COLLEGE OF ENGINEERING
SUNY POLYTECHNIC INSTITUTE

ECE 260
Name:____

Date:____

Laboratory 8 – Series and Parallel Capacitors

Purpose: In this lab, you will gain more in-depth knowledge of capacitors.

Equipment Required

- Breadboard and variable power supply
- FLUKE Hand-held Digital Multimeter (DMM)
- Various capacitors

Learning Objectives

1. Discuss the behavior of capacitors in series and parallel circuit configurations
2. Predict and calculate the capacitance of a given configuration of capacitors
3. Measure the capacitance of a configuration of capacitors

Theory

A capacitor is a passive two-terminal electrical component that can store energy in an electric field created by storing electrical charge along two plates that make up the capacitor. Every capacitor consists of two conductors separated by an insulating layer. This insulating layer can be comprised of many different materials. As we will see in the lab, adding capacitors to a circuit in series has the effect of reducing the circuit's equivalent (total) capacitance. And, adding capacitors in parallel, will increase the total capacitance.

Capacitors, in a series configuration can be used in power distribution systems, safety circuitry and obtaining capacitance values not readily available with single capacitors.

Capacitors, in a parallel configuration can be used in energy storage devices, such as those in high-power audio systems) and to filter and eliminate ripple in DC power supplies.

Capacitors can also be used in many other applications, including filter circuits, filtering out DC signals, noise filters absorbing radio frequency interference, and in high- and low-pass filters soring signals by frequency.

Certain capacitors change capacitance in response to external stimuli and can be used much like variable resistors, as sensors. Capacitors can also be used for coupling. Coupling allows energy to pass from one section of a circuit to another.

Capacitors can discharge energy as well as store it. This allows capacitors to be used like temporary batteries. For example, capacitors may maintain the power supply to a device while the batteries are being changed or, they may provide energy to a car audio system. Finally, capacitors are central components of pulsed power systems, in which they are used to achieve extremely concentrated bursts of electrical power. Pulsed power has applications ranging from Radar systems to medicine to experimentally simulating the effects of nuclear weapons.

Capacitor Behavior

Capacitors, in a circuit act in a manner that is opposite of resistors. The sum of the capacitance for capacitors in parallel matches the formula used to add resistors in series:

$$C_{eq} = C_1 + C_2 + \cdots + C_n \text{ (Parallel)}$$

where C_{eq} is the total capacitance and C_1 through C_n are the individual capacitances. Similar to resistors in series, the total capacitance increases the more parallel capacitors are added.

The sum of the capacitance for capacitors in series matches the formula used to add resistors in parallel:

$$C_{eq}^{-1} = C_1^{-1} + C_2^{-1} + \cdots + C_n^{-1} \text{ (Series)}$$

Similar to resistors in parallel, the total capacitance will decrease the more series capacitors are added.

Review Questions:

The equivalent capacitance of multiple capacitors connected in parallel will always be:

A. Greater than any individual capacitor
B. Equal to the largest individual capacitor
C. Less than the sum of the individual capacitors
D. Less than any individual capacitor

The equivalent capacitance of multiple capacitors wired in series will always be:

A. Greater than any individual capacitor
B. Equal to the sum of the individual capacitors
C. Equal to the smallest individual capacitor
D. Less than any individual capacitor

Which of the following statements about capacitors is UNTRUE?

A. They are often used in filters
B. They are an active component
C. They are used extensively in all types of electronic device
D. They can dissipate the charge they store somewhat like a battery

Procedure

Exercise 1 - Series: In the first part of this lab you will explore series capacitors. First, you will calculate the equivalent capacitance of this circuit:

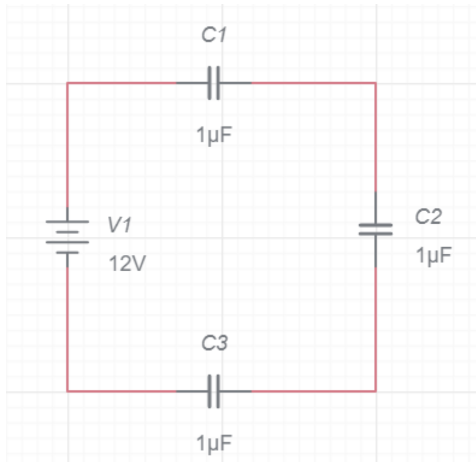

Figure 1

What is the calculated capacitance of the circuit (in μF)?

Circuit Implementation

- Select 5 capacitors from the lab instructor. Determine it's theoretical value and then measure it's actual value. Record these values in Table 1

Table 1

Capacitor	Theoretical Value	Measured Value
1		
2		
3		
4		
5		

- Connect three 1μF capacitors in series (as in Figure 1) on the breadboard.
- From the instruments tab of Measurements Live, open the Digital Multimeter (DMM)

- Set the DMM to measure capacitance with a range of 50 μF. Make sure that the circuit is connected to **DUT+** and **DUT-**. You can also use a hand-held Fluke multi-meter to measure the capacitance.
- Measure the equivalent capacitance in the circuit. Record your measurement, as well as your calculated values from the exercise above in Table 2.

Table 2

# Series Capacitors	Theoretical	Measured Value
3 (original circuit)		
4		
5		

- Add a fourth 1μF capacitor to the circuit in series.
- Calculate the equivalent capacitance of the modified circuit and record your value in Table 2.
- Measure the equivalent capacitance with the DMM and record your measurement in Table 2.
- Add a fifth series 1μF capacitor and make similar calculations and measurements. Record in Table 2.

Exercise 2 - Parallel: In the second part of this lab you will explore parallel capacitors. Calculate the equivalent capacitance of this circuit:

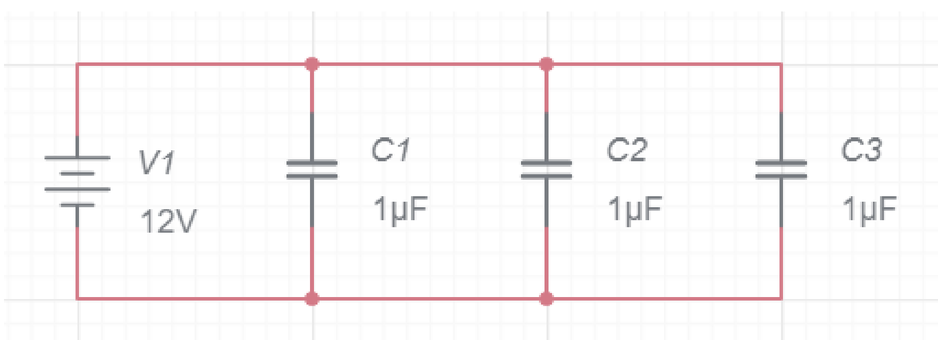

Figure 2

What is the calculated capacitance of the circuit (in μF)?

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Circuit Implementation

- Connect three 1μF capacitors in parallel (as in Figure 2) on your breadboard.
- Using the DMM, measure the equivalent capacitance in the circuit. Record your measurement, as well as your calculated values from the exercise above in Table 3.

Table 3

# Parallel Capacitors	Theoretical Value	Measured Value
3 (original circuit)		
4		
5		

- Add a fourth 1μF capacitor to the circuit in parallel.
- Calculate the equivalent capacitance of the modified circuit and record your value in Table 3.
- Measure the equivalent capacitance with the DMM and record your measurement in Table 3.
- Add a fifth series 1μF capacitor and make similar calculations and measurements. Record in Table 3.

Calculate Equivalent Capacitance: For the final step of this lab, you will combine what you know about series and parallel capacitors to calculate the equivalent capacitance of the circuit below:

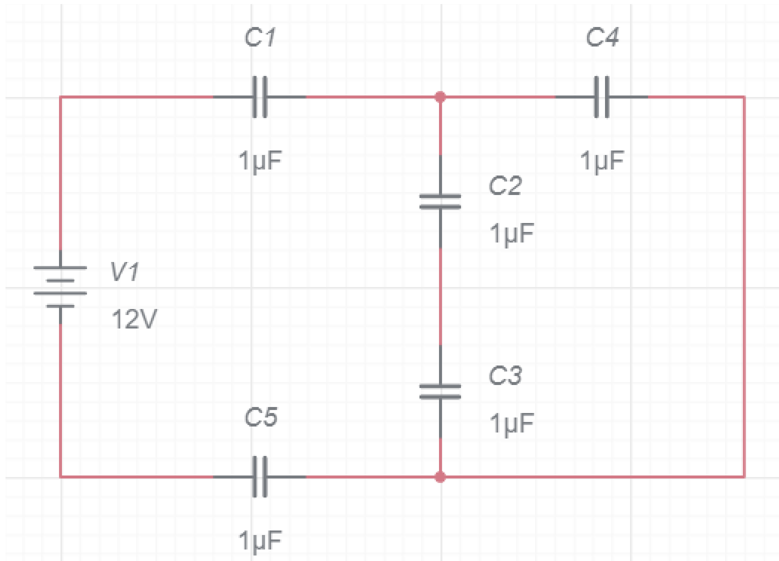

Figure 3

What is the equivalent capacitance of the circuit, in µF?

- Build this circuit on your breadboard and measure the total capacitance. Compare your calculated value with your measured value

Table 4

Circuit	Theoretical Value	Measured Value
From Figure 3		

Multi-Sim: Capacitors in Series and Parallel
Using MultiSim, verify your results for the circuit in Figure 3. Attach the simulation print-out with the lab memo you hand in.

Questions:

What would be the total capacitance of a circuit with three 6 µF capacitors wired in series?

A. 2 µF
B. 6 µF
C. 12 µF
D. 18 µF

What would be the total capacitance of a circuit with three 6 µF capacitors wired in parallel?

A. 2 µF
B. 6 µF
C. 12 µF
D. 18 µF

Compare your answers to questions 1 and 2. If you wanted to create a circuit that stored the most energy possible, how would you wire your capacitors?

A. Series
B. Parallel

What would be the total capacitance of a circuit with two parallel branches, one containing two 6 µF capacitors in series and the other one 10 µF capacitor?

A. 5.45 µF
B. 12 µF
C. 13 µF
D. 22 µF

In each experiment, were your measured values consistent with your calculated ones? If not, why do you think that may be?

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Record any observations you have made regarding series and parallel capacitors that you have not yet noted.