Series and Parallel AC Circuits

Lab Objectives:

1. Demonstrate the use of a circuit simulation package to analyze circuits in the time domain.
2. To generate a report that effectively and clearly demonstrates the data and results of a basic experiment.
3. To demonstrate basic skills in the use of the oscilloscope to measure circuit parameters.

Pre-Laboratory Preparation:

Prior to your scheduled laboratory meeting time the following items need to be completed. The prelab quizzes will be based on this preparation.

Research

1. Carefully read the textbook chapter and review your course notes on "**Series and Parallel AC Circuits.**"

Circuit Analysis and Simulation – Week 1 Prelab

1. Analyze the series R-C circuit of Figure 1:
   a. Determine Z_T (in polar form)
   b. Create an impedance diagram for the network
2. Using Multisim, perform a transient analysis on the circuit of Figure 1:
   a. Use the correct voltage source (AC_VOLTAGE).
   b. Use a 0.1 second start time, a 0.101 second stop time, and 250 minimum time points.
      i. This will eliminate circuit start-up transients and allow you to view one complete cycle of the 1kHz voltage source.
   c. View E_1, V_{R1} and V_{C1} in the plot window. Print your results in order to compare to the impedance diagram you calculated in step 1 (create an impedance diagram based on this information):
      i. Change the background color to white before printing.
      ii. Use "show grid" and the cursors to determine the time and hence phase difference between traces.
      iii. Scale the traces as necessary in order to get accurate phase-angle measurements. Using factors of 10x or 100x keeps your calculations simple.
      iv. Label each trace by hand after printing.
      v. For the circuit current, use V_{R1} divided by R_1.
3. Analyze the series R-L circuit of Figure 2:
   a. Determine Z_T (in polar form)
   b. Create an impedance diagram for the network
4. Using Multisim, perform a transient analysis on the circuit of Figure 2:
   a. Use the correct voltage source (AC_VOLTAGE).
   b. Use a 0.1 second start time, a 0.101 second stop time, and 250 minimum time points.
      i. This will eliminate circuit start-up transients and allow you to view one complete cycle of the 1kHz voltage source.
   c. View E_1, V_{R1} and V_{L1} in the plot window. Print your results in order to compare to the impedance diagram you calculated

in step 3 (create an impedance diagram based on this information):

i. Change the background color to white before printing.
ii. Use "show grid" and the cursors to determine the time and hence phase difference between traces.
iii. Scale the traces as necessary in order to get accurate phase-angle measurements. Using factors of 10x or 100x keeps your calculations simple.
iv. Label each trace by hand after printing.
v. For the circuit current, use V_{R1} divided by R_1.

Circuit Analysis, Simulation and Design – Week 2 Prelab

5. Analyze the parallel R-L circuit of Figure 3:
   a. Determine Z_T (in polar form)
   b. Create an impedance diagram for the network (Does this result suggest that there is an equivalent series circuit?).
6. Using Multisim, perform a transient analysis on the circuit of Figure 3:
   a. Use the correct voltage source (AC_VOLTAGE).
   b. Use a 0.1 second start time, a 0.101 second stop time, and 250 minimum time points.
      i. This will eliminate circuit start-up transients and allow you to view one complete cycle of the 1kHz voltage source.
   c. View V_{ab} and V_{R1} in the plot window. Print your results in order to compare to the impedance diagram you calculated in step 5 (create an impedance diagram based on this information):
      i. Change the background color to white before printing.
      ii. Use "show grid" and the cursors to determine the time and hence phase difference between traces.
      iii. Scale the traces as necessary in order to get accurate phase-angle measurements. Using factors of 10x or 100x keeps your calculations simple.
      iv. Label each trace by hand after printing.
      v. For the circuit current, use V_{R1} divided by R_1.
7. Determine the value of C_1 in the parallel R-L-C circuit of Figure 4 to cancel the reactance of L_1 so that at 1kHz, the phase angle between the voltage, V_{ab} and the current I_T is zero degrees.
   a. Show your calculations and the impedance diagram for Z_T.
8. Using Multisim, perform a transient analysis on the circuit of Figure 4 using your calculated value of C_1 from step 7:
   a. Use the correct voltage source (AC_VOLTAGE).
   b. Use a 0.1 second start time, a 0.101 second stop time, and 250 minimum time points.
      i. This will eliminate circuit start-up transients and allow you to view one complete cycle of the 1kHz voltage source.
   c. View V_{ab} and V_{R1} in the plot window. Print your results in order to compare to the impedance diagram you calculated

in step 7 (create an impedance diagram based on this information):

i. Change the background color to white before printing.

