IIE4

Modul Electricity II

Transformer

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Experiment IIE4 - Transformer

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1.1 Preliminary Questions

- How does a transformer function? Explain in your own words.
- Where are transformers used in every life? Examples?
- Are all modern transformers according to the principles described below?
- Deduce a formula for the relationship between the primary and secondary current.

1.2 Theory

A transformer essentially consists of two coils, which are connected inductively by an iron core. The primary coil with N_1 windings is connected to an alternating voltage U_1. Thereby, a current flows through the coil and generates a magnetic flux $\Delta\Phi$. This is described by the law of induction:

$$U = -N\frac{\Delta\Phi}{\Delta t} \tag{1.1}$$

This flux is passed through the iron core in the secondary coil, where it in turn induces a current and a voltage according to (1.1). Also:

$$\frac{\Delta\Phi}{\Delta t} = -\frac{U_1}{N_1}$$

used in

$$U_2 = -N_2\frac{\Delta\Phi}{\Delta t}$$

results in:

$$\frac{U_1}{U_2} = \frac{N_1}{N_2} \tag{1.2}$$

Since energy conservation is guaranteed here, the power ($= \frac{\text{energy}}{\text{time}}$) must also be obtained. It follows that the line of the primary coil to that of the secondary coil is equivalent. The electric power is defined as follows:

$$P = U \cdot I \tag{1.3}$$

Thus, a connection between the primary and secondary current independent of the turns are made.

1.3 Experiment

1.3.1 Equipment

Component	Number
Multimeter	2
Connecting Cables	6
Connecting Bridges	4
Voltage Source	1
Exercise Transformer	1

