

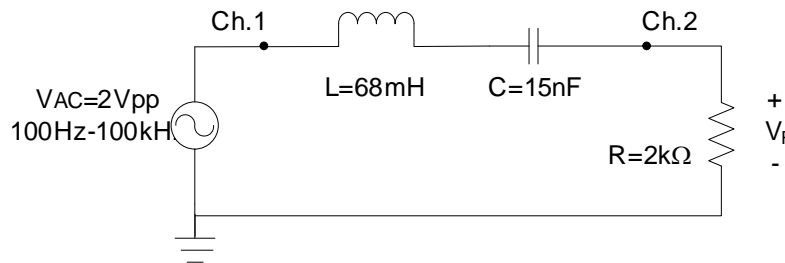
Name \_\_\_\_\_ Lab Section \_\_\_\_\_ Date \_\_\_\_\_

**INTRODUCTION:**




In this laboratory the student will investigate the operation of a series AC circuit. The Agilent 33120A Function Generator will be used to produce AC time varying waveform. The GW Instek GDS-2064 Digital Storage Oscilloscope (DSO) will be used to display and measure the waveforms. The Agilent 34401A bench-top DMM will be used to take both voltage and current measurements.

**PRELAB – PSpice SIMULATION:**

1. Using PSpice, build the circuit shown in Figure 11.1. The parts needed are: **VAC**, **r**, **L**, **C**, and **GND\_Earth**. Configure the **VAC** component's parameter: **ACMAG=0.707V**.



**Figure 11.1: AC Series Circuit.**

2. Label the wire attached to the positive terminal of the source “**Ch.1**” and the wire connected to the top of the resistor “**Ch.2**” as shown in the figure.
3. Place voltage markers at Ch.1, and Ch.2. 
4. Choose **Analysis** → **Setup...** or click  and enable an “**AC Sweep**” analysis.
5. Set the **AC Sweep Type** to **Decade** and set the Sweep Parameters to **101 Pts/Decade**, **100Hz Start Freq.** and **100kHz End Freq.**
6. Save the file and run a simulation (**F11**).  A Probe Plot will automatically pop up displaying the voltages at each marker as a function of frequency.
7. Use the cursor found in **Trace** → **Cursor** → **Display** to measure and record the voltage across the resistor at the frequencies listed in Table 11.1.

Note that each trace in the plot can be selected by clicking on the trace symbols in the lower left corner of the display window.

8. Use the cursor to determine the frequency at which the resistor voltage is at maximum and record the value in Table 11.1.

9. Save a copy of the plot on a USB memory-stick. Once the measurements have been recorded, exit the plot window and return to the schematic window.
10. In the schematic window, delete the Voltage Markers.
11. From the pull down menu select **Markers** → **Mark Advanced** → **vphase** and place a marker on the node labeled Ch.2.
12. Save the file and run a simulation. A Probe Plot will automatically pop up displaying the voltages at each marker as a function of frequency.
13. Use the cursor to measure and record the phase angle of the resistor voltage at the frequencies listed in Table 11.1.
14. Determine the frequency at which the phase angle is zero and record the value in Table 11.1.
15. Save a copy of both the plot and the PSpice schematic on a USB memory-stick.

#### PRELAB – CALCULATIONS:

4. Using your calculator, calculate the voltages ( $V_R$ ,  $V_L$ , and  $V_C$ ) across the circuit elements in phasor (polar) form at each of the frequencies listed in Table 11.2 and record the results in the table.

