American International University- Bangladesh

Department of Electrical and Electronic Engineering

COE 2102: Introduction to Electrical Circuits Laboratory

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

Theory and Methodology

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.1.

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

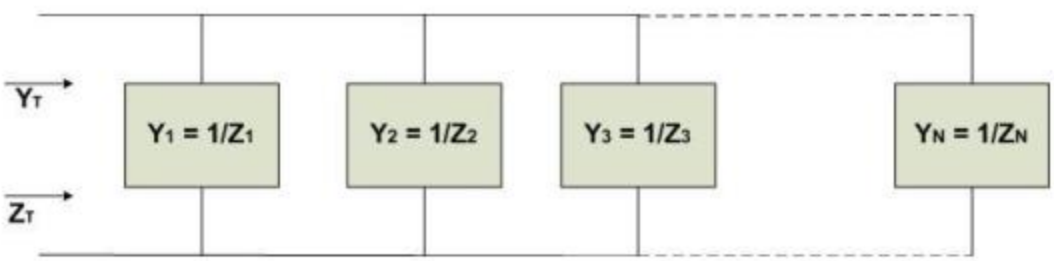

Fig.1: Parallel Branch Equivalent Admittance.

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, 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

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

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

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, θ_T is negative, whereas for capacitive networks, θ_T is positive.

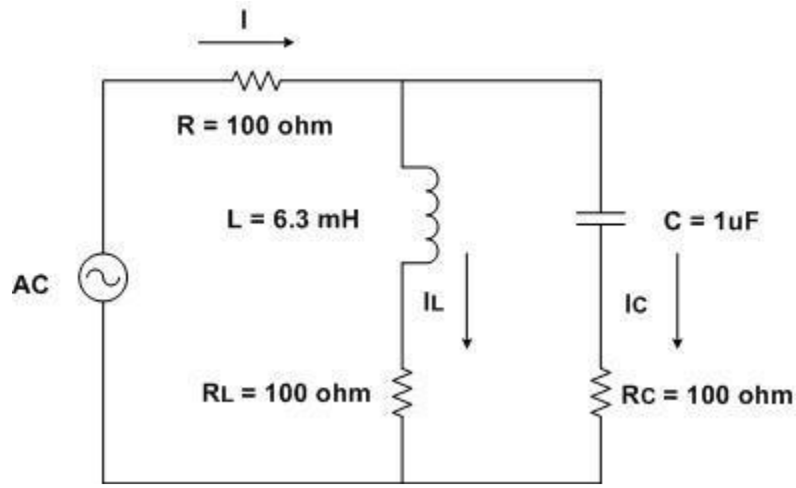

Fig. 2: Parallel Circuit KCL verification

The circuit of fig.2 represents a RLC parallel circuit where the Total Current I will divide into I_L and I_C in the parallel branches. If we apply KCL, $I = I_L + I_C$. Note that all currents need to be expressed as phasors for the calculation to be correct.

<u>Pre-Lab Homework:</u>

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 simulation software to generate the output of the circuit provided in this lab sheet.

<u>Apparatus:</u>

a) Oscilloscope

b) Function generator

c) Resistor: 100 Ω (3)

d) Inductor: 6.3 mH

e) Capacitor: 1µF

f) Connecting wire.

g) Bread board

Precautions:

1. We have proceeded according to figure understanding the connections and check initially.

2. Operated the signal/function generator smoothly and connected the probes perfectly.

3. Calibrate the oscilloscope before connecting the channels across any components and ensure that there was no problem in the probes of the oscilloscope.

4. Connected the components to the breadboard smartly to ensure the connections.

Procedure:

1. Constructed the circuit as shown in fig.1. Connected channel 1 of the oscilloscope across function generator and channel 2 of the oscilloscope across R_L.

2. We have set the amplitude of the input signal 5V peak and the frequency at 1 kHz and selected sinusoidal wave shape.

3. Measured the value of V_{RL} and I_L.

4. Determined phase relationship between E and V_{RL} (i.e., θ_L) *

5. Connected channel 2 of oscilloscope across R_C.

6. Measured value of V_{RC} and I_C.

7. Determined phase relationship between E and V_{RC} (i.e., θ_C) *

8. Add I_L and I_C as phasors.

10. Measured V_R and I_R connecting channel 2 across R.

11. Determined phase relationship between E and V_R (i.e., θ) *

12. Compared $I = I_L+I_C$ with the practically obtained value of I_R.

13. Did the same work for setting input frequency 2 kHz and 4 kHz.

Data Table:

Freq.(f) (kHz)	$I = \lvert I_L+I_C \rvert$ (A)	θ=angle of I (^{o})	I_R (A)	θ_R (^{o})	I_L (A)	θ_L (^{o})	I_C (A)	θ_C (^{o})
1								
2								
3								
4								
5								

Discussions:

i. In this experiment, RC, RL, RLC series circuits were constructed.
ii. Input shape, frequency, wave shape was modified as required. I, V_R, V_L& V_C were measured where necessary.
iii. The frequency input signal's value was adjusted several times. The obtained data was inserted into the table.
iv. Relevant calculation was done using the experimental data. The analysis and verification were completed effectively.
If we apply KCL, $I = I_L + I_C$

Reference(s):

1. Robert L. Boylestad," Introductory Circuit Analysis", Prentice Hall, 12th Edition, New York, 2010, ISBN 9780137146666.
2. R.M. Kerchner and G.F. Corcoran, "Alternating Current Circuits", John Wiley & Sons, Third Ed., New York, 1956.
3. Lamar University website, [Cited: 12.01.2014] Available: http://ee.lamar.edu/eelabs/elen2107/lab5.pdf
4. Lamar University website, [Cited: 12.01.2014]

   Available: http://ee.lamar.edu/eelabs/elen2107/lab6.pdf