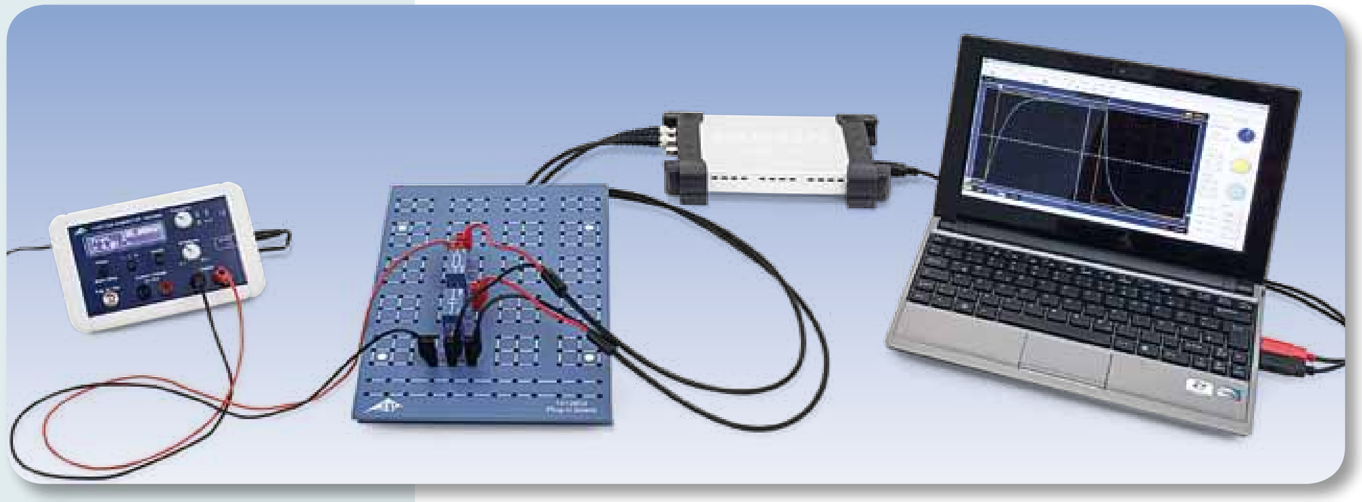
CHARGING AND DISCHARGING A CAPACITOR

UE3050101



EXPERIMENT PROCEDURE

- **Measure the voltage across a capacitor as it charges and discharges when the DC supply voltage to a circuit is turned on and off.**
- **Determine the half-life period for charging and discharging.**
- **Investigate how the half-life period depends on the capacitance and the resistance.**

OBJECTIVE

Investigation of how the voltage across a capacitor changes over time when the capacitor is charging or discharging.

SUMMARY

In a DC circuit, current only flows through a capacitor at the point in time when the power is turned on or off. The current causes the capacitor to charge up until the voltage across it is equal to the voltage applied. When the power is switched off, the capacitor will discharge till the voltage across it drops to zero. A plot of the capacitor voltage against time can be shown as an exponential curve, i.e. the voltage drops by half in the space of a fixed period $T_{1/2}$ called the half-life. The same period elapses when the voltage drops from a half to a quarter and from a quarter to an eighth. The half-life period is proportional to the capacitance and the resistance through which the capacitor discharges.

REQUIRED APPARATUS

Quantity	Description	Number
1	Plug-In Board for Components	1012902
1	Resistor 470 Ω, 2 W, P2W19	1012914
1	Resistor 1 kΩ, 2 W, P2W19	1012916
1	Resistor 2.2 kΩ, 2 W, P2W19	1012918
3	Capacitor 1 µF, 100 V, P2W19	1012955
1	Function Generator FG 100 (230 V, 50/60 Hz)	1009957 or
	Function Generator FG 100 (115 V, 50/60 Hz)	1009956
1	USB Oscilloscope 2x50 MHz	1017264
2	HF Patch Cord, BNC/4 mm Plug	1002748
1	Set of 15 Experiment Leads, 75 cm 1 mm²	1002840
1	Set of 10 Jumpers, P2W19	1012985

GENERAL PRINCIPLES

In a DC circuit, current only flows through a capacitor at the point in time when the power is turned on or off. The current causes the capacitor to charge up until the voltage across it is equal to the voltage applied. When the power is switched off, the capacitor will discharge till the voltage across it drops to zero. A plot of the capacitor voltage against time can be shown as an exponential curve.

(For a DC circuit featuring a capacitance *C*, resistance *R* and a DC voltage U_0, the following applies when the supply is turned on:

(1) $$U(t) = U_0 \cdot \left(1 - e^{-\frac{t \ln 2}{T_{1/2}}}\right)$$

The following applies when the power supply is switched off:

(2) $$U(t) = U_0 \cdot e^{-\frac{t \ln 2}{T_{1/2}}}$$

where

(3) $$T_{1/2} = \ln 2 \cdot R \cdot C$$

$T_{1/2}$ is the half-life period, i.e. the voltage across the a discharging capacitor will halve within a time $T_{1/2}$. The same period elapses when the voltage drops from a half to a quarter and from a quarter to an eighth.
These aspects will be investigated in the experiment. How the capacitor voltage changes over time is recorded using a storage oscilloscope. Since the DC voltage U_0 is set to 8 V, it is easy to read off a half, a quarter and an eighth of that value.

