Characterization of a High Current Measurement System with Rogowski Current Sensor

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*Abstract-*This paper describes the design, realization and basic characterization of the high current measurement system based on Rogowski sensor using an electrooptical transfer of the measuring signal. We present the principal schemes of the system and results of linearity measurements at 50 Hz frequency. The system is aimed for the on-site measurements on the distribution grids.
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I. Introduction

The work was done as a part of „Power and Energy" project in the framework of the European Metrology Research Programme [1]. The aim was to design, to realize and to characterize a measurement system for electrical current up to 10 kA based on the Rogowski coil with application in the on-site measurements.

II. Design

Because of the safety of the operation we decided for the galvanic separation of the sensor placed in the high voltage environment from the reading part of the measurement system, which is on the ground. Thus the measurement system cosists of two parts connected mutually via the optical fiber. The measuring data obtained with the sensor part are transferred through the optical fiber to the output unit.

The second optical fiber is conducted to the sensor unit to cover its power supply. This fiber is feeded by a laser emitter. The laser beam leaving the fiber is convfrted to an electrical energy in the sensor unit using power converter with high efficiency. Those concept of power supply enables the continual measurement of the current without any interruption as it is needed because of battery exchanges or recharging them.

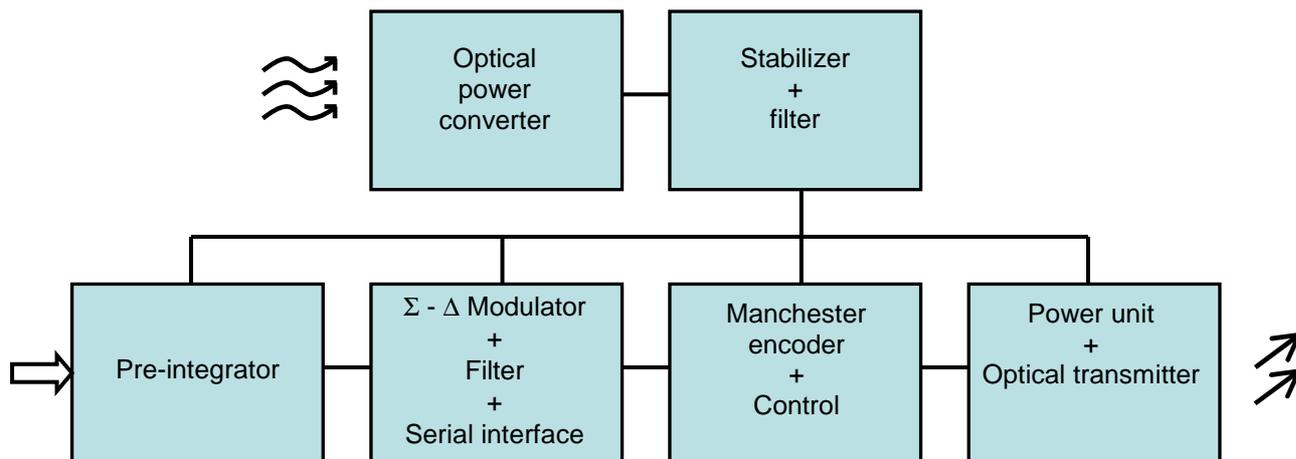The principal scheme of the sensor unit is shown in the figure 1.

Figure 1. Tje sensor unit communicating and feeded using an optical fiber

To avoid the saturationof the measurement system in case, when the signal from the Rogowski coil contains the components with high harmonics, the signal is pre-integrated in the sensor unit before further acquisition. The linearity is guarranted using the Σ - Δ modulation technique.

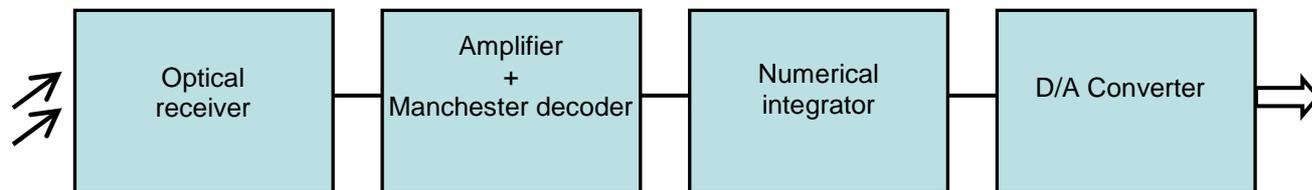The figure 2 shows the principal scheme of the output unit.