1.3.2 Experimental Setup

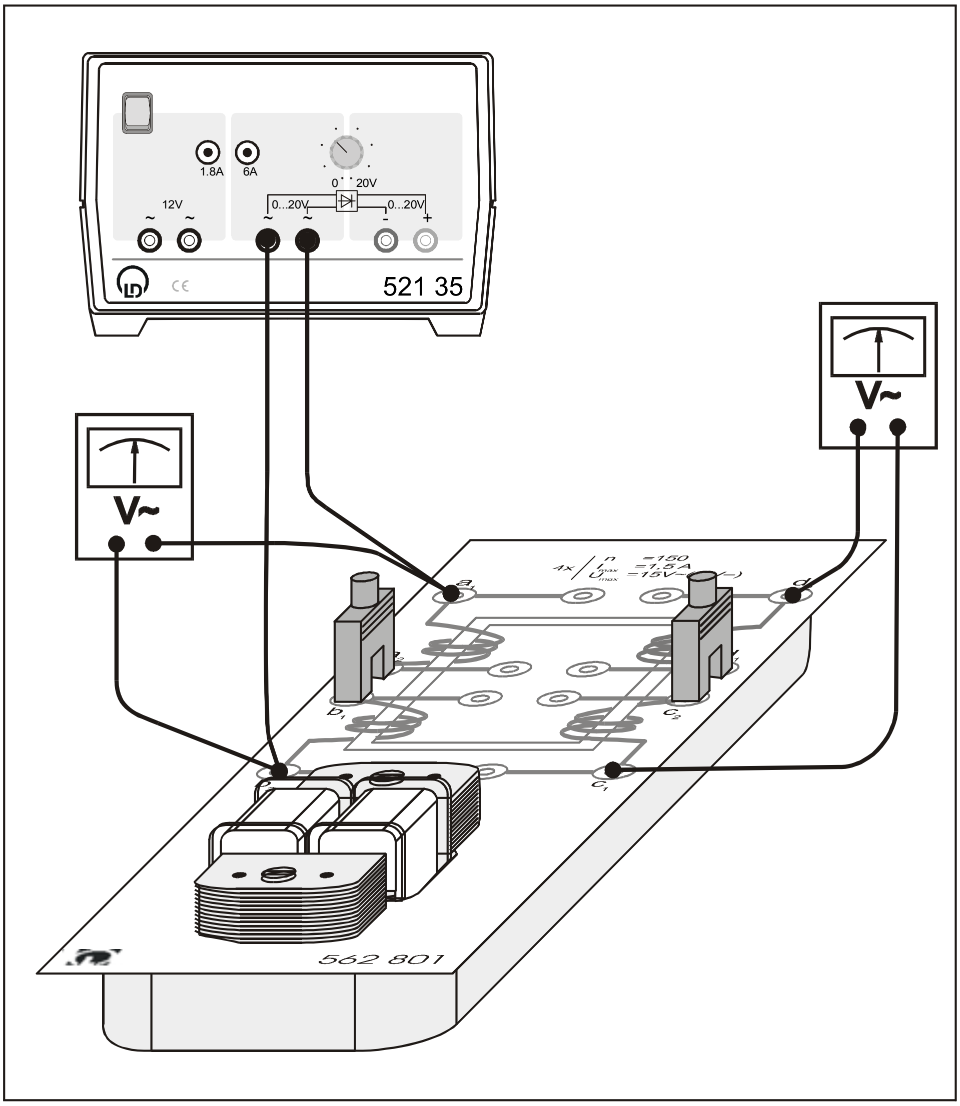

Figure 1.1: Schematic setup of exercise transformer with voltage source

The exercise transformer consists of two primary and two secondary coils. Each of these four coil has 150 turns. Two coils are connected together by connecting bridges. With this setup, the following conditions $\frac{N_1}{N_2}$ are possible: 150: 150, 150: 300, 300: 150 and 300: 300th Figure 1.1 shows schematically how the individual components are connected. If the multimeter across the coils is parallel, the voltage can be measured. They are connected in series, so we measure the (short circuit) current. The multimeter must have the appropriate position provided and experiment leads are corrected to the correct jacks. During the tests, it must be ensured that the current through the primary and secondary coils does not exceed the value of 1.5 A. After each partial test and during the conversion, the voltage source must be turned off. During the experiment, the voltage should be turned up only slowly.

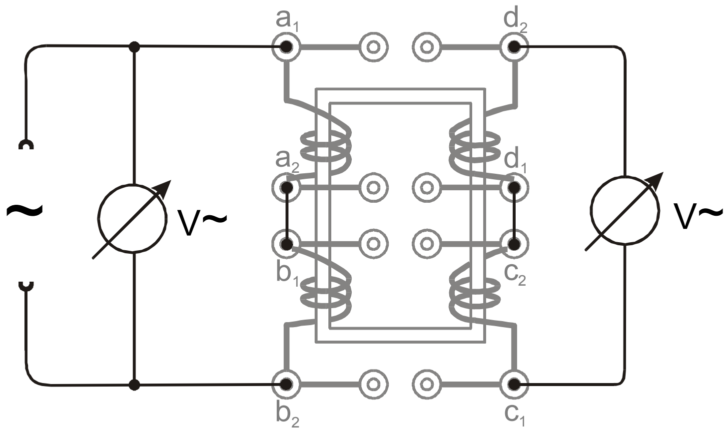

Figure 1.2: Scheme for the voltage measurement

1.3.3 Execution and Evaluation

Task a) Voltage Measurement

- Build the experiment for the voltage measurement.
- Choose for the turns the ratio 300:300.
- Vary the voltage at the voltage source stepwise between 0 V and 10 V and measure the voltage at the primary and secondary coil.
- Plot the value pairs in a plot, and determine the slope with a fit.
- Plot together the plot in addition to the theoretical measurements of the voltage according to Eq. (1.2). Do the measured values match those of the theory?
- Repeat the experiment for the ratios 150:300 and 300:150.

Task b) Voltage Measurement

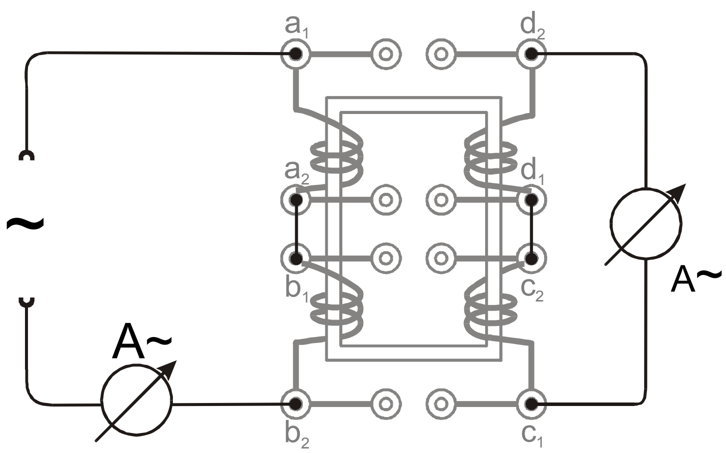

Figure 1.3: Scheme for the Current Measurement

- Build the experiment for the current measurement.

