Physics 4700 Experiment 2

R-L-C Circuits

Total number of plots: 2 + 4. Show all formulas used in the theoretical predictions.

The black terminals of your cables connected to the signal generator and scope are both connected to ground. If the two black terminals are connected to two different points in the circuit, both points will be at the same potential, i.e. ground. Therefore make sure that the scope ground and the signal generator ground are connected to the same point in the circuit for any measurement. Use one channel on the scope to measure input voltage and the other for the voltage across the device of interest simultaneously.

1) Design and construct either a high or low pass RC filter with a minimum impedance between 5 kΩ and 50 kΩ and a 3 dB point of about 600 Hz (Hint: at what frequency the impedance is minimum?).

Measure the frequency response (i.e. voltage gain and output voltage phase shift relative to the input voltage) of the filter you built in part 1) to a sine wave. Make measurements over the frequency range 10 Hz-100 kHz (or as high as you can go). Plot the measurements with the theoretical expectations superimposed on the **same** plots. Use a **Bode** plot for the voltage gain.

2) Design and construct an LRC series circuit with a resonant frequency between 1 kHz and 10 kHz and a Q between 1 and 10. Choose a resistor with resistance of less than 100 Ω.

Measure the frequency response of the circuit built in part 2) to a sine wave. Measure V_R, V_C and V_L as the frequency is varied from 10 Hz to 100 kHz. Measure the phase relationship between R and the voltage source. Measure the Q of the circuit using the half power points and the resonant frequency ω_o.

a) Plot the measurements with the theoretical expectations superimposed on the same plots. How are your measurements compare with the theoretical calculations. Use **Bode** plots for all gain measurements.

b) Measure the internal resistance of the inductor using a multimeter. Draw a new circuit diagram that includes an internal resistor in series with the inductor. Why the internal resistor is treated as in series instead of parallel to the inductor? (Hint: consider the behavior of an inductor at high frequency.) Derive the new formulas for the voltage gains and phase shift using complex numbers but the final formulas must be presented as real numbers in the lab report since the scope measures real numbers. Superimpose the new predictions on the **same** plots. How are your measurements compare with the new calculations.

Some useful readings:

- a) Diefenderfer pages 27-34, 48-50.
- b) Hayes and Horowitz lab manual pages 32-50.
- c) Horowitz and Hill pages 29-44.

Advanced experiments (10 points)

Calculate and measure the response of the circuit built in part 1) to a rectangular voltage pulse. Vary the pulse width (include the case where RC is close to the pulse width) and capture the response of the circuit (i.e. output voltage) (see the instruction on a separate handout). Under what conditions does your circuit integrate or differentiate the input pulse?