Figure 2. The output unit of the measurement system placed on the ground

The Manchester coding is used with aim to reduce the number of the optical fibers needed for the transfer of data into the output unit. The signal is decoded, integrated and converted using the D/A converter in the output unit for the further analogue acquisition.

III. Characterization

The measurements were done in the range of current 2 – 3000 A at industrial frequency 50 Hz using the measuring standard RS 2310E with the maximum current measurement error of 0,01%.

A. The current linearity in the range 2 – 120 A

The calibration curve of the whole measurement system with the Rogowski coil is shown in the figure 3 by the linear function. The measurement error for amplitude of the current for the whole range is not higher than $\pm$ 0,01% from the calibration curve and for currents above 10 A remains in the rance $\pm$ 0,005%.
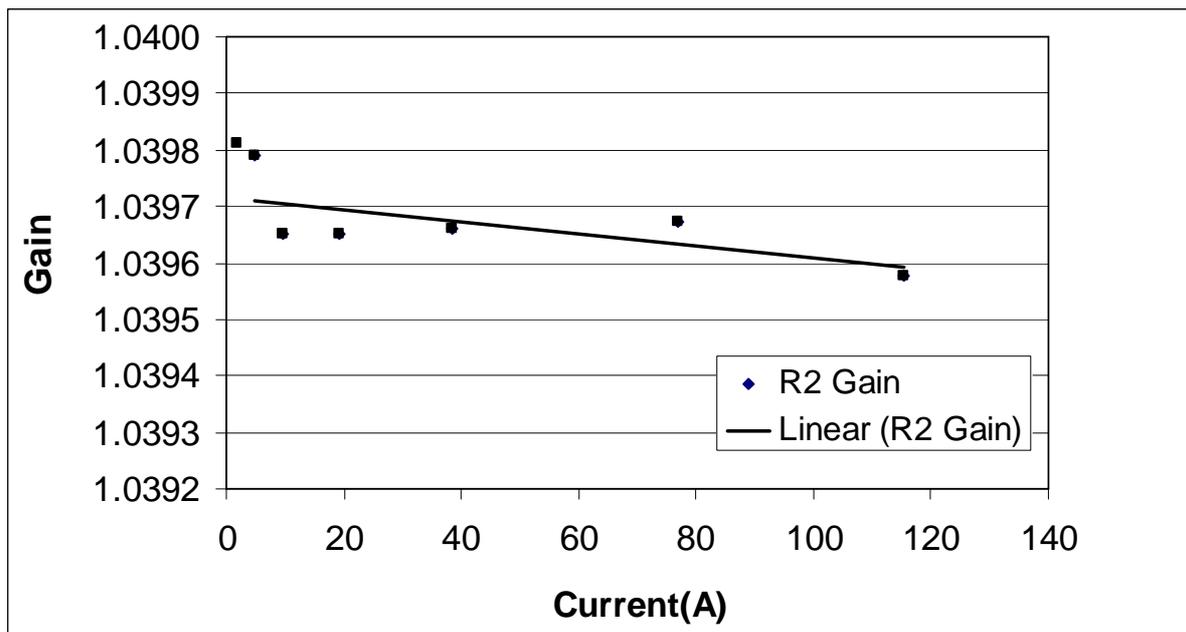
Figure 3. The current amplitude measurement error and the calibration curve for I < 120 A
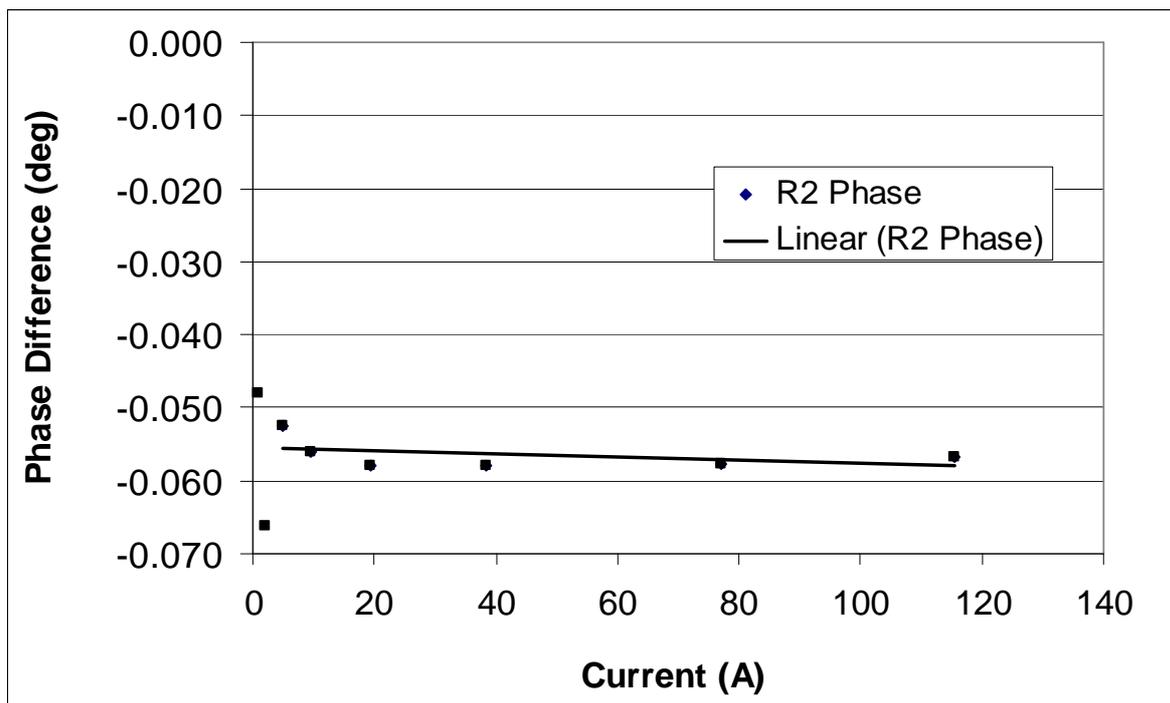
Figure 4 shows the current phase error.

