Exercise 8
Coil self-inductance

Aim

Determination of the inductance L of a coil on the basis of the coil impedance measured in the AC circuit and the coil resistance measured in the DC circuit.

Required theoretical knowledge

Faraday's Law of Induction. Lenz's Law. Definition of the inductance. The SI-unit of the inductance. Self-Inductance. Magnetic energy stored by an inductor. Factors that determine the inductance of a coil. Inductors in DC circuits. Inductors in AC circuits. Inductive reactance, impedance, conductance, inductive susceptance, admittance. Phase shift between the voltage and the current in RL circuits. Hysteresis loop of a ferromagnetic.

Equipment

The measurement set up is shown in Fig. 1. It consists of a DC/AC power supply, a wire-potentiometer, a digital voltmeter, a digital ammeter and a coil.

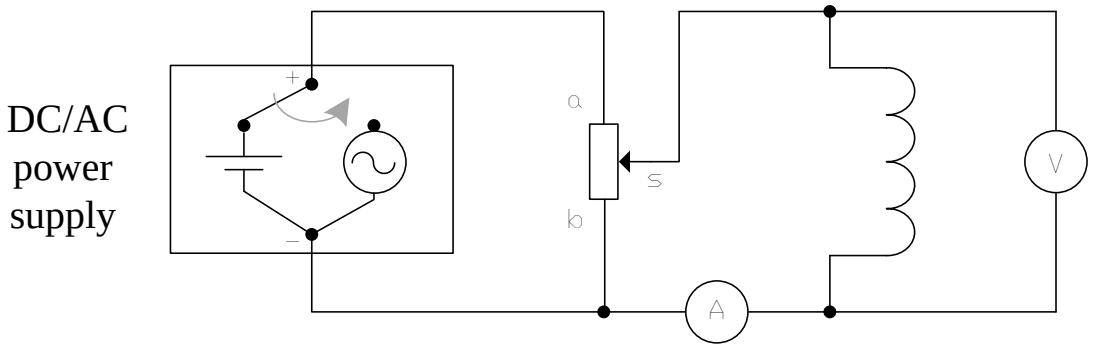

Fig. 1. Exercise 1 measurement setup.

Two types of coils are investigated by measurements of current flowing through coils as a function of voltage applied to the coil terminals. Voltage applied to the coil terminals is controlled by the wire-potentiometer with a movable wiper. Digital voltmeter and ammeter have both AC and DC settings. They also have buttons that allow the user to choose the appropriate range for the voltage or current that are to be measured. DC/AC power supply is available. The two coils - number 1 and number 2 - are wounded on the common core.

Problems for discussion:

What is the difference between impedance and admittance? What other physical quantities they are made of?
What does the coil inductance depend on?
Transformer principal of operation.

Measurement plan:

1. Set-up a circuit as it is shown in Fig. 1. Connect Coil 1 or Coil 2 (ask assistant which one). Set the digital voltmeter and the digital ammeter for DC operation in the range 20V and 2A, respectively.
2. Turn on the PC. Open *Calc* software.
3. Set the power supply to the DC mode. Turn on the DC voltage supply. By moving the wiper across the wire-potentiometer, change the voltage applied to the coil in the range 0-12 V. Measure the voltage drop across the coil *V* and current *I* through the coil. Collect about 10 – 15 measurements in order to draw the plot $I_{DC}(V_{DC})$. Write down the results in Tab.1. in your measurement card. Use *Calc* program.
4. Turn off power supply, change it to AC mode, turn it back on. Set the digital voltmeter and the digital ammeter for AC operation (change terminals on ammeter if necessary). Make the correction of the ammeter range.
5. Measure characteristics $I_{AC}(V_{AC})$ for the same coil. Write down the results in Tab.2. in your measurement card. Use *Calc* program.
6. Turn off the power supply

Data processing:

1. Draw the plots $I_{DC}(V_{DC})$ and $I_{AC}(V_{AC})$ in one rectangular coordinates.
2. Fit the straight line $y = ax$ to the experimental points of the plot $I_{DC}(V_{DC})$ using one parameter linear regression method. Find the regression coefficient *a* and its uncertainty.
3. Calculate conductance and resistance of measured coil.
4. Fit the straight line $y = cx$ to the experimental points of the plot $I_{AC}(V_{AC})$ using one parameter linear regression method. Find the regression coefficient *c* and its uncertainty.
5. Using resistance and conductance values measured in point 2 calculate impedance and admittance of measured coil.
6. On the basis of calculated values, calculate reactance and inductive susceptance of measured coil.
7. Knowing the frequency of the electricity grid *f* of voltage changes and have inductive reactance X_L calculated in point 6, find inductance *L* of a coil and its uncertainty ΔL using the rule of propagation of uncertainties,
8. Finally calculate the tangent of the phase angle: $tg\delta = \frac{\omega L}{R}$ and the phase angle δ (in degrees)

Literature

1. Halliday, Resnick "Fundamentals of Physics - 8th edition", John Wiley 2007,