Optoelectronic Current Transformer Based on Remotely Powered GMR Solid-State Device

A. B. Lobo Ribeiro, A. G. Matos and J. A. R. Salcedo

Abstract--**An optoelectronic current transformer based on a remotely optical powered giant magnetic resistance (GMR) via an optical fiber link is demonstrated. Preliminary measurements of 1200 A_{rms} nominal current at 50 Hz in high-voltage power line under 300 kV with accuracy of 1.2 A_{rms} (±1% of the measured signal) are achieved. Relaying field tests of 310 A_{rms} current signal at 50 Hz on a 150 kV high voltage power line are demonstrated.**

Index Terms—**Current sensors, Fiber optic sensors, Magnetic sensors.**

I. Introduction

MAGNETIC sensors are ideal for all kinds of contactless position registration (e.g. distance, speed, sense of rotation), and for contactless measurement of electrical currents and power. They guarantee functional reliability even under harsh environmental conditions like dirt and high temperature. Giant magnetic resistance (GMR) sensors overcome a weakness in conventional magnetoresistors and Hall sensors, with their high sensitivity to air gap deviations apparent in many applications [1]. Optical fibers are widely accepted for data transmission in the industrial sensing field. They offer excellent protection against electromagnetic disturbances in addition to high strength.. A logical complement to achieve complete isolation is to power fiber terminating equipment optically. Since 1978, optical powering via a fiber link has been proposed to supply active electronic circuits for measuring electric currents at high-voltage power systems [2],[3]. This approach requires that sufficient optical power be transmitted to the sensor head via the fiber link so that a usable electrical power is available for data transmission electronics [4].

In this paper, the primary current at the high-voltage power line is measured using a multiplayer solid-state giant magnetic resistance (GMR) [5] device optically powered by a laser diode source via a unidirectional optical fiber link. [6].

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II. System Description

The schematic view of the optoelectronic current transformer is shown in Fig. 1. The measuring system has a control unit and a sensor unit connected to each other by two 100 m long optical fibers with one power transmitting fiber and one data returning fiber. Both ends of each fiber are terminated by FC-type connectors. For the power link, a laser diode emitting 300 mW CW output power at 810 nm wavelength, in a 200 μm core diameter hard clad silica fiber was used. The conversion of optical power into electrical power necessary to supply the GMR solid-state device and all the electronics contained in the sensor unit, is achieved by a 6-V (open circuit voltage) photovoltaic GaAs diode. The supply voltage is stabilized at ≈ 5 V by a low drop-out voltage regulator.

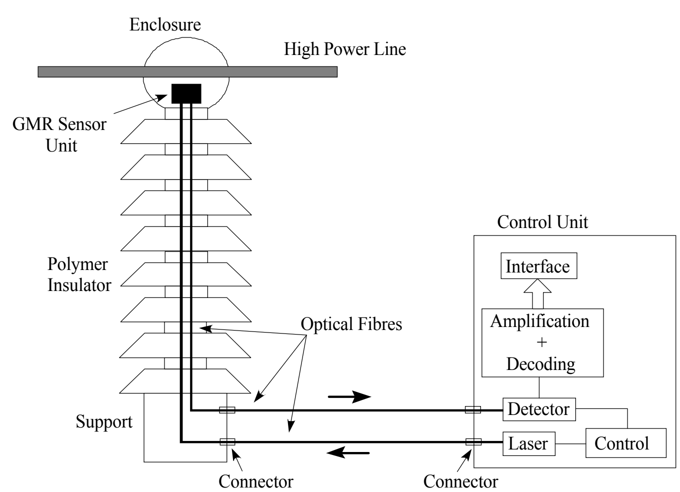

Fig. 1. Schematic design of the optoelectronic current transformer.

This photovoltaic power converter had an optimal efficiency of 40% at room temperature for an optimal power of 300 mW. The GMR solid-state device detects the magnetic flux in the power conductor line and produces a voltage output proportional to this magnetic field that is representative of the electrical current flowing through the power conductor. This voltage variation is converted to frequency modulation. An LED transmitter emitting at 820 nm wavelength, converts the

GMR frequency modulated signal into digital optical signal, which is then transmitted via a 62.5/125 µm multimode optical fiber to the control unit, shown in Fig.2.

Fig. 2 Photo of the control unit.

This control unit contains the following blocks: (1) The power laser diode, the laser driver and diode current monitoring; (2) the optical receiver and post-amplification block; (3) The decoding and the analog-to-digital output blocks necessary to process the optical coded information transmitted by the GMR sensor unit.

