AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH

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Assignment Title:	Analysis of RLC parallel circuit and verification of KCL in AC circuits.		
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Course Title:	Introduction to Electrical Circuits Laboratory		
Course Code:	COE2102	Section:	T
Semester:	FALL 2022-23	Course Teacher:	BISHWAJIT BANIK PATHIK

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	Marks Obtained	9
	Total Marks	

Abstract:

The experiment was conducted to analyze of RLC circuit and verified KCL in AC circuit. The objective of this experiment are to determine phase relation-ship between I_L and R_C in a RLC parallel circuit and verify the KCL in AC circuits. In this experiment, some basic tools like oscilloscope, Function generator resistor, inductor, capacitor, connecting wire, multimeter, bread board etc are used. By completing this experiment, we can develop the understanding of RLC circuit and verified KCL

Theory:

The definition of conductance (G) in dc circuit was 1/R. The conductance of each branch was then added to determine the overall conductance of a parallel circuit. Simply said, RT is equal to 1/GT. We define admittance (Y) in ac circuit as being equal to 1/Z. According to the SI system the unit of measurement for admission is the siemens, which is represented by the letter

5. A measure of an ac circuit's ability to a[illegible] or permit, current to flow, is called admitta[illegible] Therefore, for a given applied potential, a heavier circuit flow results from a bigger value. finding the sum of the parallel admittances is another method for determining the circuit's total admittance. The total impedance ZT of the circuit is then $1/Y_T$; that is, for the Network of fig-1.

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

since $Z = 1/Y$

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

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,

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

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

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

Note that for inductance, an increase in frequency or inductance will result in a decrease in susceptance or, correspondingly, in admittance.

For the capacitor,

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

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

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

For the capacitor, therefore, an increase in frequency or capacitance will result in an

~~de~~increase in susceptance or, correspondingly, in admittance.
for ~~th~~ any configuration (series, parallel, series-paparallel, 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.

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, $I = I_L + I_C$.

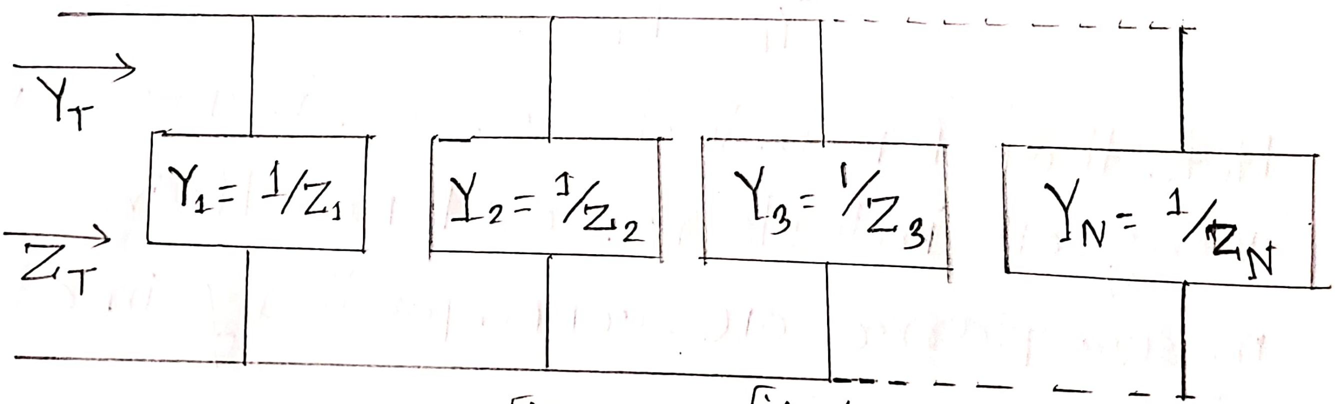

fig-1

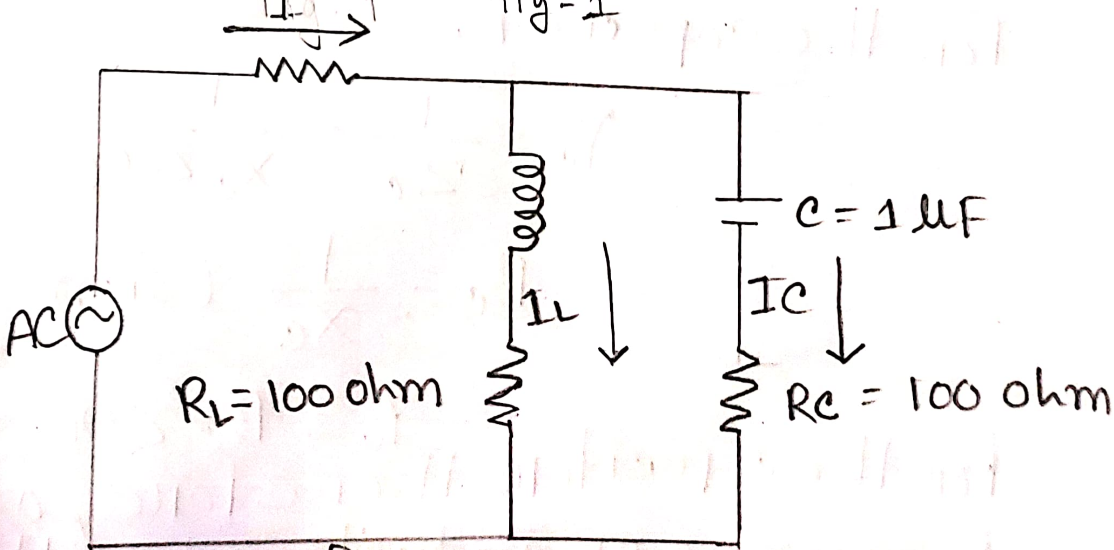

fig-2

Apparatus:

- Oscilloscope
- Function generator
- Resistor
- Inductor
- capacitor
- connecting wire.
- Bread board.

precautions:

- 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.
- Operate the signal/function generator smoothly and connect the probes perfectly.
- Calibrate the oscilloscope before connecting the channels across any components to ensure that there is no problem in the probes of oscilloscope
- connect the components to the bread board smartly to ensure the connections.

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
1KHz	2	414 mV × 0.707	2.93	54°	410 mV × 0.707	2.92	58.5°	5.85	920 × 0.707	6.54
5KHz	2	444 × 0.707	0.99	63.45°	400 × 0.707	2.85	17.1°	3.84	444 × 0.707	3.15
10KHz	2	140 × 0.707	0.99	5.85°	500 × 0.707	3.56	85.5°	4.55	500 × 0.707	3.56

Calculations:-

① For 1 KHz:

