California State University, Fresno
Department of Electrical and Computer Engineering

ECE 90L Principles of Electronic Circuits Laboratory

Experiment No. 7: Capacitance and Inductance

Objective

The objective of this laboratory is to study the behavior and basic circuit properties of the capacitor and the inductor, and to become more familiar with the storage operation of the Tektronix 2221A oscilloscope.

Prelab

1.) If the voltage across a capacitor is a square wave, predict the resulting current waveform (draw the voltage and current waveforms). Repeat the process when the voltage across the capacitor is a sine wave.

2.) How do you measure the current waveform through an inductor in an RL circuit if all you have available is an oscilloscope to make your measurements?

Procedure

1.) Become familiar with the storage operation of the digital oscilloscope. To set up for a single-shot acquisition, perform the following steps:

- Adjust the vertical VOLTS/DIV and horizontal SEC/DIV to appropriate ranges for the signal
- Push the ACQUIRE button to see the Acquire menu.
- Push the **Peak detect** button.
- Push the TRIGGER MENU button to see the Trigger menu.
- Push the Mode button to select Single (single sequence) or Normal.
- Push the Slope button to select Rising.
- Use the LEVEL knob to adjust the trigger level to a voltage midway between the open and closed voltages of the relay.
- If the readout at the top of the screen does not display Armed or Ready, then push the RUN/STOP button to start the acquisition.

2.) Connect the circuit shown in Figure 1, ensure that you measure actual capacitor and resistor values with the digital multimeter. Observe the resistor voltage as the switch is opened and closed. Practice storing the voltage waveform and gain as much familiarity with the storage feature of the oscilloscope as necessary until you are comfortable with the procedure. Tabulate and sketch typical waveforms, including the scale factors for voltage and time.

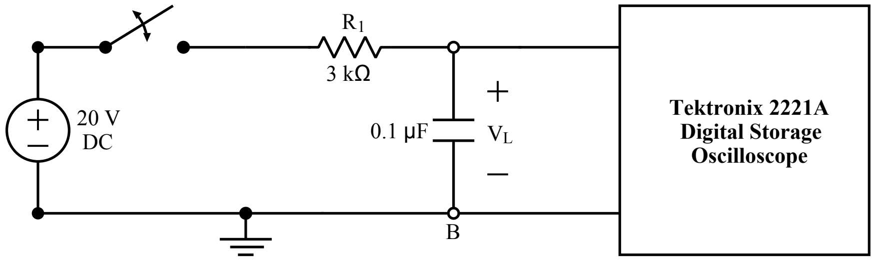

Figure 1: A Direct-Current RC Circuit

3.) Connect the circuit shown in Figure 2, and adjust the signal generator to produce a 1 kHz square wave. (Before connecting the output of the function generator to the circuit, adjust the peak-to-peak voltage to be 10 V by checking the output on the oscilloscope.) Observe the capacitor and resistor voltages and tabulate and sketch the voltage waveforms, showing all pertinent values of voltage and time on your sketches. Calculate the frequency and peak voltage.

Note: You can measure the capacitor voltage as shown in the circuit, but to measure the resistor voltage, you will need to first physically switch the positions of the resistor and capacitor. Comment on why this must first be done.

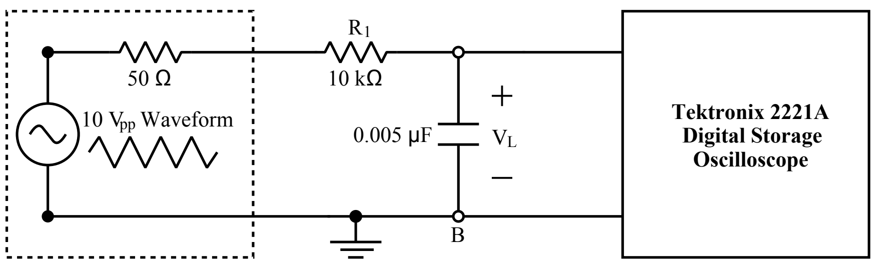

Figure 2: An Alternating-Current RC Circuit

4.) Repeat Part 3 for a series *RL* circuit where $R = 10$ kΩ and $L = 500$ mH.

5.) Connect the circuit shown in Figure 3, and measure each resistor voltage. Then connect a 0.5 H inductor in series (measure its resistance first) and a 0.01 μF capacitor in parallel with each resistor. Remember to measure the actual value of the capacitor. Again, measure the resistor voltages. What do observe, and why? Compare your results to theory, accounting for the resistance of the inductors.

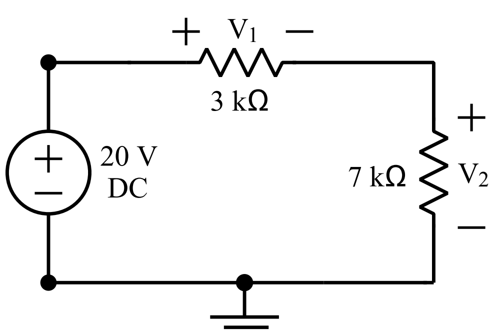

Figure 3: A Voltage Divider Circuit

Conclusion

What conclusions can you draw between the relationship between voltage and current in RC and RL circuits? Are the waveforms you measured what you expect them to be? What are the differences between the DC and AC circuits?

Group Report

1.) Discuss briefly the important features of the oscilloscope and its basic operation.

2.) Using the waveforms obtained in Parts 3 and 4 of the Procedure, prove that

$$i = C\frac{dv}{dt} \text{ for the capacitor} \tag{1}$$

$$v = L\frac{di}{dt} \text{ for the inductor} \tag{2}$$

3.) Compare the two sets of voltage readings made in Part 5 of the Procedure. How would the readings compare if small resistances (say 10 Ω) had been used instead of those specified? What principle does this step of the procedure illustrate?