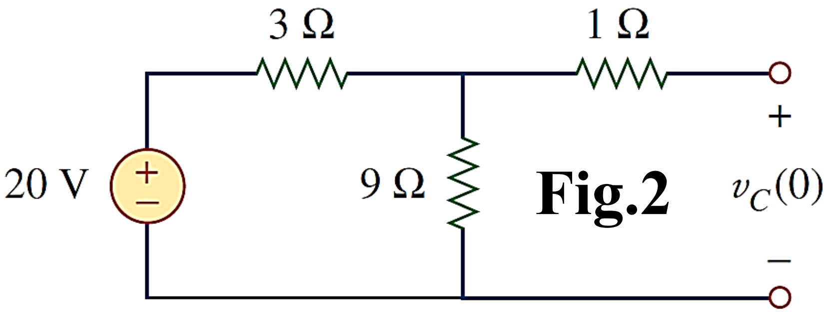
Fig.1

For $t < 0$ the switch is closed; the capacitor is an open circuit as shown in Fig.2. Using voltage division to find $v_c(t)$.

$$v_c(t) = \frac{9}{9+3} \times 20 = 15V, \quad t < 0$$

Since the voltage across a capacitor cannot change instantaneously, the voltage across the capacitor at $t = 0^-$ is the same at $t = 0$, or

$$v_C(0) = V_0 = 15 \text{ V}$$



For $t > 0$ the switch is opened, and we have the RC circuit shown in **Fig.3**. [Notice that the RC circuit in **Fig.3** is source free; the independent source in **Fig.1** is needed to provide or the initial energy in the capacitor.] The 1Ω and 9Ω resistors in series give $R_{eq} = 9 + 1 = 10\Omega$

$$\tau = R_{eq}C = 10 \times 20 \times 10^{-3} = 0.2 \text{ s}$$

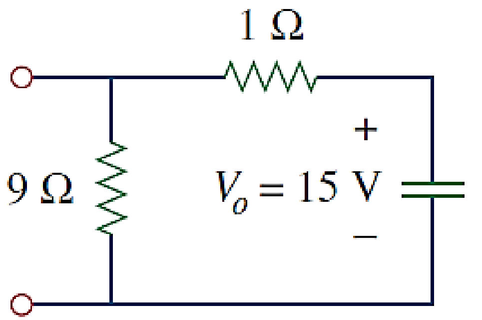


Fig.3

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Thus, the voltage across the capacitor for $t \geq 0$ is

$$v(t) = v_C(0)e^{-t/\tau} = 15e^{-t/0.2} \text{ V}$$

or

$$v(t) = 15e^{-5t} \text{ V}$$

The initial energy stored in the capacitor is

$$w_C(0) = \frac{1}{2}Cv_C^2(0) = \frac{1}{2} \times 20 \times 10^{-3} \times 15^2 = 2.25 \text{ J}$$

Example 3: The switch in the circuit of **Fig.1** has been closed for a long time, and it is opened at *t=0*. Calculate $i(t)$ for $t > 0$.

For $t < 0$ the switch is closed; and the inductor acts as a short circuit. The 16Ω resistor is short circuit as well and the resulting circuit is shown in **Fig.2.** In order to get i_1 in Fig.2 , we combine the 4Ω and 12Ω resistors in parallel to get the following resistor.

$$R_{eq} = \frac{4 \times 12}{4 + 12} = 3\Omega \qquad i_1 = \frac{40}{2 + 3} = 8\text{ A}$$

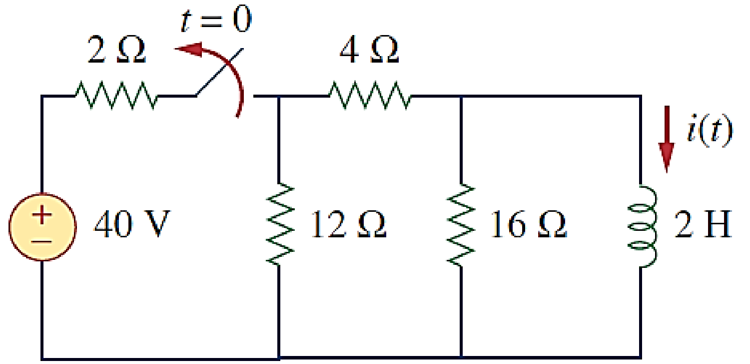

Fig.1

Since the current through an inductor cannot change instantaneously,

$$i(0) = i(0^-) = 6\text{ A}$$

When $t > 0$, the switch is open and the voltage source is disconnected. We now have the source-free *RL* circuit in **Fig.3** Combining the resistors, we have