$f = 1KHz$

$V_R = (920 \times 0.707)\,mV$

$= 651.854\ mV = 0.65V$

$I_S = \dfrac{920 \times 0.707}{99.6}$

$= 6.54\,mA$

$V_{RL} = 414\ mV \times 0.707$

$= 0.41V \times 0.707$

$I_{RL} = \dfrac{1.99}{99.1} = 2.93\,mA$

$V_{RC} = 410\,mV \times 0.707$

$= 289.87\,mV$

$I_{RC} = \dfrac{289.87}{99.4} = 2.92\,mA$

$I_s = 6.54mA$

$I_{RL} + I_{RC} = 5.85mA$

L

$T = 8 \times 500 \mu s$

$dt = 1.2 \times 500 \mu s$

$$\theta_L = \frac{dt \times 360^\circ}{T}$$

$$= \frac{1.2 \times 500 \times 360}{8 \times 500}$$

$$= 54^\circ$$

C

$T = 8 \times 500 \mu s$

$dt = 1.3 \times 500 \mu s$

$$\theta_C = \frac{1.3 \times 360}{8}$$

$$= 58.5^\circ$$

(2) For 5 KHz

$f = 5KHz$

$V_R = 444 \times 0.707 mV$

$$I_R = \frac{444 \times 0.707}{99.6}$$

$$= 3.15mA$$

$V_{RL} = 140 \times 0.707 mV$

$$I_{RL} = \frac{140 \times 0.707}{99.1} = 0.99mA$$

$V_{RC} = 400mV \times 0.707$

$I_{RC} = \frac{400 \times 0.707}{99.4}$

$= 2.85 mA$

$I_R = 3.15 mA$

$I_{RC} + I_{RL} = 3.54 mA$

$\underline{\theta_L}$ $T = 8 \times 100 \mu s$

$t_d = 1.41 \times 100 \mu s$

$\theta_L = \frac{1.41 \times 360}{8}$

$= 63.45^\circ$

$\underline{\theta_C}$ $t_d = 0.38 \times 100 \mu s$

$\theta_C = \frac{0.38 \times 360}{8}$

$= 17.1^\circ$

(3) For 10 KHz

$f = 10 KHz$

$V_{RC} = 500 mV \times 0.707$

$I_{RC} = \frac{500 \times 0.707}{99.1}$

$= 3.56 mA$

$V_{RL} = 140 mV \times 0.707$

$I_{RL} = \frac{140 \times 0.707}{99.1} = 0.99 mA$

$V_R = 820mV \times 0.707$

$$I_R = \frac{820 \times 0.707}{99.6}$$

$= 5.82 mA$

$I_R = 5.82 mA$

$I_{RL} + I_{RC} = 4.55 mA$

$\underline{Q_C}$ $T = 8 \times 50 \mu s$

$t_d = 0.13 \times 50 \mu s$

$$\theta_C = \frac{0.13 \times 360^\circ}{8}$$

$= 5.85^\circ$

$\underline{Q_L}$ $t_d = 1.9 \times 50 \mu s$

$$\theta_L = \frac{1.9 \times 360}{8}$$

$= 85.5^\circ$

<u>Theoritically :</u>

① For, 1 KHz

$X_L = 2\pi f L$

$= 2 \times 3.1416 \times 1000 \times 20 \times 10^{-3}$

$= 125.664 \Omega$

② +√

$Z_s = 100\,\Omega$

$Z_c = (100 - j125.67)$

$Z_L = (100 + j125.664\,\Omega$

$$X_c = \frac{1}{2\pi f c}$$

$$= \frac{1}{2 \times 3.1416 \times 1000 \times 10^{-6}}$$

$$= 159.15\,\Omega$$

$$Z_{LC} = \frac{Z_L Z_c}{Z_L + Z_c}$$

$$= 50.01 - 62.83j$$

$$Z_T = Z_c + Z_{LC}$$

$$= 150.01 - 62.83j$$

$$I_s = \frac{E}{Z_T}$$

$$= \frac{2}{150.01 - 62.83j}$$

$$= 0.01 + 4.75 \times 10^{-3} A$$

$$V_{LC} = \frac{Z_{LC}}{Z_T} E$$

$$= 6.865 - 0.475j$$

$$I_L = \frac{V_{LC}}{R_c}$$

$$= \frac{0.865 - 0.475}{100} = 8.65 \times 10^{-3} - 4.75 \times 10^{-3} j$$

$$I_c = \frac{V_{LC}}{R_c}$$

$$= 8.65 \times 10^{-3} - 4.75 \times 10^{-3} j$$

② For 5KHz

$X_L = 2\pi f L$

$= 2 \times 3.1416 \times 5000 \times 20 \times 10^{-3}$

$= 628.32\,\Omega$

$X_C = \dfrac{1}{2\pi f C}$

$= \dfrac{1}{2 \times 3.1416 \times 1000 \times 10^{-6}}$

$= 31.83\,\Omega$

$Z_s = 100\,\Omega$

$Z_C = 100$

$Z_{LC} = \dfrac{Z_L Z_C}{Z_L + Z_C}$

$= 105.68 - 30.81j$

$Z_T = Z_R + Z_{LC}$

$= 205.68 - 30.80j$

$I = \dfrac{E}{Z_T}$

$= \dfrac{2}{205.68 - 30.80j}$

$= 9.51 \times 10^{-3} + 1.42 \times 10^{-3}$

$V_{LC} = \dfrac{Z_{LC}}{Z_T} \times E$

$= 1.04 - 0.14j$

$I_L = \dfrac{V_{LC}}{R_L}$

$= \dfrac{1.04 - 0.14j}{100}$

$= 0.011 - 1.43j$

$$I_C = \frac{V_{LC}}{R_C}$$

$$= \frac{1.04 - 0.14j}{100}$$

$$= 0.11 - 1.43j$$

(B) For 10KHz

$$X_L = 2\pi f L$$

$$= 2 \times 3.1416 \times 10000 \times 20 \times 10^{-3}$$

$$= 1256.64\,\Omega$$

$$X_C = \frac{1}{2\pi f C}$$

$$= \frac{1}{2 \times 3.1416 \times 1000 \times 10^{-6}}$$

$$= 0.0159\,\Omega$$

$$Z_R = 100\,\Omega$$

$$Z_C = 100 - 0.0159j$$

$$Z_L = 100 + 1256.64j$$

$$Z_{LC} = \frac{Z_L Z_C}{Z_L + Z_C}$$

$$= 98.76 + 7.74j$$

$$Z_T = Z_R + Z_{LC}$$

$$= 198.76 + 7.74j$$

$$I = \frac{E}{Z_T}$$

$$= \frac{2}{198.76 + 774j}$$

$$= 0.01 - 3.9 \times 10^{-4}j$$

$$V_{LC} = \frac{Z_{LC}}{Z_T} \times E$$

$$= 0.995 \times 0.039j$$

$$I_L = \frac{V_{LC}}{R_L}$$

$$= \frac{0.995 + 0.03j}{100}$$

$$= 9.95 \times 10^{-3} + 3 \times 10^{-4}j$$

$$I_C = 9.95 \times 10^{-3} + 3 \times 10^{-4}j$$

Result :

from the data table

for, 1 KHz,

$I_L + I_c = 5.85$ mA

$I_s = 6.54$ mA

$I_L + I_c \approx I_s$

for 5KHz,

$I_L + I_c = 3.84$ mA

$I_s = 3.15$ mA

$I_L + I_c \approx I_s$

for 10KHz,

$I_L + I_c = \cancel{5}4.55$ mA

$I_s = 3.56$ mA

$I_L + I_c \approx I_s$

for, All the frequency $I_L + I_c$ is almost close to I_s.

Discussion:

In this experiment, first of all we checked the Oscilloscope and if the probs were perfect we started calibration. Then we converted to the probe to the channel. In function generator and also right frequency in there. After doing all these things we got a value which was very close to our expected value.

Conclusion:

In this experiment we have analyazd RLC parallel circuit and verified KCL in AC circuit. ~~This was~~ The summation of I_L & I_C is almost equal to the I_S.. so the, Σentering current = Σusing current. The experiment was conducted sucessfully.

References:

1. R.M Kerchener and G.F. corcorn, "Alternating current circuits", John wiley & sons. Third Ed, New York., 1956.