AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

ELECTRICAL CIRCUIT LAB - 1

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Section: W, Group: 2

LAB REPORT ON

Analysis of RC, RL, RLC series circuits and verification of KVL in RLC series Circuit

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Submitted By

Name	ID	Contribution
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2. PRANTO BISWAS	21-45026-2	Theory and Methodology, Calculation, Simulation and Result
3. KAZI ABDULLAH JARIF	22-46386-1	Calculation, Discussion and Conclusion, Experimental Procedure
4. MD. NESAR UDDIN	22-46313-1	Precautions, Theory and Methodology, Discussion and Conclusion

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1.Introduction:

The RC & RL circuit is used to determine the input and output relationship of voltage and current for different frequencies. In RC series circuit the voltage lags the current by 90˚and in RL series circuit the voltage leads the current by 90˚.

An RLC circuit is an electrical circuit consisting of a resistor, an inductor, and a capacitor, connected in series. The RLC part of the name is due to those letters being the usual electrical symbols for resistance, inductance and capacitance respectively. Series RLC circuits are classed as second-order circuits because they contain two energy storage elements, an inductance and a capacitance.

The primary objectives of the lab experiment are-

- To determine the reactance of the RL and RC circuits and the impedance equation both practically and theoretically.
- To determine phase relationship between voltage and current in an RLC circuit.
- To draw the complete vector diagram.
- Design an RLC series circuit and verify KVL.

2.Theory and Methodology:

RC Series Circuit:

A resistor–capacitor circuit(RC circuit), or RC network, is an electric circuit composed of resistors and capacitor is in series driven by a voltage or current source(See the Figure-1). A first order RC circuit is composed of one resistor and one capacitor and is the simplest type of RC circuit.

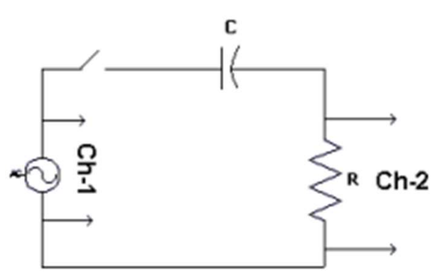


Figure 1

Analysis of a Series RC Circuit:

For doing a complete analysis of a series RC circuit, given the values of R, C, f, and V_T.

Step 1. Calculate the value of X_C:

$X_C = 1 / (2\pi fC)$

Step 2. Calculate the total impedance Z:

$$Z = \sqrt{(X_c^2 + R^2)}$$

Step 3. Use Ohm's Law to calculate the total current I_T:

$I_T = V_T / Z$

Difference between Rectangular & Polar representation of Impedance:

- In Rectangular form:

  $Z_T = R - j\,X_C$

- In Polar form:

  $Z_T = \sqrt{R^2 + (Xc)^2}$

  $\theta = \tan^{-1}(-X_C/R) = \tan^{-1}(-1/\omega RC)$

Impact of frequency on the value of capacitance:

Figure 1.1 will shows the impact of frequency by varying the value of Capacitance in series resonance.

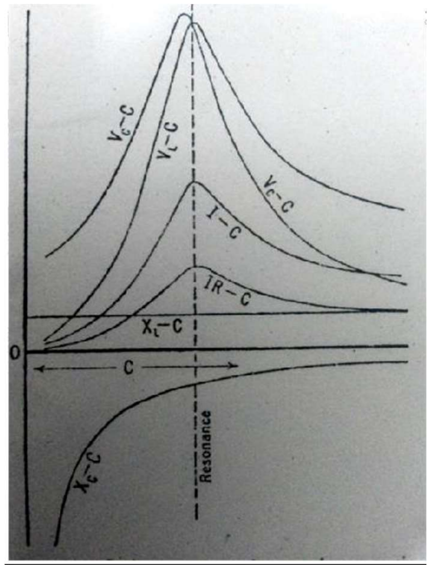


Figure 1.1

RL Series Circuit:

