AMERICAN INTERNATIONAL UNIVERSITY- BANGLADESH (AIUB)

Introduction to Electrical Circuit

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Section: L, Group: 07

LAB REPORT ON

Analysis of RLC parallel circuits and verification of KCL in RLC parallel circuit related to AC circuit

Supervised By

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Abstract:

An RLC circuit (or LCR circuit or CRL circuit or RCL circuit) is an electrical circuit consisting of
a resistor, an inductor, and a capacitor, connected in series or in parallel. The RLC part of the name
is due to those letters being the usual electrical symbols for resistance, inductance and capacitance
respectively. The Parallel RLC Circuit is the exact opposite to the series circuit. The analysis of
parallel RLC circuits can be a little more mathematically difficult than for series RLC circuits. This
time instead of the current being common to the circuit components, the applied voltage is now
common to all so we need to find the individual branch currents through each element. The total
impedance, Z of a parallel RLC circuit is calculated using the current of the circuit similar to that
for a DC parallel circuit, the difference this time is that admittance is used instead of impedance.
The objectives of this experiment are-

- To determine phase relationship between IL and IC in a RLC parallel circuit.
- Draw the complete vector diagram for a RLC parallel circuit.
- Verification of KCL in AC circuits.

Circuit diagram:

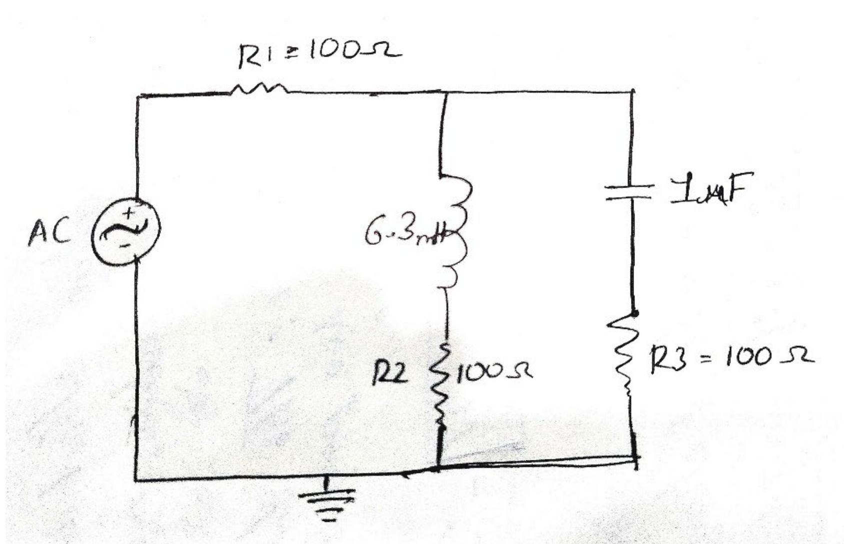

Figure 1: RLC parallel circuit

Apparatus:

a) Oscilloscope

b) Function generator

c) Resistor: 100 ohm (3)

d) Inductor: 6.3 mH

e) Capacitor: 1microF

f) Connecting wire.

g) Bread board

Experimental Procedure:

The circuit shown in Figure 1 was successfully constructed, with channel 1 of the oscilloscope connected across the function generator and channel 2 across RL. We set the amplitude of the input signal to 5V peak, adjusted the frequency to 1 kHz, and selected a sinusoidal wave shape. The values of VRL and IL were measured, and the phase relationship (θL) between E and VRL was determined. Channel 2 of the oscilloscope was then connected across RC, and measurements for VRC and IC were taken. The phase relationship (θC) between E and VRC was determined. Phasors IL and IC were added, and subsequently, channel 2 of the oscilloscope was connected across R to measure VR and IR. The phase relationship (θ) between E and VR was determined. The theoretical sum of IL and IC was compared with the practically obtained value of IR. The same procedures were repeated for input frequencies of 2 kHz and 4 kHz to comprehensively analyze the circuit behavior across different frequency settings.

