

**University of Utah**  
**Electrical & Computer Engineering Department**  
ECE 2210/2200 Lab 6  
**Resonance**

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### Objectives

- 1.) Observe, measure and plot the resonance of a series RLC circuit.
- 2.) Observe the effect of R on the “Q”. Observe the resonance of a parallel RLC circuit.
- 3.) Observe oscillation and resonance in the servo system.

### Parts: (Parts in **bold** are new to this lab)

- 100 (brn,blk,brn), 390 (org,wht,brn) and 2 k $\Omega$  (red,blk,red) resistors
- **0.001  $\mu$ F capacitor** (typ. marked 102)
- **Inductor**, 2 to 4 mH (ask for a 3.3 mH blue plastic cylinder marked “●332” or 2.8mH marked “LH233”)

### Equipment and materials from stockroom:

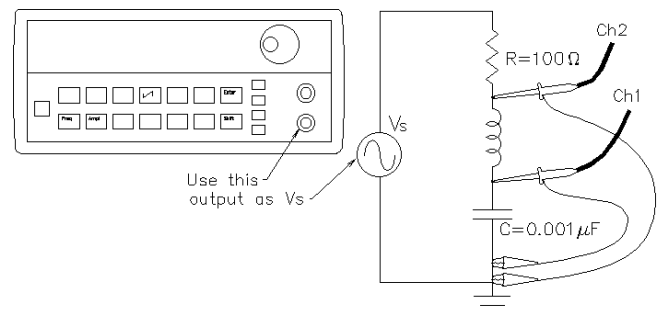
- Servo
- From the post in the lab: 2 10X Oscilloscope probes (If they have switches, make sure they’re set to 10X)

### Inductor Resistance

Measure the resistance of your inductor with an ohmmeter. Ideally this should be 0  $\Omega$ , although you will measure some (hopefully small) value.

### Series RLC Circuit

Construct the circuit shown. Use the A1 button and the “Probe” softkey to let the scope you are using a 10x probe. Turn on channel 2 and repeat.

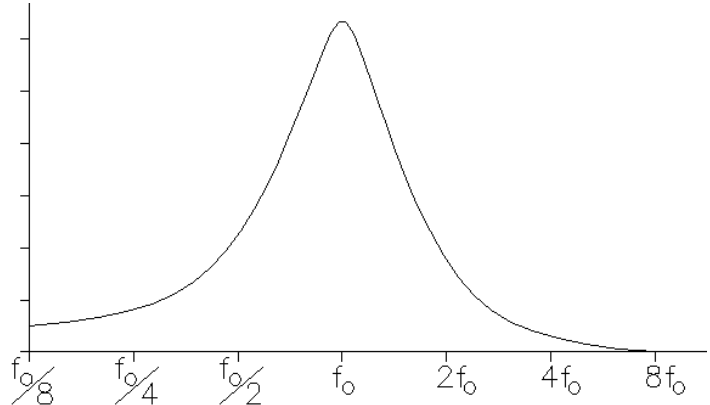


**Find resonance:** Compute the resonant frequency ( $f_0$  in Hz or kHz) of your capacitor and inductor combination (calculated value). Set the function generator to this frequency. Now vary the frequency up and down while looking at  $v_c$  on the scope. The frequency where  $v_c$  is at its maximum is the actual resonant frequency ( $f_0$ ) of your circuit. This can be a little tricky to find with the 33120A because the knob adjusts one digit at a time. To find the true maximum, use the right-arrow button to adjust the lower digits. When you find the frequency where  $v_c$  is greatest, record the frequency shown on the function-generator. Compare the actual  $f_0$  to your calculated  $f_0$  value.



**Plot freq. response:** Take enough measurements of the CH1 and CH2 voltages to plot them both as a function of frequency from  $f_0/8$  to  $8f_0$ . Generally, when a value is plotted as a

function of frequency, the frequency is plotted on a log scale, it makes your curves look much more symmetric. You may have done this before by plotting 100Hz, 300Hz, 1kHz, 3kHz,... measurements on an evenly divided scale. Another simple way to do this is to take and plot your measurements by factors of two. Divide your horizontal axis into six divisions (seven marks). Label the center mark with the nearest whole number to  $f_0$ . Double the frequency for each mark to the right and halve the frequency for each mark to the left. This way the left-most mark will be about  $f_0/8$  and the right-most will be about  $8f_0$ . Wah-lah..., A simple log scale.