ii. Use "show grid" and the cursors to determine the time and hence phase difference between traces.

iii. Scale the traces as necessary in order to get accurate phase-angle measurements. Using factors of 10x or 100x keeps your calculations simple.

iv. Label each trace by hand after printing.

v. For the circuit current, use V_{R1} divided by R_1

Pre-Lab Quiz Preparation

1. The online prelab quiz questions will be based on your calculations and simulation results.

AC Circuits Lab Procedure: Work with your lab partners and make sure you know your assigned roles

<u>**Lab Week 1 – Series Circuits**</u>

1. Build the series R-C circuit shown in Figure 1. Use a ceramic disk capacitor for C_1, NOT an electrolytic capacitor as the quality factor of such a capacitor would adversely affect circuit operation.

*** Measure the component values (at the signal frequency) for each circuit and record them on your lab schematics ***

a. Using the oscilloscope, view E_1, V_{R1} and V_{C1} simultaneously. Using E_1 as the reference, determine the phasor representing each quantity.
   i. Think carefully about probe placement and using the MATH function.
   ii. Place each channel ground on the same major horizontal line.
   iii. Use an appropriate time scale in order to easily determine phase differences given time differences between corresponding points on each waveform (show between one and two cycles of the waveforms).
   iv. Acquire an instructor sign-off for this data

b. Save your oscilloscope plot showing all three waveforms to a WORD document and include your calculations below this plot.
   i. Label each trace clearly
   ii. Title your plot appropriately

c. Create an impedance diagram for Zt using this information and include it on the same page below your calculations and oscilloscope plot.
   i. Remember: It is V_{R1}/R_1

2. Build the series R-L circuit shown in Figure 2. Use the inductor supplied by your lab instructor for L_1.
   a. Using the oscilloscope, view E_1, V_{R1} and V_{L1} simultaneously. Using E_1 as the reference, determine the phasor representing each quantity.
      i. Think carefully about probe placement and

using the MATH function.

ii. Place each channel ground on the same major horizontal line.

iii. Use an appropriate time scale in order to easily determine phase differences given time differences between corresponding points on each waveform (show between one and two cycles of the waveforms).

iv. Acquire an instructor sign-off for this data

b. Save your oscilloscope plot showing all three waveforms to a WORD document and include your calculations below this plot.

i. Label each trace clearly

ii. Title your plot appropriately

c. Create an impedance diagram for Zt using this information and include it on the same page below your calculations and oscilloscope plot.

i. Remember: I_t is V_{R1}/R_1

ii. Use this diagram to determine the series resistance of L1 and include this information on the same page.

3. Make sure you keep your WORD document and calculations handy; you will need this information for the lab write-up.

Lab Week 2 – Parallel Circuits

4. Build the parallel R-L circuit shown in Figure 3. Use the inductor supplied by your lab instructor for L_1.

*** Measure the component values (at the signal frequency) for each circuit and record them on your lab schematics ***

a. On the oscilloscope, view V_{ab} and V_{R1} simultaneously. Using V_{ab} as the reference, determine the phasor representing each quantity.

i. Think carefully about probe placement and using the MATH function.

ii. Place each channel ground on the same major horizontal line.

iii. Use an appropriate time scale in order to easily determine phase differences given time differences between corresponding points on each waveform.

iv. Acquire an instructor sign-off for this data

b. Save your oscilloscope plot showing both waveforms to a WORD document and include your calculations below this plot.

i. Label each trace clearly

ii. Title your plot appropriately

c. Create an impedance diagram for Zt using this information and include it on the same page below your calculations and oscilloscope plot.