Result analysis :

Data Table:

f	V_{RL}	$I_L = V_{RL}/R_L$	θ_L	V_{RC}	$I_c = V_{Rc}/R_c$	θ_c	I_L+I_c	V_R
1KHz	$2.32\angle-2.87°$	0.02	$\angle-24.47°$	$2.32\angle-2.\ 87°$	0.01	$\angle 54.99°$	$0.03\angle 2.5°$	$2.64\angle 2.5°$
2KHz	$17.62\angle 33.8°$	0.02	$\angle-38.62°$	$2.245\angle 0.25°$	0.02	$\angle 38.76°$	$0.03\angle 0°$	$2.75\angle 0°$
4KHz	$2.298\angle 0.13°$	0.0123	$\angle-54.435°$	$2.325\angle 2.91°$	0.0123	$\angle-54.435°$	$0.0268\angle-2.2°$	$4.999\angle 0.014°$

Simulation:

TABLE 1:

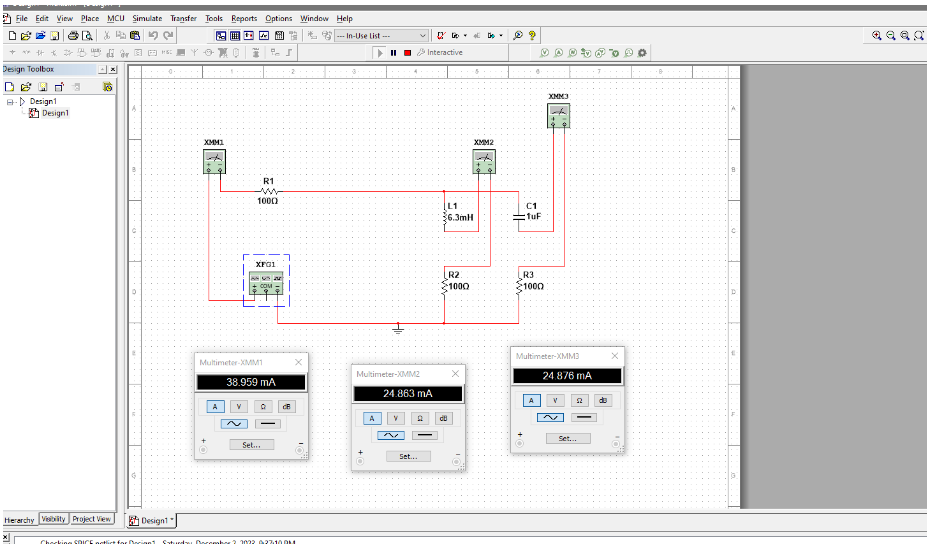

Figure: Frequency 1kHz

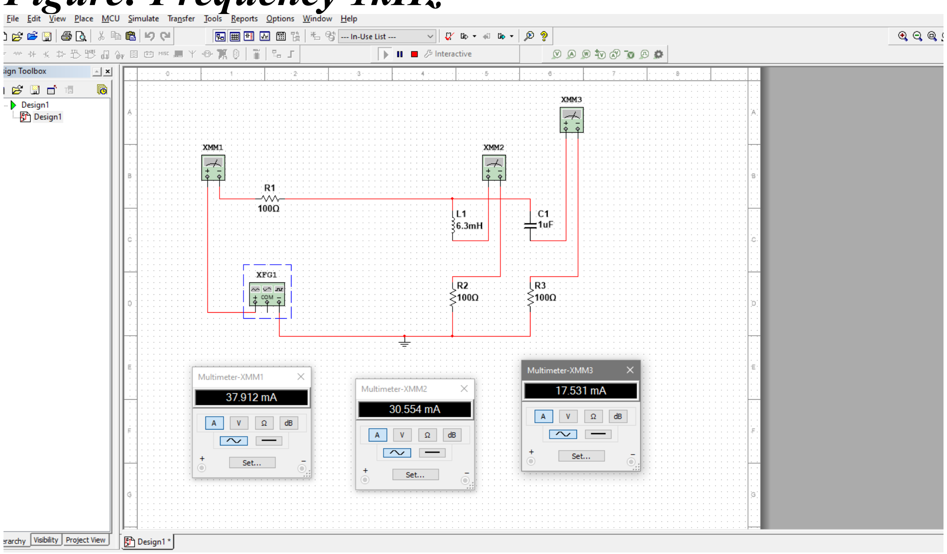

Figure: Frequency 2kHz

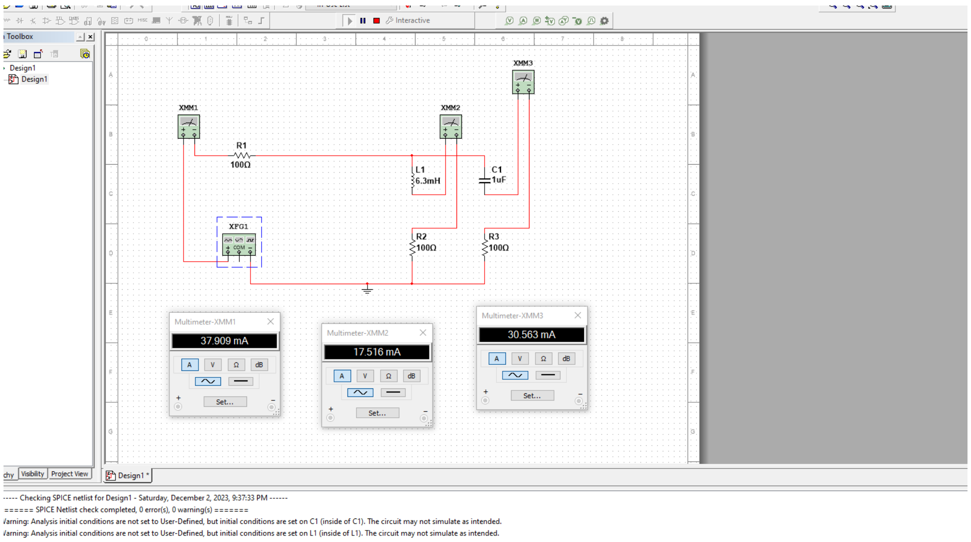

Figure: Frequency 4kHz

Calculation:

① $f = 1\ kHz = 1000\ Hz$

$$X_L = 2\pi f L = 2\times 3.1416\times 10^3 \times 6.3\times 10^{-3} = 39.584\ \Omega$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\times 3.1416\times 10^3 \times 10^{-6}} = 159.155\ \Omega$$

$$Z_R = R = 100\ \Omega$$

$$Z_{RL} = R_L + jX_L = 100 + 39.584j\ \Omega$$

$$Z_{RC} = R_C - jX_C = 100 - 159.155\ \Omega$$

$$\therefore Z_T = Z_R + (Z_{RL} \parallel Z_{RC})$$

$$= Z_R + \frac{Z_{RL} \times Z_{RC}}{Z_{RL} + Z_{RC}}$$

