EE 462G Laboratory # 1

By

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(No pre-lab due for this lab)

I. Instructional Objectives

- Introduce lab instrumentation with linear circuit elements
- Introduce lab report format
- Analyze different measurement procedures based on 3 theoretical models

II. Background

A circuit design requires a capacitor. The value of an available capacitor cannot be determined from its markings. Thus, the value must be measured; however no capacitance meter is available. The only resources available are different value resistors, a variable frequency signal generator, a digital multimeter, and an oscilloscope. Three possible ways of measuring the capacitor's value are described in the following paragraphs. For this experiment, the student needs to select resistors and frequencies that are ***convenient*** or ***feasible*** for the required measurements and instrumentation. Be sure to use the digital multimeter (DMM) to measure and record the actual resistance values used in each measurement procedure.

III. Pre-Laboratory Exercise

None. (See lecture notes for analysis results).

IV. Laboratory Exercise

To use the **step response model** in the capacitor measurement, build the Circuit A shown in Fig. 1. Use a 0 to 5V square wave input (function generator), and use the oscilloscope to measure the voltage across the capacitor. Generate and record capacitor voltage waveforms and frequencies used for 3 different values of *R* in the **results section and data sheet.** From the information in the waveform and measurement conditions, compute the measured value of *C* for the 3 different values of *R*. In the **procedure section**, address/include the following:

1. Briefly describe how the square wave frequency should be chosen based on general *C* and *R* values in order to clearly observe the critical points of the circuits' step responses, and indicate how you determined the specific square wave frequencies used in your measurements.
2. Identify independent and dependent variables for your experiment.
3. Describe probe placement and grounding issues associated with this circuit. (Where are the grounds for the oscilloscope and signal generator this circuit, and why should they be there?)

4. Add proper ground symbols to Circuit A.

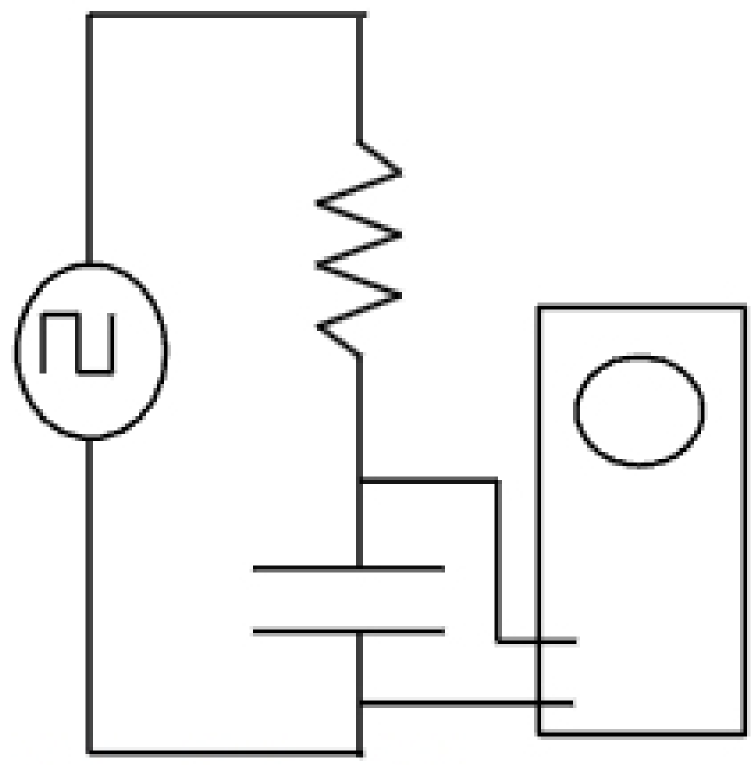

Figure 1. Circuit A

To use the **frequency response model** for the capacitor measurement, build Circuit B shown in Fig. 2. Use a 10V peak-to-peak sine wave input (function generator). Adjust the frequency so the capacitor and the source voltages are 45 degrees out of phase (and/or output 3 dB down from input). Record the input voltage waveforms and their frequencies in the **results section and data sheet** for 3 different values of *R*. Compute the value of *C* in the **results section** from the information generating this condition. In the **procedure section**, address/include the following:

1. Indicate the general relationship between capacitance reactance (X_c) and *R* when the source and the capacitor voltages are 45 degrees out of phase.
2. Identify independent and dependent variables of your experiment.
3. Briefly describe how you determined the frequencies that generated the 45 degree phase shift.
4. Discuss probe placement and grounding issues for the measurements of this circuit. Add proper ground symbols to Circuit B.

