THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical and Computer Engineering

ELEC 391 – Electrical Engineering Design Studio II

Lab Assignment 4 – Capacitors and Inductors

1 Objectives

This lab consists of free-form experiments that explore the issues associated with designing, constructing and measuring the response of capacitors and inductors. During these experiments, you and your group will:

- Use an RCL meter to measure the capacitance of a commercially-built variable capacitor and report the variation in capacitance with rotation angle,
- Use an RCL meter to measure assorted capacitors and assorted inductors, each of nominally equal value, and report the variability of the result,
- Devise and test a scheme for measuring the permeability of a ferrite rod or core,
- Design a resonant circuit with a reasonably high value of Q that will cover the AM broadcast band – 535 – 1705 kHz,
- Design, implement and measure the response of a ferrite core inductor and ferrite rod inductor suitable for use in such a resonant circuit, and,
- Demonstrate the function and operation of such a resonant circuit.

2 Lab Preparation

Before the lab session, please perform the following tasks *on your own* and submit the answers to your teaching assistant at the beginning of the lab session. Although the pre-lab assignments will not be formally marked, they will be checked for completeness and correctness and will be considered when your mark for the lab assignments are assigned.

2.1 Fluke PM6303A Video Tutorial(s)

Watch the short (2:15) YouTube tutorial entitled, “The RLC Meter, Measuring Inductance and Capacitance” at

https://www.youtube.com/watch?v=BYjNkWE2v2E

which features the PM6303A Automatic RCL meter that you will use in the lab.

Optional: Watch the long (26:51) YouTube tutorial entitled, "TSP #73 - Teardown and Repair of a Fluke PM6303A Automatic RCL Meter" at

https://www.youtube.com/watch?v=vd9VdphNst4 .

Two copies of the complete operating manual are available in MCLD 322 on the bench next to the units.

2.2 Fluke Application Note - Flexible RCL testing under actual operating conditions

Review the Fluke Application Note entitled, "Fluke Application Note - Flexible RCL testing under actual operating conditions." Although the application note suggests the desirability of measuring resistance, inductance and capacitance at frequencies other than 1 kHz, our PM6303A can only conduct such measurements at 1 kHz.

Answer the following review questions:

1. Draw the equivalent circuit of a chip resistor. What determines the values of the parasitic capacitance and inductance?
2. What are two classes of ceramic capacitors?
3. Draw the equivalent circuit of a chip capacitor. What determines the values of the parasitic resistances and inductance?
4. Sketch the relative capacitance as a function of frequency for typical electrolytic capacitors?
5. Draw the equivalent circuit of an inductor. What determines the values of the parasitic resistances and capacitance?
6. Sketch the Q/frequency characteristic of a typical inductor.
7. What is the 4-wire vs. the 2-wire measurement method? What is the advantage of the latter?

2.3 Amidon Associates Data Sheets

Review the Amidon Associates data sheets on Ferrite Materials; Ferrite Rods, Bars, Plates, and Tubes; Ferrite Toroidal Cores; and Inductance-Turns Chart, Ferrite Toroids.

Answer the following review questions:

1. What are the defining characteristics of Material 61?
2. What are the principal applications of ferrite rods?
3. What are the principal applications of ferrite toroids?
4. What are the principal differences between ferrite rods and ferrite toroids?

2.4 Instructables 10-Minute Variable Capacitor

Review the 10-Minute variable capacitor instructions at

http://www.instructables.com/id/10-Minute-Variable-Capacitor/

and be prepared to assemble one in class. We will provide the CDs and the slim jewel case. Everything else is your responsibility.

3 Lab Schedule

1. *Before your assigned lab period:* Review the lab assignment and begin the prelab assignment in Section 2 on your own! Although the assignment will not be formally marked, it will be checked for completeness and correctness and will be considered when your mark for this lab assignment is assigned.

   Meet with your lab partners to discuss the lab assignment and to assign responsibilities during the lab session.

2. *During the scheduled lab period:* Submit your individual prelab assignment and work with your lab partners to complete the four experiments described in the lab assignment handout.

3. *During the few days after your assigned lab period:* Meet with your lab partners to plot and/or reduce your data, to draw conclusions, and to the group lab report.

4. *On the third day after your assigned lab period (Fri, 28 July 2017):* Submit your group lab report for marking.

2 Test and Measurement Equipment

The following equipment and accessories will be available for use in this lab session. Where applicable, please record the serial numbers of each item.

1. Automatic RCL Meter (Fluke Model PM6303A)
2. RF Signal Generator (Agilent, model 8648B, 9 kHz – 2 GHz)
3. Function/Arbitrary Waveform Generator (Rigol, model DG1022, 2 Channel, 20 MHz, 100 MSa/s)
4. Spectrum analyzer (Rigol, model DS 815), 9 kHz-1.5 GHz)
5. Dual-channel oscilloscope (Tektronix, model TDS 2012C, 100 MHz)

You will not necessarily need to use all of this equipment.

Note that there are only two Automatic RCL meters that must be shared between the six groups. They are located on the table next to the technical support room, MCLD 312.

In order to protect the input of the spectrum analyzer, please make absolutely certain that the signal at the output of the signal generators does not exceed 5 V_{p-p}

3 Components

The following components will be supplied to you:

1. 365 pF variable capacitor
2. Ferrite rod – (Amidon R61-050-400) (half-length)
3. Ferrite core – (Amidon FT-114-61)
4. Ferrite core (Amidon FT-50-61)
5. (2) CD-ROMs, including cases
6. Magnet wire of selected gauges
7. Assorted capacitors
8. Assorted inductors

You will have access to a 3D printer in order to produce a coil form that will pass the ferrite rod and around which you can wrap wire.

4 Experiment

Unlike previous lab assignments, this one requires that you devise the procedure mostly by yourself. Here is a general outline:

1. Use the Fluke PM6303A RCL meter to measure the capacitance of a commercially-built variable capacitor and report the variation in capacitance with rotation angle.
2. Use an RCL meter to measure assorted capacitors and assorted inductors, each of nominally equal value, and report and comment on the variability of the result.
3. Implement and evaluate a variable capacitor using a pair of CD-ROMs, as described at
   http://www.instructables.com/id/10-Minute-Variable-Capacitor/ .
4. Devise a scheme for measuring the permeability of the ferrite rod.
5. Design a resonant circuit based on the 10-Minute variable capacitor that will cover the AM broadcast band, 535 – 1705 kHz, with a reasonably high value of Q.
6. Design, implement and measure the response of a ferrite core inductor and ferrite rod inductor suitable for use in such a resonant circuit in conjunction with the variable capacitor realized in Task 3.
7. Demonstrate the function and operation of such a resonant circuit.

We suggest that you sketch your plan and review it with the TA before proceeding.