

REMOTE VERIFICATION OF KIRCHHOFF'S CURRENT LAW

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Abstract: *The contribution presents one of the possibilities of the remote measurement of basic electric circuits. The remote measurement verifies the validity of Kirchhoff's current law and gives practical knowledge of this problem to the user. It describes the remote measuring facility used at the European Polytechnic Institute in Kunovice, Czech Republic. The implemented remote access to the measurement via internet gives the possibility to use this facility for any user all over the world.*

Key words: *Remote measurement, Electrical engineering, E-learning, Arduino, Kirchhoff's laws*

1. INTRODUCTION

In 1845, Gustav Robert Kirchhoff derived the two basic circuit laws from the general law of energy conservation. The Kirchhoff's current law (KCL) states that the sum of all currents in a circuit node equals zero. The Kirchhoff's voltage law (KVL) states that the sum of all voltages in a circuit loop equals zero.

The laboratory of remote measurement, which has been implemented at the EPI, enables the students to understand and verify the knowledge of the theory given in lectures. The students are connected to the laboratory via internet. The laboratory is built by the students who have this task given in their BSc theses. They also create the web portal for the access to the measurements. The laboratory serves not only for the students of EPI but also for the public. The laboratory experiments for the remote measurement implemented at EPI are for example:

- Diode measurements
- Bipolar transistor measurements
- Electromagnetic field measurements
- Load characteristics of supply sources measurements
- KCL verifications

This paper deals with KCL verifications.

The experiment consists of a measured hardware part and a software part transforming the measured values to the students.

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2003 - 2007: Secondary School Uherský Brod - mechanics, electronics, focusing on computer technology

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2. REMOTE MEASUREMENT

The task was to create the remote verification of KCL via internet. Thus it was necessary to construct a facility for this experiment which gives the access for students via the web explorer. The configuration of the measured circuit should demonstrate KCL in a simple way. The core of this facility is the open-source Arduino platform which is extended by an ethernet modul for the ethernet communication.

The experiment is implemented on a series-parallel circuit with resistors of various values.

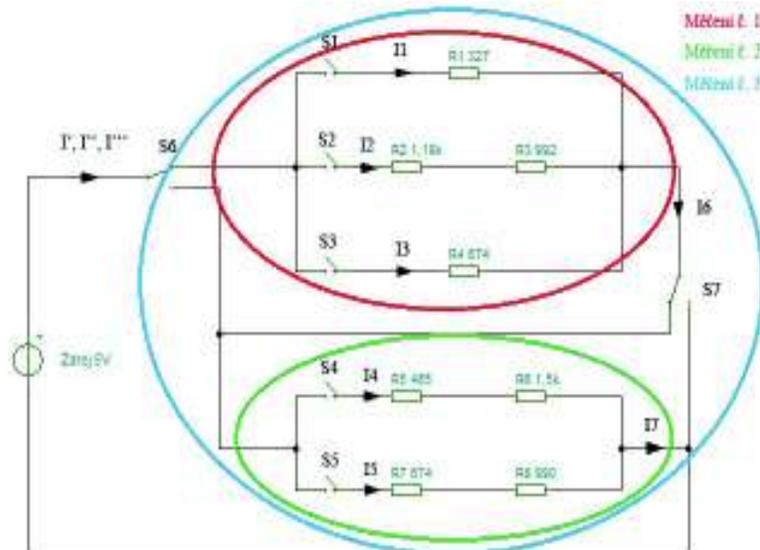


Figure 6: Circuit diagram of the measured circuits

The circuit can be divided into three different circuits by controlled relays for the independent measurement. The students can try various measurements in this way. Moreover, for each of these measurements the circuit branches can be switched independently for various situations.

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1951-1955 Higher School of Electrical Engineering in Brno

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Practice:

1961-1963 METRA Blansko – researcher

1963-present FE (FEI FEEC) Brno - assistant professor, associate professor

1980-1993 FE (FEI FEEC) Brno - Head of the Department of Microelectronics

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Publications:

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Work abroad:

1969-1971, 1973-1976, University of Sulaimaniyah, Iraq, expert MFA ČSSR- Lecturer, Department of Electrical Engineering

The coordinator and participant in TEMPUS, SOCRATES, LEONARDO, COPERNICUS, STAREUROPE, SUB-UK, 5th EP-Frame SMARTFUEL ...

