Course and Section_______ Names ___________________________

Date___________ ________________________________

CAPACITORS EXPERIMENT

Introduction

In this experiment you explore how voltages and charges are distributed in a capacitor circuit. Capacitors can be connected in several ways: in this experiment we study the series and the parallel combinations.

Equipment

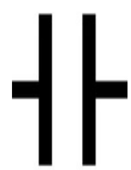
Power supply, Multimeter, three 0.1μF (104k yellow) capacitors, one 0.01μF (103k red) capacitor, one unknown (rainbow) capacitor, five cables.

Theory

Capacitors are electronic devices which have fixed values of capacitance. The capacitance C depends on the physical and geometrical proprieties of the device and is given operationally by the charge Q stored in the device divided by the voltage difference across the device ΔV.

$$C = \frac{Q}{\Delta V}$$

The schematic symbol of a capacitor is two parallel lines which represent the capacitor plates.



<u>Series</u>

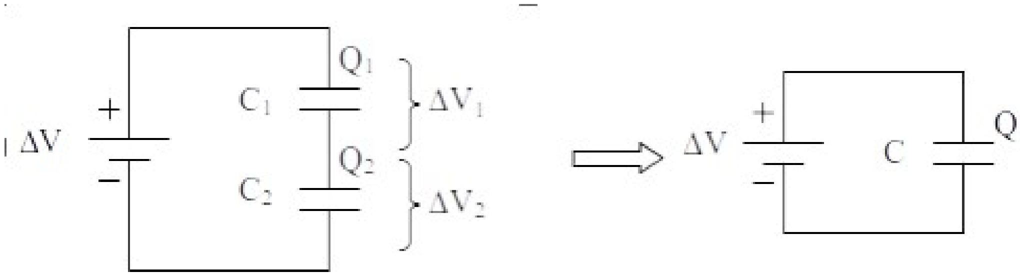
In a series connection the components are connected at a single point, end to end.

When the series combination is connected to a power supply ΔV, the charges on each capacitor Q_1, Q_2 are equal to the equivalent charge Q. The potential difference across each capacitor add to ΔV

$$Q = Q_1 = Q_2$$

$$\Delta V = \Delta V_1 + \Delta V_2$$

The equivalent capacitance C is



$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

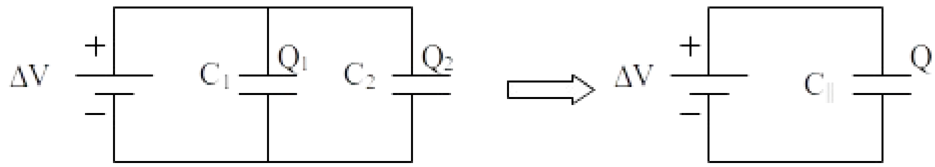
Parallel

In the parallel connection, the components are connected together at both ends.

When the parallel combination is connected to a power supply ΔV, the charges on each capacitor Q_1, Q_2 add to the equivalent charge Q. The potential difference across each capacitor are equal to ΔV.

$$Q = Q_1 + Q_2$$

$$\Delta V = \Delta V_1 = \Delta V_2$$



The equivalent capacitance C is

$$C = C_1 + C_2$$

Preliminary Questions

You have three identical capacitors. You connect two of them in series and to a 12V power supply. If you add the third capacitor in series with the other two:

1. How does the voltage across the first two capacitors changes?

2. How does the equivalent capacitance change?

3. How does the charge on the first two capacitors change?

You have three identical capacitors. You connect two of them in parallel and to a 12V power supply. If you add the third capacitor in parallel with the other two:

4. How does the voltage across the first two capacitors changes?

5. How does the equivalent capacitance change?

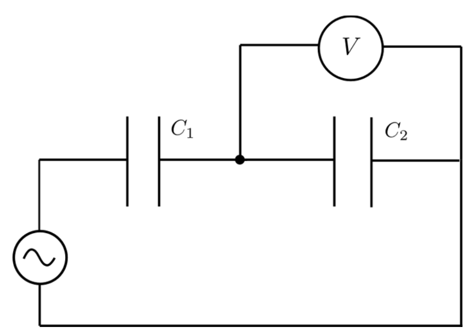
6. How does the charge on the first two capacitors change?

Procedure

Step 1. Turn on the power supply and set the AC voltage to 6 V.

7. Measure the actual power supply voltage V_{PS} with the multimeter and record it below

V_{PS} = _______________V



Step 2. Connect two 0.1 μF (yellow) capacitors in series.