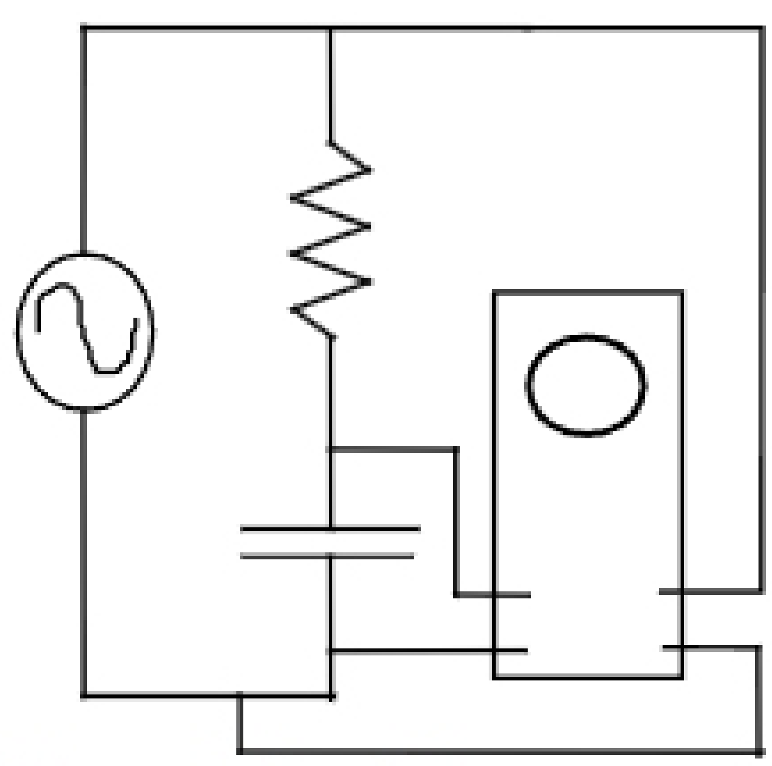

Figure 2. Circuit B

To use the **impedance model** for the capacitor measurement, build Circuit C shown in Fig. 3. Use a resistor value on the order of 100Ω to limit the current in the circuit in case a defective (shorted) capacitor is used. Use a 10V peak-to-peak sine wave input (function generator). Use the DMM to record the RMS capacitor current, and use the oscilloscope to measure the RMS capacitor voltage. Record these measurements in the **results section and data sheet** for 6 different frequency values of the input voltage. From the direct measurements, compute the capacitor's impedance (X_c) and value C in the **results section**. In the **procedure section**, address/include the following:

1. Indicate the general relationship between X_c and the measured current, voltage, and source frequency. Identify independent and dependent variables. Clearly indicate whether the measured values are peak, peak-to-peak, or rms.
2. Explain how limitations of the DMM affected your choice of frequencies used and what frequencies you actually used.
3. Discuss probe placement the grounding issues.

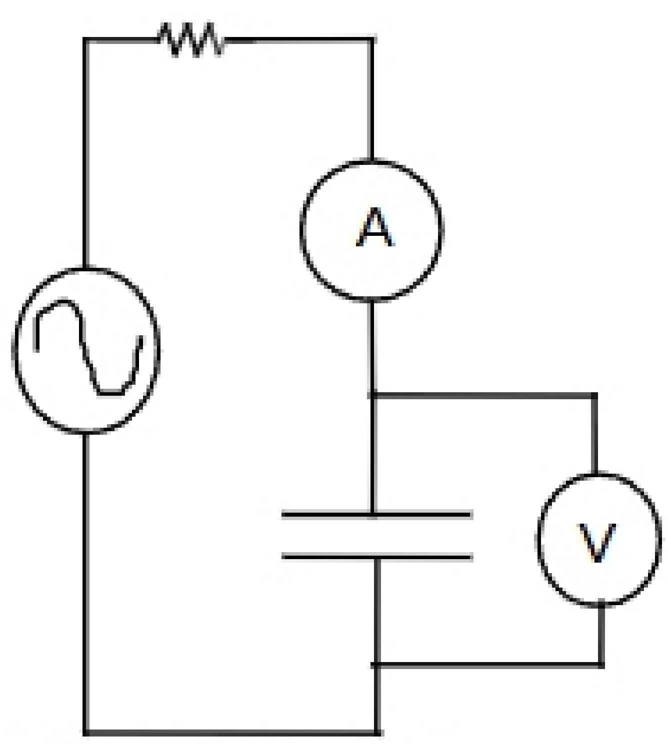

Figure 3. Circuit C

It is expected that the same capacitance value was not estimated for each method and/or each attempt with the same method (using the different resistor and/or frequency values). In the **discussion section**, propose possible reasons for the different capacitor estimates. Consider if variations were within the precision of the measurement process and component value variations (i.e. typical experimental error). If error (difference between methods and measurement trials) was outside this range, consider contributions from mistakes in your implementation of the procedures, faulty connections/components/equipment, or a limitation of the theory used to develop the estimation process. Comment on the difficulty or efficiency of each measurement procedure. Rank the methods (or indicate no difference) in terms of estimation precision/accuracy. Rank the procedures in terms of the complexity/difficulty of the measurement process.

In the **conclusion section** discuss how well the lab exercise met the lab objectives.