i. Remember: I_t is V_{R1}/R_1

5. Build the parallel R-L-C circuit shown in Figure 4. Use the inductor supplied by your lab instructor for L_1 and an R-C box for C_1, selecting your value from the prelab, STEP 7.
    a. On the oscilloscope, view V_{ab} and V_{R1} simultaneously. Using V_{ab} as the reference, determine the phasor representing each quantity.
        i. Think carefully about probe placement and using the MATH function.
        ii. Place each channel ground on the same major horizontal line.
        iii. Use an appropriate time scale in order to easily determine phase differences given time differences between corresponding points on each waveform.
        iv. Acquire an instructor sign-off for this data
    b. Save your oscilloscope plot showing both waveforms to a WORD document and include your calculations below this plot.
        i. Label each trace clearly
        ii. Title your plot appropriately
    c. Create an impedance diagram for Zt using this information and include it on the same page below your calculations and oscilloscope plot.
        i. Remember: I_t is V_{R1}/R_1
        ii. Explain why the reactance of L_1 and C_1 do not quite cancel at 1kHz for this circuit. Hint – Is something missing? It's not resistor tolerance…
6. Make sure you keep your WORD document and calculations handy; you will need this information for the lab write-up.

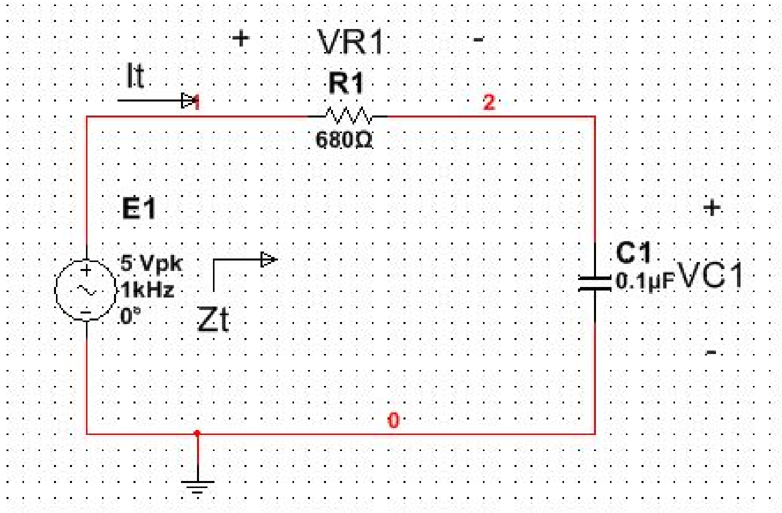

Figure 1 - Series R-C Circuit

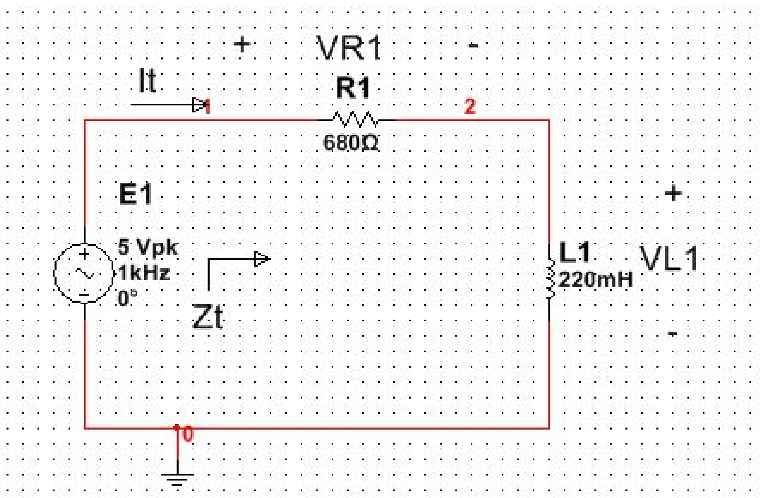

Figure 2 - Series R-L Circuit

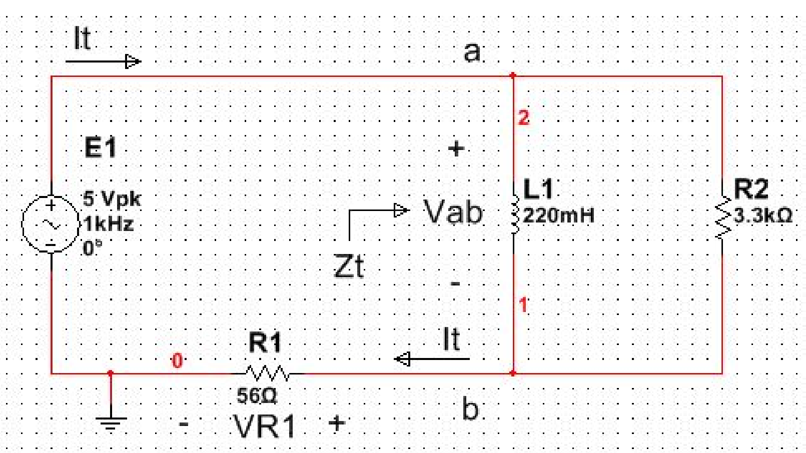

Figure 3 - Parallel R-L Circuit

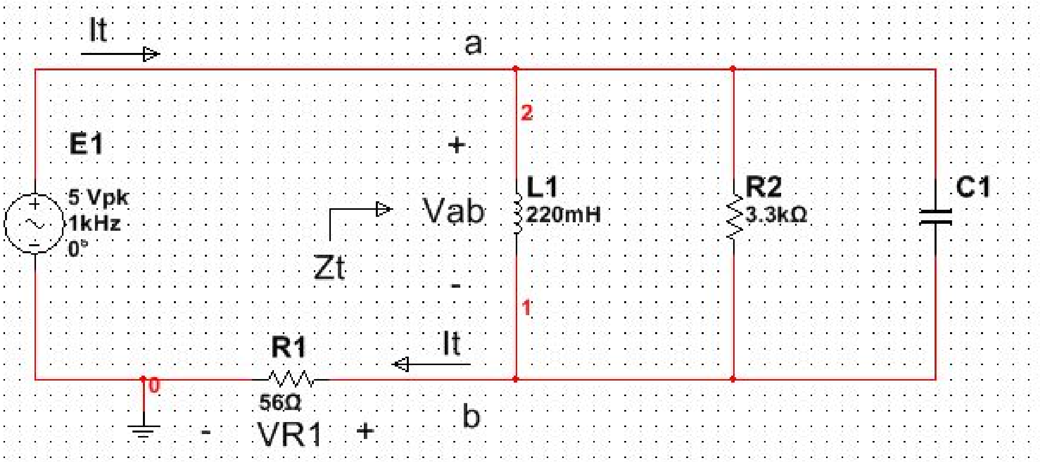

Figure 4 - Parallel R-L-C Circuit

