University of Diyala

College of Engineering

Department of Power and Electrical Machines Engineering

Academic Year 2025-2026

Second Year – Bachelor (BSc) – EPE 204

Spring Semester

EPE 204 Electric Circuits Analysis II

Lecture 4

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Lecture 4

Initial and Final Values

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A ***second-order circuit*** is characterized by a second-order differential equation. It consists of **resistors** and the equivalent of **two energy storage elements**.

Perhaps the major problem arise in handling second-order circuits is finding the initial and final conditions on circuit variables. It's always easy getting the initial and final values of v and i but often have difficulty finding the initial values of their derivatives: dv/dt and di/dt. So that, this lecture is explicitly devoted to the explanation of getting, $v(0)$, $i(0)$, $dv(0)/dt$, $di(0)/dt$, $i(\infty)$, and $v(\infty)$.

There are two key points to keep in mind in determining the initial conditions. First—as always in circuit analysis—we must carefully handle the polarity of voltage across the capacitor and the direction of the current through the inductor. Keep in mind that *v* and *i* are defined strictly according to the passive sign convention (See Fig.1 & Fig.2). One should carefully observe how these are defined and apply them accordingly. Second, keep in mind that the capacitor voltage is always continuous so that $v(0^+) = v(0^-)$ and the inductor current is always continuous so that $i(0^+) = i(0^-)$.

where $t = 0^-$ denotes the time just before a switching event and $t = 0^+$ is the time just after the switching event, assuming that the switching event takes place at $t = 0$.

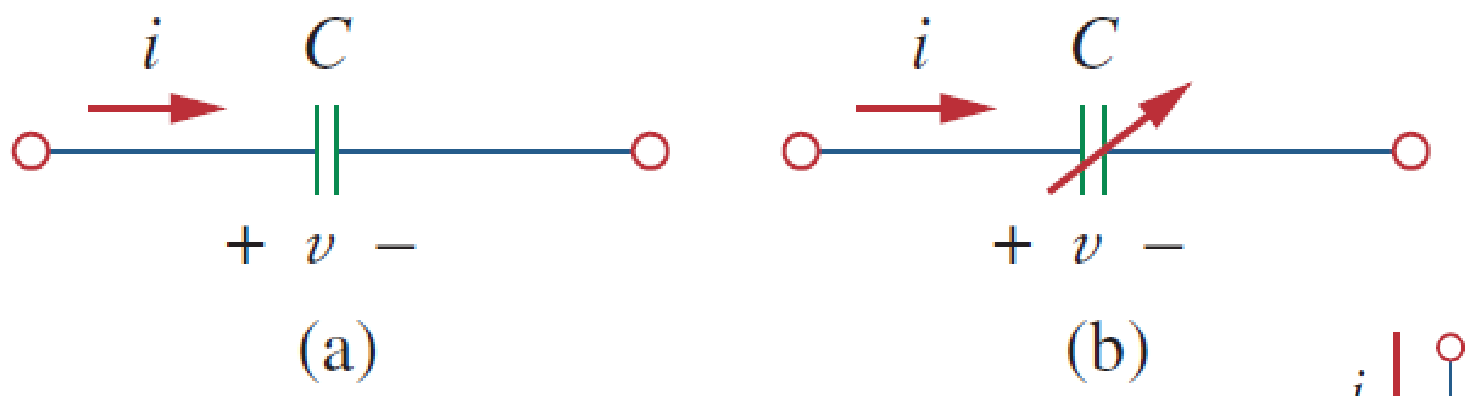


Fig.1 (a) Fixed capacitor, (b) variable capacitor.