A resistor–inductor circuit (RL circuit), or RL network, is an electric circuit composed of resistors and inductor is in series driven by a voltage or current source (See the Figure-2). A first order RL circuit is composed of one resistor and one inductor and is the simplest type of RL circuit

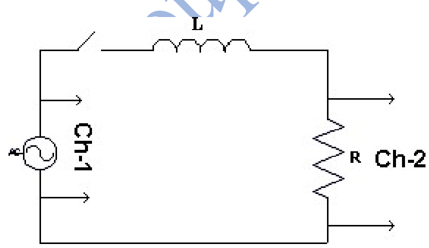


Figure 2

Analysis of a Series RL Circuit:

For doing a complete analysis of a series RL circuit, given the values of R, L, f, and V_T.

Step 1. Calculate the value of X_L:

$$X_L = 2\pi f L$$

Step 2. Calculate the total impedance Z:

$$Z = \sqrt{(X_L^2 + R^2)}$$

Step 3. Use Ohm's Law to calculate the total current I_T:

$I_T = V_T / Z$

Difference between Rectangular & Polar representation of Impedance:

- In Rectangular form:

  $Z_T = R + jX_L$

- In Polar form:

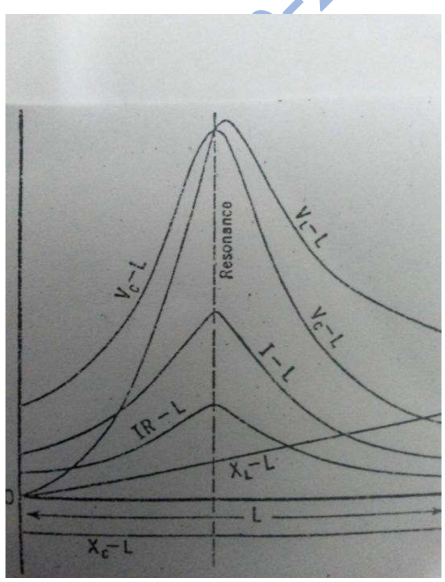
  $Z_T = \sqrt{R^2 + (X_L)^2}$

  $\theta = \tan^{-1}(X_L / R) = \tan^{-1}(\omega L / R)$

Impact of frequency on the value of inductance:

Figure 2.1 will shows the impact of frequency by varying the value of Inductance in series resonance.

Figure 2.1



RLC Series Circuit:

Three basic passive components- R, L and C have very different phase relationships to each other when connected to a sinusoidal AC supply. In case of a resistor the voltage waveforms are "in-phase" with the current. In case of pure inductor, the voltage waveform "leads" the current by 90° whereas in case of pure capacitor, the voltage waveform "lags" the current by 90°. This phase difference depends upon the reactive value of the components being used. Reactance is zero if the element is resistive, positive if the element is inductive and negative if the element is capacitive.

Instead of analyzing each passive element separately, we can combine all three together into a series RLC circuit. The analysis of a series RLC circuit is the same as that for the dual series RL and RC circuits we studied in the last experiment, except this time we need to take account the magnitudes of both inductive reactance and capacitive reactance to find the overall circuit reactance.

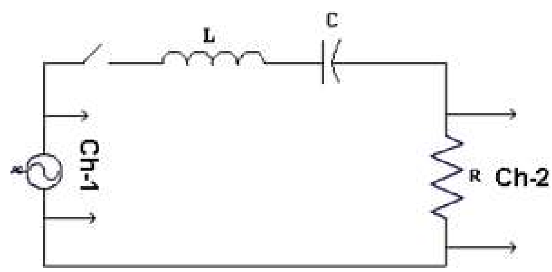


Figure 3: RLC series circuit

Relevant Equations:

