EE 2010 Circuit Analysis
Lab 13: Transient Response

Lab Section: **Printed Name (Last, First):**

Learning Objectives:

- Understand the concept of Transient Responses
- Simulate the transient response using a unit-step excitation
- Observe the transient response in lab using a square-wave excitation

Transient Response:
From WIKIPEDIA: "In electrical engineering and mechanical engineering, a *transient response* or natural response is the *response* of a system *to a change* from an equilibrium or a steady state. The transient response is not necessarily tied to "on/off" events but to any event that affects the equilibrium of the system. The *impulse response* and *step response* are transient responses to a specific input."

A. Before coming to lab:

1. Background:

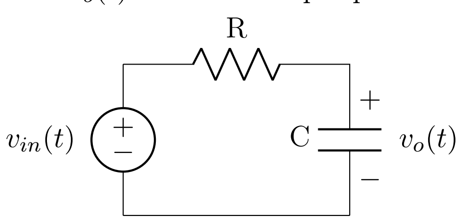
1.1 Read this WIKIPEDIA overview of transient responses.

1.2 View this Youtube video on Interview Questions about transient responses.

In this lab, we examine the output due to a unit-step excitation by via a Multisim simulation.

2. Step Response of an RC Circuit:

Find $v_o(t)$ for a unit-step input:



2.1 Construct the circuit above with $R = 100\Omega$ and $C = 1mF$.

2.2 Place a 5V Step-Voltage source as shown. Note: This is NOT a 5V DC source.

2.3 Set the Step Time at 5mS (so the step occurs a bit AFTER t=0).

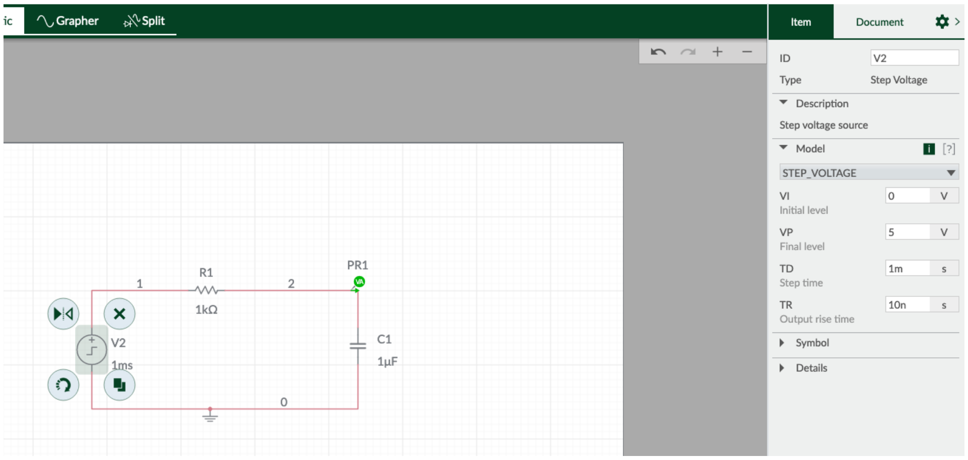
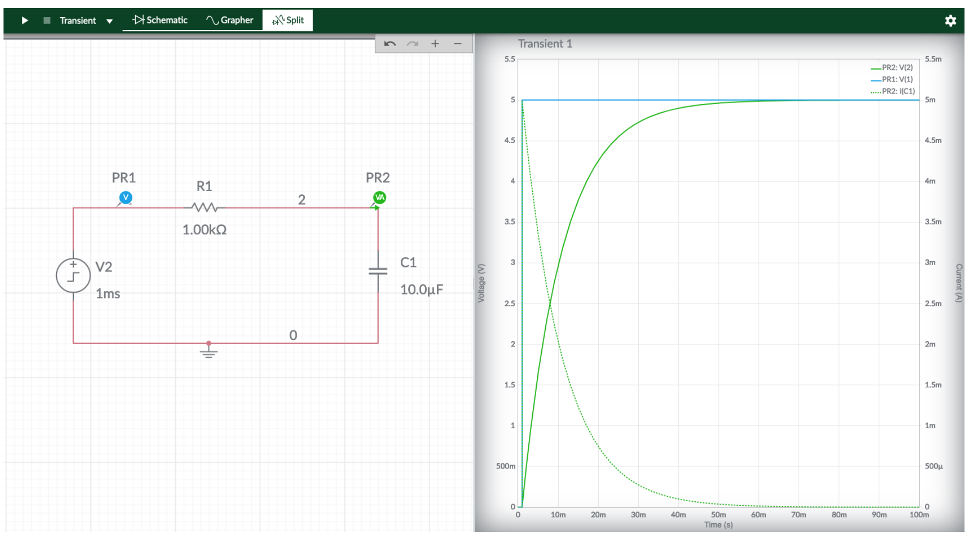


