

System for High Voltage Current Transformers Onsite Calibration

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Abstract-This paper presents a solution for high voltage current transformers calibration on site, using a system composed basically by an optical current sensor as reference standard, suitable for live line installation up to 550 kV. The system is described; its performance results are presented, as well as field applications and results.

I. Introduction

The energy market is strongly based on current and voltage measurement, the “billing measurement system” as named in Brazil, formed by the energy meter and the instrument transformers basically.

In the high voltage case, it is known that the calibration of the instrument transformers has operational and economic problems intrinsic to the calibration solutions available nowadays. The heavy and large instrument transformers involved make handling and transportation difficult and expensive. Either removing the transformer for lab calibration or installing a reference standard for field calibration will cause power supply interruption, and its technical and economic consequences.

Due to those facts, most of Brazilian instrument transformers used on the “billing measurement system” (extra high voltage mostly) have never been calibrated, or were calibrated once before installation. A considerable part of those transformers are installed for over twenty years, and its actual state of accuracy is not known. Besides, there is no calibration periodicity established by law due to the technical problems involved on this operation.

Analysing a Brazilian case of a 1000 MW load, and considering a low error of 0,1% for each current transformer (CT), using a conservative energy price, the losses involved may be up to US\$ 120.000,00 per month, or US\$ 40.000,00 per CT.

An onsite calibration of current transformers was presented at [1] using rogowski coil and a high current generator. No other CT onsite calibration method was found on the technical literature that would avoid supply interruption.

The system presented in this paper is based on an optical current sensor, and its application does not require power supply interruption or switching off for installation. The sensor is fitted with a flexible fiber optic cable that is connected directly to the live line up to 550 kV. A complete onsite CT calibration including assembling and disassembling takes about three hours and demands a live line maintenance team properly prepared for the sensor installation. The system performance and obtained results are presented below.

II. Onsite Calibration System

A. System Description

The current transformers calibration system is composed by a high accuracy optical current sensor and a power system analyser. The complete calibration system is divided in three parts: Electronics and optical modulator (Figure 1), and power system analyser (Figure 2). The reference standard used for calibration is the current sensor Nxct-F3 from AREVA T&D (formerly NXP HASE), and is based on the magneto-optic Faraday Effect. The sensor has a flexible fiber optic cable that is wrapped around the conductor where the current measurement is desired. The power system analyser Arbiter 933A is responsible for current comparison.



Figure 1. Electronics hack (left) and optical modulator (right)



Figure 2. Power system analyser Arbitr 933A

B. Live line installation

The dielectric characteristic of the flexible fiber optic cable of the optical current sensor was tested at the high voltage laboratory of LACTEC, Brazil. Figure 3 shows in detail the high voltage test and the flexible fiber optic cable.



Figure 3. High voltage test up to 320 kV phase to ground (equivalent to 550 kV phase to phase)
At the substation, a live line maintenance team properly prepared for handling the optical current sensor must be responsible for performing the connection and disconnection of the flexible fiber optic cable around the conductor.
The connection method used on the first applications consisted on a live line technician attached to the conductor potential, pulling the flexible fiber optic cable up using a proper dielectric rope, and wrapping the fiber optic cable around the conductor (Figure 4).

III. System Performance

The accuracy results obtained from a several tests are presented bellow. The optical current sensor was tested against a current comparator TETTEX type 4764, with 10 ppm uncertainty, used as a reference standard. The rate and phase errors are presented at Figure 4.

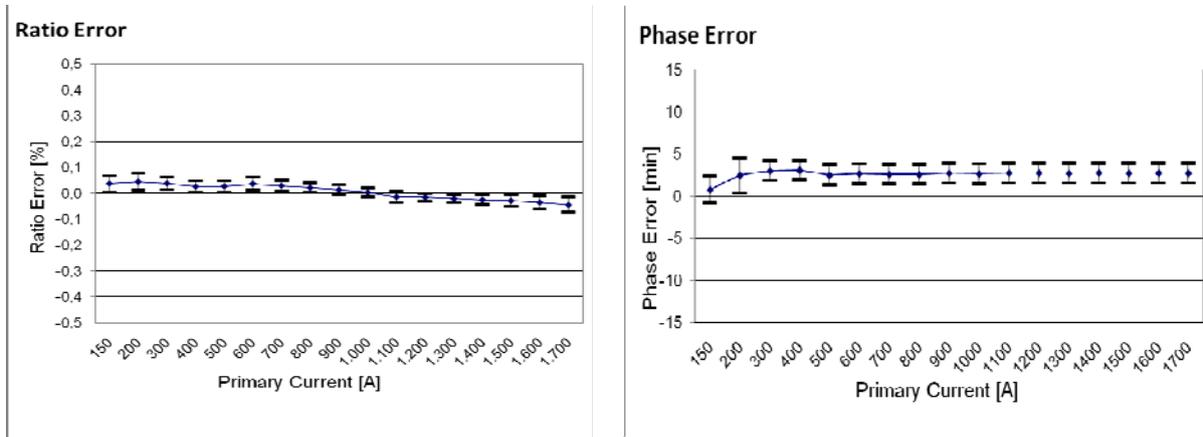


Figure 4. Average ratio and phase errors.

Figure 5 presents the same errors against the limits for a current transformer class 0,3.

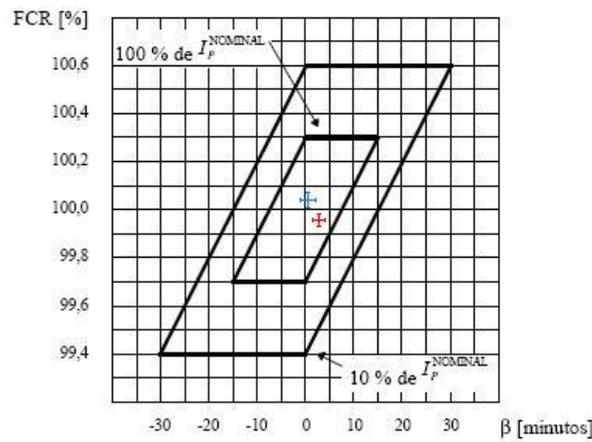


Figure 5. Comparison to a CT class 0,3. Blue mark representing 150 A and red mark representing 1700 A.

Figure 6 presents the error variation during the set of tests during one week, showing an analysis of the short period stability of the optical current transformer.

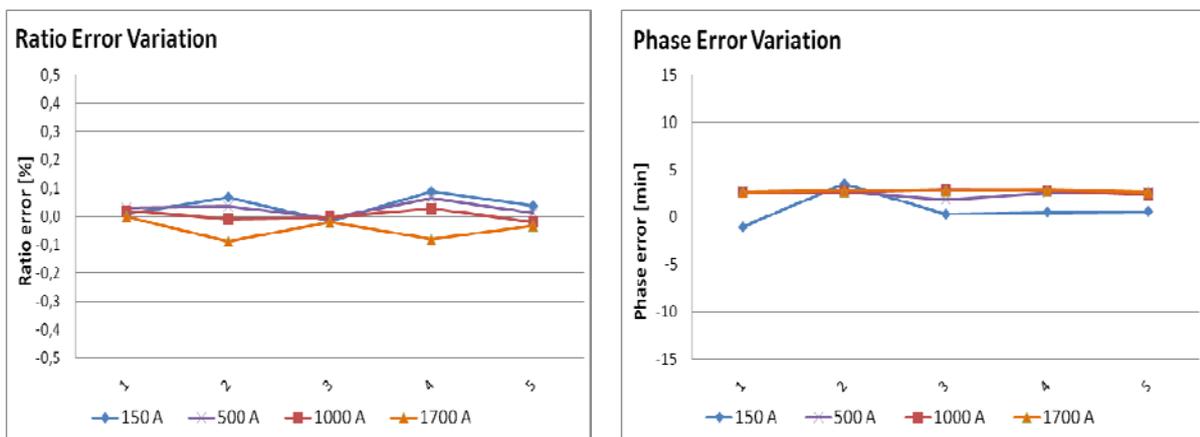


Figure 7. Ratio and Phase Error Variation

IV. Field Application

The current transformer calibration system was applied on three measuring points on 230 kV substations, in a total of seven current transformers, at Belém, Brazil. The facilities are under the responsibility of Centrais Elétricas do Norte do Brasil – ELETRONORTE. Figure 6 illustrates the fiber optic cable installation on the 230 kV live line at UTINGA Substation, Belém, Brazil.



Figure 6. Live line CT calibration on 230 kV Substation. ELETRONORTE, Belém, Brazil.

Figure 7 shows the portability of the system and the complete system at field. The complete test takes about three hours.



Figure 7. Calibration system application.

V. Conclusions

The calibration system presented has demonstrated its high accuracy performance and possibility to high voltage live line installation, as been proved on the applications. The system must allow the energy market agents to regulate the current transformers calibration and know the actual state of the current transformers installed, avoiding the technical and economical barriers intrinsic to the calibration solutions available nowadays.

References

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