$$= \frac{(100 + 35.584j)(100 - 159.155j)}{100 + 39.584j + 100 - 159.155j} + 100$$

$$= 186.37 - 8.148j$$

$$I_T = \frac{E}{Z_T} = \frac{5}{186.37 - 8.148j}$$

$$= 0.02677 + 0.00117j$$

$$= 0.03 \angle 2.5^\circ$$

$$I_L = \frac{Z_{RC}}{Z_{RC} + Z_{RL}} \times I$$

$$= \frac{(100 - 159.155j)(0.02677 + 0.00117j)}{100 - 159.155j + 100 + 39.584j}$$

$$= 0.01967 - 0.00893j$$

$$= 0.02 \angle -24.47^\circ$$

$$I_C = \frac{Z_{RL}}{Z_{RC} + Z_{RL}} \times I = \frac{(100 + 39.584j)(0.02677 + 0.00117j)}{100 - 159.155j + 100 + 39.584j}$$

$$= 0.00709 + 0.01012j$$

$$= 0.01 \angle 54.99j$$

$I = I_L + I_C$

$= 0.01967 - 0.00895j + 0.00709 + 0.01012j$

$= 0.02676 + 0.00117j$

$= 0.03 \angle 25°$

$V_R = I_T \times Z_R = (0.02677 + 0.00117j) \times 100$

$= 2.677 + 0.117j$

$= 2.68 \angle 25°$

$V_{RL} = I_L \times Z_{RL} = (0.01967 - 0.00895j) \times (100 + 39.584j)$

$= 2.32 - 0.116j = 2.32 \angle -2.87°$

$V_{RC} = I_C \times Z_{RC}$

$= (0.00709 + 0.01012j) \times (100 - 159.155j)$

$= 2.32 - 0.1164j$

$= 2.32 \angle -2.87°$

(ii) $f = 2kHz = 2000 Hz$

$X_L = 2\pi f L = 2 \times 3.1416 \times 2 \times 10^3 \times 6.3 \times 10^{-3}$

$= 79.168$

$X_C = \frac{1}{2\pi f C} = \frac{1}{2 \times 3.1416 \times 10^3 \times 2 \times 10^{-6}} = 79.577$