Figure 1: Unit-step input settings

2.4 Measure the output waveform with a voltage probe.

2.5 The result should approximate the figure below.

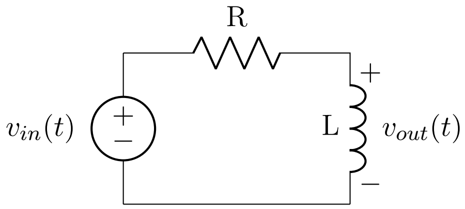


2.6 Compare the simulation result to a Matlab symbolic prediction of $v_o(t)$ for a unit-step input.

2.7 Screen capture into a document to upload to dropbox.

3. Step Response of an RL Circuit:

Find $v_o(t)$ for a unit-step input:



3.1 Construct the circuit above with $R = 100\Omega$ and $L = 10H$.

3.2 Place a 5V Step-Voltage source as shown. Note: This is NOT a 5V DC source.

3.3 Set the Step Time at 5mS (so the step occurs a bit AFTER t=0).

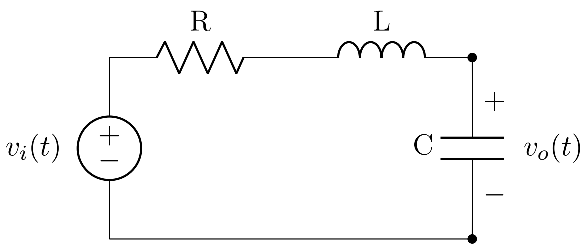
3.4 Measure the output waveform with a voltage probe.

3.5 Compare the simulation result to a Matlab symbolic prediction of $v_o(t)$ for a unit-step input.

3.6 Screen capture into a document to upload to dropbox.

4. Step Response of an RLC Circuit:

Find $v_o(t)$ for a unit-step input:



4.1 Construct the circuit above with $R = 20\Omega$ and $L = 1H$ and $C = 0.1mF$.

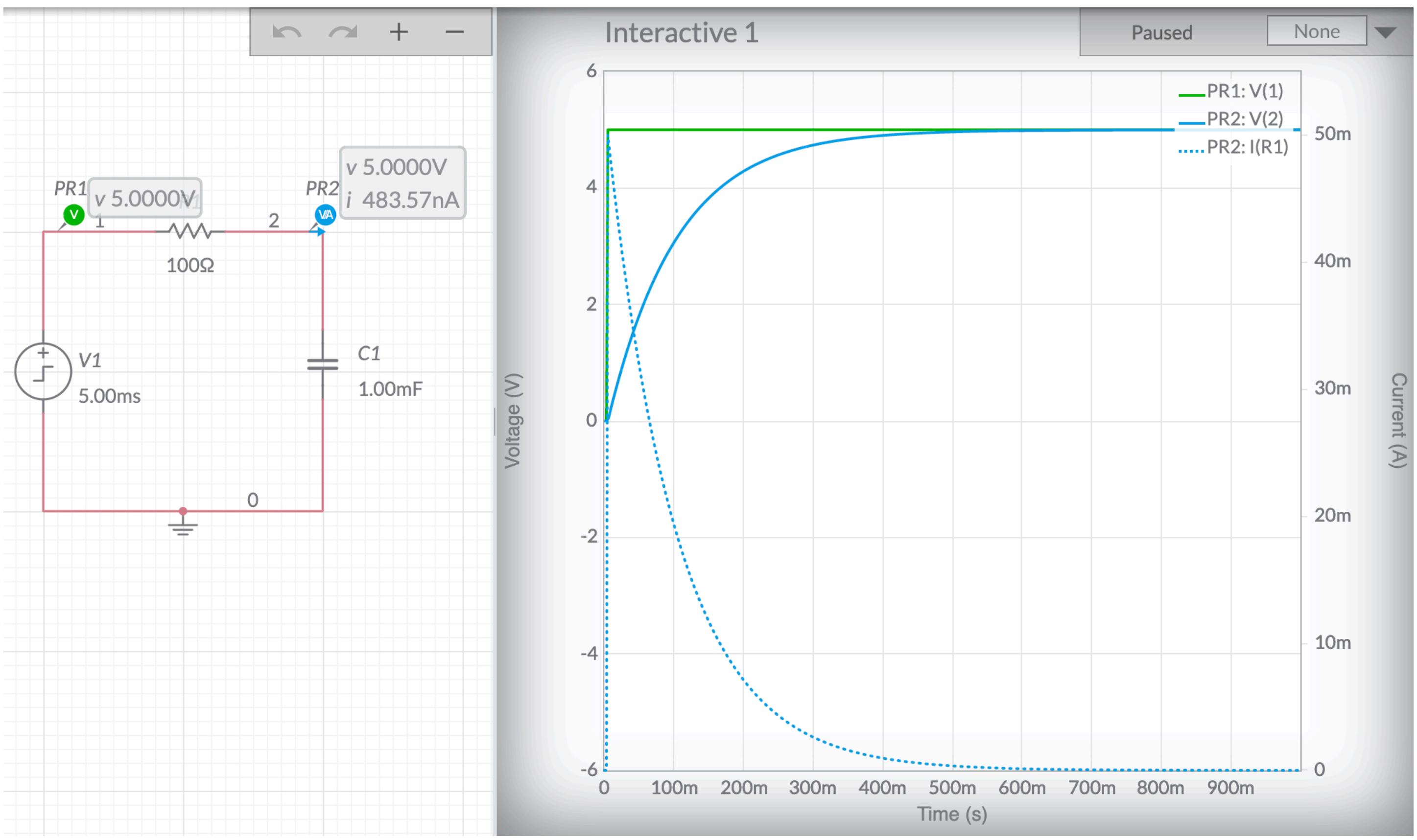
4.2 Place a 5V Step-Voltage source as shown. Note: This is NOT a 5V DC source.

4.3 Set the Step Time at 5mS (so the step occurs a bit AFTER t=0).

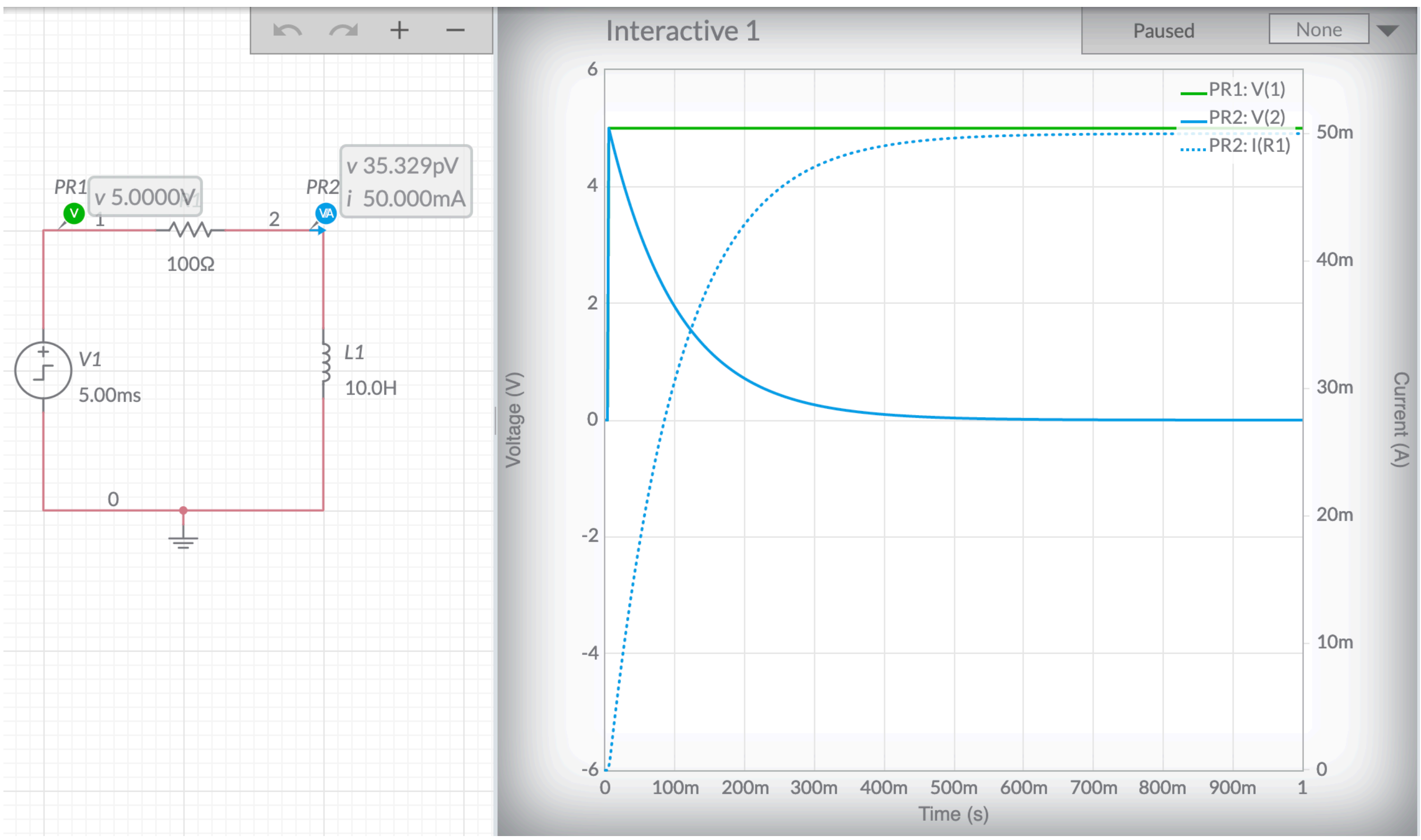
4.4 Measure the output waveform with a voltage probe.

