American International University- Bangladesh (AIUB)
Faculty of Engineering (EEE)

Course Name:	Introduction to Electrical Circuits (IEC) Lab	**Course Code:**	EEE 2109
Semester:	Summer 2021-22	**Sec:**	W
Faculty:	DR.MD.KABIRUZZAMAN		

Task:	Perform Open End Lab following given instructions.
Experiment title:	Analysis of RLC parallel circuit and verification of KCL in AC circuits.

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Group Members		**ID**	**Name**
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	2.	21-45026-2	PRANTO BISWAS
	3.	22-46386-1	KAZI ABDULLAH JARIF
	4.	22-46313-1	MD. NESAR UDDIN

CO1: Function as effective team leader/member in multi-disciplinary problems

Marking Rubrics (to be filled by Faculty)

	Objectives	**Unsatisfactory (0-1)**	**Good (2-3)**	**Excellent (4-5)**	**Marks**
Performance (20)	**Identify experiment goals**	Cannot identify goals	Can identify some goals but unable to draw adequate hypothesis	Can identify necessary and sufficient goals	
	Setup of experiment	Cannot setup experiment without support	Can setup some of the portions of experiment without support	Can setup the whole experiment without support	
	Take organized and accurate measurement	Cannot take measurements	Can take measurements but inaccurately	Can take organized and accurate measurements	
	Summarize findings and compare actual to expected results	Cannot summarize or compare findings to expected results	Summarize finding in an incomplete way	Summarize finding in a complete way	
Viva (10)	**Viva Observation 1**	Cannot answer any question related to the experimental setup	Can answer some of the questions	Can answer most or all the questions	
	Viva Observation 2	Unexpected experimental outcome between calculated data and experimented data	Somewhat unexpected experiment outcome	Accurate data collected from the hardware	
	Comments	Assessed by (Name, Sign, and Date)	Total (out of 30):		

Group-2

<u>**Table of contents**</u>

1.Objectives:

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˚.

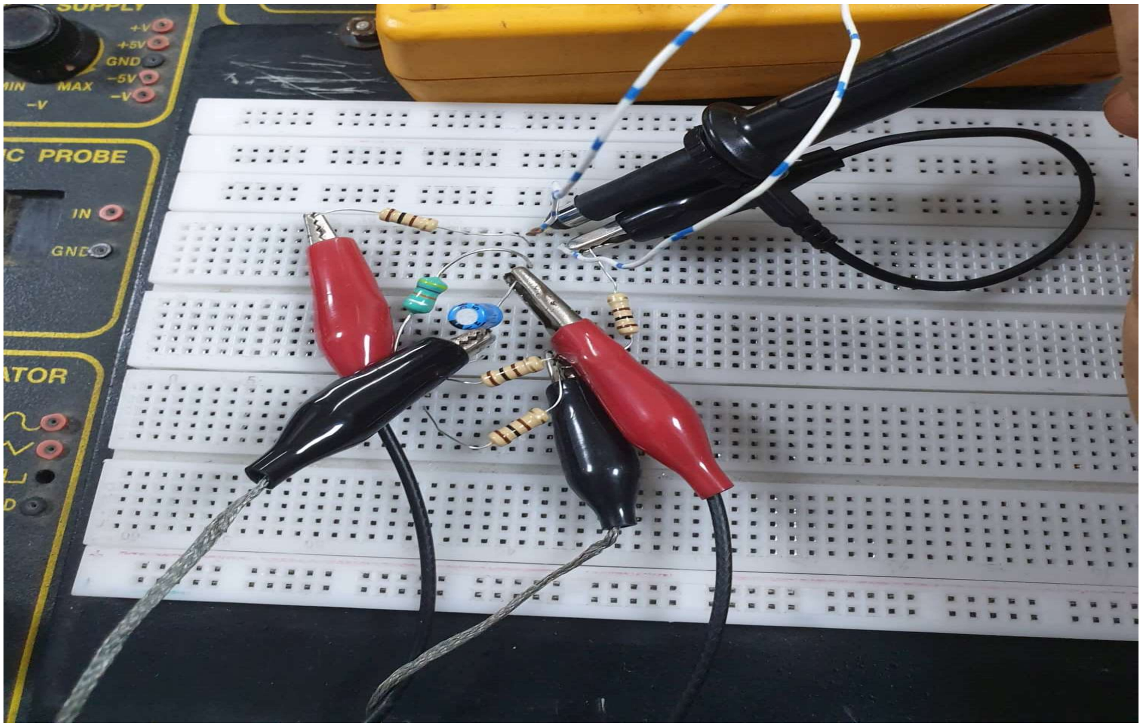
An RLC circuit is an electrical circuit consisting of a resistor, an inductor, and a capacitor, connected in series. The RLC part of the name is due to those letters being the usual electrical symbols for resistance, inductance, and capacitance respectively. Series RLC circuits are classed as second-order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

