Exp. 3: Capacitance

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Abstract

A study was done to determine various capacitances of certain capacitor configurations and the dielectric constant of paper used in a makeshift capacitor. The capacitances were determined by creating a circuit using a 500 and 2000 µF capacitor and measuring the half-life of the circuit’s electric potential. The values for the 500 and 2000 µF capacitors were 511.04 and 1856.66 µF, respectively. When the capacitors were combined in series and parallel configurations, the capacitances of the configurations were 391.15 and 2336.48 µF, respectively. The dielectric constant of the paper used to make a capacitor was 1.52.

Introduction

A capacitor is a device used to store electrical energy for use in a circuit when necessary. The ability of an object, specifically a capacitor, to store energy is denoted as its capacitance, with the SI unit of capacitance being the Fared. In this experiment, a capacitor is used in a circuit in conjunction with a resistor and power supply. By measuring the time taken for the potential difference to decrease by half (t\*), the capacitance can be calculated using the formula , with *R* being the measured resistance of the resistor.

To calculate the capacitance of multiple capacitors in a single circuit, one of two formulas can be used, depending on the structure of the circuit. If the capacitors are set up in a series configuration, the formula for the combined capacitance of both capacitors is , with *Ci* being the capacitance of each successive capacitor. If the capacitors are set up in a parallel configuration, the formula is instead .

For a parallel plate capacitor, the formula for its capacitance is given as , where *k* is the dielectric constant for the material in between the parallel plates, is the constant of vacuum permittivity (8.85 x 10-12), *A* is the area of the parallel plates, and *d* is the distance between the plates. In this experiment, the goal is to determine the value of *k* by testing greater and greater values of *d* and taking the slope of the data to find *k*.

Procedure

In this experiment, an AC power supply was used to supply power to a circuit consisting of a 2000 Ω resistor and a 500 or 2000 µF capacitor. Various wires were then used to connect the circuit in various patterns that used some combination of the two capacitors. After turning on the power supply, an oscilloscope was then used to measure the time taken for the electric potential of the circuit to drop by half. This procedure was repeated five times each for four different circuit configurations. The first configuration consisted of just the 500 µF capacitor, and the second configuration consisted of just the 2000 µF capacitor. The third and fourth configurations used both capacitors, with the third configuration connecting the wires to create a series circuit and the fourth configuration using a parallel circuit. Then, using the value of the time taken for the electric potential to drop by half, the capacitance could be calculated. For the series and parallel circuit configurations, the capacitance was also calculated using the given formulas for series and parallel circuits. For the last part of the experiment, two sheets of aluminum foil were placed inside a textbook with several textbook pages in between the sheets. This was done to create a makeshift capacitor. Starting with five pages in between the aluminum foil, a multimeter was used to measure the capacitance of the makeshift capacitor. By then, progressively adding five more pages to each trial for seven trials, a data set of measured capacitances was taken. This data set was then used to create a trendline whose slope was taken as the dielectric constant, *k*, of the textbook pages.

Results

The capacitance values for the 500 and 2000 µF capacitors were 511.04 and 1856.66 µF, respectively. For the series and parallel circuit configurations, the capacitances of the configurations were 391.15 and 2336.48 µF, respectively. The dielectric constant of the paper used to make a capacitor was calculated to be 1.52.

Questions to Answer

1. They are both acceptable.
2. The percent difference for the series configuration is 2.4% and the percent difference for the parallel configuration is 1.3%
3. The experimental value of *k* was found to be 1.52, while the textbook value is 3.7. This is a significant difference in magnitude and is most likely due to human error in the construction of the capacitor.
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