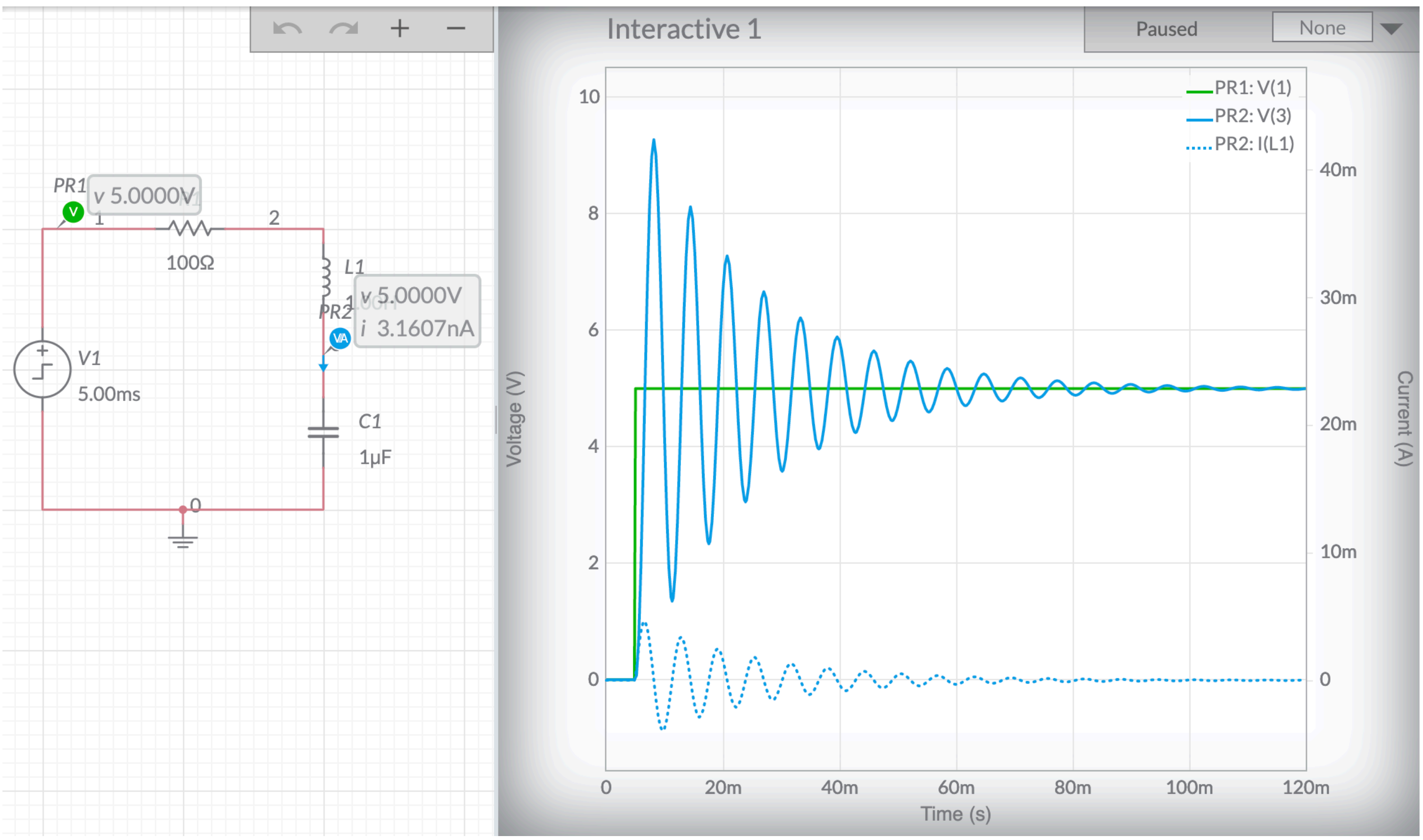
4.5 Compare the simulation result to a Matlab symbolic prediction of $v_o(t)$ for a unit-step input.

