Preliminary data plots due Wed, 11/14/10; Report due Friday 11/16/10 Upload to BB 11pm.

Series LRC Harmonic Response Laboratory

HARMONIC RESPONSE: Measure the circuit's response to a harmonic voltage input.

Measure the current in a series LRC circuit to a sinusoidal voltage input at a series of frequencies about the resonance frequency. For each voltage applied, note the frequency and amplitude. It doesn't matter if the amplitude changes a few percent because you'll take a ratio, anyway. Measure the current in the circuit (how will you do this with only a voltmeter – the oscilloscope?) Note the output current frequency, amplitude, and time shift (could be behind or ahead of the driving voltage, and you have to think carefully about this!). Record your data in efficient tabular form with data labeled clearly. From your data, determine the complex admittance of the LRC circuit as a function of frequency, in the amplitude/phase form. Estimate the quality factor Q and the resonance frequency ω_1 from the admittance data. Compare it to the quantities calculated from the model discussed (or to be discussed!) in class.

Lab hints: • There must be one person taking PH411 in each group. • Make sure the resistor has one side connected to the common ground of the function generator and of the oscilloscope. This is a practical matter, because ground loops cause signal instability. • The function generator has its own impedance that we'd like to be able to neglect. This is best accomplished if both the "attenuation" buttons are enabled. You should be able to achieve a driving voltage of 50 – 100mV. • The C, R values can be independently measured with the LCR meter supplied, but the inductance is trickier. It's frequency dependent and even a bit dependent on signal size. You should extract the value from the data, (approximately 120 – 190 mH near 1kHz and 100 mV) • Get a feel for the system response over the whole frequency range before starting to write down results. You must know what frequency range to explore, and how closely spaced your points should be. About 10 readings should be enough, with more clustered near the resonance where the response changes faster. • Make a quick consistency check with the model BEFORE you start writing up. You may need more data than you originally thought. • See last page for quick overview of oscilloscope.

On WEDNESDAY in class, you must bring a plot of the response of your series LRC circuit (amplitude and phase) as a function of frequency. This lab is an integral part of the course, so you need you data to discuss in class. Upload 1 copy to BB, and bring another to class.

Report:

This week's lab involves measuring the response of a series LRC circuit to sinusoidal driving voltages of various frequencies. Describe the experimental setup, present the data, analyze it, and compare it to the model.

This series of questions will help you to work through the model that you'll present in your lab writeup:

(a) Abstract

What was the result and significance of your experiment? (write this last).

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(b) Experimental set up:

Provide brief description of what you did. At minimum, you should present a circuit diagram and the values of L, R, C, and a schematic of the oscilloscope traces for interesting cases with clear labels.

(c) Results: Present the raw data in tabular form. Obtain the amplitude and phase of the circuit admittance (inverse of impedance) from your data. Present graphically. Calculate the Q value for your circuit from the resonance frequency and the width of the resonance. Remember that Dw is the FWHM of the power response curve, which corresponds to the difference in frequency between the $\frac{1}{\sqrt{2}}x_{max}$ points of the displacement response curve.

(d) Model: Derive the current response (amplitude and phase) of the series LRC circuit to sinusoidal driving voltages of various frequencies. Plot amplitude and phase as a function of frequency. You may find it a good idea to relegate parts of the calculation to an appendix, but include enough in the body of the report that the text flows smoothly.

(c) Discussion: Compare your experimental results quantitatively to the circuit model displaying your data clearly on a plot. What is the lesson from this lab? How might these results from the circuit lab be generalizable to other situations?

(e) PH521 and challenge for Ph41: measure the voltage across the capacitor and discuss the circuit response in terms of charge.

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Quick overview of Rigol Oscilloscope:

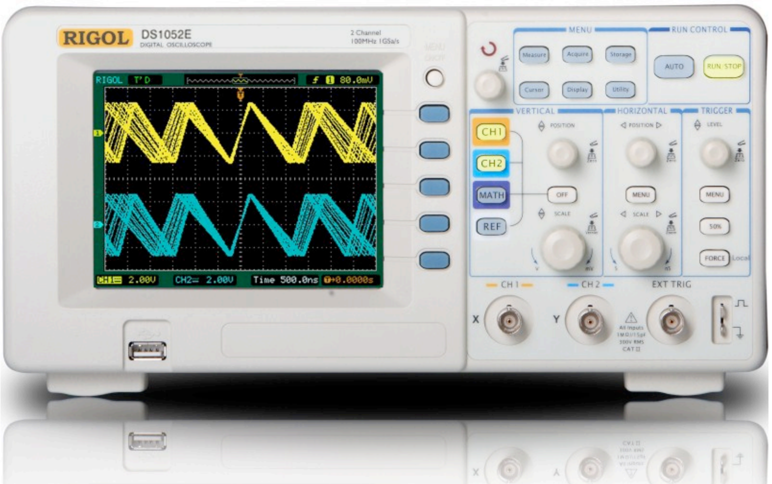

Image from: http://www.rigolna.com/ds1052e/

Menu on/off button (round white at top) toggles display of menu.
When menu displays on screen, blue rectangular buttons access corresponding sub-menus.

Alter settings in submenu with rotating knob – push knob to set. 

Vertical scale: 2 input channels, toggle Ch1 switch to show (lighted) or not show (not lighted) trace (Also Ch2). If both on (lighted button), pressing Ch1 makes scale knob change Ch1 scale, pressing Ch2 makes scale knob change Ch2 scale.
Horizontal Time base: 1 ms/div is a good starting point for this experiment (100- 5,000 Hz)
Trigger: External (from function generator) is best for this experiment.

MENUS:

Acquire: Average 8 measurements keep signal stable (Normal is a bit noisy)
Cursor: Track mode gives 2 cursors, A and B. Set cursor A to track one channel and cursor B to track the other. Tack mode automatically produces a menu that gives positions of cursors and difference between them. Use this to measure distances between peaks.
Measure: Set function generator channel (usually Ch1) to measure $V_{peak-peak}$ and frequency. Set resistor voltage signal channel (usually Ch2) to measure $V_{peak-peak}$.

 **USB:** Bring USB drive to collect data.