LAB #4
Series R, L, C Circuits

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CSE-203L CS 2 LAB

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This exercise examines the voltage and current relationships in series R, L, C networks. Of particular importance is the phase of the various components and how Kirchhoff's Voltage Law is extended for AC circuits. Both time domain and phasor plots of the voltages are generated.

Theory Overview:

Each element has a unique phase response: for resistors, the voltage is always in phase with the current, for capacitors the voltage always lags the current by 90 degrees, and for inductors the voltage always leads the current by 90 degrees. Consequently, a series combination of R, L, and C components will yield a complex impedance with a phase angle between +90 and -90 degrees. Due to the phase response, Kirchhoff's Voltage Law must be computed using vector (phasor) sums rather than simply relying on the magnitudes. Indeed, all computations of this nature, such as a voltage divider, must be computed using vectors.

Equipment:

- AC Function Generator
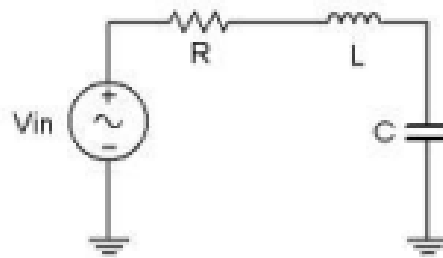- Oscilloscope

Components:

- o 10 nF
- o 10 mH
- o 1 kΩ

Figure 1

Procedure:

1. Using Figure 1 with Vin=2Vp-p sine at 10 kHz, R=1kΩ, L=10mH and C=10nF, determine the theoretical inductive and capacitive reactance and circuit impedance, and record the results in Table 1 (the experimental portion of this table will be filled out in step 4). Using the voltage divider rule, compute the resistor, inductor and capacitor voltages and record them in Table 2.
2. Build the circuit of Figure 1 using R=1kΩ, L=10mH and C=10nF. Set the generator to a 10 kHz sine wave and 2 Vp-p. Using oscilloscope measure the signals. Unfortunately, it is impossible to see the voltages of all the three components simultaneously using only two probes of the oscilloscope. To obtain the proper readings, place one probe on the function generator to see the input signal and the second probe across the last element. This step is repeated three times. The first time the components are so arranged that capacitor is the last

component, the second time inductor is connected as the last component and finally resistor is made the last component. The peak-to peak voltages and phase angles of each one of the three components, relative to the source are thus determined in turn. Thus Vs, VC, VL and VR are measured. Record in Table 2.
3. Compute the deviations between the theoretical and experimental values of Table 2 and record the results in the final columns of this table.
4. Based on the experimental values, determine the experimental Z, XL and XC values via Ohm's Law (i=VR/R, XL=VL/i, XC=VC/i, Z=Vin/i) and record back in Table 1 along with the deviations.
5. Create a phasor plot showing Vin, VL, VC, and VR.
6. Repeat the experiment for 1nF capacitor, 1mH inductor and 1kΩ resistor.

Data Tables:

Table 1

	Theoretical	Experimental	%Deviation
XC	1592	1632	2.51
XL	628	612	-2.55
Z	1388	1442	3.89
Ө	-43.9	-45.5	-1.44

Table 2

	Theoretical	Experimental	%Deviation
VC	2.29 V	2.4 V	4.80
VL	0.90 V	0.9 V	0.00
VR	1.44 V	1.5 V	4.17
VS	2 V	2 V	0.00

Ө	-44	-45	-2.27

R

1000

θ 45.5°

Z

1020 $X_L - X_C$
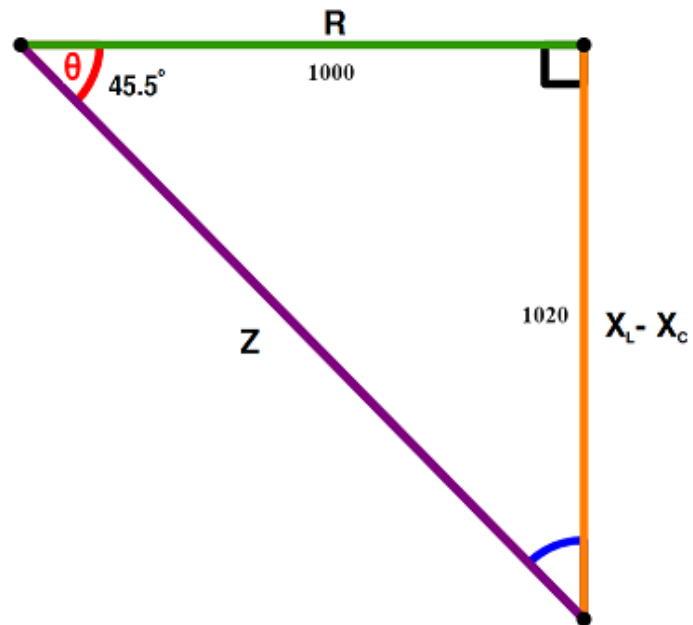
Table 3

	Theoretical	Experimental	%Deviation
XC	15915	16949	6.50
XL	62.8	67.8	7.96
Z	15884	16910	6.46
Ө	-86.4	-86.6	-0.23

Table 4

	Theoretical	Experimental	%Deviation
VC	2.0049 V	2 V	-0.24
VL	0.0079 V	0.008 V	1.27
VR	0.1259 V	0.125 V	-0.71
VS	2 V	2 V	0.00
Ө	-86.39	-86.12	0.01
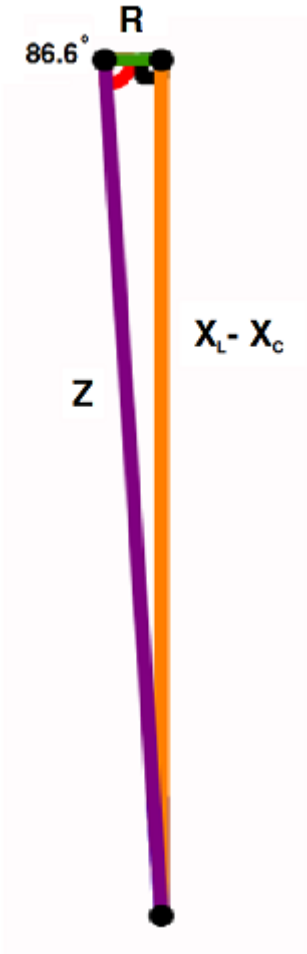
Questions:

1. **What is the phase relationship between R, L, and C components in a series AC circuit?**

    Answer: The voltage across resistor is in phase with current.
    The phase of voltage across Inductor leads the current by 90 degrees.
    The phase of voltage across Capacitor lags from current by 90 degrees.

2. **Based on measurements, does Kirchhoff's Voltage Law apply to the tested circuits?**

    Answer: Yes

3. **In general, how would the phasor diagram of Figure 1 change if the frequency was raised?**

    Answer: It will not change

4. **In general, how would the phasor diagram of Figure 1 change if the frequency was lowered?**

    Answer: It will not change