4.6 Screen capture into a document to upload to dropbox.



PR1
v 5.0000V
PR2
v 5.0000V
i 483.57nA
1
2
100Ω
V1
5.00ms
C1
1.00mF
0
Interactive 1
Paused
None
PR1: V(1)
PR2: V(2)
PR2: I(R1)
Voltage (V)
Current (A)
Time (s)
6
4
2
0
-2
-4
-6
50m
40m
30m
20m
10m
0
100m
200m
300m
400m
500m
600m
700m
800m
900m

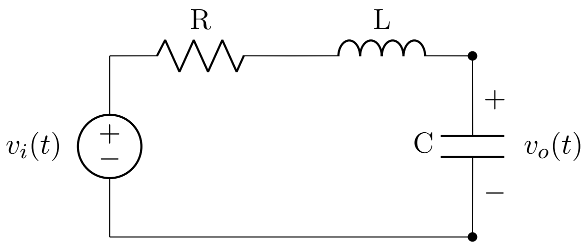

PR1
v 5.0000V
PR2
v 35.329pV
i 50.000mA
1
2
100Ω
V1
5.00ms
L1
10.0H
0
Interactive 1
Paused
None
PR1: V(1)
PR2: V(2)
PR2: I(R1)
6
4
2
0
-2
-4
-6
50m
40m
30m
20m
10m
0
0
100m
200m
300m
400m
500m
600m
700m
800m
900m
1
Time (s)
Voltage (V)
Current (A)


PR1
v 5.0000V
1
2
100Ω
L1
PR2
v 5.0000V
i 3.1607nA
V1
5.00ms
C1
1μF
0
Interactive 1
Paused
None
PR1: V(1)
PR2: V(3)
PR2: I(L1)
Voltage (V)
Current (A)
Time (s)
0
20m
40m
60m
80m
100m
120m
10
8
6
4
2
0
40m
30m
20m
10m
0

B. In-Lab Procedures

1. Step Response of an RLC Circuit:

Find $v_o(t)$ for a square-wave input:



1.1 Construct the circuit above with $R = 20\Omega$ and $L = 1H$ and $C = 0.1mF$.

1.2 Place a 5V *rectangular-pulse* from the function generator source as shown.

1.3 Adjust the *frequency* to be about 2 Hz so that the *period* of the square wave is about 500mS.

1.4 Measure the output waveform with the oscilloscope. overdamped

1.5 Adjust the period of the square wave and the time-scale of the oscilloscope to obtain an aesthetically-pleasing display of the transient response.

1.6 Show the transient response waveform to your TA.

C. Takeaways:

- Transient responses are the result of disturbances to dynamic systems.
- The characteristics of transient responses provide great insight to system dynamics.
- Step responses are an observable characterization of transient responses.
- Every physical system exhibits transient behaviors. It is important for engineers to understand their causes and behaviors.