EXPERIMENT V

CAPACITORS AND INDUCTORS

OBJECTIVE: In this experiment you will learn about:

1. Terminal characteristics, parallel and series connections of linear capacitors;
2. Capacitance and inductance measurement methods.

EQUIPMENT & COMPONENT LIST:

Multimeter,
Digital Oscilloscope,
Function Generator,
Capacitors (0.1 μF, 0.47 μF, 100 μF, 220 μF),
Inductor (0.1 mH),
Resistors (100 Ω, 1 kΩ, 100 kΩ)

PRELIMINARY WORK:

1. Capacitor

An actual capacitor can be modeled as in Fig. 5.1 where the conductance *G* represents the (leakage) loss of the capacitor. As *G* is usually quite small it will be neglected in this experiment.

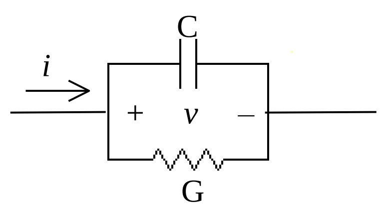


Figure 5.1 Real capacitor model.

A. Consider the circuit of Fig. 5.2. Find the capacitance of the capacitor in terms of the measured current (Ammeter A) and voltage (Voltmeter V) values (rms values) and the angular frequency ω. *Hint*: What is the phase relationship between capacitor voltage and current (Chapter 9 Figure 9.13 of Nilsson and Riedel)?

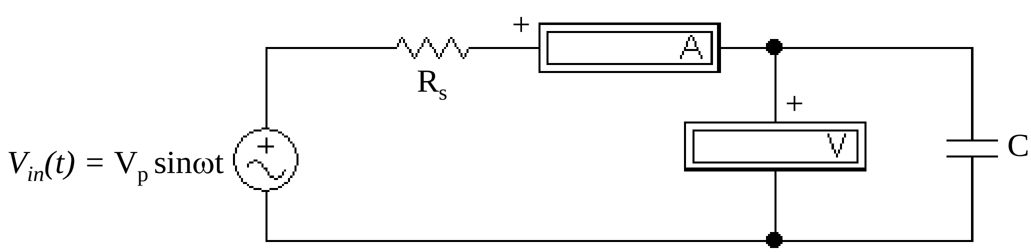


Figure 5.2 Capacitor characterization setup.

B. Consider the circuit of Fig. 5.3.

- **a.** Find the expressions for charge *q* and the capacitance of the capacitor C in terms of *K*, R, v_2 and v_c.
- **b.** How can *q*-*v* characteristics be obtained on the digital oscilloscope using this setup?

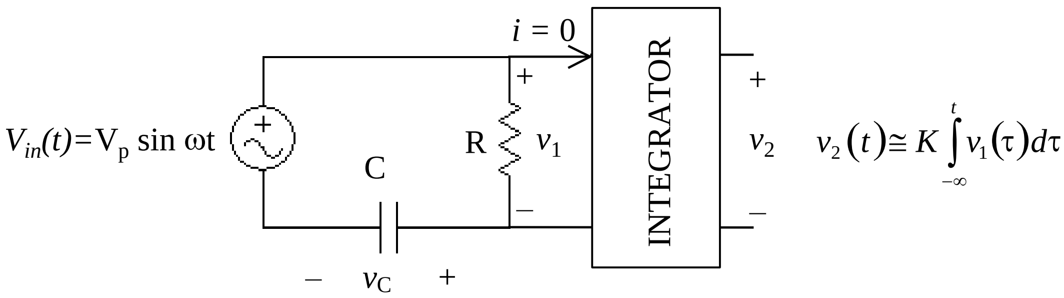


Figure 5.3 Integrator circuit.

2. Inductor

An actual inductor can be modeled as in Fig. 5.4 where the resistance *r* represents the resistance of the turns of the inductor.

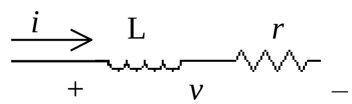


Figure 5.4 Real inductor model.

The resistance of the inductor actually cannot be neglected and therefore it should be taken into account in the calculations in this experiment.

Replace C in Fig. 5.2 by an inductor L. Find L in terms of the measured current and voltage values, the angular frequency ω and the resistance *r*. *Hint*: What is the phase relationship between inductor voltage and current (Chapter 9 Figure 9.11 of Nilsson and Riedel)?

EXPERIMENTAL WORK:

Note: There are three demonstrations in this laboratory. Once you are done with any of the demos, please have one of the lab instructors take a look at your setup, measurement, and results in order to get credit for this portion of the lab. You may be asked questions about your demonstration.

1. Capacitor

A. Adjust the output of the function generator to 500 Hz, 6V peak and apply the signal to a capacitor C of 0.47 μF nominal capacitance value. Measure the AC current through and AC voltage across the capacitor using a multimeter, and determine its capacitance.

Demo 1: Demonstrate your circuit setup, measurement, and calculated capacitance to the lab instructor.

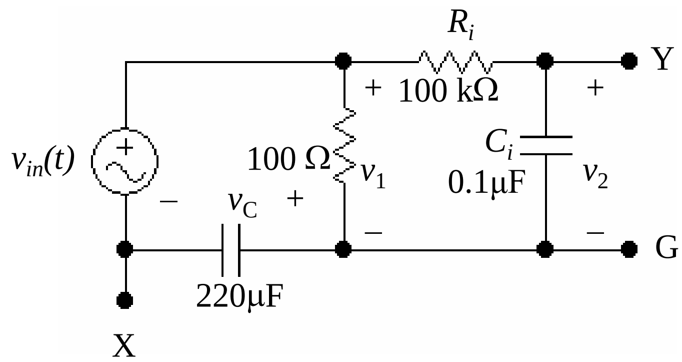
B. Setup the circuit of Fig. 5.5 for $v_{in}(t)$ = (10sin2πft) volts, f = 200 Hz.

a. Obtain and plot *q-v* characteristics of the capacitor C of 220 μF nominal value and determine its capacitance.

b. Connect a capacitor of 100 μF nominal capacitance value in parallel with C. Find the equivalent capacitance using the new *q-v* characteristics.

c. Connect a capacitor of 100 μF nominal capacitance value in series with C. Find the equivalent capacitance using the new *q-v* characteristics.

Demo 2: Demonstrate your last circuit setup, measurement, and calculated capacitance to the lab instructor.



$$v_2(t)=\frac{1}{R_iC_i}\int_{-\infty}^{t} v_1(\tau)d\tau$$

Figure 5.5 Integrator experiment setup.

2. Inductor

Adjust the output of the function generator to 5 kHz, 6 V peak and repeat Part 1(A) for an inductor L of 0.1mH nominal inductance value, to determine its inductance. Use a 100 Ω resistor in series with the inductor and function generator for protection. Note that first, the resistance of the inductor should be measured using the multimeter.

Demo 3: Demonstrate your last circuit setup, measurement, and calculated inductance to the lab instructor.