Inductive reactance, $X_L = 2\pi fL$

Capacitive reactance, $X_C = \frac{1}{2\pi fC}$

Net reactance, $X = X_L - X_C$

Total impedance, $Z = \sqrt{R^2 + X^2}$

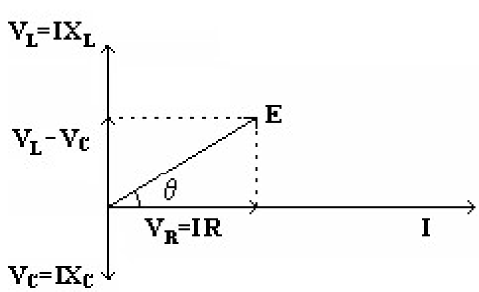
Current, $I = \frac{V}{Z}$

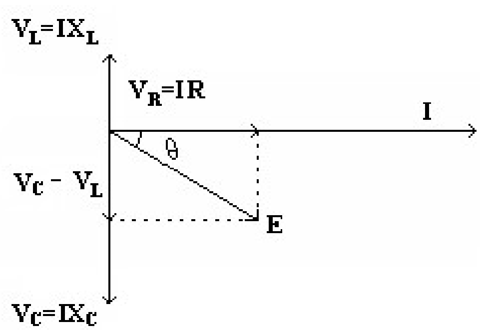
Resistive voltage drop, $V_R = I*R$

Reactive voltage drops = $V_L - V_C$, where $V_L = I*X_L$ and $V_C = I*X_C$

Total voltage drop = $\sqrt{V_R^2 + (V_L - V_C)^2}$

Vector Diagram:





3.Apparatus:

- Oscilloscope
- Function generator
- Resistor: 100 Ω (For RC and RL)
- Inductor: 2.4mH (For RC and RL)
- Capacitor: 1 μF/ 10 μF (For RC and RL)
- SPST switch
- Resistor (200 Ω) For RLC
- Inductor (6.3 mH) For RLC
- Capacitor(1 uF) For RLC
- Connecting wire
- Bread board

4.Precautions:

- Oscilloscopes should be properly calibrated using the information provided at the calibration port before obtaining the wave shapes using the experimental set up.
- Do not short any connections. Short connection can produce heat (due to high current flow) which is harmful for the components.

5.Experimental Procedure:

For RC and RL Series Circuit:

1. Construct the circuit as shown in the Fig. 1. Connect channel 1 of the oscilloscope across function generator and channel 2 of the oscilloscope across R.
2. Set the amplitude of the input signal 5V peak and the frequency at 1 kHz. Select sinusoidal wave shape.
3. Measure peak value of the both wave shapes.
4. Determine phase relationship between the waves.
5. Write down the wave equations for I and E.
6. Calculate resistance and reactance from the relevant data.
7. Do the same experiment setting input frequency 5kHz and 10kHz.
8. Complete the following table.

Table-1

f	E (V)	$I=V_R/R$ (A)	Z= E/I (Polar) Ω	Z (Rectangular) Ω	R	$X_C=1/2\pi fC$ Ω	V_R	$V_C=IX_C$
1KHz	10	0.053	186.61	97.3-j159.24	97.3	159.24	5.25	8.44
5KHz	10	0.098	102.041	9.3-j31.83	97.3	31.83	9.54	3.119
10KHz	10	0.1	96.39	97.3-j15.92	97.3	15.92	9.73	1.592

- Now construct the circuit as shown in fig.2. Connect channel 1 of the oscilloscope across function generator and channel 2 of the oscilloscope across R.
- Do the same procedure stated in 2 to 7. Complete the following table.

Table-2

f	E (V)	$I=V_R/R$ (A)	Z= E/I (Polar) Ω	Z (Rectangular) Ω	R	$X_L=2\pi fL$ Ω	V_R	$V_L=IX_L$
1KHz	10	0.102	98.461	97.3+j15.08	97.3	15.08	9.88	1.531
5KHz	10	0.081	123.07	97.3+j75.36	97.3	75.36	7.88	6.104
10KHz	10	0.0557	179.398	97.3+j150.72	97.3	150.72	5.42	8.395

For RLC Series Circuit:

1. Construct the circuit as shown in the Figure 3. Connect channel 1 of the oscilloscope across the ac voltage source and channel 2 of the oscilloscope across R.
2. Set the amplitude of the input signal 5V peak.
3. Set the frequency of the signal generator 1 kHz.
4. Determine phase relationship between the waves.
5. Measure value of I.
6. Measure value of V_R, V_L& V_C.
7. Verify KVL using the experimental data and draw the complete vector diagram.
8. Set the frequency of the signal generator 2 kHz. Repeat step 4-7.
9. Set the frequency of the signal generator 4 kHz. Repeat step 4-7.
10. Complete the following table.

