Chapter 8 - The Complete Response of RL and RC Circuits

Lecture 27
Sections 8.4 & 8.5

MEMS 0031 Electrical Circuits

Mechanical Engineering and Materials Science Department
University of Pittsburgh

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Student Learning Objectives

At the end of the lecture, students should be able to:

- Formulate the time constant of RL and RC circuits for when sequential switching occurs
- Analyze the stability of RL and RC circuits with switching

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Sequential Switching

- Sequential switching occurs when two or more switches within the circuit change state at different times
- To analyze the behavior of the circuit, we will employ the same method we used for RL and RC circuits, but just keep a time history of the behavior
- Our text provides no real explanation on how to approach these problems

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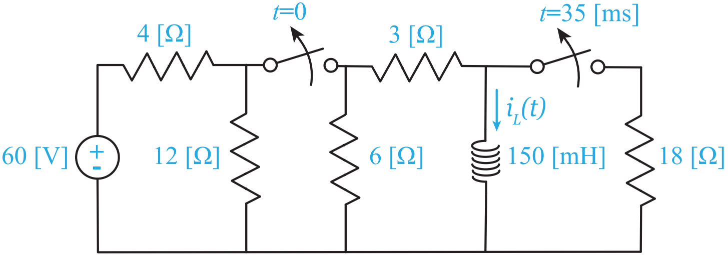
Example #1

Consider the following circuit. At $t = 0$, switch 1 is opened. Then 35 [ms] later, switch 2 is opened. Determine $i_L(t)$ for $0 \leq t \leq 35$ [ms] and $t \geq 35$ [ms].



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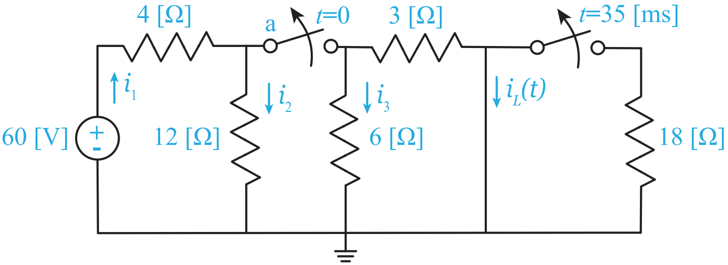
Example #1



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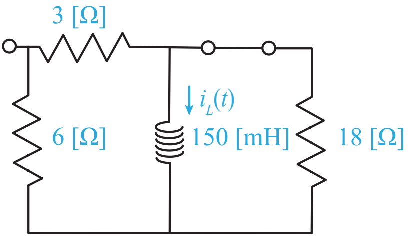
Example #1



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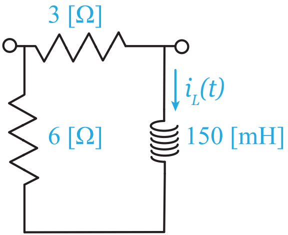
Example #1



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Stability

- The complete response of a RL or RC circuit is the sum of the natural and forced response

  $$x(t) = x_n(t) + x_f(t)$$

  This is can be expressed as

  $$x(t) = x_f + (x(t_0) + x_f)\mathrm{e}^{-\frac{t-t_0}{\tau}}$$

- If $\tau > 0$, $x_n(t) \to 0$ leaving only $x_f(t)$, which is a stable configuration
- If $\tau < 0$, $x_n(t) \to \infty$, which is an unstable configuration

  $$\tau = R_T C = \frac{L}{R_T} \implies R_T > 0$$

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Student Learning Objectives

At the end of the lecture, students should be able to:

- Formulate the time constant of RL and RC circuits for when sequential switching occurs
  - The time constant τ remains unchanged, but the numerator of the fraction within the exponential must be updated to include the time-history, i.e. expressed in terms of the time-interval of interest
- Analyze the stability of RL and RC circuits with switching
  - For a RL or RC circuit to be stable, the resistance R_T must be positive

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Suggested Problems

- 8.4-1, 8.4-2, 8.4-4, 8.4-6, 8.5-1, 8.5-2, 8.5-4

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