Move CH2 of the scope to measure  $v_s$  (other side of the resistor). Tune your circuit to  $f_0$ . Find the ratio of  $v_c/v_s$ . How can this be greater than 1? Explain.

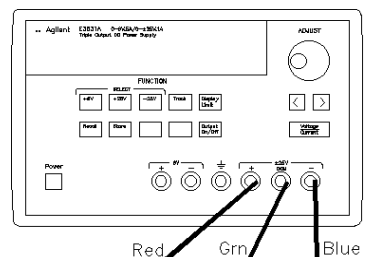
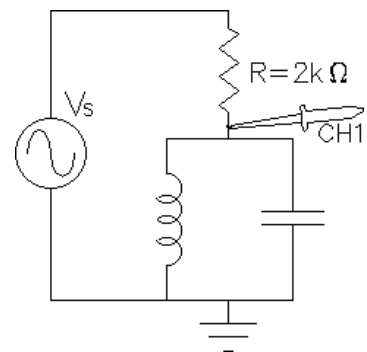
**Phases:** Adjust the function generator up and down around the resonant frequency while you observe the phase relationship between the two traces. Explain or sketch what you see. Explain why this makes sense. Think in terms of the inductor and capacitor impedances. Which one dominates above the resonant frequency and which one dominates below the resonant frequency? The dominant one will determine the phase of the current in the circuit.

**Different resistor:** Replace the 100  $\Omega$  resistor with a 390  $\Omega$  resistor. Connect CH2 of the scope back to where it was. Take measurements to make the same type of plots as you made before. You may want to plot these on the same horizontal axis, but be sure that all your plotted lines are clearly labeled.

**Q:** Resonant circuits are also characterized by a factor known as the “quality” or “Q” of the circuit. The higher the Q value the sharper the resonant peaks and valleys. Judging by your plots, which of your two circuits has the higher Q? Usually the Q is inversely related to the resistance in the circuit. Comment in your notebook.

### Parallel RLC Circuit

Construct the circuit shown at right, using the same components. Experimentally find the resonant frequency ( $f_0$ ) of this circuit. Is it the same as that of the series circuit? How is resonance different in this circuit? Reset the scope triggering from EXT to INT.



### Oscillation and Resonance of the Servo

Turn off the power switch on the servo and hook it up to the

power supply. Adjust the power supply to provide  $\pm 6V$  as you did in the first lab. If you've forgotten how to do this, refer back to the lab handout for lab 1. Turn on the power switch on the servo and make sure that it is functioning properly. Remember, to comment in your lab notebook that you hooked power to the servo and made sure it was still working.

Hook the scope probe ground clip to the servo ground (the green banana jack where the power supply is connected). Hook the scope probe up to the center wire of the "Motor Position Sensor" potentiometer (yello wire). Remark in your notebook that you hooked the scope up to the "Motor Position" signal.

Set the "Input Position" potentiometer to about center position. Turn up the "Gain" (CW) as far as it will go. If the servo doesn't begin to oscillate on its own, make a slight adjustment to the "Input Position" potentiometer and it should start. If it still doesn't oscillate, turn off the power and adjust the rubber link between the mechanics and the "Motor Position Sensor" to get less friction in the gears. Once you get your servo to oscillate, describe what is happening in your notebook. Adjust the scope to get a repeating trace if you can. Otherwise, hit the "Run/Stop" key to freeze the trace. Find the period and frequency of oscillation.

Now slowly turn down the gain until the oscillations stop. Leave the gain at this "barely stable" position. Hook a BNC-to-BNC cable from the function generator to the servo "SIGNAL" input. Turn on the function generator and adjust the amplitude to show 500mVpp (actual output will be 1Vpp). Listen to the servo motor. Is it trying to move back and forth 1000 times per second? It's not moving very far, is it? Why can't the mechanical system keep up?

Hit the "Run/Stop" key on the scope again if necessary to unfreeze the trace. Turn down the frequency until you get significant movement. Adjust the function generator mVpp to a lower value, say 200mVpp. Lower the frequency farther and try to find a resonance. (You may have to lower the mVpp again to keep the scope trace looking decent. Find the resonant frequency of the servo (where the output is the greatest). Be careful, there may be more than one peak. This seems to be caused by strange dynamics of the rubber link between the mechanics and the "Motor Position Sensor". Make sure that you are on the are biggest peak for true resonance. How does this frequency compare to the natural oscillation frequency that you found earlier? It should be pretty close (but I have to admit, the servos are not very accurate and few people get this resonance to match the oscillation frequency).

**Conclude**  
As always,  
check off  
and write a  
conclusion.

