American International University- Bangladesh
Faculty of Engineering (EEE)

EEE 1202: Introduction to Electrical Circuits Laboratory

Title: Analysis of RLC parallel circuit and verification of KCL in AC circuits.

Introduction:

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 I_L and I_C in a RLC parallel circuit.
- Draw the complete vector diagram for a RLC parallel circuit.
- Verification of KCL in AC circuits.

Theory:

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 R_T is simply $1/G_T$. 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 Z_T of the circuit is then $1/Y_T$; that is, for the network of Fig.

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

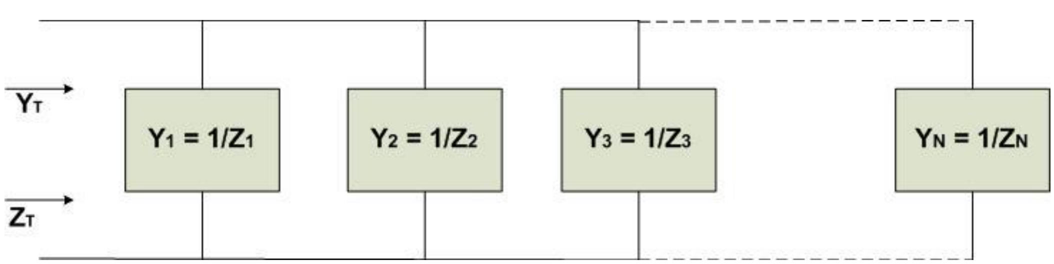

Fig. 1

Or, Since *Z = 1/Y*,

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

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, and

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

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

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

Note that 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 $B_C = \frac{1}{X_C}$ (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, θ_T is negative, whereas for capacitive networks, θ_T is positive.

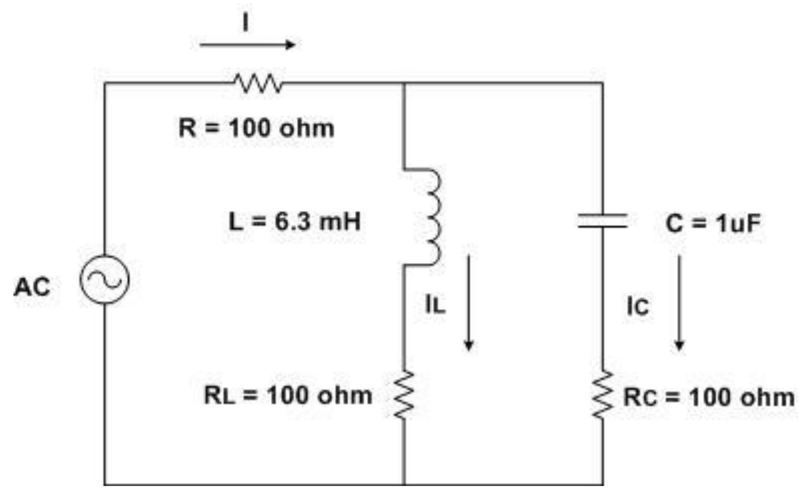

Fig. 2

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

Pre-Lab Homework:

Study the phase relation of the reactive elements and how to solve the complex impedance equations. Try to write the related equations and practice some mathematical problems to get clear idea. Observe the graphs related to parallel RLC circuit. Use PSIM to generate the output of the circuit provided in this lab sheet.

Apparatus:

- Oscilloscope
- Function generator
- Resistor: 100 Ω (3)
- Inductor: 6.3 mH
- Capacitor: 1μF
- Connecting wire.
- Bread board

Precautions:

1. Proceed according to figure understanding the connections and check initially, if all the other buttons in the inductor and capacitor box are in off position or not.
2. Operate the signal/function generator smoothly and connect the probes perfectly.
3. Calibrate the oscilloscope before connecting the channels across any components to ensure that there is no problem in the probes of oscilloscope.
4. Connect the components to the bread board smartly to ensure the connections.

Procedure:

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_L
2. Set the amplitude of the input signal 5V peak and the frequency at 1 kHz. Select sinusoidal wave shape.
3. Measure value of V_{RL} and I_L
4. Determine phase relationship between E and V_{RL} (i.e. θ_L)*
5. Now connect channel 2 of oscilloscope across R_C.
6. Determine phase relationship between the waves.
7. Measure value of V_{RC} and I_C
8. Determine phase relationship between E and V_{RC} (i.e. θ_C)*
9. Add I_L and I_C
10. Measure V_R and I connecting channel 2 across R
11. Compare I_L+I_C with practically obtained value of I.
12. Do the same work for setting input frequency 2 kHz and 4 kHz.

*Phase relation between two waves can be found by:

$$\theta = \frac{T_D}{T} \times 360^0$$

Where, T = Total horizontal divisions in the Time Period of waveform E, and T_D= Total horizontal divisions between two waveforms.

Data Table:

f	E	V_{RL} volts	$I_L=V_{RL}/R_L$ A	θ_L	V_{RC} volts	$I_C=V_{RC}/R_C$	θ_C	I_L+I_C A	V_R volts	$I=V_R/R$ A
1 kHz										
2 kHz										
4 kHz										

Results and Discussions:

If we apply KCL,

$$I = I_L + I_C$$

N.B: 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.

Report:

1. Complete Table~1.

2. Show E, I_L , I_C and I in vector diagram for 1kHz, 2kHz and 4kHz input frequency.

3. Verify KCL.

4. Comment on the role of frequency to θ_L and θ_C.

References:

1. R.M. Kerchner and G.F. Corcoran, "Alternating Current Circuits", John Wiley & Sons, Third Ed., New York, 1956.