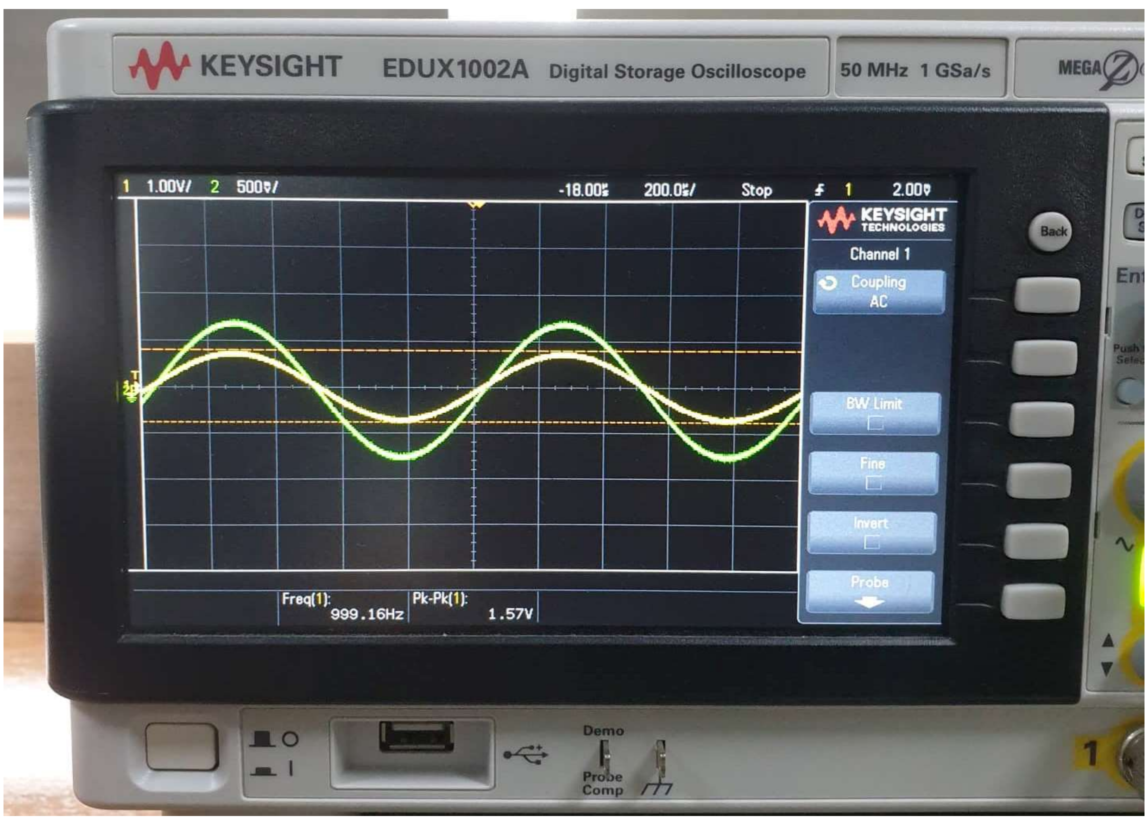
The primary objectives of the lab experiment are-

- 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.Equipment:

- Oscilloscope
- Function generator
- Resistor: 98 Ω (3)
- Inductor: 10 mH
- Capacitor: 1µF
- Connecting wire.
- Bread board




KEYSIGHT
EDUX1002A Digital Storage Oscilloscope
50 MHz 1 GSa/s
Channel 1
Coupling
AC
BW Limit
Fine
Invert
Probe
Freq(1):
999.16Hz
Pk-Pk(1):
1.57V
Back
Demo
Probe
Comp

Group-2

3.Procedure:

In DC circuits, conductance (G) was defined as being equal to $1/R$. The total conductance of a parallel circuit was then found by adding the conductance of each branch. The total resistance RT is simply $1/GT$. In ac circuits, we define admittance (Y) as being equal to $1/Z$. The unit of measure for admittance as defined by the SI system is Siemens, which has the symbol S. Admittance is a measure of how well an ac circuit will admit, or allow, current to flow in the circuit. The larger its value, therefore, the heavier the current flow for the same applied potential. The total admittance of a circuit can also be found by finding the sum of the parallel admittances.