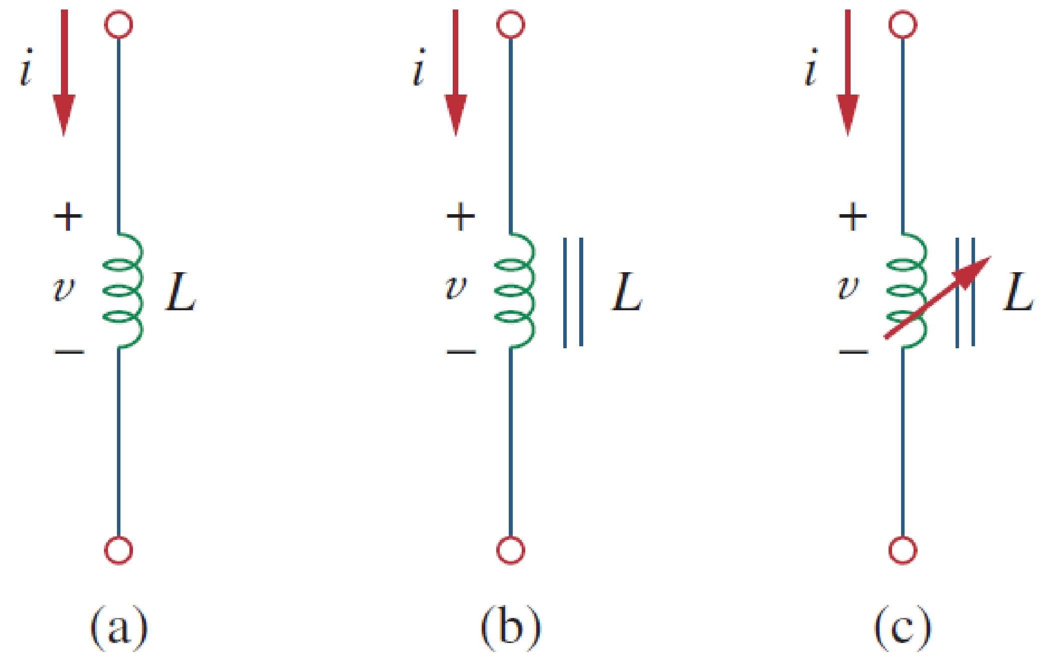


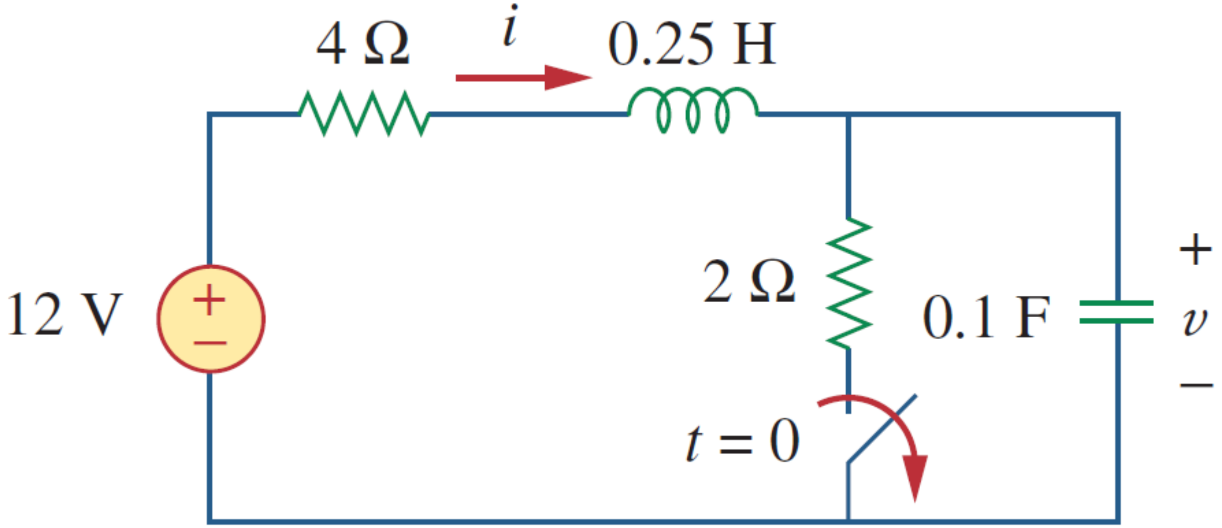
Fig.2 (a) air-core, (b) iron-core, (c) variable iron-core.

Ex:1/ The switch in the following figure has been closed for a long time and it is opened at t=0. Find:

a) $i(0^+)$ *and* $v(0^+)$

b) ${}^{di(0^+)}/_{dt}$ *and* ${}^{dv(0^+)}/_{dt}$

c) $i(\infty)$ *and* $v(\infty)$

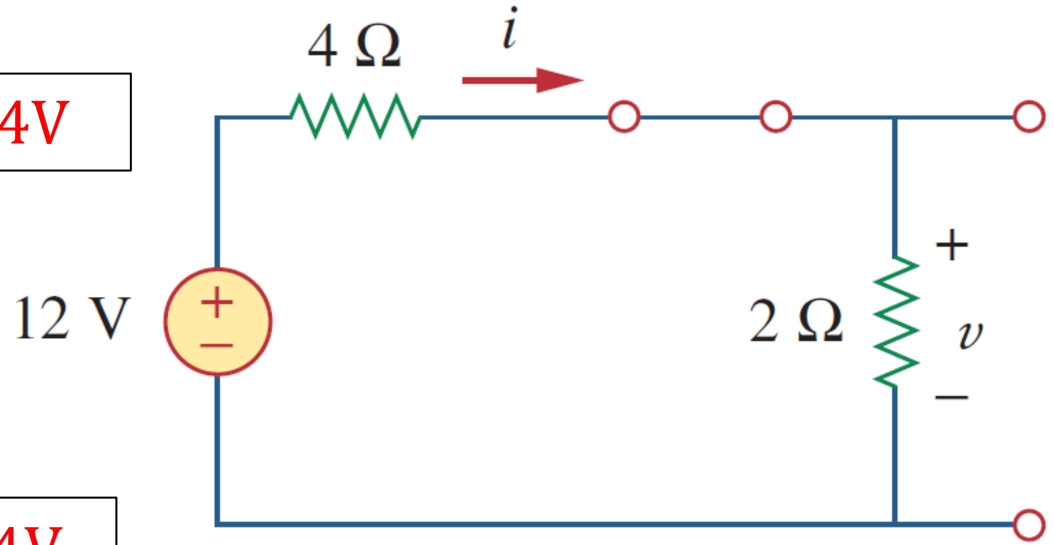


Let's study each scenario of these $t = 0^-, t = 0$ and $t = 0^+$ for the given circuit.