Post Lab Requirements:

*** There is NO post-lab quiz for the project***

Your team will submit an Application Note that instructs the reader how to determine the impedance diagram from circuit measurements at a given frequency for any series R-L or series R-C circuit. You must include the effect of a non-zero DC coil resistance (R_L). Use your lab data from week 1 as an example and to check the clarity of your work. Use figures, tables, diagrams and calculations as you see fit to explain the process and show an example. Note:

1. Your team will create and submit <u>ONE computer generated Application Note</u> (including figures and tables). Use the outline provided to get started.
2. Your signature sheet (one per team) will be used as your cover sheet for this application note.
3. Do not submit additional information if it isn't referenced in your Application Note.
4. Pay close attention to the sample application note AND the grading rubric provided.

Series and Parallel AC Circuits

Team Name and Lab Section:..

Team Members Present (printed)

First Name, Last Name	Role This Lab	RIT Program

TEAM LABORATORY RESULTS GRADE

(all work done neatly, legible and properly organized, all signoffs in place, oscilloscope plots and annotations including measurements, calculations and impedance diagrams, no missing information and no extraneous information)

Laboratory Results **/40**

Step 1.a.iv
Instructor Signature: ______

Step 2.a.iv
Instructor Signature: _______

Step 4.a.iv
Instructor Signature: ______

Step 5.a.iv
Instructor Signature: _______

Post Lab Write-up (Your App Note, proofread) **/40**

Final Grade .... **/80**

Instructor comments: