Phys 241 Signal Processing: Lab 2

Remember to always write down your observations as you make them! Sketch your input and output signals for each circuit (or circuit element) that you test. Sketch the circuits themselves. Discuss the guesses and trials you made over the course of the experiment. Where did you go right? Where did you go wrong?

15% of your mark is for investigation that goes beyond the stated goals of the lab. (See the last page of this handout for a full marking scheme)

Warm up exercises:

Still for marks; to get your brain in gear

Consider the following circuits:

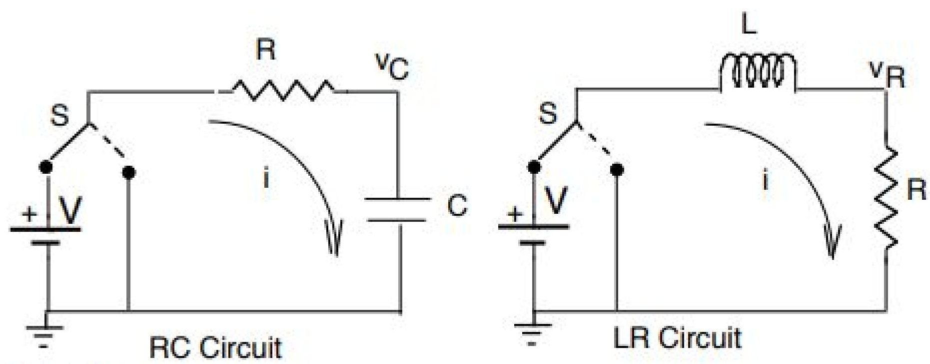

Figure 1

- What do you expect the voltage at v_C and v_R will look like (as a function of time) when the switch is first moved from the dashed line position to the solid line position S?
- What about if you open it?

Recall the equations for voltage across these circuit elements as seen in class:

$$V_R = iR,\ V_C = 1/C\int idt,\ V_L = L\tfrac{di}{dt}$$

We can combine these to build equations that describe the whole of each circuit, for example for the RC circuit in Figure 1:

$$V = V_R + V_C = iR + 1/C\int idt$$

Using these equations for the circuit voltages, we can find an expression for the current in each circuit:

$$i = I_0 e^{-t/RC} \text{ (charging) and } i = I_{max}(1 - e^{-tR/L}) \text{ (discharging)}$$

- What is this initial current, I_0, in terms of other quantities in the circuit?
- What is I_{max}?

Use this current expression to find an expression for the voltages of interest, v_C and v_R, as a function of time

- Now what do you think the voltages will look like as a function of time?
- How long does it take for the voltages to reach 100%?

Often, 'rise-time' is used as a measure of how fully charged a circuit is. This quantity is usually defined as being the time taken for the voltage to rise from 10% to 90% of its maximum possible range.

- What is the relation between rise-time and the time constant of your circuit, tau? (recall that $\tau = RC$ for RC circuits, and $\tau = L/R$ for LR circuits)

Lab exercises:

1. Build the circuits in Figure 1 and check if you were right about the shapes of the voltage over time. *Hint: a square wave is effectively a switch opening and closing very quickly. Hint #2: try using different resistor values (how will this affect the shape you see?).*
2. Find the value of your inductor.
3. Build a circuit that makes a waveform that looks like Figure 2 when fed square waves.

