Preliminary data plots due Wednesday, 10/06/10; Prelim report due Friday 10/08/10; Final report due Wed 10/26/10.

Series LRC Harmonic Response Laboratory

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

Measure the current response (via the voltage across the resistor) of the series LRC circuit to a sinusoidal voltage input at a series of frequencies about the resonance frequency. For each voltage input (vary frequency but keep amplitude constant), note the output current frequency, output current time lag (could be behind or ahead of the driving voltage), and applied voltage amplitude and output current amplitudes. 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: • 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 a value of 140mH for the inductor is more appropriate for your frequency range. • 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. Note that you should have more data points in the range where the response changes more rapidly with frequency. 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.

VERY IMPORTANT: 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. As before, bring two copies, one with your name for the instructors (10/100 points for an honest attempt at completion of this assignment), another with a number for your classmates to help with. This time we will be focusing on the content more – you must be sure your plots are well-presented, otherwise your peers won't be able to read them.

More guidance on report content:

This week's lab involves measuring the response of a series LRC circuit to sinusoidal driving voltages of various frequencies. As you did last week, you should describe the

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experimental setup, present the data, analyze it. Now you'll also present the model that you compare to the measurements. Can you extract useful circuit parameters, like β or Q ? This series of questions will help you to work through the model that you'll present in your lab writeup:

(a) Provide a circuit diagram and the values of L, R, C, and a schematic of the oscilloscope traces with clear labels.

(b) <u>Derive</u> 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. Usually, a circuit response is characterized by an "admittance" (reciprocal of impedance), which measures the ratio of the current to the voltage.

(c) Compare your experimental results quantitatively to the circuit model displaying your data clearly on a plot.

(d) Calculate the Q value for your circuit from the resonance frequency and the width of the resonance. Remember that $\Delta\omega$ 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.

[(e) Challenge: measure the voltage across the capacitor and discuss the circuit response in terms of charge. (Be careful about circuit grounds in this measurement).]