**Task**

To connect up a model of a transformer, use it to increase and reduce given alternating voltages and examine which conformity to law is given.

**Equipment**

| | | |
|---|---|---|
| Plug-in board | 06033.00 | 1 |
| On/off switch | 39139.00 | 1 |
| Coil, 400 turns | 07829.01 | 2 |
| Coil, 1600 turns | 07830.01 | 1 |
| U-core | 07832.00 | 1 |
| Yoke | 07833.00 | 1 |
| Tightening screw | 07834.00 | 1 |
| Connecting cable, 25 cm, red | 07313.01 | 2 |
| Connecting cable, 25 cm, blue | 07313.04 | 2 |
| Connecting cable, 50 cm, red | 07314.01 | 2 |
| Connecting cable, 50 cm, blue | 07314.04 | 2 |
| Multi-range meter | 07028.01 | 2 |
| Power supply, 0...12 V-,6 V~, 12 V~ | 13505.93 | 1 |

**Set-Up and Procedure**

— Connect up the circuit as shown in Fig. 1; the primary and secondary coils of the transformer (see Fig. 2 for the principles of the construction and terms used) first have the same number of turns ($N_p = N_s = 400$).
— Select the 10 V- measurement range, open the switch, set the power supply to 0 V and switch it on.
— Adjust the voltage to 4 V-, close and open the switch several times; observe the voltmeter across the secondary coil and note your observation under (1).
— With the switch open, select the 10 V~ measurement range.
— Connect the 6 V~ voltage instead of 4 V-.T
— Open the switch and measure the voltage across the primary coil ($U_p$) and across the secondary coil ($U_s$); enter the measured values in Table 1.
— Open the switch and replace the secondary coil with 400 turns by the 1600 turn coil; change the measurement range of the voltmeter across the secondary coil to 30 V~.
— Close the switch, measure $U_p$ and $U_s$ and note the measured values in Table 1.
— Open the switch and interchange the coils with each other; to do this, disconnect the transformer and turn it 180° around, so that the 1600 turn coil is now the primary coil; select the 10 V~ measurement range for $U_s$.
— Close the switch, again measure $U_p$ and $U_s$ and note the values.
— Select the 30 V~ measurement range on the voltmeter across the primary coil and pick up 12 V~ from the power supply; measure $U_p$ and $U_s$ and note the values.
— Remove the yoke and U-core, measure $U_p$ and $U_s$ and note the values under (2).
— Switch off the power supply.

Fig. 2

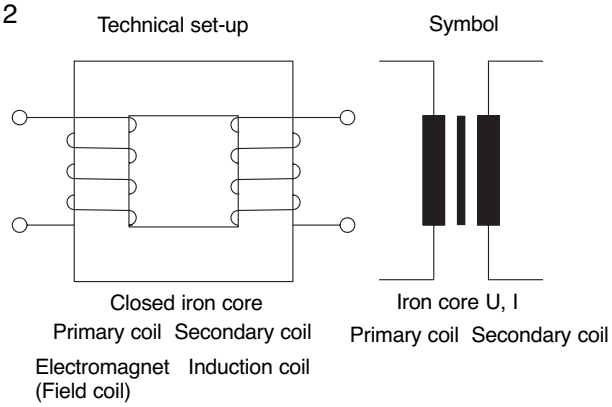
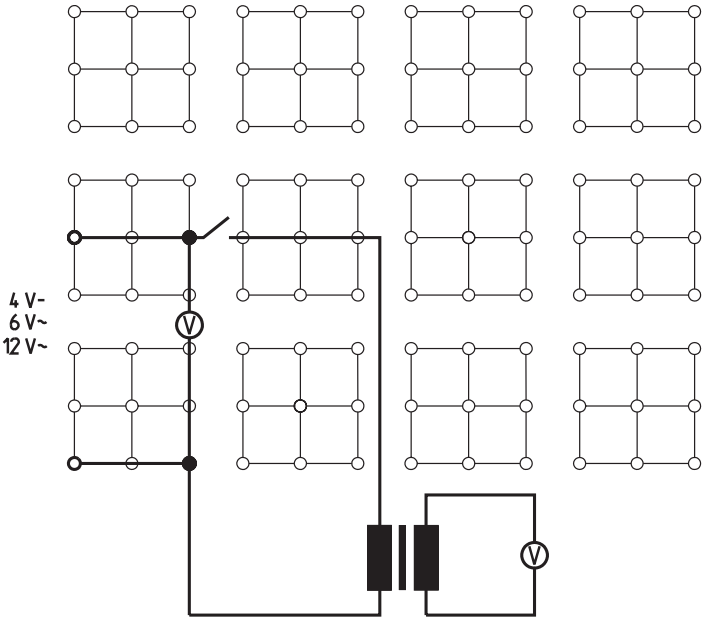



