EELE 354 Lab Assignment 6: Effects of Reactive Components in AC Circuits

Lab Overview:

In addition to resistance, electric loads often have "reactive" components due to inductance or capacitance. In some cases, these reactive components are necessary for circuit operation. For example, inductors are often used as instantaneous current limiters in electrical transmission systems as a means to protect equipment; And capacitors are often used to correct the power factor of a power system, thus increasing the system's efficiency. However, reactive components can also be detrimental. The reason capacitors are even needed to correct the power factor of power systems is due to parasitic self-inductance in transmission lines, transformers, and loads! Thus, it is important that you begin to understand the effects of reactive components in AC circuits. In this lab, you will use a capacitor in two different circuit configurations to study the effect of reactance on our understanding of electric circuit laws and the relationship between current and voltage.

Objectives:

The objectives of this laboratory assignment are:

- Observe and measure the effects of reactive circuit elements on our current understanding of Kirchhoff's Current and Voltage Laws.
- Observe and measure the effect of reactive circuit elements on the phase relationship between current and voltage.
- Begin to familiarize yourself with AC circuit analysis.

Pre-lab Assignment:

Read through the entire lab assignment.

In Part I of this lab, you are asked to construct a circuit consisting of a 100 Ω resistor connected in **series** with a 6 μF (micro-Farad) capacitor. This circuit is power by a 120 V AC 60 Hz power source. Draw the schematic diagram of this circuit in the space provided on the next page. In the schematic, show the connection of a power analyzer used to measure the total power consumed by the circuit.

In part II of this lab, you will reconstruct the circuit so that the 6 μF capacitor is in **parallel** with the resistor. However, to protect the capacitor, you will be asked to put a small current-limiting resistor in series with it. Thus, the circuit consists of a 100 Ω resistor in parallel with the series combination of the current limiting resistor and 6 μF capacitor. Draw the schematic for this circuit along with the connection of a power analyzer used to measure the total power consumed by the circuit.

Draw the circuit schematic for Part I here:

Draw the circuit schematic for Part II here:

Lab Experiment Part I: Series RC Circuit

1. Prior to circuit construction, based on your schematic drawn for part I of the pre-lab, calculate the following circuit values and record them in the top row of the table below.

   - The **magnitude** of the circuit's total impedance, $|Z|$. For the series RC circuit,
   $$|Z| = \sqrt{R^2 + X_C^2}$$
   with
   $$X_C = \frac{1}{2\pi f C}$$
   - The **magnitude** of the total circuit current, $|I|$. For AC circuits, $|I| = |V|/|Z|$.
   - The **magnitude** of the voltage drop across the resistor. Because the resistor does not have a reactive component, $|V_R| = |I|R$.
   - The **magnitude** of the voltage drop across the capacitor. $|V_C| = |I||X_C|$.

	Supply Voltage $\lvert V_{in}\rvert$	Circuit Impedance $\lvert Z\rvert$	Circuit Current $\lvert I\rvert$	Resistor Voltage $\lvert V_R\rvert$	Capacitor Voltage $\lvert V_C\rvert$
Calculated	120 V				
Measured					

2. Set-up the RC circuit and power analyzer based on the Part I schematic you sketched in your pre-lab. Ask for your instructor to approve your circuit.

3. Once your instructor has approved your circuit, **he will set up the oscilloscope at your lab bench so that you can "view" the power source voltage and current waveforms.**

4. **Have your instructor energize your circuit.**

5. Using the digital multimeter at your lab bench, measure the values for $|V_{in}|$, $|V_R|$, and $|V_C|$, and record them in the table above. From the power analyzer, record the magnitude of the total circuit current in the table above.

6. From the oscilloscope, sketch the voltage and current waveforms below and label them. Does the circuit current appear to be lagging or leading the supply voltage? Explain.

7. **Have your instructor move the voltage probes on your circuit and adjust the oscilloscope so that you can view the resistor voltage, V_R, and the capacitor voltage, V_C.** Sketch these waveforms below and label them. Are these two waveforms "in phase" or "out of phase"? Explain.

8. De-energize your circuit.

Lab Experiment Part II: Parallel RC Circuit

9. Prior to circuit construction, based on your schematic drawn for part II of the pre-lab, calculate the following circuit values and record them in the top row of the table below. **NOTE: These calculations ignore the current limiting resistor.**

   - The **magnitude** of the circuit's total impedance, $|Z|$. For the parallel RC circuit,
   $$|Z| = \left(\sqrt{\frac{1}{R^2} + \frac{1}{X_C^2}}\right)^{-1}$$
   with
   $$X_C = \frac{1}{2\pi f C}$$
   - The **magnitude** of the total circuit current, $|I|$. Again, for AC circuits, $|I| = |V|/|Z|$.
   - The **magnitude** of the current through the resistor. Because the resistor does not have a reactive component, $|I_R| = |V_{in}|/R$.
   - The **magnitude** of the current through the capacitor. $|I_C| = |V_{in}|/|X_C|$.

	Supply Voltage $\lvert V_{in}\rvert$	Circuit Impedance $\lvert Z\rvert$	Circuit Current $\lvert I\rvert$	Resistor Voltage $\lvert I_R\rvert$	Capacitor Voltage $\lvert I_C\rvert$
Calculated	120 V				
Measured					

10. Set-up the RC circuit and power analyzer based on the Part II schematic you sketched in your pre-lab. **Ask for your instructor to approve your circuit.**

11. Once approved, energize your circuit. After a few seconds, short out the current limiting resistor by connecting a cable across the current limiting resistor's terminals.

12. Using the power analyzer, measure the values for $|V_{in}|$, $|I|$, $|I_R|$, and $|I_C|$, and record them in the table above. **NOTE: You will have to de-energize and re-energize your circuit a few times so you can move the power analyzer's current connections. Ask your instructor for help with this as well as reconnecting the current limiting resistor when needed.**)

13. De-energize your circuit.

Lab Questions:

1. Based on your calculated and measured data of Part I, does Kirchhoff's Voltage Law (as we know it) hold for AC circuits? Explain by referencing your measured voltages **and the sketch of Part I, Item 7**.

2. Based on your calculated and measured data of Part II, does Kirchhoff's Current Law (as we know it) hold for AC circuits? Explain.

Name and initial of lab partners:

Lab Partner 1: ________________________________

Lab Partner 2: ________________________________

Lab Partner 3: ________________________________