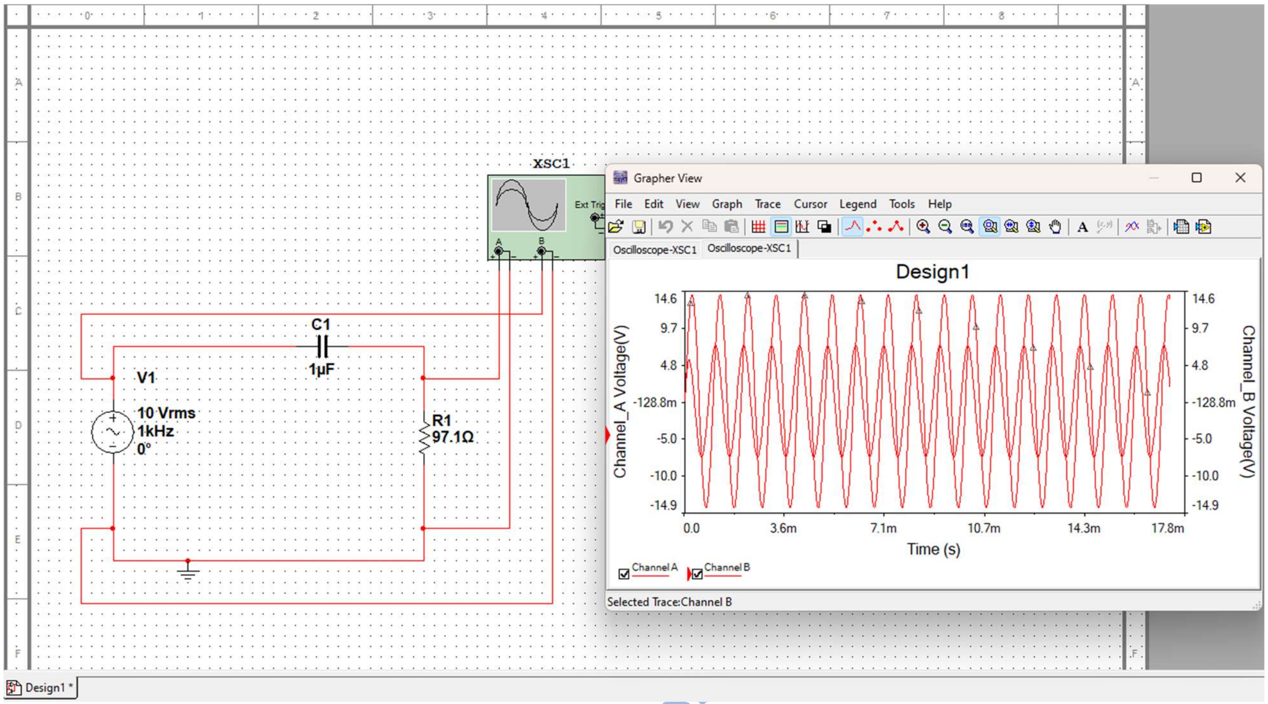
Table~3

f	E (V)	$\theta=\tan^{-1} X/R$	V_R (V)	$I=V_R/R$ (A)	$X_L=2\pi fL$ (Ω)	$V_L=IX_L$ (V)	$X_C=1/2\pi fC$ (Ω)	V_C (V)	V* (V)	Comment
1kHz	10	55.98º	5.6	0.0575	15.08	0.87	159.24	9.16	10	V*=E
5kHz	10	24.09º	9.13	0.094	75.36	7.083	31.85	2.9939	10	V*=E
10kHz	10	54.178º	5.84	0.06	150.72	8.939	15.92	0.9552	9.89	V*≈E