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The relations for each particular measurement verifying its correctness are given further.

The values of the resistors are measured exactly so that the measurement results are exact as well.

The first measurement is done for the first part of the circuit shown in **Figure 7**.

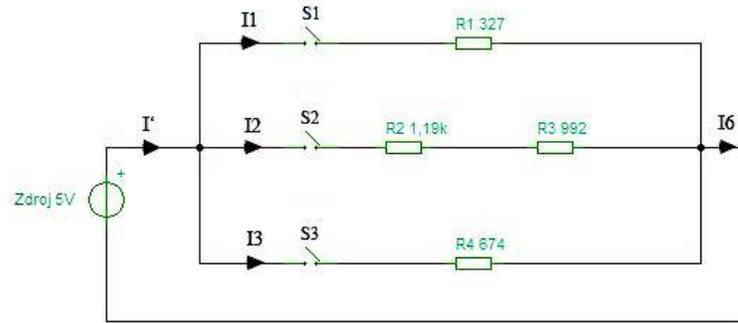


Figure 7: Circuit diagram for the measurement No. 1

Applying KCL:

$$I' = I1 + I2 + I3 \quad (1)$$

$$I' - (I1 + I2 + I3) = 0 \quad (2)$$

$$I1 + I2 + I3 = I6 \quad (3)$$

$$(I1 + I2 + I3) - I6 = 0 \quad (4)$$

$$I' = I6 \quad (5)$$

The second measurement is done for the second part of the circuit shown in **Figure 8**.

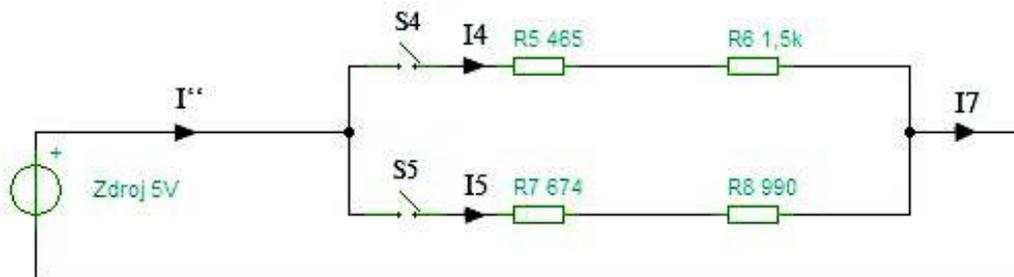


Figure 8: Circuit diagram for the measurement No. 2

Applying KCL:

$$I'' = I4 + I5 \quad (6)$$

$$I'' - (I4 + I5) = 0 \quad (7)$$

$$I4 + I5 = I7 \quad (8)$$

$$(I4 + I5) - I7 = 0 \quad (9)$$

$$I'' = I7 \quad (10)$$

$$I'' - I7 = 0 \quad (11)$$

The third measurement is done for the complete circuit shown in **Figure 9**.

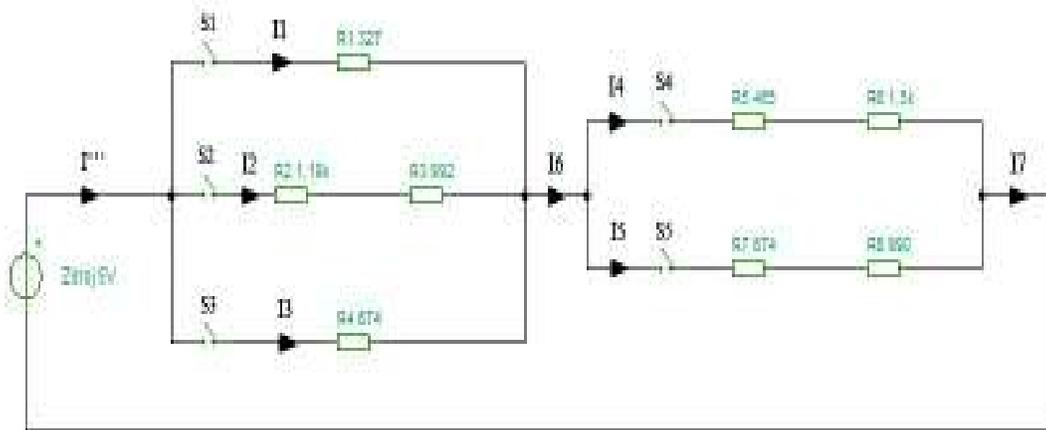


Figure 9: Circuit diagram for the measurement No. 3

Applying KCL:

$$I''' = I1 + I2 + I3 \quad (12)$$

$$I1 + I2 + I3 = I6 \quad (13)$$

$$I6 = I4 + I5 \quad (14)$$

$$I4 + I5 = I7 \quad (15)$$

$$I''' = I6 = I7 \quad (16)$$

$$I''' - (I1 + I2 + I3) + I6 - (I4 + I5) = 0 \quad (17)$$

The circuit diagram of the designed circuit including the indicating diodes visualising the active measured branches is shown in **Figure 10**.

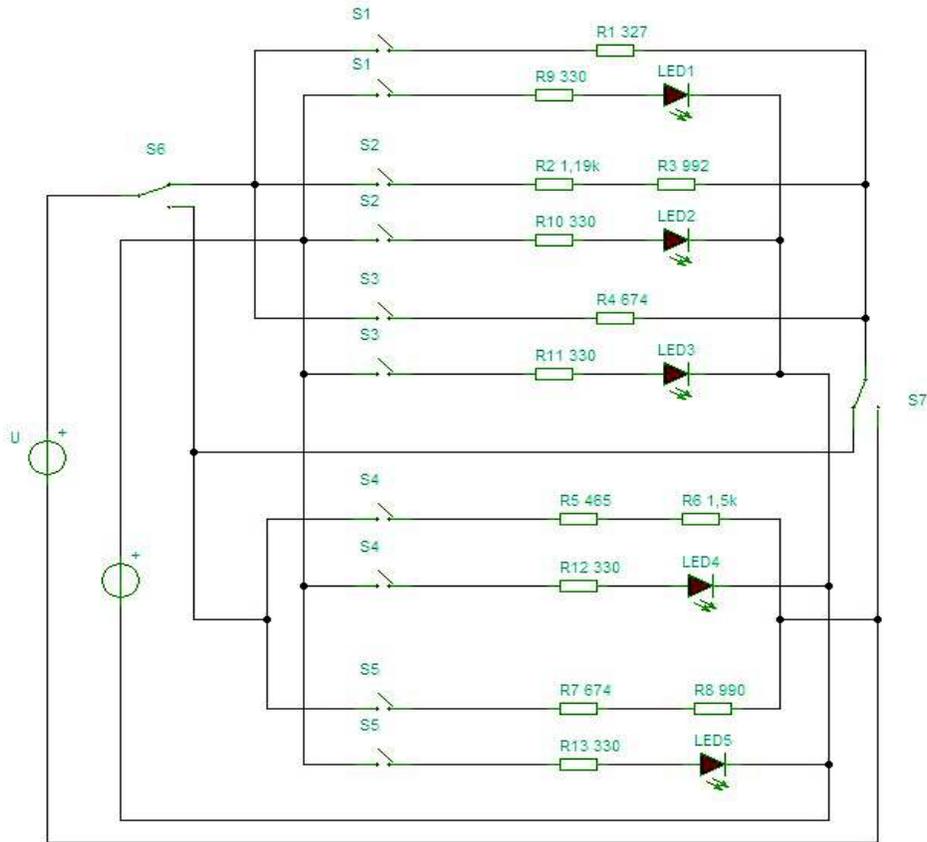


Figure 10: Designed circuit including the indicating diodes

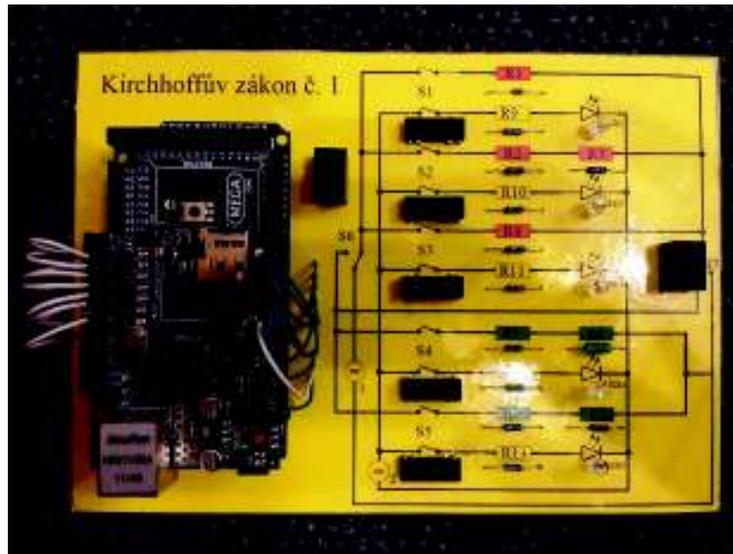


Figure 11: Printed circuit board with the complete measured circuit

The user has the possibility to control the complete course of the measurement with the help of a web camera for visual contact. The measured results are displayed for the students on the web page of the measurement shown in **Figure 12**.

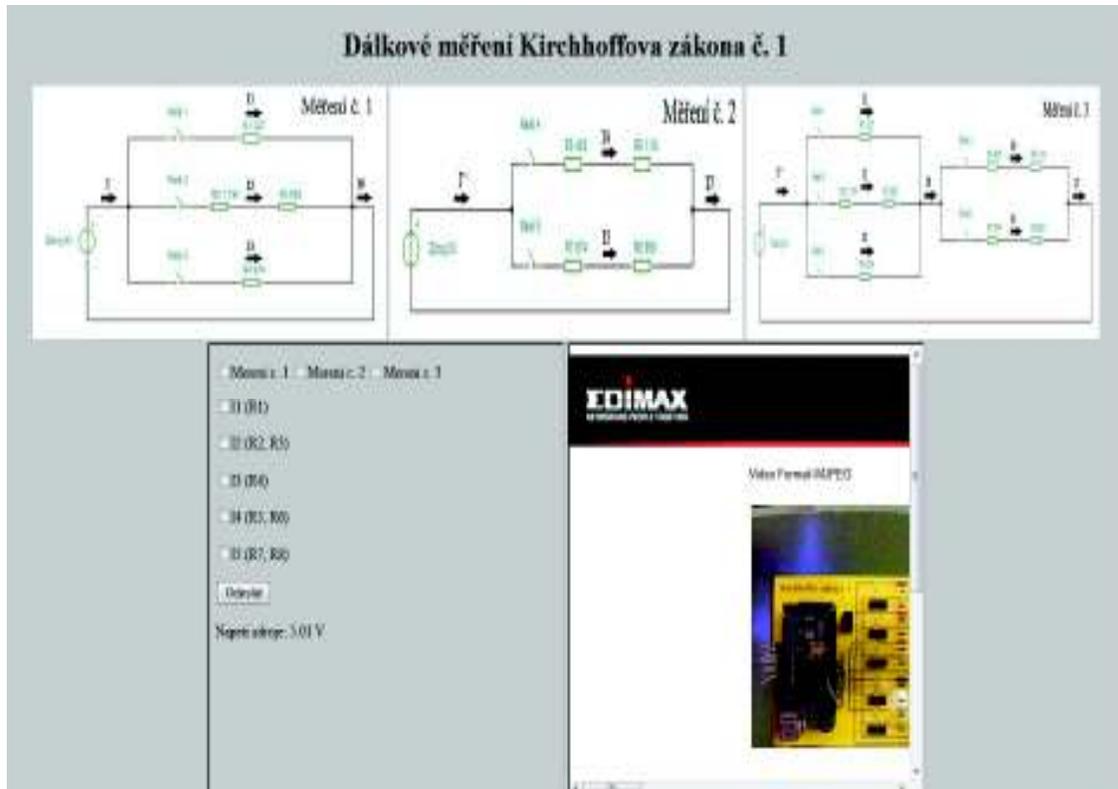


Figure 12: View of the measurement web page

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2013-present SGaSOŠ, Ltd. Kunovice - Professional Teacher

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3. CONCLUSION

Any theoretical study should be always completed by related practical experiments especially in technical science. The problem is that the students do not have the necessary and usually expensive equipment at home. The popular combined form of study can fully employ the remote measurement for laboratory practicals. Of course the work in a real and fully equipped laboratory is always the best solution.

The complete equipment described in the contribution is implemented in the special EPI laboratory. It is connected with the EPI central computer together with the other projects. The

web page of this measurement contains the pattern of the measurement report. The correct way of the measurement is shown in a supporting video.

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