The total impedance ZT of the circuit is then $1/YT$ that is, for the network of Fig.1

$$Y_T = Y_1 + Y_2 + Y_3 + \dots\dots\dots\dots + Y_N$$

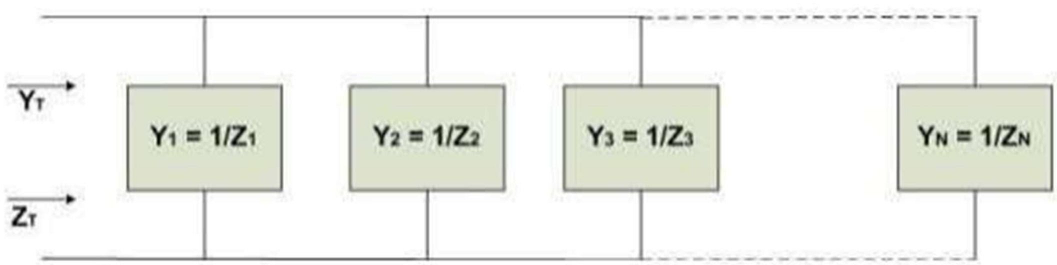


Fig.1: Parallel Branch Equivalent Admittance

Or, Since $Z = 1/Y$,

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \dots\dots\dots\dots + \frac{1}{Z_N}$$

For two impedances in parallel,

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$Z_T = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

For three parallel impedances,

$$Z_T = \frac{Z_1 Z_2 Z_3}{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}$$

As pointed out in the introduction to this section, conductance is the reciprocal of resistance

$$Y_R = \frac{1}{Z_R} = \frac{1}{R\angle 0^\circ} = G\angle 0^\circ$$

The reciprocal of reactance (1/X) is called susceptance and is a measure of how susceptible an element is to the passage of current through it. Susceptance is also measured in Siemens and is represented by the capital letter B.
For the inductor,

$$Y_L = \frac{1}{Z_L} = \frac{1}{X_L\angle 90^\circ} = \frac{1}{X_L}\angle -90^\circ$$

Defining

$$B_L = \frac{1}{X_L} \text{ (siemens, S)}$$

$$Y_L = B_L\angle -90^\circ$$

For inductance, an increase in frequency or inductance will result in a decrease in susceptance or, correspondingly, in admittance.

For the capacitor,

$$Y_C = \frac{1}{Z_C} = \frac{1}{X_C\angle -90^\circ} = \frac{1}{X_C}\angle 90^\circ$$

Defining

$$B_C = \frac{1}{X_C} \text{ (siemens, S)}$$

$$Y_C = B_C\angle 90^\circ$$

For the capacitor, therefore, an increase in frequency or capacitance will result in an increase in its susceptibility.
For any configuration (series, parallel, series-parallel, etc.), the angle associated with the total admittance is the angle by which the source current leads the applied voltage. For inductive networks, θT is negative, whereas for capacitive networks, θT is positive.

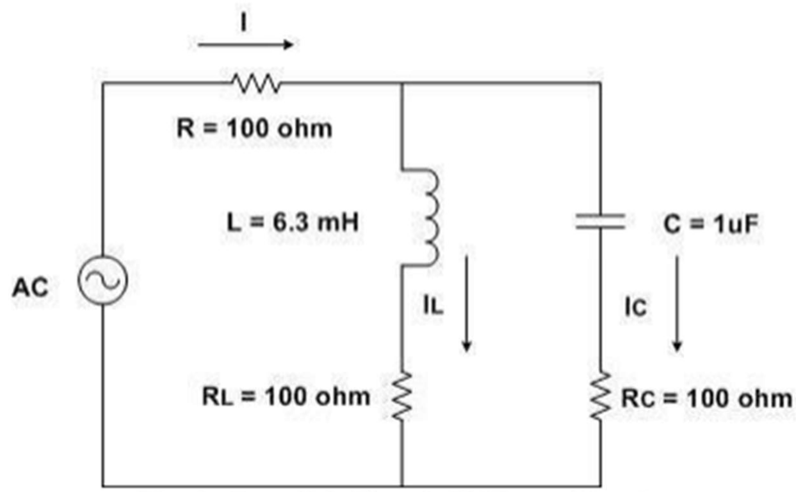


Fig. 2: Parallel Circuit KCL verification

The circuit of fig.2 represents a RLC parallel circuit where the Total Current I will divide into IL and IC in the parallel branches. If we apply KCL, $I = IL + IC$.

