Homework 5: Homework 5: AC Circuits

Assigned: Monday, 10/31/2014

Due: Monday, 11/10/2014

The homework consists of five problems. The last one is an additional problem that combines several topics we've discussed in class and lab. Each problem is worth 10 points total.

1. For the circuit shown in Figure 1, assume the voltage source (V_{in}) is a 120 V, 60 Hz source. Assume the resistance is $R = 5$ kΩ, and the inductance is $L = 10$ H.

   (a) Draw a phasor diagram for the impedance (consists of resistance, inductor, and total impedance phasors). Use resistance as your reference.

   (b) What is the total impedance of the circuit from the perspective of the power source? Give in terms of a complex number. Then, convert that number to a magnitude ($|Z|$) and phase (ϕ_Z).

   (c) What is the magnitude of the current ($|I|$)?

   (d) What is the magnitude of the voltages across the resistor and the inductor?

   (e) Draw a phasor diagram for the voltage (consists of the resistance voltage, inductor voltage and input voltage phasors). Use resistance voltage as your reference.

   (f) What is the real power (P), the reactive power (Q), and the total apparent power (P_{app}) drawn by the circuit?

   (g) Draw a phasor diagram for the power (consists of the real, reactive, and apparent power phasors). Use the real power phasor as your reference.

   (h) What is the power factor (PF) of the circuit? Is it leading or lagging?

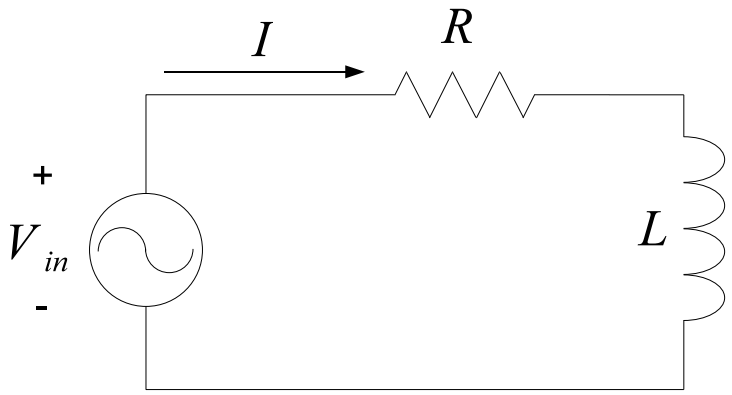

Figure 1: Practice Circuit 1

Show work:

2. For the circuit shown in Figure 2, assume the voltage source (V_{in}) is a 120 V, 60 Hz source. Assume the resistance is $R = 5$ kΩ, and the inductance is $L = 10$ H.

   (a) What is the total impedance of the circuit from the perspective of the power source? Give in terms of a complex number. Then, convert that number to a magnitude ($|Z|$) and phase (ϕ_Z).

   (b) Determine the current magnitudes through the resistor and the inductor.

   (c) Draw a phasor diagram for the current (consists of the resistance, inductor, and total circuit current phasors). Use resistance current as your reference.

   (d) What is the magnitude of the total circuit current ($|I|$)?

   (e) What is the real power (P), the reactive power (Q), and the total apparent power (P_{app}) drawn by the circuit?

   (f) Draw a phasor diagram for the power (consists of the real, reactive, and apparent power phasors). Use the real power phasor as your reference.

   (g) What is the power factor (PF) of the circuit? Is it leading or lagging?

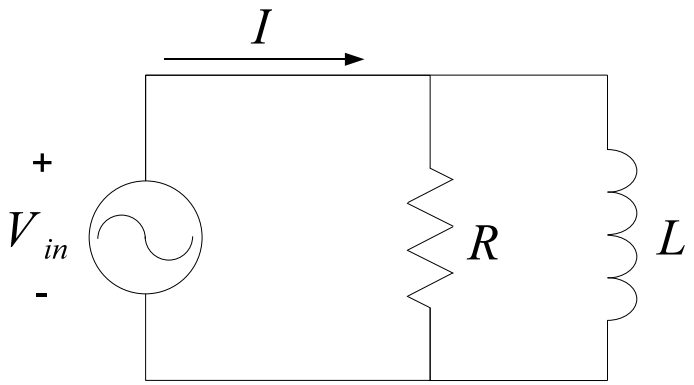

Figure 2: Practice Circuit 2

Show work:

3. For the circuit shown in Figure 3, assume the voltage source (V_{in}) is a 277 V, 60 Hz source. Assume the resistance is $R = 1$ kΩ, and the capacitance is $C = 4$ μF.

   (a) Draw a phasor diagram for the impedance (consists of resistance, capacitor, and total impedance phasors). Use resistance as your reference.

   (b) What is the total impedance of the circuit from the perspective of the power source? Give in terms of a complex number. Then, convert that number to a magnitude ($|Z|$) and phase (ϕ_Z).