(a) If the switch is closed a long time before $t = 0$, it means that the circuit has reached dc steady state at $t = 0$. At dc steady state, the inductor acts like a short circuit, while the capacitor acts like an open circuit, so we have the circuit in the figure below at $t = 0^-$. So that we'll have:

$$i(0^-) = \frac{12}{4+2} = 2\text{A}$$

$$v(0^-) = 2i(0^-) = 4\text{V}$$

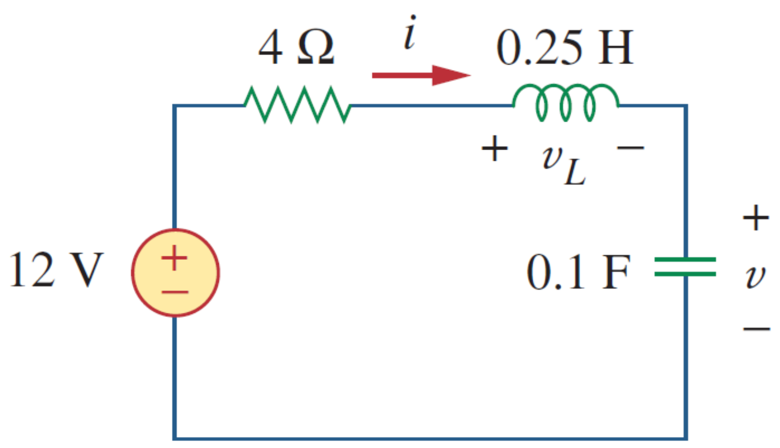


As the inductor current and the capacitor voltage cannot change abruptly, this leads to:

$$i(0^+) = i(0^-) = 2\text{A}$$

$$v(0^+) = v(0^-) = 4\text{V}$$

(b) At $t = 0^+$ the switch is open; the equivalent circuit is as shown in figure below. The same current flows through both the inductor and capacitor. Hence,



$$\boxed{i(0^+) = i_c(0^+) = 2\text{A}}$$

$$i_c = C\frac{dv}{dt} \Longrightarrow \frac{dv}{dt} = \frac{i_c}{C} \Longrightarrow \frac{dv(0^+)}{dt} = \frac{i_c(0^+)}{C} = \frac{2}{0.1} = 20\text{V/s}$$

Similarly, since $L\,di/dt = v_L$, $di/dt = v_L/L$. We now obtain v_L by applying KVL to the loop

$$-12 + 4i(0^+) + v_L(0^+) + v(0^+) = 0$$

or

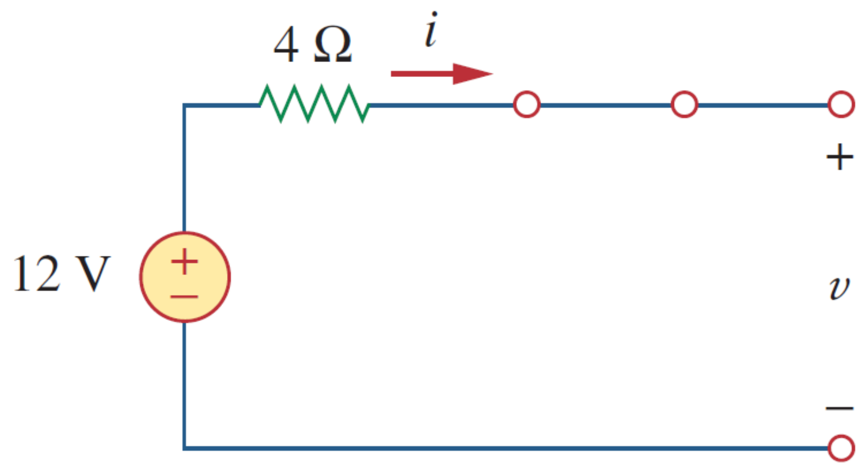
$$v_L(0^+) = 12 - 8 - 4 = 0$$

Thus,

$$\frac{di(0^+)}{dt} = \frac{v_L(0^+)}{L} = \frac{0}{0.25} = 0 \text{ A/s}$$

(c) For $t > 0$ the circuit undergoes transience. But as $t \longrightarrow \infty$ the circuit reaches steady state again. The inductor acts like a short circuit and the capacitor like an open circuit, so that the circuit becomes like that shown in figure below. from which we have

$$i(\infty) = 0 \text{ A}, \qquad v(\infty) = 12 \text{ V}$$



HOMEWORK

1. **Resolve Example 8.1: Page no. (315) with these parameters:**

$R = 6\Omega, L = 0.45H$ **&** $C = 0.02F$

2. **Solve practice Problem 8.1: Page no.(316)**

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Report Assignment

Step Response of an RC and an RL Circuits

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