$Z_R = 100\Omega$

$Z_{RL} = R_L + jX_L = 100 + 79.168j$

$Z_{RC} = R_C - jX_C = 100 - 79.577j$

$Z_T = \frac{(100 + 79.168j)(100 - 79.577j)}{(100 + 79.168j + 100 - 79.577j} \times 100$

$= 181.5 - 0.0378j$

$= 181.5 - 0.01°$

$$I_T = \frac{E}{Z_T} = \frac{5}{181.5 - 0.0378j} = 0.0275 + 0j$$

$$= 0.03 \angle 0^\circ$$

$$I_C = \frac{Z_{RL}}{Z_{RL} + Z_{RC}} \times I = \frac{(100 + 79.168j)(0.0275 + 0j)}{(100 + 79.166j)(100 - 79.377j)}$$

$$= 0.0137 + 0.011j$$

$$= 0.02 \angle 38.76^\circ$$

$$I_L = \frac{Z_{RC}}{Z_{RC} + Z_{RL}} \times I = \frac{(100 - 79.577j) \cdot 0275}{(100 + 79.168j)(100 - 79.577j)}$$

$$= 0.01377 - 0.011j$$

$$= 0.02 \angle -38.62^\circ$$

$$I = I_C + I_L = 0.02747 = 0.03 \angle 0^\circ$$

$$V_{RL} = I_L + Z_{RL} = (0.01377 - 0.011j)(100 + 79.168j)$$

$$= 2.298 + 0.00986$$

$$= 2.298 \angle -0.25^\circ$$

$$V_R = I \times Z_R = 0.0275 \times 100 = 2.75 + 0j$$

$$= 2.75 \angle 0^\circ$$

(iii) $f = 4kHz = 4000 Hz$

$$X_L = 2\pi f L = 2 \times 3.1416 \times 4000 \times 6.3 \times 10^{-3} = 158.3366$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2 \times 3.1416 \times 4000 \times 10^{-6}} = 39.7886$$

$$Z_{RL} = R_L + jX_L = 158.3366j + 100$$

$$Z_{RC} = R_L - jX_C = 100 - 39.7866j$$

$$Z_T = \frac{(100+158.3366j)(100-39.7866j)}{(100+158.3366j)(100-39.7886j)} + 100$$

$$= 186.31 + 8.115j$$

$$I = \frac{E}{Z_T} = \frac{5}{186.31 + 8.113j}$$

$$= 0.02678 - 0.00116j$$

$$= 0.0268 \angle -2.48^\circ$$

$$I_C = \frac{Z_{RL}}{Z_{RC} + Z_{RL}} \times I = \frac{(100+158.3366j)(0.0268 - 0.001j)}{(100+158.3366j + 100 - 39.7886j)}$$

$$= 0.01964 + 0.00899j$$

$$= 0.0216 \angle 24.6^\circ$$

$$I_L = \frac{(100-39.7866j)(0.0268 - 0.00116j)}{100 + 158.3366j + 100 - 39.7886j}$$

$$= 0.00715 - 0.01j$$

$$= 0.0123 \angle -54.435^\circ$$

$$I_C + I_L = 0.02679 - 0.00101j = 0.0268 \angle -2.2^\circ$$

$$V_{RL} = I_L \times Z_{RL} = (0.00715 - 0.01j)(158.3366j + 100)$$

$$= 2.298 + 0.132j$$

$$V_{RC} = I_C \times Z_{RC} = (0.01964 + 0.0899j) \times (100 - 39.7886j)$$

$$= 2.322 + 0.0118j = 2.323 \angle 2.9^\circ$$

$$V_R = I \times Z_R = (0.02678 - 0.00116) \times (186.31 + 8.113j)$$

$$= 4.999 + 0.0012j$$

$$= 4.999 \angle 0.014$$

Discussion

If we apply KCL,

I = IL + IC

This condition must be true. But there might be some mismatch of the measured value with the theoretical value because we are taking the value as fraction. If we take all the values from the fractional part, results must be equal. When we are taking the values from the waveforms, approximate data are taken so there might be some error too.

In this experiment, we got a value which was very close to our expected value.

Conclusion:

By completing this experiment we had become familiar with function generator and oscilloscope. Measuring RLC parallel circuits and we verified KCL in RLC series circuit.