   (c) What is the magnitude of the current ($|I|$)?

   (d) What is the magnitude of the voltages across the resistor and the capacitor?

   (e) Draw a phasor diagram for the voltage (consists of the resistance voltage, capacitor voltage and input voltage phasors). Use resistance voltage as your reference.

   (f) What is the real power (P), the reactive power (Q), and the total apparent power (P_{app}) drawn by the circuit?

   (g) Draw a phasor diagram for the power (consists of the real, reactive, and apparent power phasors). Use the real power phasor as your reference.

   (h) What is the power factor (PF) of the circuit? Is it leading or lagging?

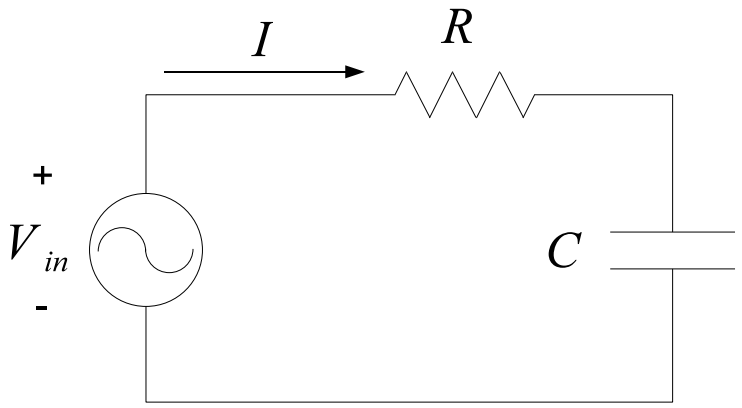

Figure 3: Practice Circuit 3

Show work:

4. For the circuit shown in Figure 4, assume the voltage source (V_{in}) is a 277 V, 60 Hz source. Assume the resistance is $R = 1$ kΩ, and the capacitance is $C = 4$ μF.

   (a) What is the total impedance of the circuit from the perspective of the power source? Give in terms of a complex number. Then, convert that number to a magnitude ($|Z|$) and phase (ϕ_Z).

   (b) Determine the current magnitudes through the resistor and the capacitor.

   (c) Draw a phasor diagram for the current (consists of the resistance, capacitor, and total circuit current phasors). Use resistance current as your reference.

   (d) What is the magnitude of the total circuit current ($|I|$)?

   (e) What is the real power (P), the reactive power (Q), and the total apparent power (P_{app}) drawn by the circuit?

   (f) Draw a phasor diagram for the power (consists of the real, reactive, and apparent power phasors). Use the real power phasor as your reference.

   (g) What is the power factor (PF) of the circuit? Is it leading or lagging?

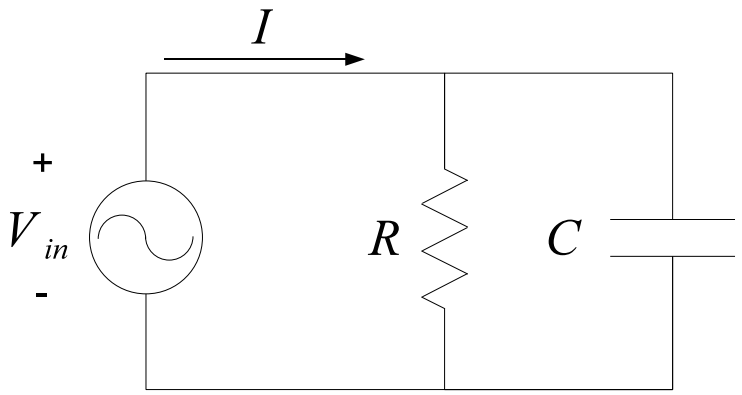

Figure 4: Practice Circuit 4

Show work:

5. **Application Problem:** An AC motor used in a manufacturing plant produces 200 N-m of torque at a rotational speed of 100 rad/s (955 RPM). This motor takes as input a 480 V ac power source, and has a rated efficiency of 75%, and a lagging power factor of 0.8.

   (a) What is the mechanical power produced by the motor? Answer in kW.

   (b) What is the amount of **real** electrical power drawn by the motor? Note: When calculating the efficiency of an electric motor, the input power is the real power.

   (c) What is the total apparent power delivered from the power source? What is the amount of reactive power required by the motor?

   (d) Draw a phasor diagram for the real, reactive, and total apparent power delivered to the motor.

   (e) If you wanted to bring this motor's power factor into unity, what size capacitor would you need to add in parallel with the motor? Note: See Lab 7.

   (f) Without the capacitor added, what is the magnitude of the current delivered to the motor?

   (g) If the ambient temperature of the manufacturing plant is 125° F, and the cables used to connect the motor to the power source are THHN insulated wire, what size of cables should be used? Note: See Table 8-1 in Appendix B of your book.

Show work: