Resistor - Capacitor Time Constants (Datadisc)

While conducting this experiment, you will be assessed for CPAC1: Following written instructions, including your ability to set up the circuit and use the data logger. Your lab report will be assessed for CPAC5: analysis of ln graph with ICT and researching and referencing.

Theory

When a capacitor is discharged through a resistor, the voltage falls exponentially from its original value according to the equation

$$V = V_0 e^{-t/RC}$$

where the quantity RC is known as the time constant. This is the time for the voltage to fall to 37% (or 1/e) of the original value.

A graph of V against t will give an exponential decay curve, however if we take logs of both sides of the above equation a straight line relationship is produced as follows:

$$\ln(V/V) = \ln(V_0/V) - t/RC$$

$$\ln(V/V) = -(1/RC) * t + \ln(V_0/V)$$

$$y = m \quad x + c$$

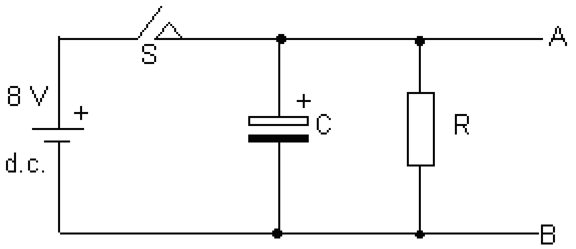
Hence a graph of ln(V/V) against t will have a gradient of – 1/RC from which the time constant can be found.

Apparatus

Electrolytic capacitor of capacitance about 48 000µF
Decade box (with 100 Ω resistor ranges)
Smoothed d.c. power supply
Switch
Computer voltmeter sensor unit
Computer and interface unit

Method

Set up the circuit shown with the decade box set on 200 Ω. Take care to connect the capacitor with the correct polarity. A reverse p.d. can damage the capacitor irreversibly. **Have your circuit checked before proceeding.**



Connect the voltmeter sensor between points A and B in the circuit and connect its output to channel 1 of the interface unit. Select the 10 V range on the sensor and switch it on. On the computer, select the ScienceScope Datadisc Pt program and go to "Set-up" then "Calibrate". Select voltmeter and then select the range. Click on "OK" then "Close".

Return to "Measure" then "Record". Select record at regular intervals. Select a recording duration of about 1 minute. Close the switch to connect the capacitor to the power supply. Open the switch to discharge the capacitor through the resistor R and start recording. By the end of the recording time, the capacitor should have discharged sufficiently. Once a suitable set of results has been obtained, keep the data. Repeat the experiment with a different resistor value set on the decade box.

Analysis

Although it is possible to produce a logarithmic graph in Datadisc Pt, for this exercise you should export your data to Excel. To do this, first switch to table view by clicking on the table icon. Click on the “Edit” menu and “Select all”. Then click on the “Edit” menu again and select “Copy….Copy for spreadsheet”. You can then open a spreadsheet file and paste the data in. You may want to move the data to change the order of your columns in the spreadsheet. You may find that you don’t actually want all of the data, as the log graph becomes slightly non linear for very small voltages. You should delete all readings of V below 1 V. You also don’t want to print the spreadsheet in datasheet view – not unless you want to waste a lot of paper and printer credit!

Now use a formula within Excel to calculate a column of ln(V/V) values. Then plot a graph of ln(V/V) against t and produce a straight line fit, with the equation for the line. If you are unsure of how to do this, look back at the AS spreadsheet exercise or ask your teacher. When you have completed your graph, you should print out a copy for your practical report.

For each set of results, compare the value of RC obtained from the gradient of your graph with the **value calculated from the values of the components, R and C.** Don’t forget the quantity ‘time constant’ has units!

Discuss any discrepancies between the expected and actual values in light of the likely measurement uncertainties. Be aware that big electrolytic capacitors are often manufactured with a large ‘tolerance’**. Look up what this means and don’t forget to reference your findings.**