#### LABORATORY PROCEDURE:

1. Use the LCR meter at the front of the lab to measure the resistor, capacitor and the inductor. Record the results in Table 11.3.
2. Construct the circuit shown in Figure 11.1 and connect the Agilent 33120A Function Generator (or 33220A) to the circuit where the source is located.
3. Configure the function generator for a high-impedance load by pressing the following softkey sequence: **Utility**→**Output Setup**→**High Z**→**Done**.
4. Choose a sinusoidal output by pressing the **Sine** button. Configure the waveform for a frequency of **10kHz** and a **2Vpp** amplitude, and then press the **Output** button to “turn on” the supply.
5. Utilize a GW Instek GDS-2064 Digital Storage Oscilloscope to display the source and resistor voltages as a function of time. Connect the red lead from CH1 of the scope to node Ch.1 in the circuit and the red lead from CH2 of the scope to node Ch.2 in the circuit.
6. Turn on the scope and press the lighted yellow CH1 button to select CH1. Configure the channel for DC Coupling by pressing the **F1** key repeatedly until the DC symbol  $\overline{\text{-----}}$  is displayed.
7. Press the **F4** key repeatedly until the Probe setting is x1. The setting x1 matches the BNC-to-Alligator cable to the voltage scaling ratio of 1-to-1. Both the Invert and BW Limit options should be off.
8. Press the lighted blue CH2 and set it up with the same settings as CH1.

9. Press the blue **Auto Set** button to the lower right of the power button. This causes the DSO to search for the signals on both channels. The yellow and blue lighted CH1 and CH2 button should be on. On the screen should be displayed two horizontal lines: the top line is the yellow CH1 trace and the bottom line is the blue CH2 trace.
10. Rotate the **VOLT/DIV** knob below the CH1 so that the display setting in the lower left of the screen is set at **CH1 ----- 500mV**. Likewise, set CH2 to the **500mV** per division setting.
11. Rotate the CH1 **POSITION** knob so that the **Position(1)=0.00V** is displayed in the lower left of the screen. Do the same for the CH2 trace. The 1 and 2 arrow on the left of the screen will overlap in the center of the display.
12. Save the screen image to a USB flash drive by pressing **Save/Recall** → **Save Waveform (F4)** → **Save Waveform (F1)** → **Destination USB (F3)**.
13. Press the **Cursor** button to the right of the power button. On the right of the screen is a gray pop up menu with the title of CURSOR at the top. Cycle the **F1** key so that the **Source** is **CH1**. Note that CH1 of the scope is connected across the voltage source in the circuit.
14. Cycle the **F3** Vertical key so that the lower line is solid and the upper line is dashed. Use the **VARIABLE** knob just below the power button to move the lower cursor line to the center grid of the screen. Doing so will display **V2:0.00V** in the lower right of the screen.
15. Cycle the **F3** key again so the top line is now solid and the lower line is dashed. Adjust the **VARIABLE** knob so the upper cursor line at the peak of the yellow CH1 horizontal trace. The peak voltage level of the upper cursor will be displayed in the lower left of the screen. Record the peak voltage in Table 11.4.
16. Now cycle the **F1** key to **CH2** and repeat the cursor measurement of the blue horizontal CH2 trace. Record the results in Table 11.4.
17. Press the **Cursor** button again this time selecting the **Horizontal** cursors. Measure the time difference  $\Delta t$  between the zero-crossing of Ch.1 (the source voltage) and the zero-crossing of Ch.2 (the resistor voltage) and record the result in Table 11.4.
18. Calculate the phase shift between the resistor and source voltages in degrees and state whether the resistor voltage is lagging or leading the source voltage. Record the results in Table 11.4.  
  
Note that the phase shift in degrees can be calculated by multiplying the time difference both by the frequency and by  $360^\circ$ . ( $\angle \theta = \Delta t \cdot f \cdot 360^\circ$ ) Furthermore, if the trace of Ch.2 is behind in time (to the right) of Ch.1 then it is **lagging** or it has a negative phase-shift, and if the trace of Ch.2 is ahead in time (to the left) of Ch. 1 then it is **leading** or it has a positive phase-shift.
19. On the oscilloscope, press the **Measure** button right beside the Cursor button. In the gray pop up menu area MEASURE should be displayed.
20. Press the **F1** key repeatedly to select **CH1** and Press the **F2** key repeatedly to select **CH2**.
21. Press the **F3** key repeatedly to select **Voltage**.

