Experiment 9: Connecting Capacitors in a Series-Parallel Combination
Objective

• To demonstrate that capacitors can be connected in a series-parallel combination.
• We have previously connected capacitors either in a series or parallel combination.

• In this experiment we will combine the two circuits to show capacitors can be connected in a series-parallel combination.
• We are not limited to using capacitors in this combination.
• We could use resistors, inductors as well as capacitors or a mixture of these components in a series-parallel combination.
\[ C_T = \frac{C_1 \times C_2}{C_1 + C_2} \]

CT for 2 Capacitors in Series

Total Capacitance = \( C_T \)
\[ C_T = C_A + C_B \]

\( C_T \) for 2 Capacitors in Parallel

Total Capacitance = \( C_T \)
Steps to calculating $C_T$ in a Series-Parallel Circuit

1. Calculate Total Capacitance for Parallel parts of circuit.
2. You should have equivalent circuit values which give you a Series Circuit.
3. Calculate Total Capacitance for Series Circuit.
• We are giving you a problem to solve mathematically. You will build the experiment to prove your solution works with a small %error.

• You will be given some circuit givens to use with the supplied formula to solve the problem.

Experiment Discussion
• Find the values of $C_1$ and $C_X$ necessary to obtain 10V for $E_{C2}$
  • $C_X$ is the unknown capacitor value
• Assume the following: $E = 30V$ and $C_1 = 0.1\mu F$; calculate the value of $C_X$ using the formula on the next slide.
Apply Ckt givens on previous slide to solve for $C_X$

$$C_X = -C_1 \left[ 1 - \frac{E}{E_{C_X}} \right]$$
\[ C_x = -0.1 \mu [ 1 - \frac{30}{10} ] \]

\[ C_x = -0.1 \mu [ 1 - 3 ] \]

\[ C_x = -0.1 \mu [ -2 ] \]

\[ C_x = 0.2 \ \mu F \]

Example solved
• You do not have a 2µF capacitor in stock.
• You do have three 0.1µF capacitors
• How would you design the circuit to obtain a 0.1µF capacitor in series with a 0.2µF capacitance?

Discussion continued
• You would have to design a series-parallel circuit using the three 0.1µF capacitors you have in stock.
• The following slide has the schematic for the circuit you will build.
• The slide after that illustrates what the wired circuit would look like on the trainer’s breadboard.
Schematic for Series-Parallel Capacitor Circuit
Circuit wired for Series-Parallel Capacitor Circuit
Calculate %error using above formula:

\[
%error = \frac{E_{c2}\ (desired) - E_{c2}\ (measured)}{E_{c2}\ (desired)} \times 100
\]
\[
\text{error} = \frac{10 - 10.2}{10.2} \times 100 = 1.96\\%
\]
or about 2\\%

Example for circuit values
• Our results were better than average, with only an approximate 2% error between the required (10V) and the measured or voltage obtained (10.2V).

• While using the two 0.1µF capacitors, your measurements should be close to ours.

• Re-check measurements if your %error is greater than 2%.

Brief look at our Results
• You learned it is possible to connect capacitors in a series-parallel combination and how to calculate the total capacitance of a series-parallel circuit.

• You learned you can simplify the circuit by applying the rules previously learned for series and parallel circuits.

Final Discussion
• You also learned a series-parallel combination circuit can be substituted if a desired value of capacitance is unavailable.

• Such a substitution should be considered only a temporary, emergency solution, lasting until a single capacitor of the desired value can be obtained.
Please Note the Following:

- Be careful to choose capacitors of the proper voltage rating.
- Too low a rating will result in the capacitors being damaged.
- You can always use a rating higher than the total voltage being applied.
Resources

The End

Developed and Produced by the Instructors in the CIE Instruction Department.

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