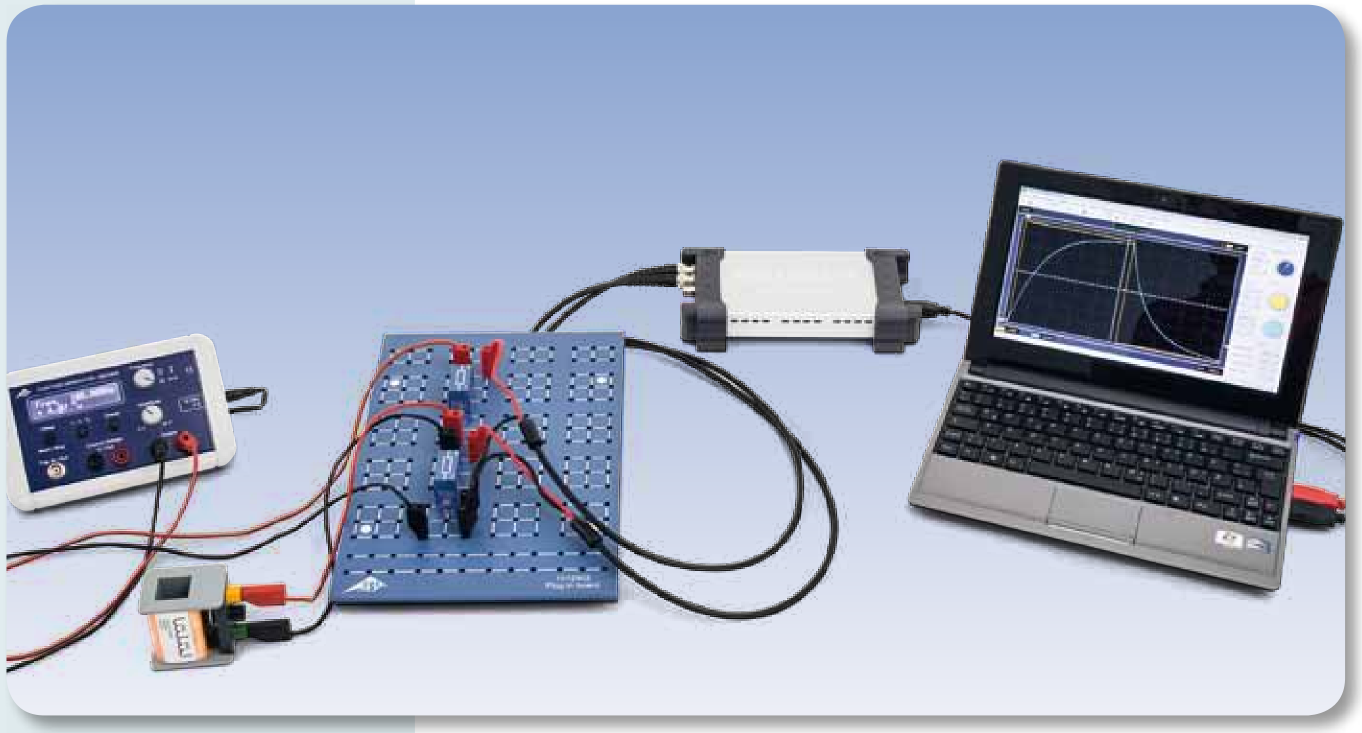
UE3050201 — CHARGING AND DISCHARGING A COIL



EXPERIMENT PROCEDURE

- Measure the current in a coil when a DC supply is turned on and when it is turned off.
- Determine the half-life period when a DC supply is turned on and when it is turned off.
- Investigate how the half-life depends on inductance and resistance.

OBJECTIVE

Investigation of how the current through a coil changes over time when the DC supply is turned on and off

SUMMARY

The behaviour of a coil in a DC circuit changes as soon as the DC supply is turned on or off. The change in current is delayed by self-induction of the coil until it reaches its final value when turning on or zero when turning off. A plot of the coil current against time can be shown to be an exponential curve, i.e. the current through the coil drops by half in the space of a fixed period $T_{1/2}$ called the half-life. The same period elapses when the current drops from a half to a quarter and from a quarter to an eighth. The half-life period is proportional to the inductance and the resistance of the circuit.

REQUIRED APPARATUS

Quantity	Description	Number
1	Plug-In Board for Components	1012902
1	Resistor 1 Ω, 2 W, P2W19	1012903
1	Resistor 10 Ω, 2 W, P2W19	1012904
1	Resistor 22 Ω, 2 W, P2W19	1012907
1	Resistor 47 Ω, 2 W, P2W19	1012908
1	Resistor 150 Ω, 2 W, P2W19	1012911
1	Set of 10 Jumpers, P2W19	1012985
2	Coil S with 1200 Taps	1001002
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

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BASIC PRINCIPLES

The behaviour of a coil In a DC circuit changes as soon as the DC supply is turned on or off. The change in current is delayed by self-induction of the coil until it reaches its final value when turning on or zero when turning off. A plot of the coil current against time can be shown to be an exponential curve.

For a DC circuit featuring an inductance L, resistance R and DC voltage U_0, the following applies when the supply is switched on:

(1) $$I(t) = I_0 \cdot \left(1 - e^{-\frac{t \cdot \ln 2}{T_{1/2}}}\right)$$

The following applies when the power is supply off:

(2) $$I(t) = I_0 \cdot e^{-\frac{t \cdot \ln 2}{T_{1/2}}}$$

where

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

$T_{1/2}$ is the half-life period, i.e. the current through the coil will halve within a time $T_{1/2}$. The same period elapses when the current drops from a half to a quarter and from a quarter to an eighth.

These aspects will be investigated in the experiment. How the coil current changes over time is recorded using a storage oscilloscope. The current is measured by means of the voltage drop across a resistor R_M. The current I_0 has been selected such that a half, a quarter and an eighth of this current are easy to read off.

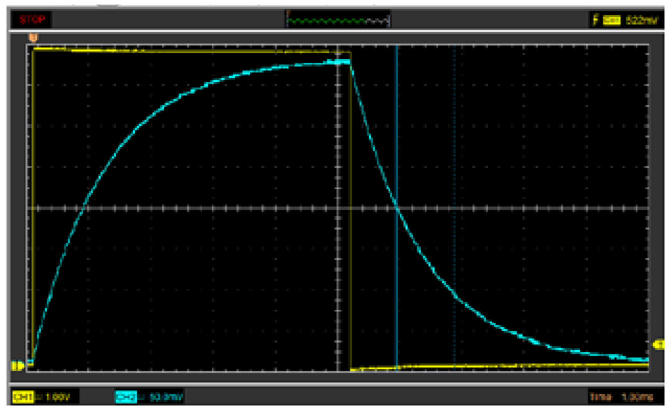

Fig. 1: Traces of current through a coil while charging and discharging recorded with an oscilloscope

EVALUATION

The fact that the measured results 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) and (2). Plots of the half-life periods measured as a function of the resistance and of the inductance shows that they can fit along a straight line through the origin in either case, see (3).

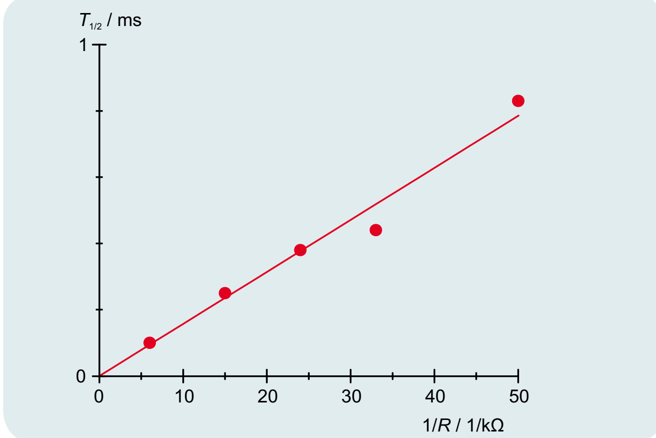

Fig. 2: Half-life $T_{1/2}$ as a function of the inverse of resistance R

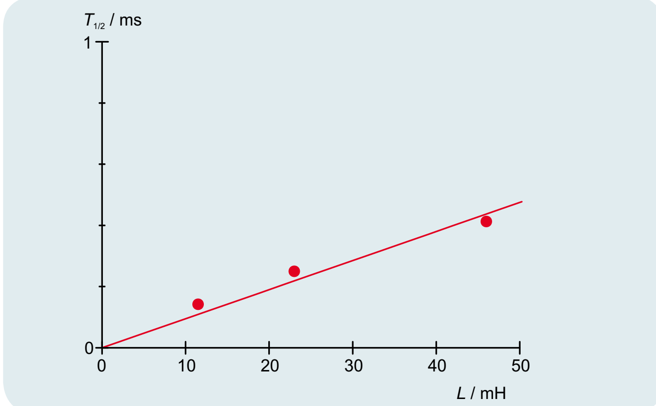

Fig. 3: Half-life $T_{1/2}$ as a function of inductance L

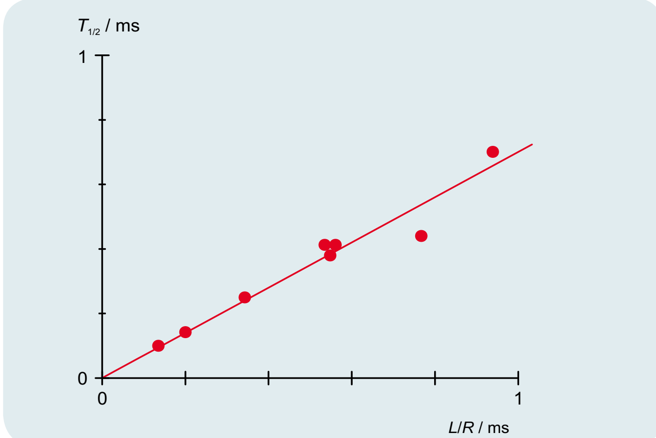

Fig. 4: Half-life $T_{1/2}$ as a function of $\frac{L}{R}$