III. System Results and Discussion

Fig. 3, shows the sensor output response to a sinusoidal primary current at 50 Hz frequency and driving current ranging from zero to 1200 A_{RMS} on a 300 kV power line.

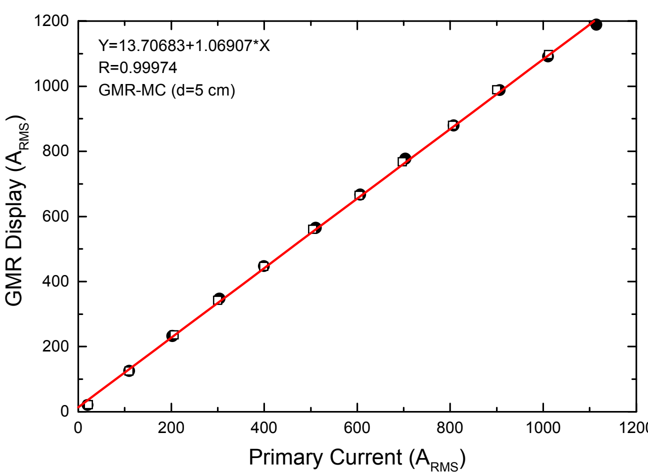

Fig. 3 Output response linearity of the optoelectronic current transformer to applied primary current at 50 Hz frequency.

From these experimental results, linearity can be observed throughout the measured region and the obtained data indicates a current resolution of 1.2 A_{RMS}, that is ± 1 % of the measured signal. For metering purposes, the requirements are high accuracy (0.2%) and a dynamic range between 0.1 and twice the nominal current. For relaying, the respective figures are for instance 2% and 0.1 to 40 times the nominal current. These values show that the system described here could be used, in principal, for relaying purposes.

To test the performance of the optoelectronic transformer to power line protection conditions, a relaying field-test of 310 A_{RMS} current signal at 50 Hz on a 150 kV high voltage power line was performed. Fig. 4 shows the current signal measured simultaneously by the optoelectronic transformer (GMR curves) and a conventional current transformer (CT curves).

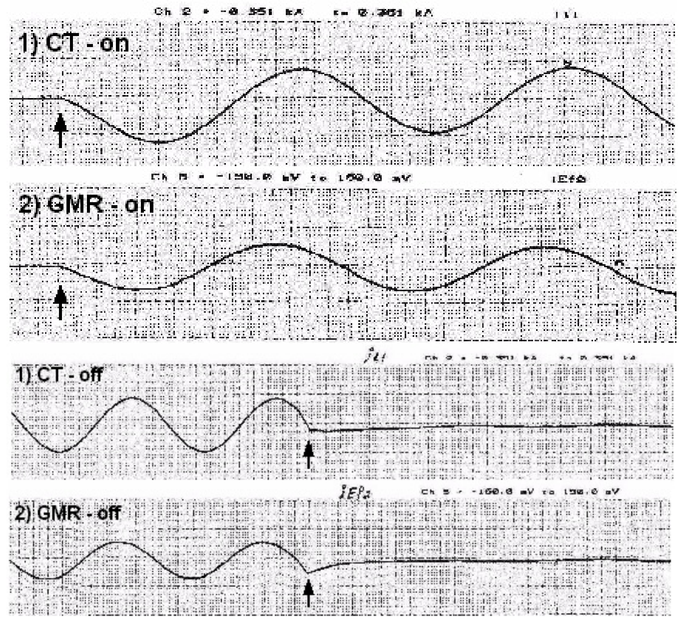

Fig. 4 Relaying field test of 310 A_{RMS} current signal at 50 Hz on a 150 kV high voltage power line (CT – conventional current transformer, GMR – optoelectronic current transformer).

The high-power laser diode is a critical component since it has a significant effect on the system cost and reliability. This device lifetime is over 100,000 h (11.4 years), which is still low comparing with the 25 years lifetime of a conventional current transformer. Concerning the cost, this component represents about three-fourths of the hardware cost for the main components used in the presented current transformer.

IV. Conclusion

An optoelectronic current transformer has been designed that is able to remotely measure electrical current by optical power transmitted via optical fibers between the high voltage power line and ground potential. The system has a measuring range with an accuracy of ± 1 % of the measured signal.

V. Acknowledgment

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VI. REFERENCES

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José A. R. Salcedo, bibliography not available at the time of the publishing.