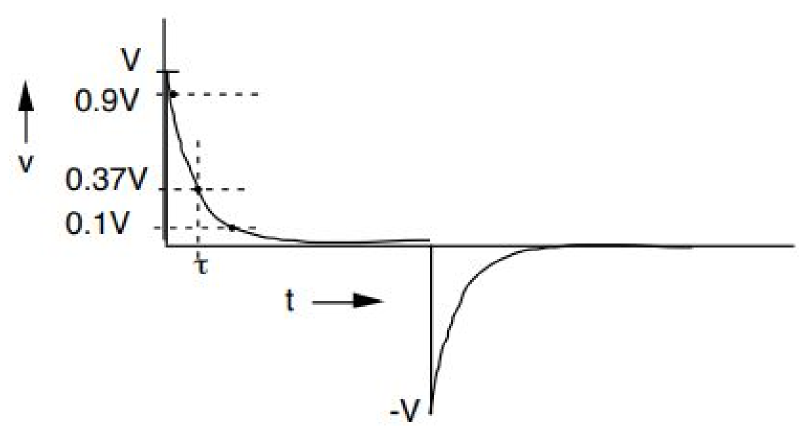

Figure 2

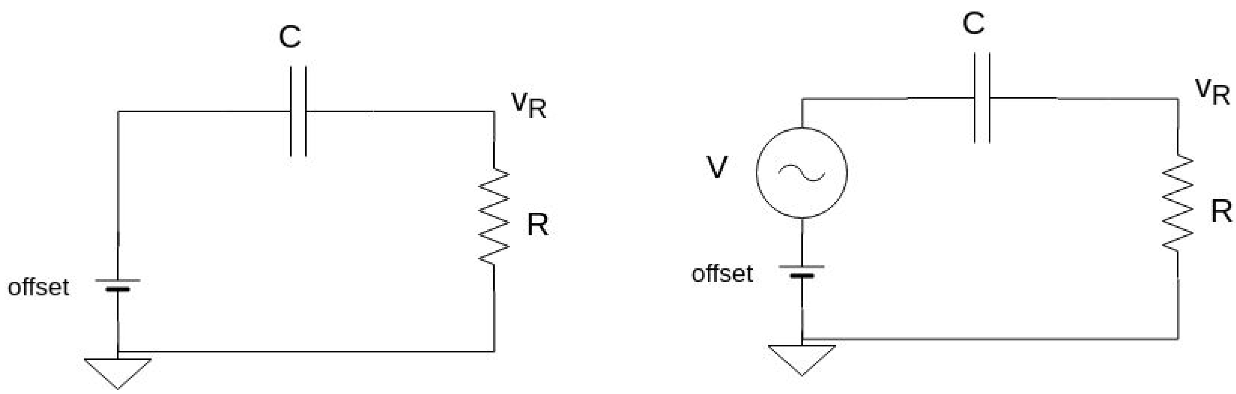

Figure 3

4. Use the function generator to emit a flat voltage (as on the left of Figure 3), and wait a moment for the circuit to equilibrate. What is v_R ? What if you use the function generator's offset in conjunction with a waveform (Figure 3, right)? What's causing this effect?
5. Using only a square wave input, make a wave that looks like Figure 3. What is causing this effect? *Hint: what is the rise-time of your circuit?*

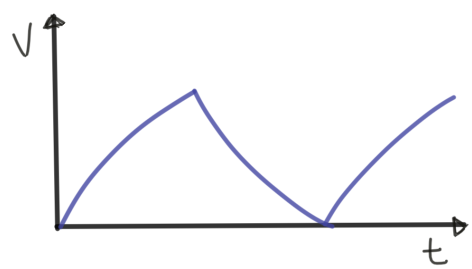

Figure 3

6. Build one circuit that acts as a differentiator, and another that acts as an integrator. Justify your designs mathematically. *Hint: consult those voltage equations you derived earlier!*

Done!

Grading scheme:

- Goals of lab activity met: **25%**
    - Are all specific questions answered?
    - Were the experiments/investigations performed as indicated?
- Discussion: **10%**
    - Analysis of experiments
    - Making hypotheses, explaining reasoning
- Report contents: **50%**
    - Diagrams (for each experiment performed)
    - Data (for each experiment performed)
    - Documentation of materials and methods used (for each experiment performed)
- Extra investigation: **15%**
    - Applying techniques/materials/knowledge used in the activity to try something related; extending the context of the lab activity
    - Be sure to explain your thought process; even if trial is unsuccessful, points will be given for well-documented attempts