- Choose for the turns ratio 300:300.
- Vary the voltage at the voltage source stepwise between 0V and 10V and measure the flow at the primary and secondary coil. Make sure that the power does not exceed a value of 1.5A!!
- Plot the value pairs in a plot, and determine the slope with a fit.
- Plot together the plot in addition to the theoretical measurements of the current according to your formula for the current of the primary and secondary coils. Do the measured values match those of the theory?
- Repeat the experiment for the ratios 150:300 and 300:150.

Task c) The Auto Transformer

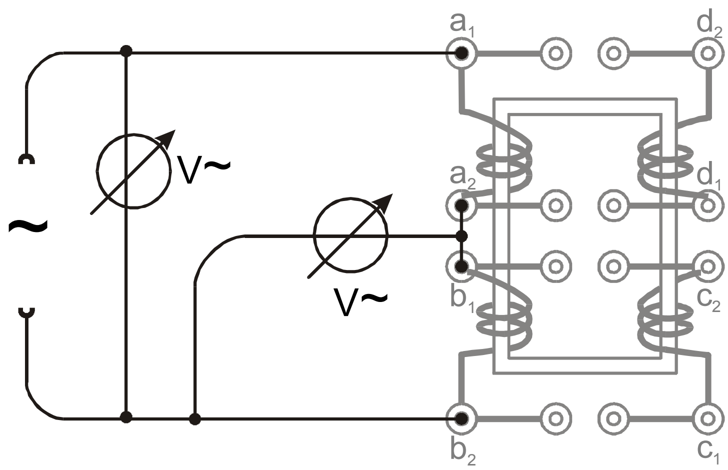

Figure 1.4: Scheme of an Auto Transformer

- Build the auto transformer according to Figure 1.4.
- Vary the voltage at the voltage source stepwise between 0 V and 10 V and measure the voltage at the primary and secondary coil.
- Plot the value pairs in a plot, and determine the slope with a fit.
- What do you notice? What are the advantages and disadvantages of this setup over the construction of task a)?

Task d) The insulating Transformer

- Figure 1.5 shows the setup of an insulating transformer.
- Describe how the voltage and current at the secondary coil is a function of the primary coil behavior. (You have measured a similar situation already in task a) and b).)
- Where can one use such a setup?

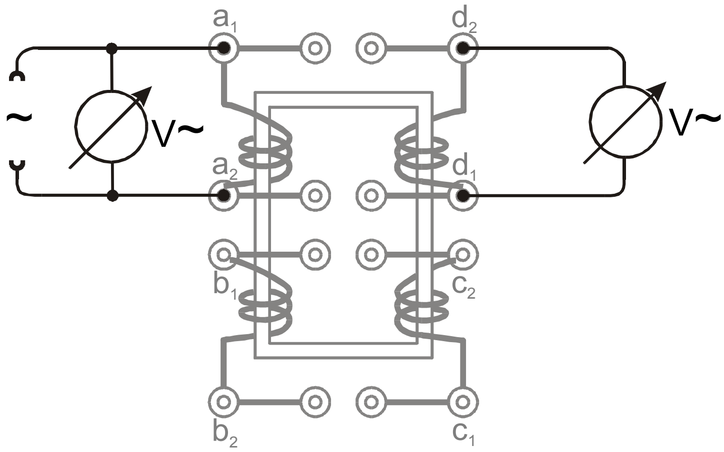

Figure 1.5: Scheme of an insulating Transformer

1.4 Literature

- Paul A. Tipler, *Physik für Naturwissenschaftler und Ingenieure*, Spektrum
- Horst Stöcker, *Taschenbuch der Physik*, Verlag Harri Deutsch
- Horowitz & Hill, *The Art of Electronics*, Cambridge University Press