

## 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 any other plotting facility, plot the charging curve of the above capacitor (voltage vs. time).

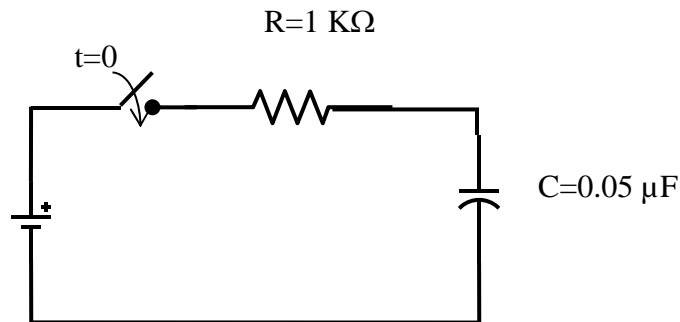


Figure L3.1 A simple RC circuit.

- Read carefully SPICE tutorial in this manual.
- Simulate the circuit in Fig. L2.2 using Q point analysis to find the voltage across every resistor and the current in every branch. Submit the schematic of the circuit with the required values shown and the SPICE code
- 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**

Construct the above circuit in Fig. L3.3.

Now, we would like to see the response to a step function (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 that the whole thing will take few microseconds and you will not be able to see it.

In order to be able to display them, we have to repeat this many many times per second. So the switch should be closed, opened, and then closed again many times per seconds.

Instead of a dc power supply and a switch, we replace it by a 2V square wave generator. So, the input is a

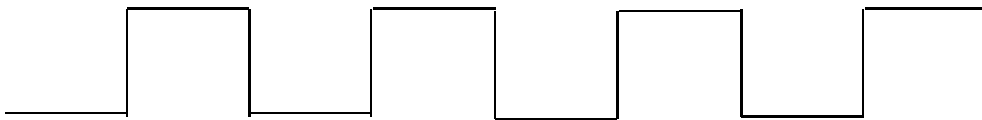


Figure L3.2 A square wave

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

Construct the following circuit; use the functional generator to generate a square wave with a frequency of 5 KHz.

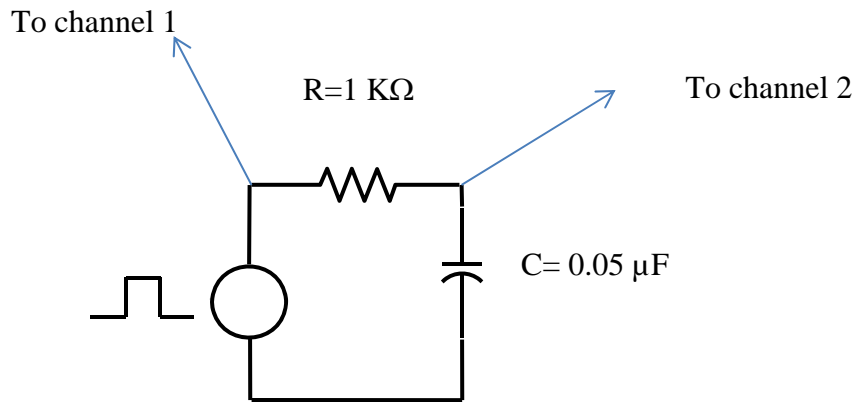


Figure L3.3 A simple RC circuit with a square wave input

Use the oscilloscope to display the voltage across the capacitor and the input voltage. Show it to your TA.

Sketch the display in your lab notebook and show it to the TA.

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).

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)

From the display, find the time at which the signal reaches 0.368 from its maximum value. Compare this with the calculated  $RC$ .

What frequency (square wave) that makes the circuit close to a real step function?

## **PART II**

Shunt the capacitor with another  $1\text{ K}\Omega$  resistor. What should be the time constant of the circuit?

Display the result on the scope and show it to your TA

What frequency would make this circuit close to a real step function?