Inductance; Resonance of LCR Circuit

TOPICS AND FILES

EM Topics

LRC circuit and alternating current

DataStudio file

72 LRC Circuit.ds

EQUIPMENT LIST

Qty	Items	Part Numbers
1	PASCO 750 Interface	
1	Voltage Sensor	CI-6503
1	AC/DC Electronics Laboratory	EM-8656
2	Banana Plug Patch Cord	SE-9750 or SE-9751

INTRODUCTION

The purpose of this activity is to study resonance in an inductor-resistor-capacitor circuit (LRC circuit) by examining the current through the circuit as a function of the frequency of the applied voltage and determine what happens to the amplitude of the current in the LRC circuit when the frequency of the applied voltage is at or near the resonant frequency of the circuit. The 'OUTPUT' feature of the PASCO 750 Interface will be used to apply voltage to the circuit and the Voltage Sensor and *DataStudio* will be used to measure the voltage across the resistor in the circuit as the frequency of the voltage is changed. The voltage measured across the resistor is related to the current through the resistor by $I = \frac{V_R}{R}$. This activity will also investigate the phase relationship between the applied voltage and the resistor voltage as you vary the frequency.

BACKGROUND

When a vibrating mechanical system is set in motion, it vibrates at its natural frequency. However, a mechanical system can be forced to vibrate at a different frequency. The amplitude of vibration, and hence the energy transferred to the system, depends on the difference between the natural frequency and the frequency of forced vibration. The amplitude becomes very large when the difference between the natural and forced frequency becomes very small. This is known as resonance and the natural frequency of the system is sometimes called the resonant frequency. At resonance, relatively little energy is required to get a large amplitude. One example of resonance is when a singer's amplified voice is used to shatter a glass.

Electrical resonance is analogous to mechanical resonance. The energy transferred to a system is a maximum at resonance.

The amplitude of the AC current (I_o) in a series LRC circuit is dependent on the amplitude of the applied voltage (V_o) and the impedance (Z).

$$I_o = \frac{V_o}{Z} \tag{1}$$

Since the impedance depends on frequency,

$$Z = \sqrt{(X_L - X_C)^2 + R^2} \tag{2}$$

where X_L = inductive reactance = ωL, X_C = capacitive reactance = $\frac{1}{\omega C}$, R = resistance, and ω = angular frequency = $2\pi f$ (f = linear frequency), the current also varies with frequency. The current will be maximum when the circuit is driven at its resonant frequency:

$$\omega_{\text{res}} = \frac{1}{\sqrt{LC}} \tag{3}$$

One can show that, at resonance, $X_L = X_C$ and thus the impedance (Z) is reduced to R. At resonance, the impedance is the lowest value possible and the current will be the largest value possible.