Experimental Procedure

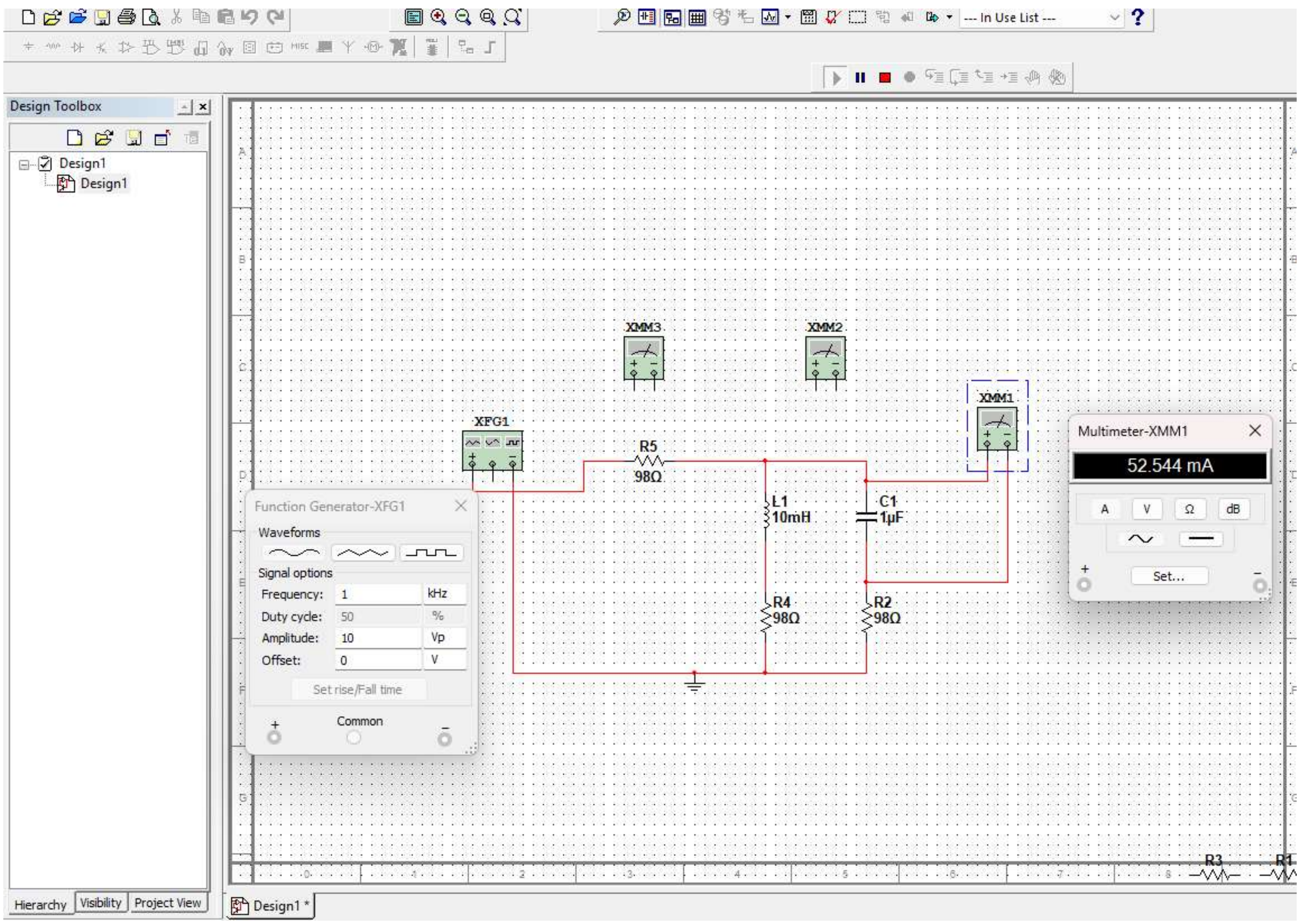
1. We constructed the circuit as shown in fig.1. connected channel 1 of the oscilloscope across function generator and channel 2 of the oscilloscope across RL
2. Then we have set the amplitude of the input signal 5V peak and the frequency at 1 kHz and selected sinusoidal wave shape.
3. We measured the value of VRL and IL
4. Then we determined phase relationship between E and VRL (i.e., θL)
5. Connected channel 2 of oscilloscope across RC.
6. Determined phase relationship between the waves.
7. Measured value of VRC and IC.
8. Determined phase relationship between E and VRC (i.e., θC)
9. Added IL and IC.
10. Measured VR and I connecting channel 2 across R.
11. Compared IL+IC with the practically obtained value of I.
12. Did the same work for setting input frequency 2 kHz

