

8. RLC Circuit

INTRODUCTION

The RLC circuit board is designed to be used with a PASCO Science Workshop 700 Series Computer Interface or 6500 Series Computer Interface to study the behaviors of resistors, inductors, and capacitors in AC circuit. The board includes several resistors, two capacitors, a miniature screw lamp, a bi-color light emitting diode, and an air-cone inductor. A steel rod can be used to increase the inductance of the coil.

THEORY

The voltages of the resistor, coil, and capacitor are as follows:

$$\left. \begin{aligned} V_R &= IR, \quad V_L = L \frac{dI}{dt}, \\ V_L &= L \frac{dI}{dt}, \\ V_C &= \frac{1}{C} \int_{t_1}^{t_2} I(t) dt. \end{aligned} \right\} \quad (1)$$

Let the current I be given as follows :

$$I(t) = I_0 \cos \omega t. \quad (2)$$

Then,

$$\left. \begin{aligned} V_R &= (I_0 R) \cos \omega t = V_R \cos \omega t, \\ V_L &= L \frac{dI}{dt} = L \frac{d}{dt} (I_0 \cos \omega t) = V_L \cos(\omega t + \frac{\pi}{2}) = I_0 X_L \cos(\omega t + \frac{\pi}{2}), \\ V_C &= (\frac{I_0}{\omega C}) \cos(\omega t - \frac{\pi}{2}) = V_C \cos(\omega t - \frac{\pi}{2}) = I_0 X_C \cos(\omega t - \frac{\pi}{2}), \end{aligned} \right\} \quad (3)$$

where $X_C = \frac{1}{\omega C}$ is capacitive reactance and $X_L = \omega L$ is inductive reactance.

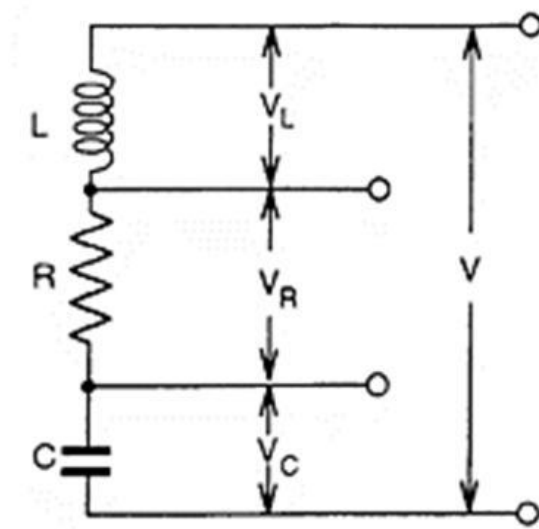


Fig. 1. R-L-C circuit.

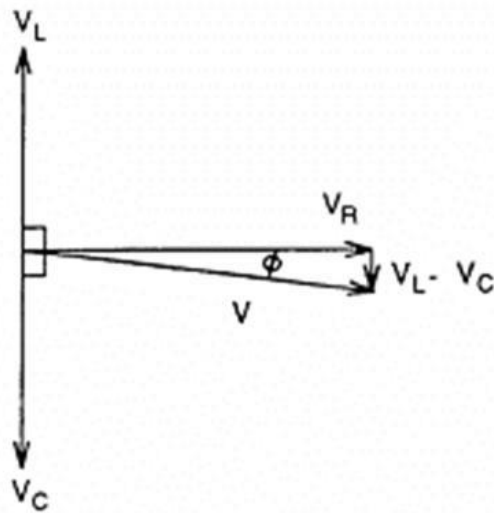


Fig. 2. Vector summation of voltages.

From the above figures, the maximum voltage of the circuit is as follows:

$$V = [V_R^2 + (V_L - V_C)^2]^{\frac{1}{2}} = I_0 Z = I_0 [R^2 + (X_L - X_C)^2]^{\frac{1}{2}}, \quad (4)$$

where $Z = [R^2 + (X_L - X_C)^2]^{\frac{1}{2}}$ is the impedance of the circuit.

The phase difference between V and V_R is as follows:

$$\tan \phi = \frac{V_L - V_C}{V_R} = \frac{IX_L - IX_C}{IR} = \frac{X_L - X_C}{R}. \quad (5)$$

PROCEDURE

I. R-L circuit

1. Create R-L circuit with the RLC Circuit board.
2. Measure V , V_R and V_L .
3. Measure I .
4. From the measurements, calculate the phase difference and the impedance of the circuit.
5. Repeat the procedure with other resistors.

II. R-C circuit

1. Create R-C Circuits with the Circuit board.
2. Measure V , V_R and V_C .
3. Measure I .
4. From the measurements, calculate the phase difference and the impedance of the circuit.
5. Repeat the procedure with other resistors.

III. R-L-C circuit

1. Create R-L-C circuit with the RLC Circuit board.
2. Measure V , V_R , V_C and V_L .
3. Measure I .
4. From the measurements, calculate the phase difference and the impedance of the circuit.
5. Repeat the procedure with other resistors.

QUIZ

What is the difference between the measured values from the circuits and the original signal?