LAB 5: RC and LC Circuit in AC analysis

A. Objective

This exercise examines the voltage and current relationships in series RC and RL networks. The Kirchhoff′s voltage law is extended for AC circuits. Both time domain and phasor plots of the voltages are generated.

B. 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.

C. Equipment

The following components will be used in the experiment.

- AC function generator (1)
- Oscilloscope (1)
- Capacitor 4.7 μF (1)
- Inductor 680 μH (1)
- Resistor 200 Ω (1)

D. Schematics

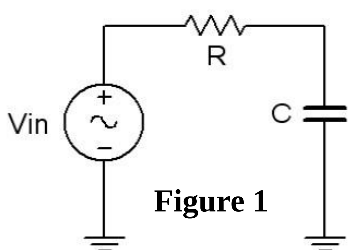

Figure 1

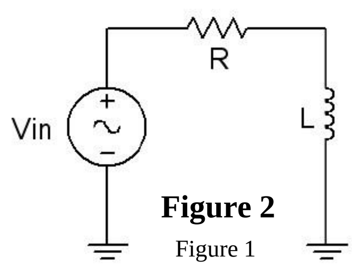

Figure 2

Figure 1

E. Procedure

<u>RC Circuit</u>

1. Using Figure 1 with $V_{in} = 2V$p-p sine wave at 2.5 kHz, R=200 Ω, and C=4.7 μF.

   Determine the theoretical capacitive reactance and circuit impedance, and record the results in Table 6.1 (the experimental portion of this table will be filled out in step 5).

   Using the voltage divider rule, compute the resistor and capacitor voltages and record them in Table 6.2.

2. Build the circuit of Figure 1 using R=200 Ω, and C=4.7 μF.
   Place one probe across the generator and another across the capacitor.
   Set the generator to a 2.5 kHz sine wave and 2Vp-p.
3. Measure the peak-to-peak voltage across the capacitor and record in Table 6.2. Along with the magnitude, be sure to record the time deviation between V_C and the input signal (from which the phase may be determined).
   Compute the phase angle and record these values in Table 6.2.
4. Take a snapshot of the oscilloscope displaying V_{in} and V_C.

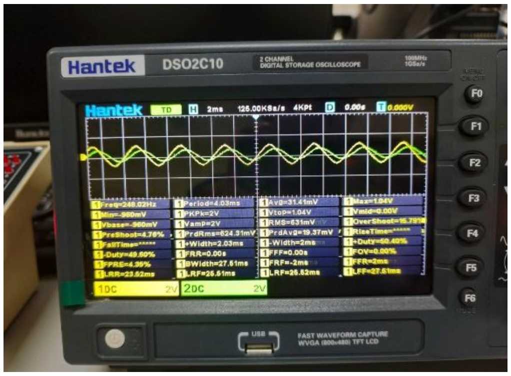

Figure 1: Vin

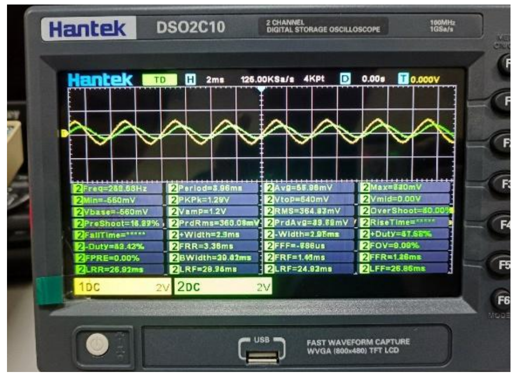

Figure 2: Vc

5. Take a snapshot of the oscilloscope displaying $-V_{in}$ and $-V_R$.

Figure3: -Vin

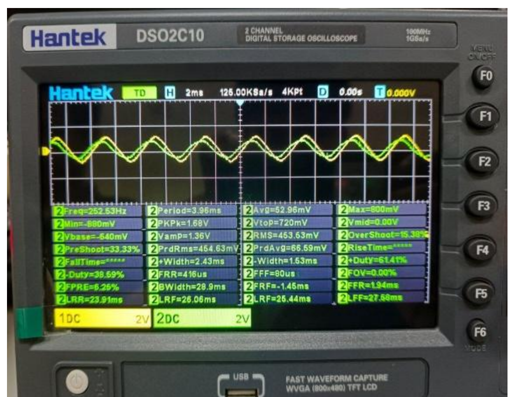

Figure4: -V_R

6. Based on the experimental values, determine the experimental Z and X_c values via Ohm's law ($i = V_R/R$, $X_C = V_C/i$, $Z = V_{in}/i$) and record back in Table 6.1.
7. Create a phasor plot showing V_{in}, V_C, and V_R.
8. Back to step 2. Increase the frequency to 25kHz then observe the variation of the amplitude and phase of V_C. Decrease the frequency to 250Hz then observe the variation of the amplitude and phase of V_C. Conclude on the result.

RL Circuit

9. Replace the capacitor with the 680 μH inductor (i.e. Figure 2), and repeat steps 1 through 8 in like manner and complete Tables 3 and Table 4.

F. Data Tables

RC Circuit

Table 1

	Theory	Experimental
X_C	0.0065	0.0054
Z Magnitude	200	240.3
Z Phase	-1	-0.7

Table 2 (F=250Hz)

	Magnitude (Theory)	Phase (Theory)	Magnitude (Experiment)	Delay (Experiment)	Phase (Experiment)
V_C	1	17.8	1	8	0.125

Table 2

Table 1 (F= 25KHz)

R = 200 Ω

	Theory	Experimental
X_C	64	78
Z Magnitude	200	200.46
Z Phase		

Table 2 (F=25KHz)

	Magnitude (Theory)	Phase (Theory)	Magnitude (Experiment)	Delay (Experiment)	Phase (Experiment)
V_L	VL	1	4.49	1	80us

Conclusion:

Overall, there's a reasonable agreement between theoretical and experimental magnitudes, although some discrepancies exist, particularly in the phase measurements and the calculated reactance (Xc). These differences could stem from component tolerances, parasitic effects, or limitations in the measurement equipment, suggesting areas for improvement in experimental setup and precision. Further investigation into the source of these discrepancies is recommended for a more comprehensive understanding.