DATE	COURSE/YEAR/GROUP	NAME

UNIVERSITY OF PLYMOUTH

Department of Communication & Electronic Engineering

COMPUTER SIMULATION USING “ELECTRONICS WORKBENCH”

CAPACITOR TIMING CIRCUIT

Learning Objectives

Study of the temporary current flow in a capacitor –resistor circuit with DC supply

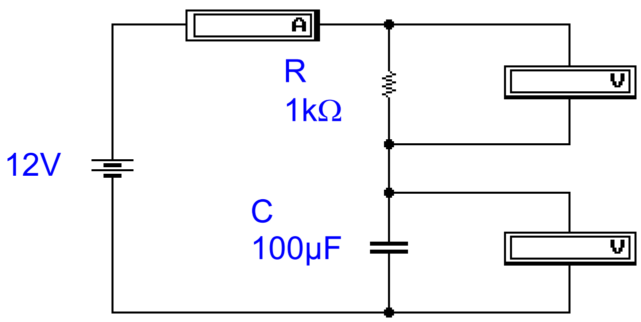
Observation of the voltage waveforms across the capacitor and resistor as the capacitor charges up

The Significance of the “two-thirds” point on the exponential charging curve.

Adjusting the speed of charging by choosing R and C values.

Capacitance in a D.C. circuit.

Wire up the circuit shown below and run the simulation.



RESULTS:

Circuit current =

Capacitor voltage =

Resistor voltage =

You will see that the current is extremely small, and nearly all the supply voltage is across the capacitor.
Does a capacitor let direct current (DC) flow through it? Yes/No …………

Why is this?

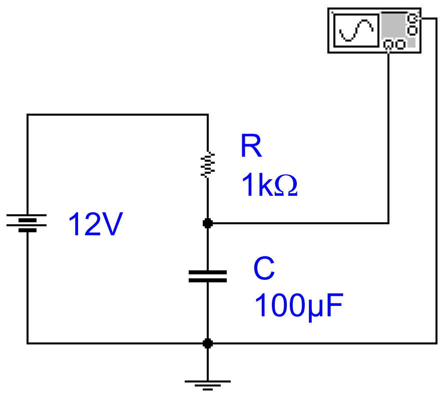
(In fact, in the above simulation, the small current is flowing through the lower voltmeter, because this does not have the infinite resistance of an ideal voltmeter. See the labsheet METER LOADING if you are interested in this problem).

However, there is a **TEMPORARY** pulse of current when the circuit is first switched on.

Remove the two voltmeters and use the Oscilloscope from the Instrument Shelf to observe the variation of

(i) the capacitor voltage and
(ii) the resistor voltage

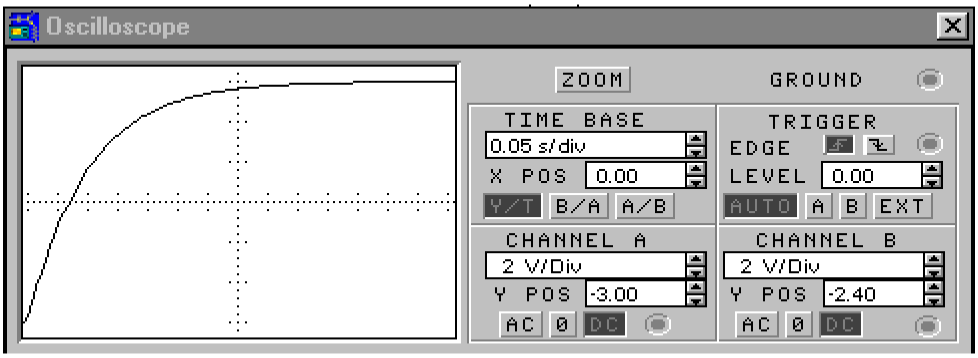
as functions of time when the simulation is run with the d.c. supply connected.



This will require a selection of 'Transient' and 'Pause after each Screen' in the Analysis Options menu (under Circuit)

NB. This option is only used on the few occasions that we want to see what happens the instant we 'start' a circuit running.

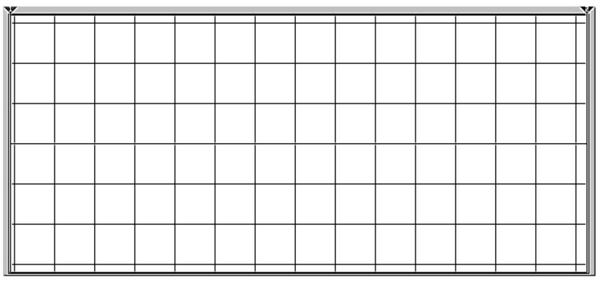
Adjust the oscilloscope controls as below to use the full screen.
Note that YPOS is set to –3.00

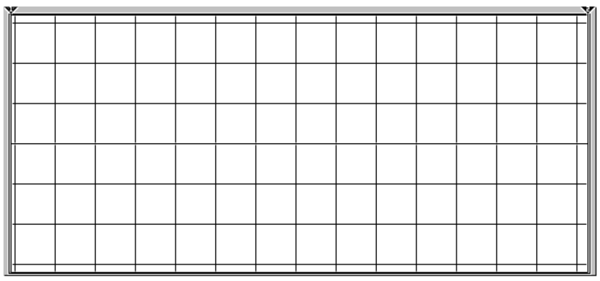


To observe the resistor voltage, you will have to swap the positions of the two components in the circuit. It is not possible to just move the oscilloscope leads, as you run into difficulty with the ground connection.