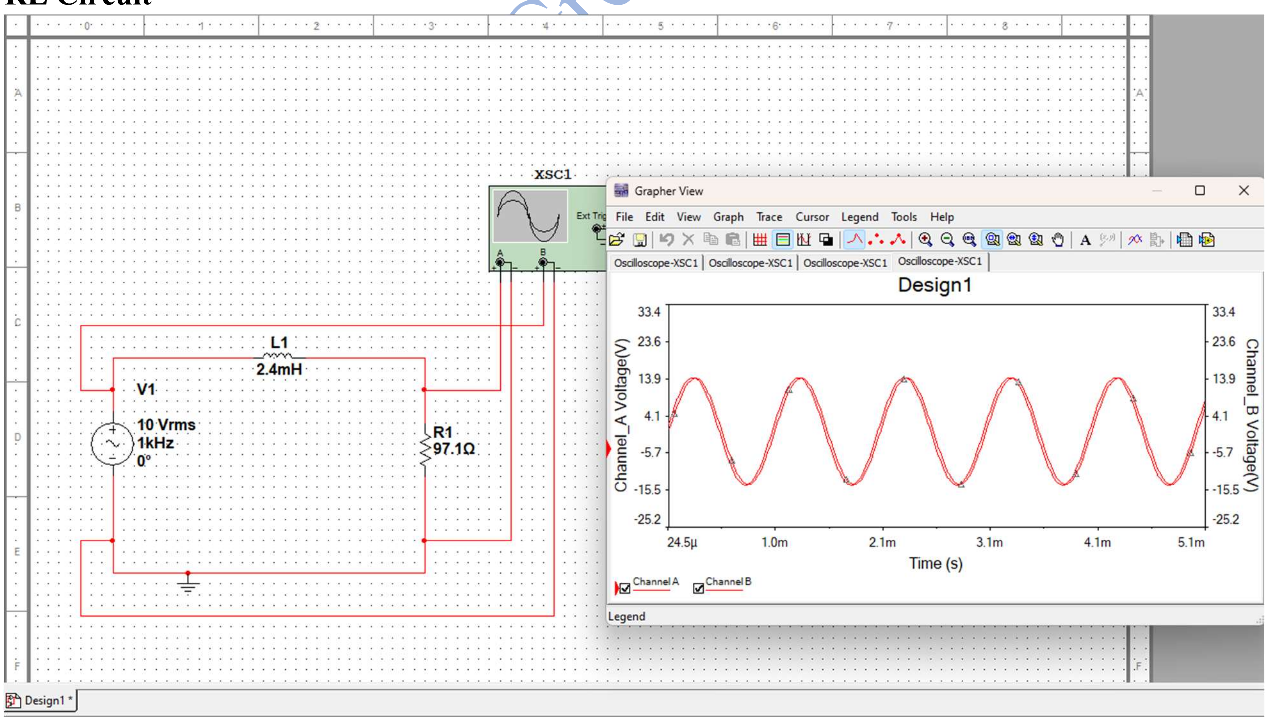
$$*V=\sqrt{V_R^2+(V_L-V_C)^2}$$

6.Simulation and Results:

