Topic 11 – Practical 2

RC circuit – Capacitor charging

Safety

The capacitor should be connected in the circuit with the correct polarity.

Apparatus and materials

- batteries or dc power supply
- resistors 10 kΩ, 22 kΩ
- capacitors 1000 μF, 2200 μF
- voltmeter or multimeter
- push-to-make switch
- connecting wires
- stopwatch
- graph paper

Introduction

A capacitor is an electrical circuit component that can store electrical charges when connected to a source. When a capacitor is charging, it stores electric energy. Capacitance C is defined as

$$C = \frac{q}{V}$$

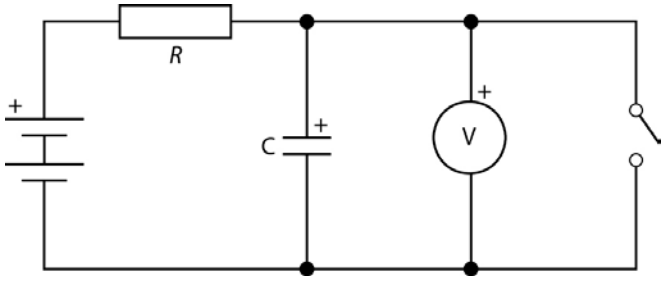
where q is the charge on each plate of the capacitor and V the potential difference applied across it.

When a capacitor is connected in series with a resistor and a source, then the amount charge q on the capacitor at time, t, after it was connected to the source is given by:

$$q = CV\left[1 - e^{-t/RC}\right]$$

where C is the capacitance of the capacitor, V is the potential difference provided by the source and R is the resistance of the resistor. The product RC is called the time constant and it is a measure of how fast the capacitor is charging.

In this experiment you will investigate the charging of a capacitor.



Procedure

1 Construct the circuit shown in the diagram above using R = 10 kΩ and C = 1000 μF. The dc power supply should be set to 9 V. Be careful to connect the capacitor with the correct polarity.

2 Close the switch to completely discharge the capacitor.

3 The moment you open the switch the capacitor will start charging and you will consider t to equal 0 seconds. Using the stopwatch and the voltmeter, measure the potential difference across the capacitor readings every 10 seconds for a total of 3 minutes.

4 Record your measurements in a suitable table.

5 Repeat the process using R = 10 kΩ and C = 2200 μF.

6 Repeat the process using R = 22 kΩ and C = 1000 μF.

7 Plot graphs of the potential across the capacitor against time for all three combinations of RC on the same axes.

8 From your graphs find the time it takes for the potential difference across the capacitor to reach 63% of its final value. Compare this time with the value of the product RC (time constant) in each case. Be careful with the units!

9 Using the boxes of your graph paper estimate the area between each graph and the x-axis. This area represents the total charge q on the capacitor after the given time.

10 Calculate the capacitance of each capacitor using the formula $C = \frac{q}{V}$, where V is the potential difference across the capacitor at t = 3 minutes. Compare the calculated values with the ones marked on the capacitors you used.

Questions

1 What is the name for the relationship demonstrated by the graph of capacitor potential difference vs time?

2 If you wish the capacitor to charge faster, what resistor would you use?