3-2022

Experiment 2.08: Series RLC ac-Circuit

Diego Castano

Victor Castro

I. EXPERIMENT 2.08: SERIES RLC AC-CIRCUIT

A. Abstract

A coil with unknown inductance and internal resistance is connected in series with a known capacitance in an ac-circuit. The current in the circuit is monitored as the driving frequency is varied. The maximum current is obtained at resonance.

B. Formulas

$$\Delta V_S = IZ\left(f_0\right) = I_0 R \tag{1}$$

$$4\pi^2 f_0^2 = \frac{1}{LC} \tag{2}$$

where these equations are relevant to a series RLC ac-circuit with capacitor (of known capacitance C) and a coil with internal resistance R and inductance L and where f_0 is the resonant frequency.

C. Description and Background

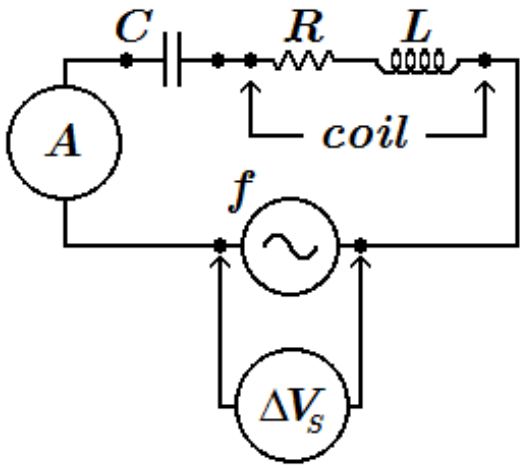

FIG. 1. RLC circuit set-up for the experiment.

The rms current in an LRC series circuit (Fig. 1) is given by

$$I = \frac{\Delta V_S}{Z} = \frac{\Delta V_S}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}} \tag{3}$$

where $\omega = 2\pi f$ is the angular frequency of the ac source. Because the reactance of inductors and capacitors depends on f, the current in an LRC circuit also depends on frequency. A graph of I *versus* f is shown in Fig. 2 for particular values of R, L, and C. For smaller values of resistance, the resonance peak will be higher and sharper.

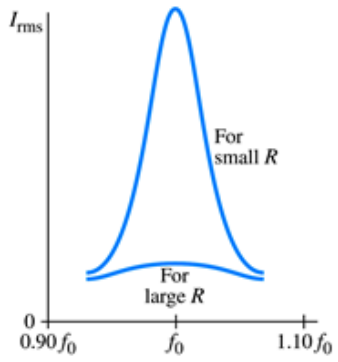

FIG. 2. I *versus* f.

From Eq. (3) we see that the current will be maximum at an angular frequency, f_0, that satisfies Eq. (2). Thus, when the source frequency matches f_0 the circuit is said to be in resonance, and f_0 is called the resonant frequency. At this frequency, the impedance is purely resistive, $Z = R$. And so, from Eq. (3), the voltage from the source would be given by Eq. (1).

D. Procedure

1. Set up the circuit in the figure on the next page.

2. Make sure the ammeter is set to measure ac current in the milli-Amp range. Turn on the sine wave generator and adjust the starting frequency to $f = 40\ Hz$. Set the voltage to $\Delta V_S = 5\ Volts$. and record the resulting current.

3. Repeat this procedure for increasing frequencies as tabulated below.

E. Measurements

ΔV_S [$Volts$]	
rated capacitance, C [μF]	

f [Hz]	I [mA]
40	
45	
50	
55	
60	
65	
70	
75	
80	
85	
90	
95	
100	

F. Instructions

1. Use the excel file, **RLCPlot.xlsx**, to plot I *vs.* f, and determine the resonant frequency, f_0, and current, I_0, from the graph.

2. Use Eqs. (1) and (2) to determine the internal resistance, R, and inductance, L, of the coil.

3. Submit your I *vs.* f graph.

G. Calculations

resonant frequency, f_0 [Hz]	
resonant current, I_0 [mA]	
internal coil resistance, R [Ω]	
internal coil inductance, L [mH]	