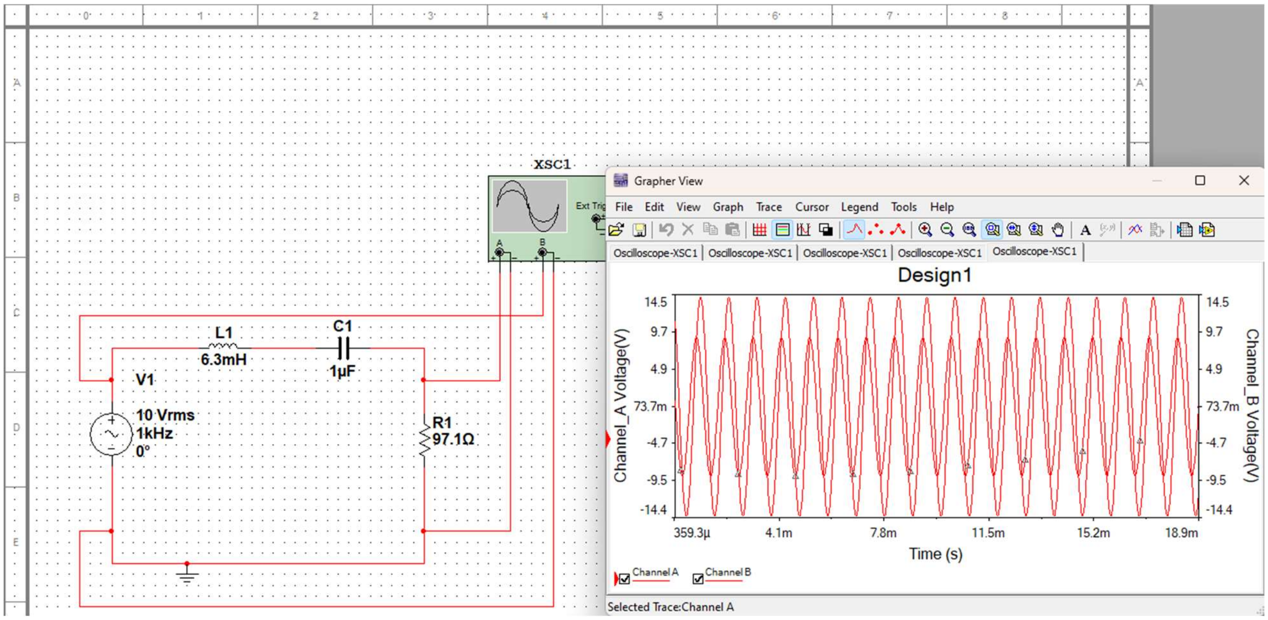
RC Circuit



RL Circuit



RLC Circuit



Group-2

Result and Calculation

For RC Circuit

Xc=1/2πfC= 1/2π×1000×10^ (-6) =159.24Ω

Z=$\sqrt{(Xc)^2 + R^2}$ = 186.61Ω

Z_o = R-jXc = 97.3-j159.24

I=E/Z= 10/186.61 = 0.053A

Vr= I×R = 5.157V

Vc= I×Xc = 8.44V

For RL Circuit

X_L=2πfC= 2π×1000×2.4×10^ (-3) =15.08Ω

Z=$\sqrt{(XL)^2 + R^2}$ = 98.461Ω

Z_o = R+j X_L = 97.3+j15.08

I=E/Z= 10/98.461 = 0.102A

Vr= I×R = 9.88V

V_L= I× X_L = 1.531V

For RLC Circuit

$X = X_L - X_C = 144.16\Omega$
$Z = \sqrt{(R)^2 + X^2} = 173.93\Omega$
$\theta = \tan^{-1}(X/R) = 55.98^o$
$I = E/Z = 10/173.93 = 0.0575A$
$Vr = I \times R = 5.6V$
$V_L = I \times X_L = 0.87V$
$Vc = I \times Xc = 9.16V$
$V = \sqrt{(Vr)^2 + (VL - VC)^2} = 10.004V$

7.Discussion and Conclusion:

In this experiment the data/findings were interpreted and determine to the extent to which the experiment was successful in complying. The goal was initially set. The ways of the study were improved, investigated, and described by measuring, converting, and calculation.

By completing this experiment, we had become familiar with the function generator and oscilloscope. Measuring RC, RL, RLC series circuits and verification of KVL in RLC series Circuit.

8.Reference:

[1] Russell M. Kerchner, George F. Corcoran, ″Alternating Current Circuits″, 4th Edition, Wiley, New York, 1960, pp. 48-50.

[2] Robert L. Boylestad, ″Introductory Circuit Analysis″, 10th Edition, Prentice Hall, New York, 2005-2006, p. 524.

[3] Er. R.K. Rajput, ″Alternating Current Machines″, 3rd Edition, Laxmi Publications, New Delhi, 2002, p. (xi).