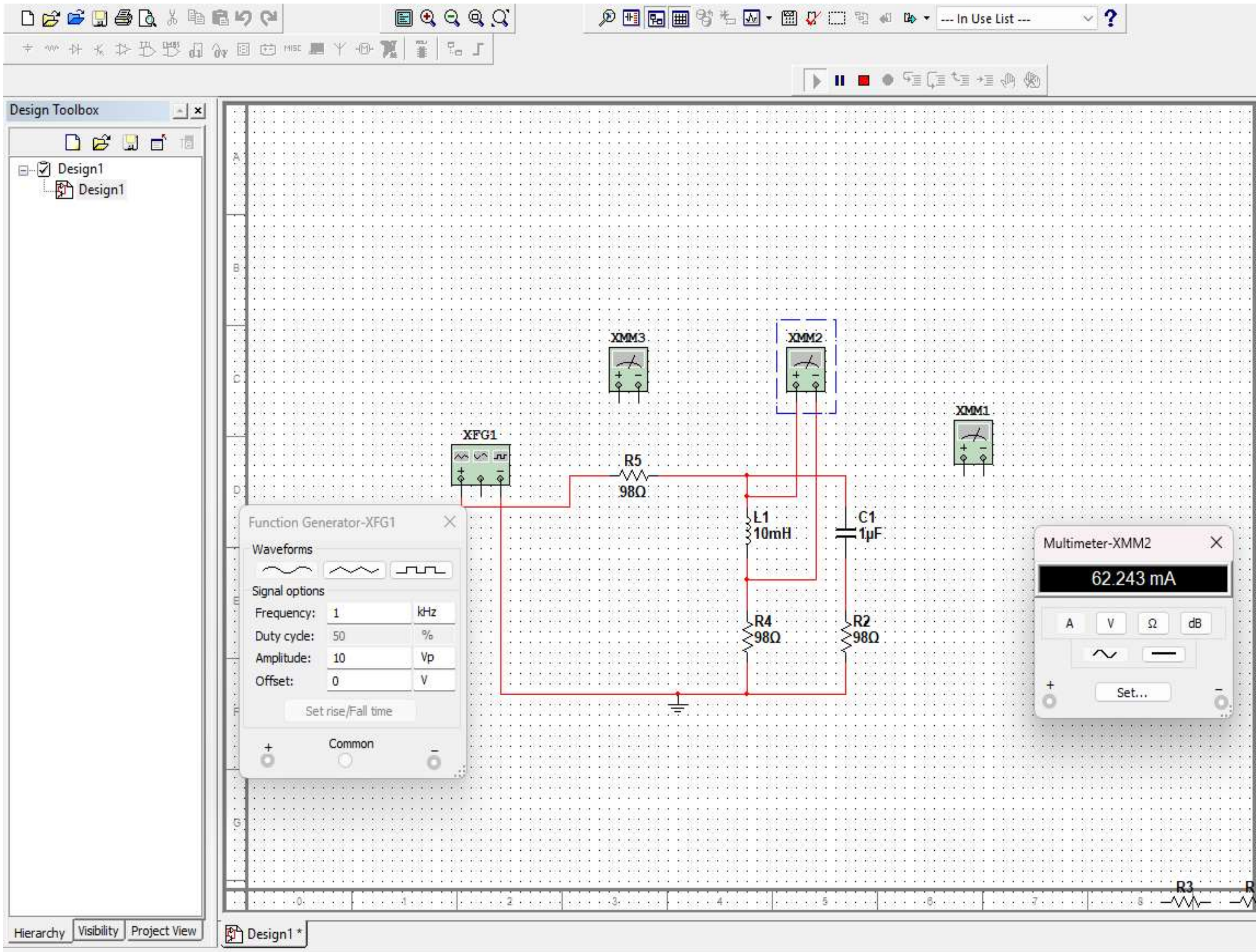
Data Table

Freq.(f) (kHz)	I (A)	θ (º)	I_R (A)	θ_R (º)	I_L (A)	θ_L (º)	I_C (A)	θ_C (º)
1	0.0089+ j0.0000106	0.0089∠0.0683^0	0.0089	∠0.0683^0	0.0075	∠-32.62^0	0.0048	∠57.29^0
2	0.00893+0.00000723j	0.00893∠0.046^0	0.00893	∠0.046^0	0.0055	∠-51.98^0	0.0071	∠37.9^0