$$R_{eq} = (12 + 4) \parallel 16 = 8\ \Omega$$

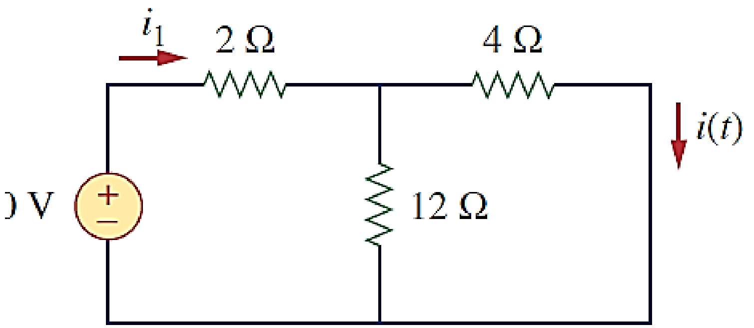

Fig.2

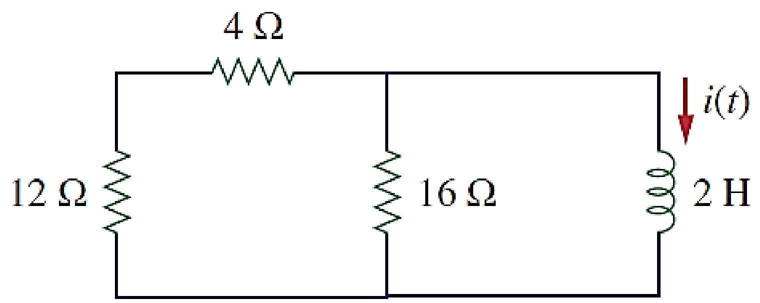

Fig.3

The time constant is

$$\tau = \frac{L}{R_{eq}} = \frac{2}{8} = \frac{1}{4}\ \text{s}$$

Thus,

$$i(t) = i(0)e^{-t/\tau} = 6e^{-4t}\ \text{A}$$

Example 4: The switch in the circuit of **Fig.1** has been in position A for a long time, and at *t=0* the switch moves to position B. Calculate $v(t)$ for $t > 0$ and calculate its value at t =1 s and 4 s.

For $t < 0$, the switch is at position A. The capacitor acts like an open circuit to dc, but v is the same as the voltage across the 5-kΩ resistor. Hence, the voltage across the capacitor just before $t = 0$ is obtained by voltage division as

$$v(0^-) = \frac{5}{5+3}(24) = 15 \text{ V}$$

Using the fact that the capacitor voltage cannot change instantaneously,

$$v(0) = v(0^-) = v(0^+) = 15 \text{ V}$$

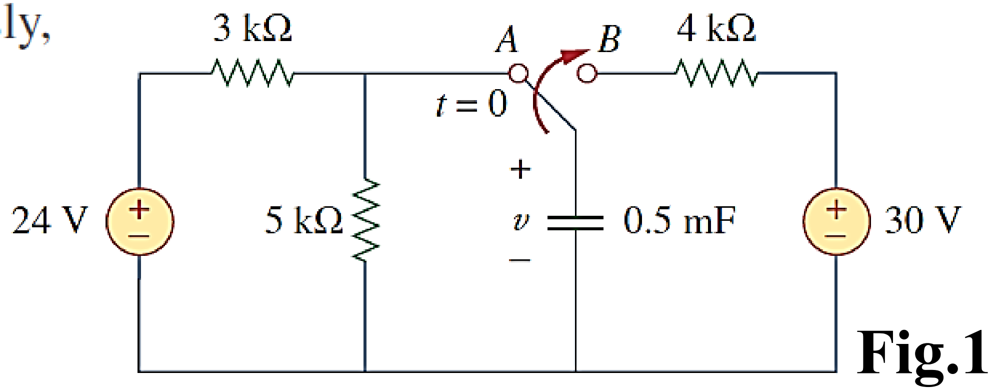

Fig.1

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For $t > 0$, the switch is in position B. The Thevenin resistance connected to the capacitor is $R_{Th} = 4\ \text{k}\Omega$, and the time constant is

$$\tau = R_{Th}C = 4 \times 10^3 \times 0.5 \times 10^{-3} = 2\ \text{s}$$

Since the capacitor acts like an open circuit to dc at steady state, $v(\infty) = 30$ V. Thus,

$$\begin{aligned} v(t) &= v(\infty) + [v(0) - v(\infty)]e^{-t/\tau} \\ &= 30 + (15 - 30)e^{-t/2} = (30 - 15e^{-0.5t})\ \text{V} \end{aligned}$$

At $t = 1$,

$$v(1) = 30 - 15e^{-0.5} = 20.9\ \text{V}$$

At $t = 4$,

$$v(4) = 30 - 15e^{-2} = 27.97\ \text{V}$$