Equipment report

Abstract

The main aim of performing this experiment was to study the behaviour of the voltage across a capacitor as it charge and discharge through a known resistor. From the experiment, it was seen that charge/ discharge of a capacitor follows an exponential function. We also studied about the time constant RC of the circuit.

Introduction

We carried out a lab experiment on an RC circuit recorded and calculated the results so as to determine the time constant. We found out that as capacitance decreases, time constant also decreases and increase in resistance lead to increase in time constant

Objective

Investigating the behaviour of a charged capacitor using an RC circuit

High-voltage DC power supply

4. 7-μF capacitor

10-Megohm resistor

Analog and Digital Multi-meter

Switch

Stopwatch or timer

Wires, clips

Theory

RC circuits are elements used in electronic devices, and they consist of both a resistor and a capacitor. A capacitor is used in storing energy charges, and a resistor is used to control the rate at which it charges or discharges. A characteristic time dependence is exhibited which turns out to be exponential. Time constant RC is the parameter used in describing the time dependence of the circuit. The charge doesn't flow through a capacitor rather it builds up in a capacitor hence resulting in an electric field. The charge may build up to a point when the voltage V= QC balances external voltage and hence pushing charge onto the capacitor. Capacitance C of a capacitor is therefore given by Q= VC and is dependent on the capacitors material and its configuration. The increase in charge in a capacitor leads to increase in voltage (potential difference). And since it is easier to measure potential difference as compared to charge, an equation can be written in terms of potential difference as V= Voe-tRC where;

Vo Is initial charge

R is resistance

C is capacitance

t is time and

V is the voltage across the capacitor.

The time constant of an RC circuit is the time taken for voltage on a capacitor to fall from V0 (its initial value) to final value divided by number e; that is V= V0e

Procedure

Using a Digital Multi-meter, we measured resistance and capacitance of the resistor and capacitor provided and recorded the values. We set the circuit as required and ensured the Multi-meter to measure voltages up to 300 volts. The power supply was turned on; the switch was opened, and we started the stopwatch at the same time. On the voltage reaching 250V, we stopped the stopwatch and recorded the time. We then closed the switch, reset the stopwatch and returned the voltage to 300V. The previous procedures were repeated for a total of three data points and time recorded. The process was repeated for voltage falling from 300-200, 300-150, 300-100, and 300-50 volts. We turned the power supply off, removed the 10 MΩ resistor from the circuit and repeated the above steps so as to take readings that we recorded on a table. On finishing the experiment, we turned off the power supply and dismantled the circuit.

Some of the potential sources of errors noticed were faulty equipment resulting from burning e. g. resistors, and lack of consistency in stopwatch operation.

Data Analysis and Calculations

With 10 MΩ resistor R, ohms 10 MΩ C, Farads 4. 7e-6 F

The following graph shows results of Ln (V/Vo) against average time (t)

Rt C Is given by slope = -1/RC Rt C=-1-0. 0348= 28. 74s

Without 10 MΩ resistor

The following graph shows results of Ln (V/Vo) against average time (t) for an RC circuit without 10 MΩ resistor

Slope of graph plotted is -0. 0173

Rm C Is given by slope = -1/RC Rm C=-1-0. 0173= 57. 8s

The calculated value of meter resistance Rm

Rm CRt C= 57. 828. 74= 2. 011

Rm *(1Rt= 1Rm +110e7) = Rm Rt = Rm Rm +Rm 10e7

= 2. 011= 1+Rm 10e7= Rm = 1. 011*10e7= 1. 011e7Ω

The calculated value of capacitance C

VV0 = e- tRC

LnVV0 = ln e - tRC

Using the number of first row of second circuit

-0. 4=-22. 951. 011e7*C=-4044000*C=-22. 95= C= 5. 68e-6F

Percent difference between calculated value and stated value

((C calculated- C stated)/([C calculated + C stated2]))* 100

5. 68e-6 F - 4. 7e-6 F5. 68e-6 F+4. 7e-6 F2* 100

(9. 8e-7 F)/(5. 19e-6 F) * 100 = 18. 88 %

Percent error assuming measured value is correct

5. 68e-6 F – 4. 7e-6 F4. 7e-6 F* 100 = 20. 85 %

Answers to the lab questions

The circuit having a greater time constant is the one without a resistor (the second circuit)

The first circuit has a greater total resistance

If we added more resistors in parallel in the circuit, the capacitor would discharge more slowly because the current will drop.

When charge flows away from a charged capacitor, the capacitor doesn't hold any charge but rather holds the separation of polarization that causes storing energy. Therefore, what happens is that polarization disappears due to loss of current in the circuit.

Discussion and Conclusion

The experiment was successful since we achieved our main objective of investigating a charged capacitors behaviour in an RC circuit. We determined the time constant of the circuit experimentally. We learnt that readings taken using a stopwatch should be taken accurately and carefully for best results. The experimental results proved the theoretical predictions as seen from the graphs of straight line plotted. The percentage difference between the calculated and the stated value of the capacitance was considerably small. Therefore, it was certain that the lab was a success. The knowledge gained on RC circuits is much useful in real life applications. For example in children toys and washing machines, RC circuits are incorporated. The lab was, therefore, really useful because there was much to learn.

References

Boylestad, Robert L., and Louis Nashelsky. 2002. Electronic devices and circuit theory. Upper Saddle River, N. J.: Prentice Hall.

Dorf, Richard C., and James A. Svoboda. 2006. Introduction to electric circuits. Hoboken, NJ: J. Wiley & Sons.