Simulation

For 1 kHz

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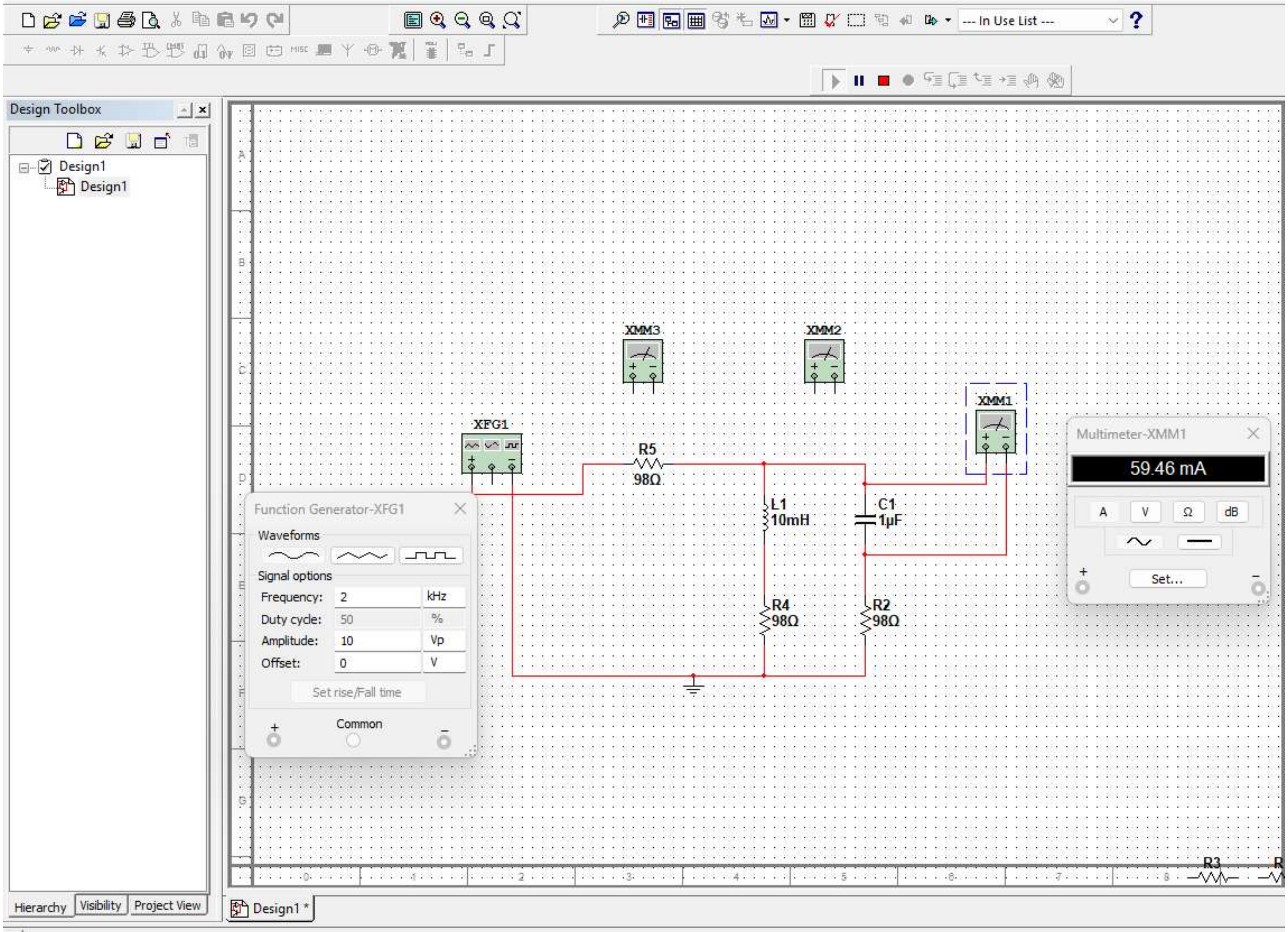
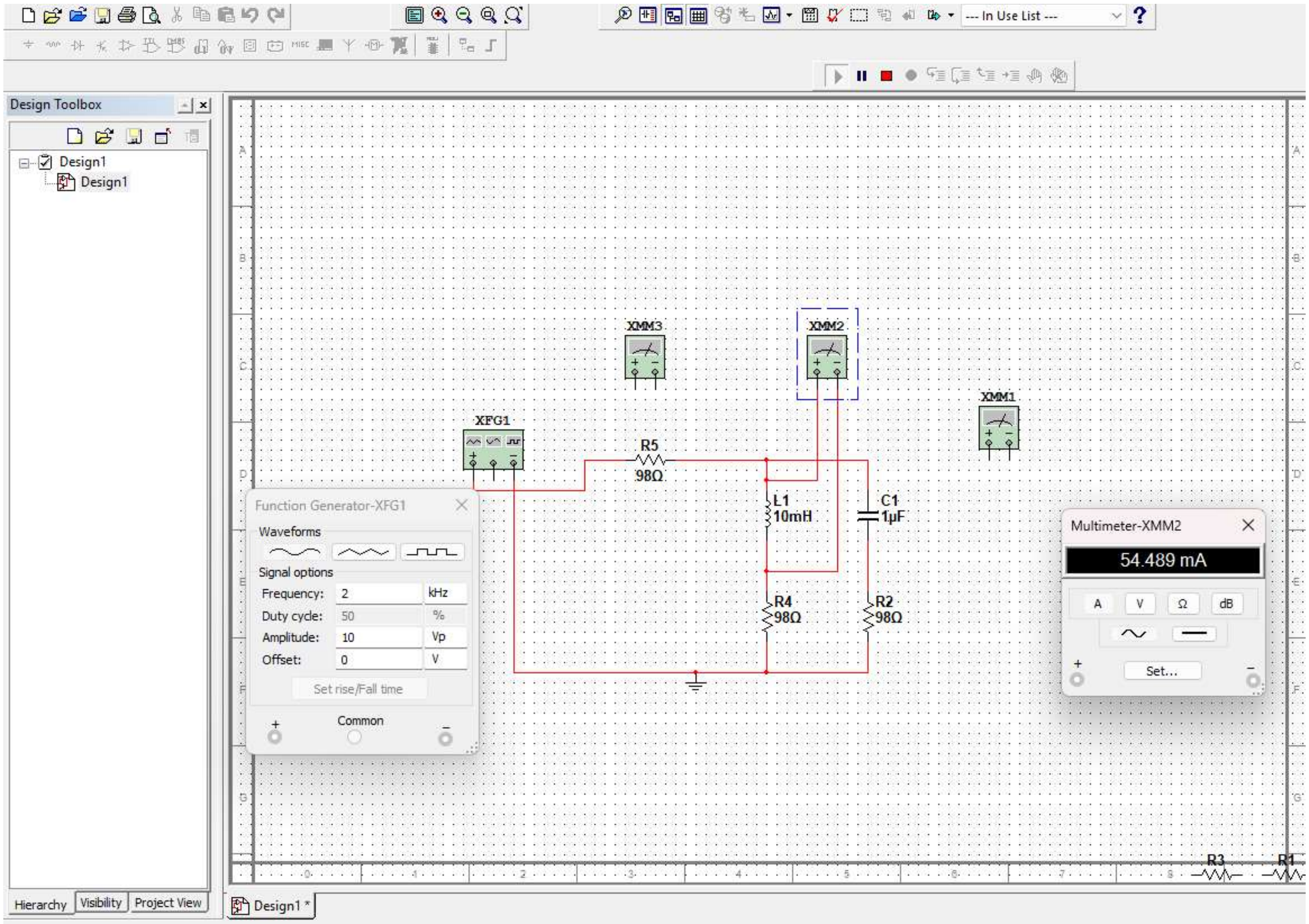
Design Toolbox
Design1
Design1
XMM3
XMM2
XMM1
XFG1
R5
98Ω
L1
10mH
C1
1µF
R4
98Ω
R2
98Ω
R3
Function Generator-XFG1
Waveforms
Signal options
Frequency: 1 kHz
Duty cycle: 50 %
Amplitude: 10 Vp
Offset: 0 V
Set rise/Fall time
Common
Multimeter-XMM2
62.243 mA
A V Ω dB
Set...
Hierarchy
Visibility
Project View
Design1 *

