Lab 3: RL and RC Circuits

OBJECTIVE

- Understand the charging and discharging of a capacitor.
- Measure the RC constant of a circuit using an oscilloscope.
- Using SPICE to simulate circuits

PRELAB

- Find the voltage across the capacitor in Fig. L3.1 as a function of time if the capacitor was initially uncharged, and the switch was closed at time t=0.
- Using MATLAB, or MS. Excel, or any other plotting facility, plot the charging curve of the capacitor (voltage vs. time).

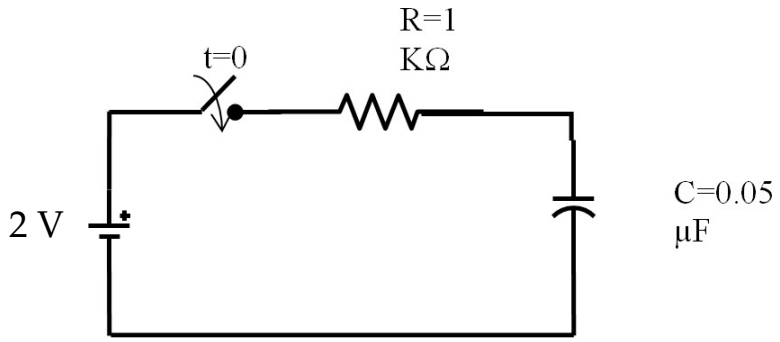

Figure L3.1 A simple RC circuit.

- Read carefully SPICE tutorial in this manual.
- Simulate the circuit shown in Figure L3.1 (time domain or transient). Submit the graph showing the voltage across the capacitor vs. time, and the SPICE code.

LAB

PART I: RC Circuit

We would like to see the response of the capacitor voltage in Fig. L3.1 to a step function (i.e., closing the switch at time t=0). We can do that by displaying the voltage on the capacitor at the scope, then closing the switch. The only problem is that the whole process takes only a few microseconds, and you will not be able to observe the voltage variation across the capacitor. In order to be able to display the

voltage change across the capacitor, we have to repeat this process many times per second. In other words, the switch should be closed, opened, and then closed again many times per seconds. Therefore, we replace the dc power supply and the switch by a 2 V square wave generator. So, the input is the square shape shown in Fig. L3.2.

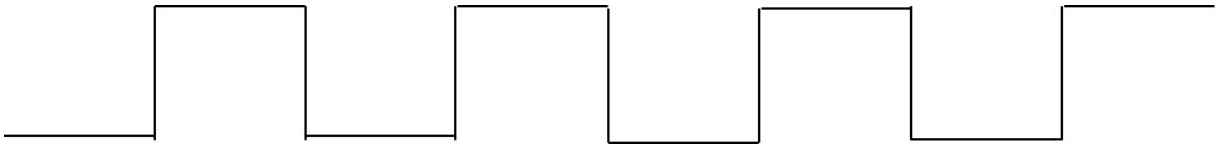

Figure L3.2 A square wave

If the high time (time in which the signal is 2 V) is more than 5 τ (τ=RC= time constant) we can assume that the capacitor is charged to 2 V. In reality it will be off by e^{-5} = 0.0067*2 V.

1. Construct the following circuit. Use the functional generator to generate a square wave with a frequency of 5 kHz.

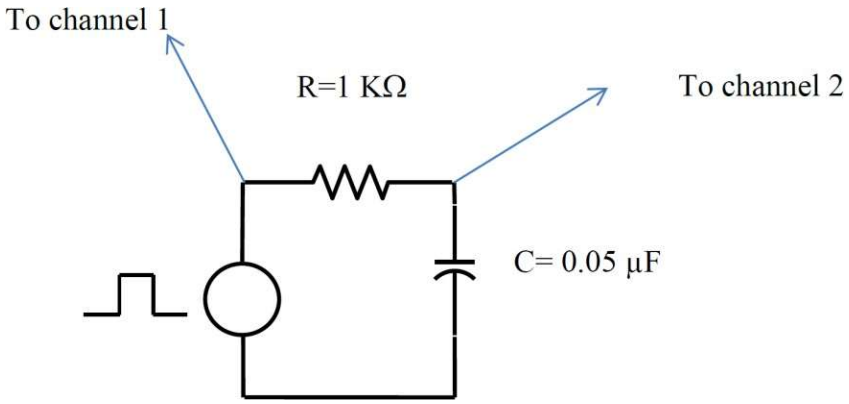

Figure L3.3 A simple RC circuit with a square wave input

2. Use the oscilloscope to display the voltage across the capacitor and the input voltage. Show it to your TA.
3. Sketch the display in your lab notebook and show it to the TA.
4. Sketch the waveform (voltage across the capacitor) in your notebook for a complete cycle recording the voltage and time (at least 5-6 different points during the cycle).
5. What is the error compared to a real step function? What is the value of the voltage compared to the actual value of a step function?
6. From the display, find the time at which the signal reaches 36.8% of its maximum value. Compare this time with the calculated RC.

7. Shunt the capacitor with another 1 KΩ resistor. What should be the time constant of the circuit? Repeat steps 2 to 6

PART II: RL Circuit

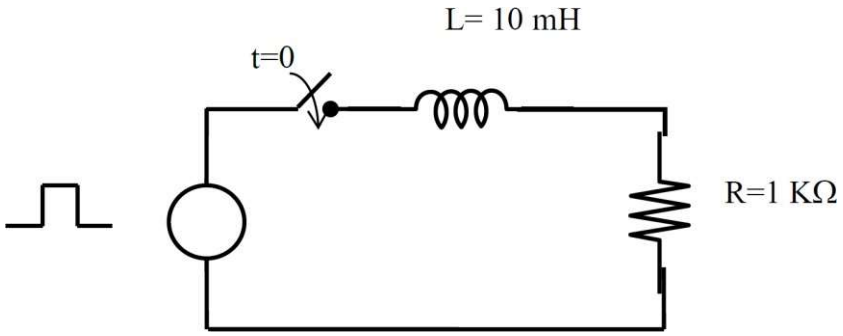

Figure L.3.4 RL Circuit

1. Construct the circuit in Fig. L3.4. Generate a square wave as you did in Part I. Choose the frequency of the square wave such that the circuit reaches the steady state in every cycle twice (once for the charging and once for the discharging). What is the frequency you chose?
2. Use the oscilloscope to display the voltage across the resistor and the input voltage. Sketch the display in your lab notebook and show it to the TA.
3. Plot the voltage across the resistor vs. time