

RLC Circuits Tutorial – Transient Analysis

Outline



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1. Introduction

In this laboratory exercise, you will be using Simulink and Simscape to model transient analysis of the RLC circuits. Transient analysis is the time domain simulation during with an initial operating point is calculated based on DC values and circuit parameters such as voltage and currents are analyzed as time-dependent entities.

Differential equations play an important role in the transient analysis and the non-linearity properties of both capacitors and inductors taught in the class are taken into consideration. Differential equations can also be converted to the frequency domain by taking Laplace transform, which is useful in controlling the behavior of the system; however, we will focus mainly on the transient analysis obtained by solving differential equations.

2. RC Circuit

- Open Simulink by typing 'simulink' in MATLAB command window.
- Open a new model by clicking on  button just below the 'File' button, or alternately go to File→New→Model.
- Save a model by clicking  or go to File→Save→*file_name.mdl* . Be sure to save it in a location where you can retrieve later.
- Build the model shown in the Figure 1 below. The components required can be found in the 'Simulink Library Browser'.
 - 'Capacitor' can be found at Simscape→Foundation Library→Electrical→Electrical Elements→Capacitor
 - 'Resistor' can be found at Simscape→Foundation Library→Electrical→Electrical Elements→Resistor
 - 'Electrical Ground' block can be found at Simscape→Foundation Library→Electrical→Electrical Elements→Electrical Ground
 - 'Voltage Sensor' block can be found at Simscape→Foundation Library→Electrical→Electrical Elements→Electrical Ground

- 'Solver Configuration' block can be found at Simscape→Utilities
- 'PS-Simulink Converter' block can be found at Simscape→Utilities
- 'Scope' block can be found at Simulink →Sinks→Display

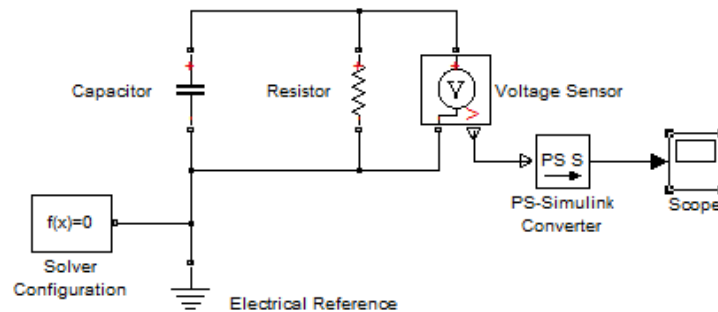







Figure 1: Circuit model containing a resistor and a capacitor only.

- You can alter the parameters values by double-clicking the components. Change the capacitance value to $10\mu\text{F}$ and give the capacitor an initial value of 10V. We want a small series resistance because we do not want the series resistance of the capacitor to affect the time constant value. **Note:** We sometimes do not set the series resistance to zero for the matter of simulation convergence.
 - Capacitor
 - Capacitance – $10\mu\text{F}$
 - Initial Voltage – 10V
 - Series Resistance – 1pF
 - Parallel Conductance – $0\text{ }1/\Omega$
- Calculate the resistor value that would give time-constant τ of 1milliseconds.
- Adjust the resistor value according to your calculations.
- What is another combination of resistors and capacitors that can be used to produce the same time-constant value?
- Double-click the 'Solver Configuration' block. Uncheck the box on the left of 'Start simulation from steady state' for this section.
- Modify the 'Configuration Parameters' as the following by clicking to Simulation → Configuration Parameters from the menu bar.
 - Stop time – 0.2 sec
 - Solver – ode23t (mod. stiff/Trapezoid)
 - Max step size – 0.0001
- Why do we have to use solver 'ode23t' instead of the default settings of 'ode45'?

- To learn about solver configurations, type 'doc' in the MATLAB command window. Then type 'solver configuration' in the search box.
- Click  from the tool bar to simulate the model. You can also click Ctrl+T to complete the same task.
- Double click the scope window to view the output.
-  button scales the graph automatically to fit the simulation time period. It can also be called as 'best fit' button. Sometimes, you may see the output waveform clipped or being out of the boundaries; in such cases,  is a handy tool. Students are encouraged to use this button to see the full waveform before using the zoom tools.
- Use zoom tools such as Zoom X-axis  and Zoom Y-axis  to have the best view of the transient response and to measure the time-constant of the system.
- Does the time constant meet the expectations from your calculation?
- Use 'Snipping Tool' or 'Print Screen' to capture the waveform and attach it to your report.

3. RLC Circuit

- Create another model provided in the Figure 2 below by introducing an inductor between capacitor and a resistor.