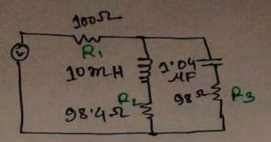
For 2 kHz



Design Toolbox
Design1
Design1
XMM3
XMM2
XMM1
XFG1
R5
98Ω
L1
10mH
C1
1μF
R4
98Ω
R2
98Ω
Multimeter-XMM1
59.46 mA
A
V
Ω
dB
Set...
Function Generator-XFG1
Waveforms
Signal options
Frequency: 2 kHz
Duty cycle: 50 %
Amplitude: 10 Vp
Offset: 0 V
Set rise/Fall time
Common
Hierarchy
Visibility
Project View
Design1 *


Design Toolbox
Design1
Design1
Hierarchy
Visibility
Project View
Design1 *
--- In Use List ---
XMM3
XMM2
XMM1
XFG1
R5
98Ω
L1
10mH
C1
1µF
R4
98Ω
R2
98Ω
R3
R1
Function Generator-XFG1
Waveforms
Signal options
Frequency: 2 kHz
Duty cycle: 50 %
Amplitude: 10 Vp
Offset: 0 V
Set rise/Fall time
Common
Multimeter-XMM2
54.489 mA
A
V
Ω
dB
Set...

4.Results and Data analysis:



$L = 10\,mH$

$C = 1.04\,\mu F$

$R_L = 98.4\,\Omega$

$R_S = 98\,\Omega$

$R_1 = 100\,\Omega$

$E = \frac{5}{2\sqrt{2}} = 1.768\,V$

$f = 1\,kH$

$f = 1\,kH$

$$X_L = 2\pi f L = 2 \times 3.1416 \times 10^3 \times 10 \times 10^{-3} = 62.832\,\Omega$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2 \times 3.1416 \times 10^3 \times 10^{-6} \times 1.04} = 153.03\,\Omega$$

$$Z_{RL} = 98.4 + 62.83j$$

$$Z_{RC} = 98 - 153.03j$$

$$Z_T = 100 + \left[\frac{Z_{RL} * Z_{RC}}{(Z_{RL} + Z_{RC})}\right] = 198.164 - 0.2363j = 198.164\angle -0.068^\circ$$

$$I = \frac{E}{Z_T} = 0.0089 + .0000106j = 0.0089\angle 0.0683^\circ$$

$$I_L = \frac{Z_{RC}}{(Z_{RL} + Z_{RC})} \times I = 0.006317 - 0.00405j = \cancel{7.50}\ 0.0075\angle -32.62^\circ$$

$$I_C = \frac{Z_{RL}}{(Z_{RL} + Z_{RC})} \times I = 0.0026 + 0.00405j = \cancel{428}\ 0.00481\angle 57.29^\circ$$

$$\therefore I_T = I_L + I_C = 0.0089 + \cancel{0.0010642}\ 0.0000106j = 0.0089\angle 0.0683^\circ$$

$f = 2\ kH$

$E = \frac{5}{2\sqrt{2}} = 1.768\ V$

$X_L = 2\pi f L = 125.663\ \Omega$

$X_C = 76.517\ \Omega$

$Z_{RL} = 98.4 + 125.663j$

$Z_{RC} = 98.0 - 76.517j$

$$Z_T = R_1 + \left(\frac{Z_{RL} \times Z_{RC}}{Z_{RL} + Z_{RC}}\right) = 198.017 - 0.16j$$

$$I = \frac{E}{Z_T} = 0.00893 + 0.00000721j$$

$$= 0.00893 \angle 0.046^\circ$$

$$I_L = \frac{Z_{RC}}{Z_{RL} + Z_{RC}} \times I = 0.00337 - 0.0043j$$

$$= 0.0055 \angle -51.98^\circ$$

$$I_C = \frac{Z_{RL}}{Z_{RL} + Z_{RC}} \times I = \cancel{7.034}\ 0.0056 + 0.0043j$$

$$= 0.0071 \angle 37.9^\circ$$

$$I_T = 0.00893 + 0.00000723j = 0.00893 \angle 0.046^\circ$$

From simulation for 1 kHz

Ic = 0.0052 and I_L=0.0062

From calculation for 1kHz

Ic = 0.0048 and I_L=0.0075

From simulation for 2 kHz
$I_c = 0.00595$ and $I_L=0.00544$

From calculation for 2kHz
$I_c = 0.0071$ and $I_L=0.0055$

5.Conclusion

- ✓ In this experiment, RC, RL, RLC series circuits were constructed.
- ✓ Input shape, frequency, wave shape was modified as required. I, VR, VL& VC were measured where necessary.
- ✓ The frequency input signal's value was adjusted several times. The obtained data was inserted into the table.
- ✓ The values obtained from simulation and calculation are almost similar.
- ✓ Relevant calculation was done using the experimental data. The analysis and verification were completed effectively.

If we apply KCL, I = IL + IC