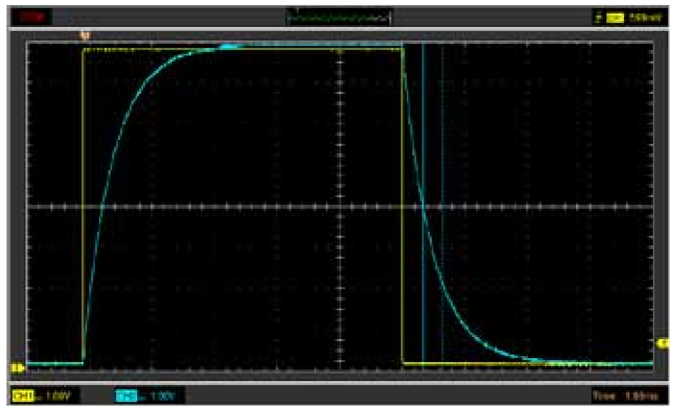


Fig. 1: Traces of voltage across a capacitor while charging and discharging recorded with an oscilloscope.

EVALUATION

The fact that the results measured for the length of the half-life over the various sections of the charging and discharging traces all match verifies that the curve is of the expected exponential nature, see (1) und (2). Plots of the half-life periods measured as a function of the resistance and of the capacitance show that they can fit along a straight line through the origin in either case, see (3).

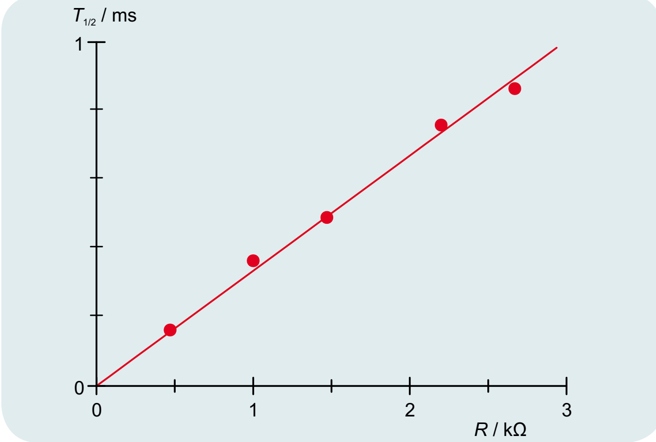


Fig. 2: Half-life $T_{1/2}$ as a function of resistance *R*.

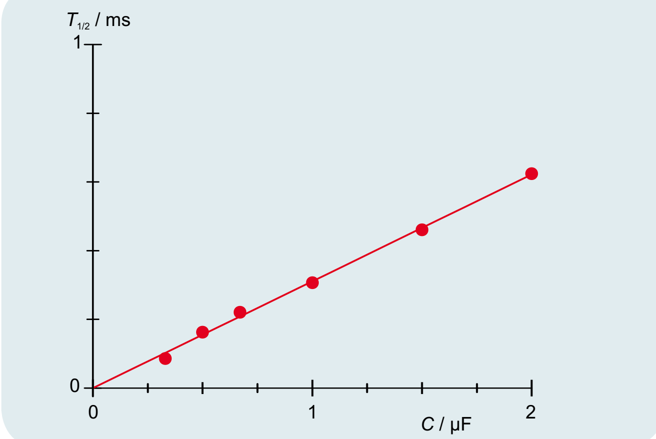


Fig. 3: Half-life $T_{1/2}$ as a function of capacitance *C*.

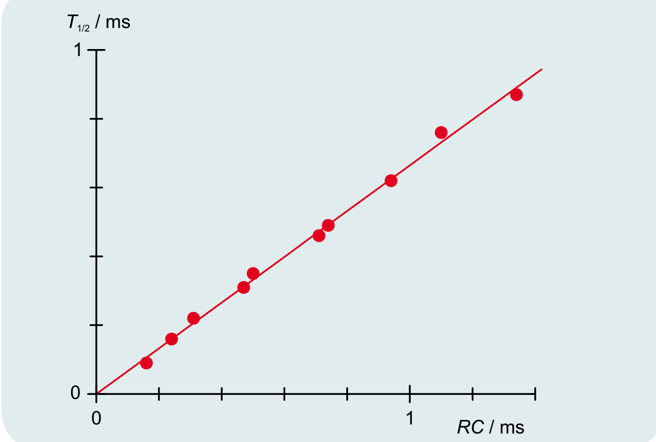


Fig. 4: Half-life $T_{1/2}$ as a function of the product of *R***C*.