22. Press the **F4** key repeatedly to measure **V<sub>pp</sub>**. The press **F5** to go back to the **Previous Menu**.
23. Press the **F2** button and repeat the process so that **V<sub>amp</sub>** is selected and press **F5** to go back.
24. Press the **F3** button and repeat the process so that **V<sub>RMS</sub>** is selected.
25. Press the **Run/Stop** button just below the blue Auto Set and the screen will freeze at that time instant. Record in Table 11.4 the voltages displayed.
26. Press the **Run/Stop** button again and the scope will go back to the Run mode.
27. Rearrange the circuit so that the capacitor is the last series component (i.e. – swap the resistor and the capacitor while leaving all other connections the same). By doing, Ch.2 of the scope is now configured to measure the capacitor voltage  $V_C$ .
28. Repeat the previous measurements to determine the peak, peak-to-peak and RMS values of the capacitor voltage along with the time-delay and phase-shift for the capacitor voltage compared to the source voltage and record the results in Table 11.5.
29. Rearrange the circuit again so that the inductor is the last series component (i.e. – swap the capacitor and the inductor while leaving all other connections the same). By doing, Ch.2 of the scope is now configured to measure the inductor voltage  $V_L$ .
30. Repeat the previous measurements to determine the peak, peak-to-peak and RMS values of the inductor voltage along with the time-delay and phase-shift for the inductor voltage compared to the source voltage and record the results in Table 11.6.

### **REPORT GUIDE:**

1. Compare the Prelab calculated values of Table 11.2 to the measured values in Table 11.4, 11.5, and 11.6. Summarize the comparisons in a well-organized table.
2. Plot the magnitude of the voltage of each circuit component versus frequency. Label the plot axis and be sure to give each plot a title.
3. Plot the phase angle of each circuit component versus frequency. Label the plot axis and be sure to give each plot a title.
4. Calculate the impedance of the inductor and capacitor at the frequency where the resistor voltage was at its maximum. What is the relationship of the series circuit current to the source voltage at this frequency?
5. Discuss any differences between the calculated and measured results.

**DATA TABLES:**

**Table 11.1: Prelab PSpice Cursor Measured Values**

Frequency (kHz)	Resistor RMS Voltage ( $V_{RMS}$ )	Resistor Phase Angle (Deg)
0.100		
1.0		
2.0		
4.0		
8.0		
10.0		
100.0		
f(max V)=	Max Voltage =	-----
f(phase=0°)=	-----	0°

**Table 11.2: Prelab Calculator Calculated Phasor Voltages**

Frequency (kHz)	$ V_L $	$\angle V_L$	$ V_C $	$\angle V_C$	$ V_R $	$\angle V_R$
1.0						
2.0						
4.0						
8.0						
10.0						

**Table 11.3: Measured Circuit Components using LCR Meter**

	R ( $\Omega$ )	L (H)	C (F)
Measured			

**Table 11.4: Resistor Phasor Voltages Measured using Oscilloscope**

Frequency (kHz)	$V_{RMS}$	$V_{Peak-to-Peak}$	$V_{Peak}$	$\Delta t$	Phase Angle	Lagging or Leading
0.100						
1.0						
2.0						
4.0						
8.0						
10.0						
100.0						

**Table 11.5: Capacitor Phasor Voltages Measured using Oscilloscope**

<b>Frequency (kHz)</b>	<b>V<sub>RMS</sub></b>	<b>V<sub>Peak-to-Peak</sub></b>	<b>V<sub>Peak</sub></b>	<b>Δt</b>	<b>Phase Angle</b>	<b>Lagging or Leading</b>
0.100						
1.0						
2.0						
4.0						
8.0						
10.0						
100.0						

**Table 11.6: Inductor Phasor Voltages Measured using Oscilloscope**

<b>Frequency (kHz)</b>	<b>V<sub>RMS</sub></b>	<b>V<sub>Peak-to-Peak</sub></b>	<b>V<sub>Peak</sub></b>	<b>Δt</b>	<b>Phase Angle</b>	<b>Lagging or Leading</b>
0.100						
1.0						
2.0						
4.0						
8.0						
10.0						
100.0						

Approved by: \_\_\_\_\_

Date: \_\_\_\_\_