LC Circuits and Radio Tuners

Introduction

In this activity we will learn how a radio tuning circuit works by investigating a circuit consisting of an inductor and a capacitor – an *LC* circuit.

When you finish this activity you should be able to

- describe the properties of an LC circuit
- describe resonance in an LC circuit
- describe why an LC circuit can be used as a radio tuner

Procedure 1 – *LC* circuit

Open the PhET "Circuit Construction Kit (AC +DC)."

1. Build a circuit that has a battery, a capacitor and a switch. What do you observe about the capacitor when you close the switch?

2. Right click on the capacitor and choose "change capacitance." Move the slider to vary the capacitance. As the capacitance increases what changes do you observe?

3. Set the capacitor at 0.09 Farad. Carefully disconnect the battery from the circuit and build a new circuit with the charged capacitor (still at 0.09 Farad) and an inductor set at 10 Henrys—no battery. Bring the Current Chart to your circuit and place the detector over a wire. You may have to adjust the +/- buttons for a good reading. Use the stopwatch to determine the time for one complete cycle. To minimize starting and stopping error you should measure for several cycles and divided appropriately to find the time for one cycle. Recall that the time for one cycle is called the period and the frequency is equal to 1/period. Record the values for *capacitance, inductance, period and frequency*

4. According to theory, the natural frequency, *f,* of this oscillating circuit is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

   Does your value in part 3 agree with this?

5. Repeat the last two steps for two other values for capacitance.

Procedure 2 – Resonance: If this circuit is "hit" at its natural frequency, it will *resonate,* that is, it will oscillate with a large current.

Add an AC power supply to your circuit.

6. Set the capacitance to C = 0.09 Farad and the inductance to L = 10 Henrys. Right click the power source and set its frequency to a value that is *not* the natural frequency of this circuit. Wait at least a *minute* and describe your observations.

7. Open the switch and reset the AC frequency so that it is equal to the natural frequency of the circuit. Wait at least a *minute* and describe your observations pointing out any similarities or differences with part A. (You may find that the current gets so large that parts of the circuit begin to burn. In a real circuit there would be enough resistance to prevent this.)

8. Repeat these steps for the other two sets of values of L and C that you used in Procedure 1.

Radio Tuners

In a radio tuner resonance is produced by an incoming electromagnetic wave rather than an AC voltage source. The tuner circuit consists of an inductor (inductance coil) and a variable capacitor. Changing the station changes the value of the capacitance. Each radio station transmits electromagnetic waves at a particular frequency and all of these frequencies from the various stations reach the antenna of your radio. Only the frequency corresponding to the natural frequency of the tuner circuit will produce a large enough current to be picked up and then amplified.

An FM radio tuner is set to receive a station. The tuner has a 1.4 microHenry ($1\mu H = 1 \times 10^{-6}$ H) inductance coil and a variable capacitor that is set to 1.8 picoFarad ($1pF = 1 \times 10^{-12}$ Farad). What is the frequency of the waves emitted by this station?
(Hint: FM stations broadcast from 87.5MHz to 107.5 MHz. Recall that $1MHz = 1 \times 10^{6}$ Hz.)

In conclusion…

Summarize what you learned from this activity by:

a. listing the key scientific terms encountered in the activity.
b. constructing a bulleted list that utilizes these key words (and, as needed, words from previous activities) in summarizing what you learned.