Figure 4. The current phase error and the calibration curve for I < 120 A

The phase error remains in the range ± 0,005deg except currents below 10 A, where is ± 0,011deg..

B. The current linearity in the range 60 – 3000 A

The figures 5 and 6 show the calibration curves of the whole measurement system within the range 60 – 3000 A. The measurement errors of current amplitude/phase are in the ranges $\pm$ 0,005%/ $\pm$ 0,018deg from the calibration curves and for currents above 120 A remain within $\pm$ 0,003%/$\pm$ 0,005deg.
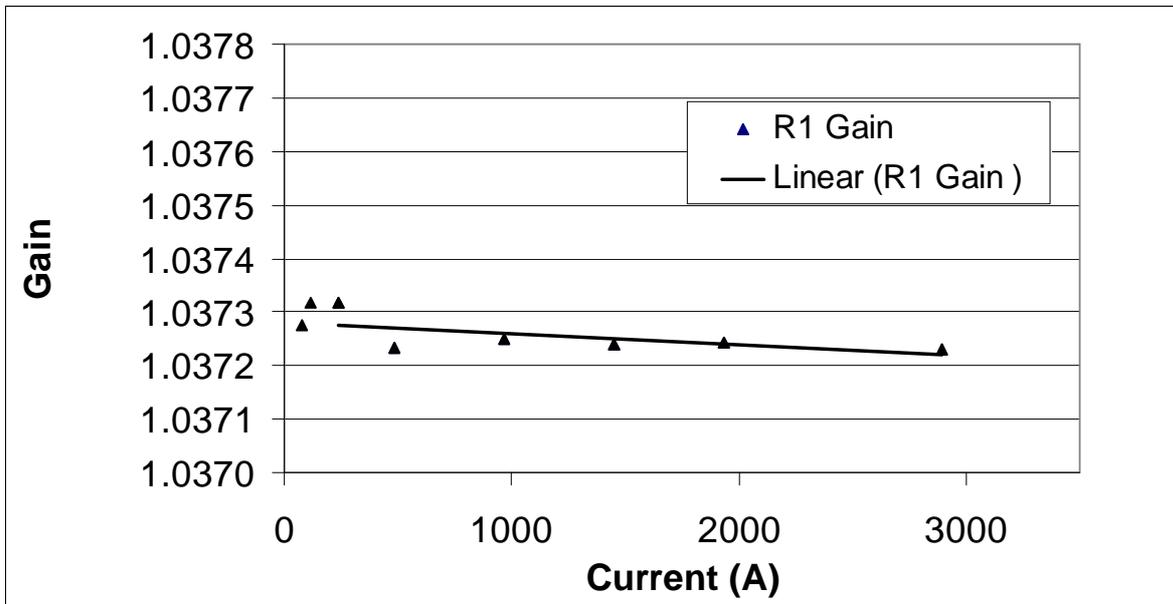