8. Measure V_2 across C_2 and record it below.

V_2 (measured) = ______________ V

Next, you want to compute the expected value of V_2 by using the given equations

9. Calculate the equivalent capacitance C_{12}

10. Calculate the total charge Q

11. Calculate the expected value of V_2

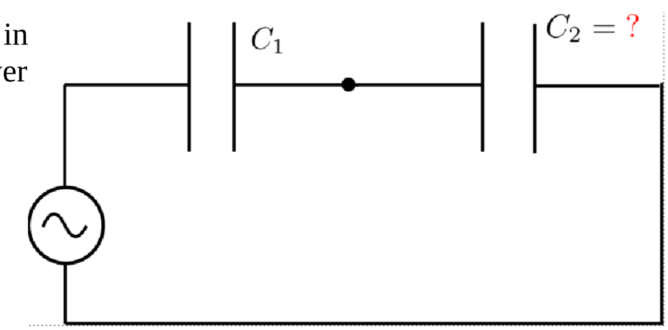
V_2 (expected) = ____________ V

12. Calculate the percentage error (assuming the exact value = measured value) of V_2

% error = (|measured - expected| / measured) x 100 = __________

By taking measurements of voltage is possible to find the unknown capacitance of a capacitor.

Step 3. Connect the unknown capacitor C_2 (rainbow) in series with the C_1 = 0.1 μF capacitor and to the power supply.



13. Measure the voltages across each capacitors

V_1 (measured) = ________ V,

V_2 (measured) = ________ V,

14. Find the capacitance of the unknown capacitor. Hint: think about the charge Q of the two capacitors.

C_2 = _________ *μ F.*

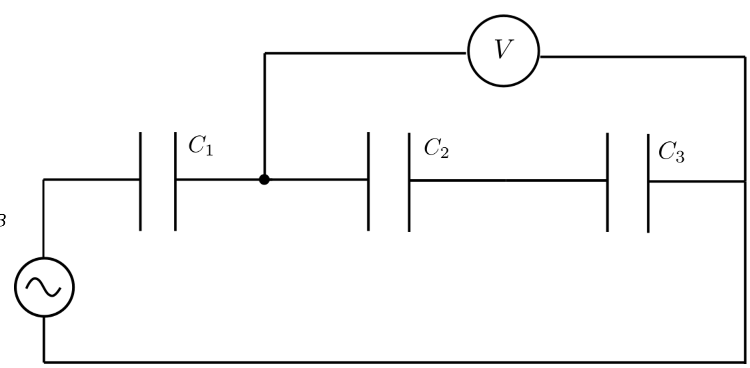
Step 4. Connect three 0.1 μF (yellow) capacitors in series and measure the voltage across each capacitor.

15. Are your results consistent with your prediction 1?

Step 5. Remove the C_3 = 0.1 μF capacitor and replace it with a C_3 = 0.01 μF (red) capacitor.

16. Measure the voltage across C_{23}.

V_{23} (measured) = ________ V,



Next, you want to compute the expected value of V_{23} using the given equations.

17. Calculate the equivalent capacitance C_{23}.

18. Calculate the equivalent capacitance C_{123}.

19. Calculate the total charge Q

20. Given Q, what is the charge Q_{23}?

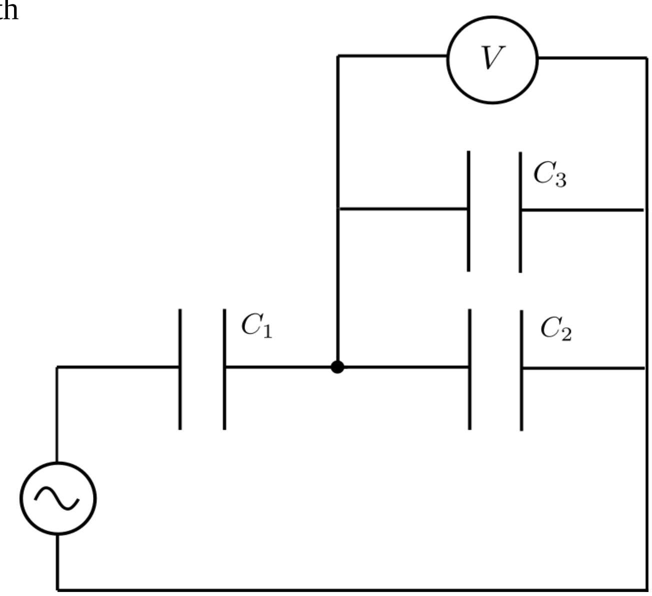
21. By knowing C_{23} and Q_{23} calculate the expected value of V_{23}

V_{23} (expected) = ____________ V

22. Calculate the percentage error (assuming the exact value = measured value) of V_{23}

% error = (|measured - expected| / measured) x 100 = __________

Step 6. Remove the C_3 = 0.01 μF capacitor and replace it with a C_3 = 0.1 μF capacitor connected in parallel with C_2.



23. Measure the voltage across C_2.

V_2 (measured) = ________ V,

Next, you want to compute the expected value of V_2 by using the given equations.

24. Calculate equivalent capacitance C_{123}

25. Calculate the total charge Q

26. Calculate the charge Q_1

27. Calculate V_1, the voltage across C_1

28. By knowing V_1 and V_{PS} calculate the expected value of V_2

V_2 (expected) = ____________ V

29. Calculate the percentage error (assuming the exact value = measured value) of V_2

% error = (|measured - expected| / measured) x 100 = __________

TURN OFF THE MULTIMETER and THE POWER SUPPLY