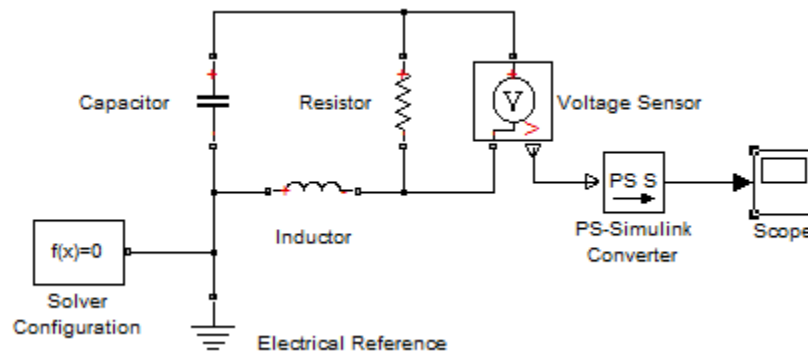


Figure 2: RC Circuit from Figure 1 with an inductor between capacitor and resistor

- Vary the inductor value to small, medium, and large values to see how the transient response changes with time.
- All other parameters are left unchanged.
- Find the inductor value that would approximately produce the system response shown in the Figure 3 below.

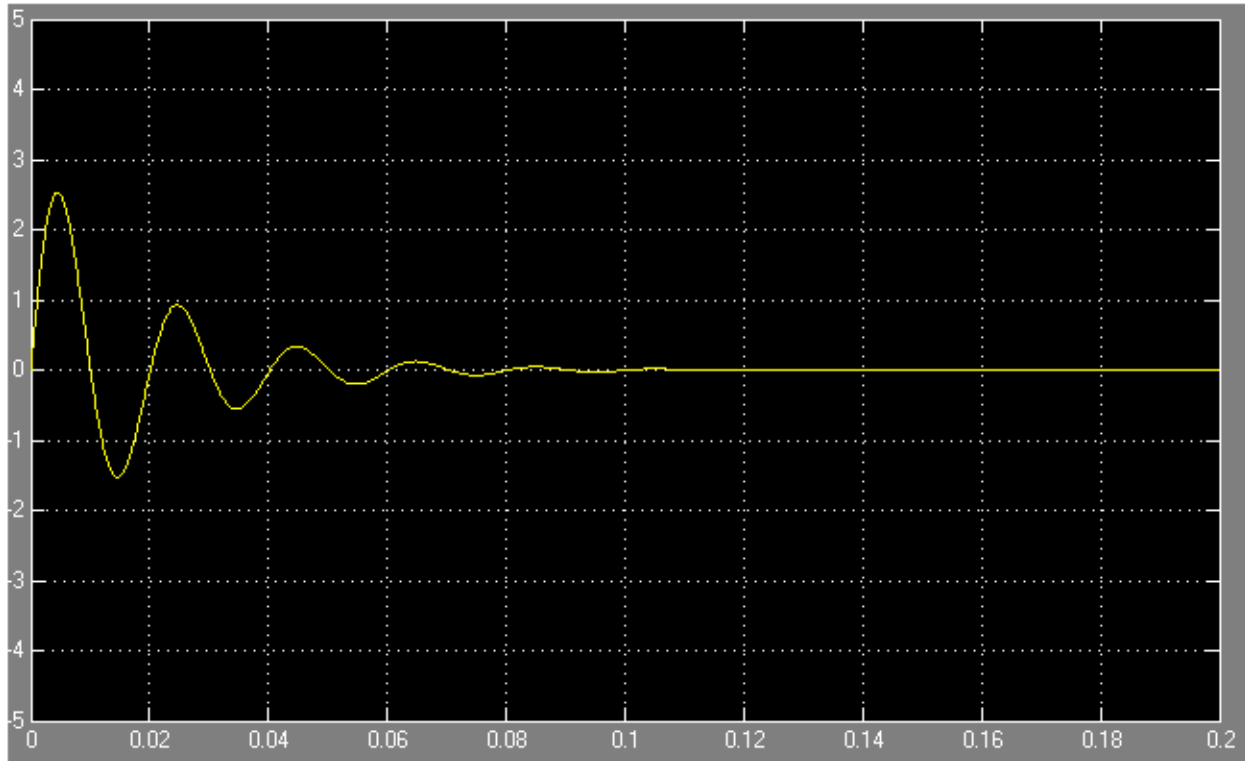


Figure 3: Transient response of an RLC circuit

- Discuss the different responses for different inductances (small, medium, large), especially regarding the shapes of the response depending on inductances.
- Attach 3 different transient responses figures in your report.