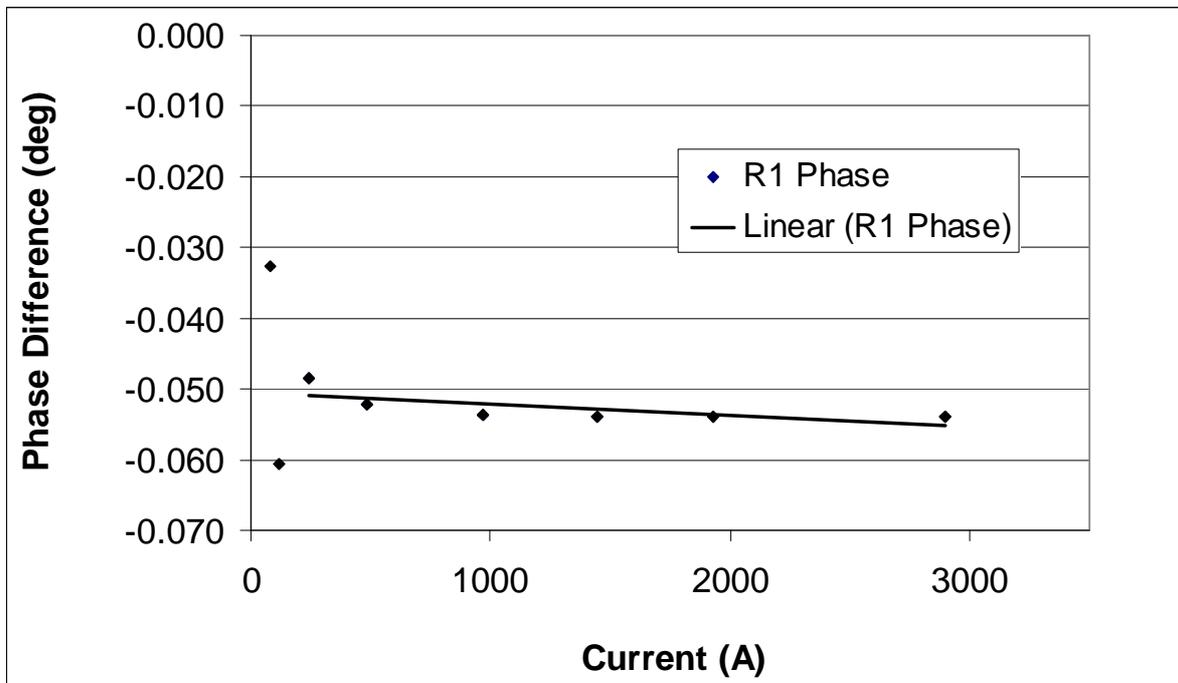Figure 5. The current amplitude measurement error and the calibration curve for I < 3000 A

Figure 6. The current phase error and the calibration curve for I < 3000 A

IV. Conclusions

The measurement system of high currents for on-site application was designed and realized. The galvanic separation of the Rogowski current sensor and the output unit was achieved by using the optical fibers for data and power transfer.The system was characterized in the current range 2 -3000 A by measurement of linearity and phase error. The amplitude measurement error was lower than $\pm\,100$ ppm in the whole range, for the currents above 10 A it was lower than $\pm\,50$ ppm. The phase measurement error did not exceed in the whole range $\pm\,0{,}018$ deg. The next measurements up to 10 kA and at 60 Hz frequency will be done in the near future.

References

[1] P. Vrabček, "The SMU Activity in the JRP T4.J01 Power and Energy " , *WP 5 Meeting, MIKES 2009 Digest*, Espoo, Finland, pp. 1-3, June, 2009.