TAP 125- 3: Charging and discharging capacitors

A foretaste

Using simply a milliammeter and stopwatch, you can study the changing currents which occur when a capacitor is charged or discharged in a simple circuit with a battery and resistor. This will enable you to explore the effects of three quantities: applied potential difference, capacitor value and resistor value.

You will need

- ✓ digital multimeter, used as milliammeter
- ✓ capacitors 47 μF, 100 μF, 220 μF, 470 μF
- ✓ clip component holder
- ✓ resistance substitution box
- ✓ variable power supply, 5 V dc(smooth and, ideally, stabilised as used for electronics) or 4 cell battery pack
- ✓ leads, 4 mm
- ✓ hand held stopwatch

Starting out

Choose a 100 μF capacitor, insert it in the component holder, set the resistance box to 1 kΩ and assemble the circuit as shown. Take care to connect the capacitor terminals with the correct polarity + and –.
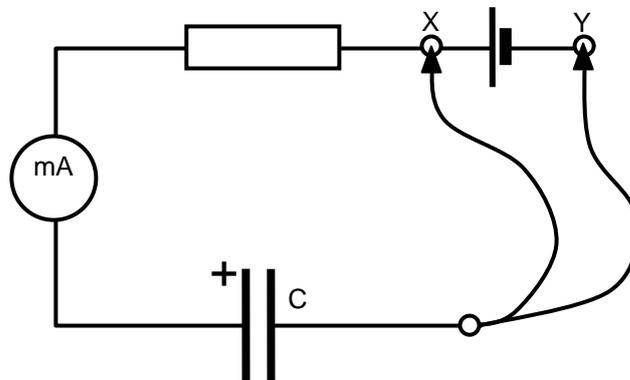
1. Briefly connect the flying lead to terminal Y. Watch the milliammeter carefully.

2. Briefly connect the flying lead to terminal X. Watch the milliammeter carefully.

Compare the similarities and differences between the magnitude, direction and duration of the current pulse in each case. Then consider how your results provide evidence for the following explanation:

Action 1 causes electric charge to flow onto one capacitor plate and off the other. The capacitor becomes 'charged' by keeping the equal and opposite charges separated. Action 2 has the reverse effect; the separated charge flows away from one side of the capacitor via the circuit to the other side through the resistor and milliammeter. The capacitor becomes discharged.

You will repeat this basic experiment several times to find out the effects of varying the potential difference, capacitance and resistance.

The effect of changing the capacitance

Repeat the experiment with different capacitors: 47 μF, 220 μF, 470 μF.

In each case note the effects on the magnitude and duration of the current pulse. A stopwatch may help you observe the duration. Write a statement that summarises the effect of capacitance value on the discharge current.

The effect of changing the resistance

Using the 100 μF capacitor, repeat the experiment with different values of resistance: 2.2 kΩ, 4.7 kΩ, 10 kΩ.

In each case note the effects on the magnitude and duration of the current. Write a statement that summarises the effect of resistance value on the discharge current.

The effect of changing the potential difference

Connect the 100 μF capacitor and set the resistance box to 1 kΩ. Increase the number of cells to make a battery.
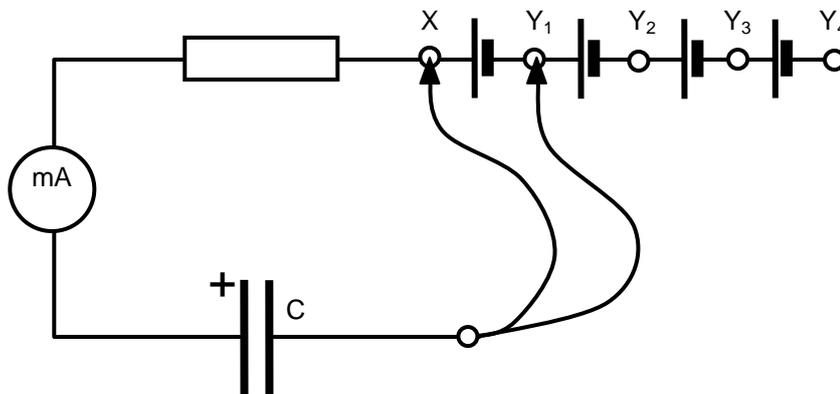
Repeat the experiment using a different Y terminal each time, providing different potential differences. In each case note the effects on the magnitude and duration of the current. Write a statement that summarises the effect of potential difference on the discharge current.

Thinking about the theory

To help make useful links with the theory of capacitors, use this chart to summarise your results; write a sentence in each cell to describe the effect.

	Magnitude of current	Duration of current
Effect of capacitance		
Effect of resistance		
Effect of potential difference		

Capacitance is defined and can be measured by dividing the charge Q stored on the capacitor by the potential difference V across its terminals. That is:

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

To help think about the effect of capacitance and potential difference on the charged stored, this can be rearranged to give:

$$Q = CV.$$

This implies that if either C or V is made larger, a larger charge Q would be stored on the capacitor. Explain how your results support this description. (Remember that when the capacitor is charged or discharged, Q coulombs of charge flow through the milliammeter.)

Theory predicts that the charging or discharging current is not steady but gradually decays over a period of time and the rate of decay depends upon R and C multiplied together. The rate appears not to depend upon the applied potential difference V. Explain how your results support these predictions.

You have learned

1. When a capacitor is charged or discharged, a pulse of current flows which quickly rises to a peak and then gradually decays.

2. The direction of the current pulse when the capacitor is charged is opposite to that of the discharge pulse.

3. The magnitude of the current pulse is larger for larger value capacitors C.

4. The magnitude of the current pulse is larger when a larger potential difference V is connected.

5. The current pulse takes longer to decay when the product RC is larger.

Teacher's notes

Practical advice

If the multimeter does not have a prominent analogue bar display then you may prefer to use a

1 mA FSD analogue milliammeter.

The activities are intended to give students a 'feel' for the quantities that affect the current pulses when a capacitor is charged or discharged. The results point the way towards the time constant for measuring the rate of decay but RC is not explicitly defined here. Qualitative observations are intended; other activities provide quantitative approaches for studying the exponential form of the decay.

External references

This activity is taken from Advancing Physics Chapter 10, 100E