Fig. 1



**Observations and Measurement Results**

(1)

Table 1

| $N_p$ | $N_s$ | $U_p$/V | $U_s$/V | $U_p$:$U_s$ | $N_p$:$N_s$ |
|---|---|---|---|---|---|
| 400 | 400 | | | | |
| 400 | 1600 | | | | |
| 1600 | 400 | | | | |
| 1600 | 400 | | | | |

(2) Transformer without yoke: $U_p$ = ..... ; $U_s$ = .....

**Evaluation**

1. Explain the observation noted under (1).

2. Calculate the quotients from the measured values for $U_p$ and $U_s$ as well as for $N_p$ = $N_s$ and enter the results in columns 5 and 6 of Table 1.
3. Compare the values of the quotients $U_p/U_s$ and $N_p/N_s$ in the lines of Table 1.
   a) From the comparison - predominately of the values in lines 1 and 2 – you can derive an assumption as to which law is valid for the transformation of voltages. How can this law be stated?

   b) How can you explain deviations from this law (as are particularly distinctive from the values in the lines 3 and 4)?

4. How can a voltage be changed with a transformer?
   a) Increasing the voltage:

   b) Decreasing the voltage

(How can a given alternating voltage be increased or reduced?)

Transformers represent a significant application of induction. They are predominately used to transmit electrical energy over long distances with as little loss as possible, or to adjust fixed supply voltages to the rated voltages of electrical appliances and equipment.
The students know that an induction voltage can also be generated without movement of the field and induction coils relatively to each other, because it only requires that the induction coil contains a part of a changing magnetic field. They will therefore understand the working principle of a transformer without any great difficulty.

**Notes on Set-Up and Procedure**
The closing and opening of a direct current circuit with the primary coil is intended to help the students to quickly understand the working principle of a transformer. It is important in this experiment that the measurement ranges are correctly selected.
The examination described is limited to the transformer without load.

**Observations and Measurement Results**
(1) Each time the primary circuit is closed or opened, the pointer of the voltmeter across the secondary coil is deflected a little to the right or to the left.
(2) Transformer without yoke: $U_p = 12.2$ V; $U_s = 1.0$ V.

**Evaluation**
1. When the direct current circuit is closed, a magnetic field is built up in the primary coil, and this is in the main – conditional on the common iron core – contained within the secondary coil. When the direct current circuit is opened, the magnetic field is broken down.
   In both cases, the changes in the magnetic field contained within the secondary coil briefly induce a voltage in the secondary coil, but of different direction.
2. Refer to columns 5 and 6 of Table 1.
3. a) The law could be stated as:
   $U_p:U_s \approx N_p:N_s$ (or: $U_p:U_s = N_p:N_s$).
   b) A part of the electrical energy in the primary circuit is required, to repeatedly reversely magnetize the iron core and to overcome the (ohmic) resistance.
4. a) Increasing the voltage: The secondary coil must have more turns than the primary coil.
   b) Decreasing the voltage: The secondary coil must have less turns than the primary coil.

**Remarks**
As the law $U_p:U_s = N_p:N_s$ is only valid for an ideal transformer, one should not take the trouble of "improving" the experimentally determined measured values.
Rather than this, it is advisable to leave the law in the form $U_p:U_s \approx N_p:N_s$ and so respond to reality.

Table 1

| $N_p$ | $N_s$ | $U_p$/V | $U_s$/V | $U_p:U_s$ | $N_p:N_s$ |
|---|---|---|---|---|---|
| 400 | 400 | 6.1 | 5.6 | 1.09 | 1.00 |
| 400 | 1600 | 6.1 | 22.6 | 0.27 | 0.25 |
| 1600 | 400 | 6.1 | 1.2 | 5.01 | 4.00 |
| 1600 | 400 | 12.2 | 2.6 | 4.69 | 4.00 |

| T | EEP 9.1 | Transforming voltage | PHYWE |
|---|---|---|---|

(How can a given alternating voltage be increased or reduced?)

Room for notes