Sketch the variation of the above voltages on the graph paper below.

Mark the axes with the origin in the bottom left-hand corner, and put values on the voltage and time scales, 0 – 12V, 0 – 0.7 sec





Variation of capacitor voltage

Variation of resistor voltage

These curves are **EXPONENTIAL** in shape. (The simulation produces an odd little upward “lift” right at the start of the trace, which I have **NEVER** seen, and is not exponential).

You need to think of the time scale (horizontal) in terms of how many **TIME CONSTANTS** it represents.

The Time Constant of this circuit = R x C = $10^3 \times 100 \times 10^{-6}$ = ……. seconds

On the oscilloscope screen there are 14 horizontal divisions, each representing 0.05 seconds.

How many time constants are contained in the 14 divisions? …………
Using the graph of capacitor voltage against time, estimate:

(i) The time taken for the capacitor voltage to reach 2/3 of the supply voltage, ie four squares up from the bottom of the screen. (We have effectively moved the X-axis down to the bottom by setting YPOS).

Time T_1 = Compare:- RC =

(ii) The time taken for the capacitor voltage to just become equal to the supply voltage.

Time T_2 = Compare:- 5RC =

The 2/3rds point (one time constant) is a very useful rule-of-thumb for how quickly the capacitor charges. Look up your notes on this point, or discuss with your tutor.

Use of the RC Circuit for Timing Purposes

The classic **"Timer"** chip, the 555, is commonly used for building either astable (oscillator) or monostable (one-shot pulse) circuits.

The R and the C are outside the chip so that circuit designer can control the time constant, and hence the frequency or pulse duration in the two types of circuit.

Inside the chip is a voltage comparator to catch the capacitor voltage at the 2/3rds point on its charging and discharging cycles. See the EWB labsheet on **OPAMPS** if you are interested in voltage comparators.

Adding the Capacitor and Resistor Voltages

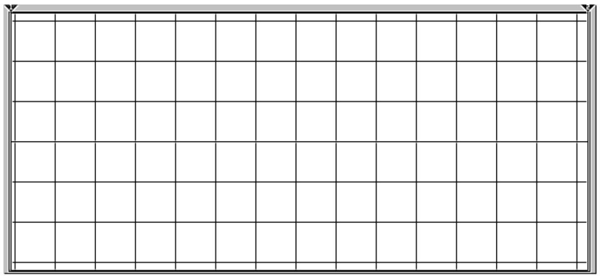
These two components are in series, forming a sort of voltage divider.

So their voltages should add up to what ? ……….

Look again at the two graphs. One is an upside version of the other.

So do they add up? YES NO

The Circuit Current



The resistor voltage gives a clue as to the temporary current pulse when the circuit is switched on.

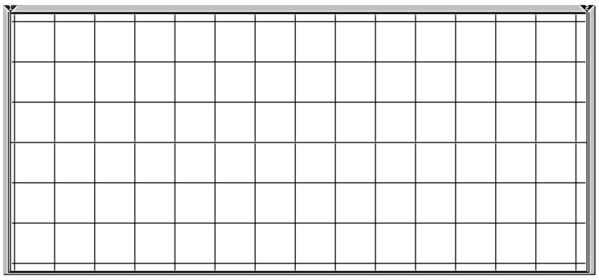
What formula links current I with voltage V? ………..

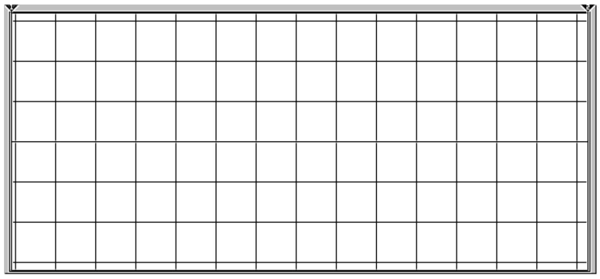
Sketch a graph of the current pulse against time. Using the formula and knowing the resistor value, can you put values on the current scale?

Changing the Time Constant

Try increasing the capacitor value to 500 μF, keeping R = 1 kΩ
Try reducing the capacitor value to 20 μF, keeping R = 1 kΩ

Sketch the graph of capacitor voltage against time for each of these situations.





Time constant = RC = $10^3 \times 500 \times 10^{-6}$ = ……. Time constant = ………….

The voltage rise is much ……….. than before The voltage rise is much …………..

Try reducing the battery voltage to 6V, restoring R and C to their original values.
Does this affect the time taken to rise to 2/3 of the supply voltage? …………..

Suggest suitable values for R and C to give a delay, up to the 2/3 point, of

a) 1 second …………………..

b) 100 μs …………………..

Conclusion

You should now have the knowledge to use the RC combination for creating a specific time delay. Well done!