Lab 4

Series R, L, C Circuits

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

1. AC Function Generator
2. Oscilloscope

Components

1. 10 nF actual:_________
2. 10 mH actual:_________
3. 1 kΩ actual:_________

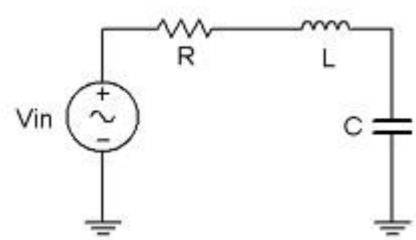

Figure 1

Procedure

1. Using Figure 1 with V_{in}=2V_{p-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 V_{p-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 V_s, V_C, V_L and V_R 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, X_L and X_C values via Ohm's Law ($i=V_R/R$, $X_L=V_L/i$, $X_C=V_C/i$, $Z=Vin/i$) and record back in Table 1 along with the deviations.
5. Create a phasor plot showing V_{in}, V_L, V_C, and V_R.
6. Repeat the experiment for 1nF capacitor, 1mH inductor and 1kΩ resistor.

Data Tables

	Theoretical	Experimental	%Deviation
X_C			
X_L			
Z			
Θ			

Table 1

	Theoretical	Experimental	%Deviation
V_C			
V_L			
V_R			
V_S			
Θ			

Table 2

Questions

1. What is the phase relationship between R, L, and C components in a series AC circuit?
2. Based on measurements, does Kirchhoff's Voltage Law apply to the tested circuits?
3. In general, how would the phasor diagram of Figure 1 change if the frequency was raised?
4. In general, how would the phasor diagram of Figure 1 change if the frequency was lowered?