Energy Measurement in High Voltage Power Networks at Low Currents

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***Abstract* — With the advance of renewable generation in power systems, a new measurement problem arises. Wind and solar plants inject energy to the power network most of the time, but during some periods, as in the night or during low wind, they consume. The meters record separately the consumption from the supply with different commercial regulations and rates. However, the energy measuring system (watthour meters, instrument transformers) is the same and it is designed for the maximum power, as generators. When consuming, the power is much lower, and the measuring system must operate in some cases between 0.1% and 1% of its nominal current, out of precision specification. The regulating bodies generally do not take into account this problem, and even states the application of fines for exceeding consuming power over the contract.**

In this paper a survey on the response of watthour meters and current transformers at very low currents, not covered by standards or manufacturer specifications, is presented.

***Index Terms* — Current transformer, electric power, measuring system, watthour meter.**

I. Introduction

New distributed generation is increasing, mostly based on wind generators and solar plants. They are connected to the power network at high voltage level, and have an energy measuring system to compute both, the supplied and the consumed energy. During some periods they supply energy to the network, but in others, as during low wind days or during the night, they consume. The regulation bodies [1] state different rules for the flux according to the direction of it (outgoing or incoming). Even more, there would be fines if the maximum consumed power is higher than stated in the contract.

The problem is that the same measuring system, comprising the watthour meter and current transformers (CT), is used for both energy measurements. It is designed for the maximum current, as generator, but during period of energy consumption, the current would be much lower, typically between 0.1% and 5%. Most meters and transformers can manage currents down to 5% of their nominal ranges. Some of them even are designed to reach 1%. However, there is no information from manufacturers or standards on their behavior below those minimum values.

II. Watthour Meters

The electronic energy meters installed in measurement nodes are, in Uruguay, of class 0.2 S and class 0.5 S. The standard [2] establishes the limit errors for a minimum current of 1% of the nominal current (I_n), and the starting current at 0.1% of I_n. Between 0.1% and 1% I_n there is no requirements for the errors. To study the general behavior in this range of currents, a group of 13 meters was analyzed. The samples were new, from different manufacturers, corresponding to same meters used in renewable generation in Uruguay. They have been separated into two groups according to their metrological characteristics:

Group I: class 0.2 S, 5 (10) A, 3x58/100 V
Group II: class 0.5 S, 5 (10) A, 3x58/100 V

A ZERA TPZ 303 energy standard was used as reference. In order to obtain comparative results, the following test current values were selected: 0.08%, 0.1%, 0.25%, 0.5% and 1% of I_n. For all cases the applied phase voltage was 58 V at unity power factor. Fig. 1 and 2 show the results. The horizontal dashed lines indicate the error limits stated by the standard. At 1% of I_n all tested units have errors much lower than those allowed by the standard, and also between 0.1% and 1% of I_n, the errors remains under the limits for higher currents. This confirms, at least for this sample, that it is possible to use modern electronic watthour meters from 0.1% of their nominal current, without exceeding the error limits stated by standards for higher currents.

III. Current Transformers

Standards state accuracy requirements for CTs according to their accuracy class. IEC standard [3] stablishes ratio and phase error limits at 5%, 20%, 100% and 120% of I_n, for classes, 0.2 and 0.5. For classes 0.2 S and 0.5 S, limits at 1% of I_n are added.

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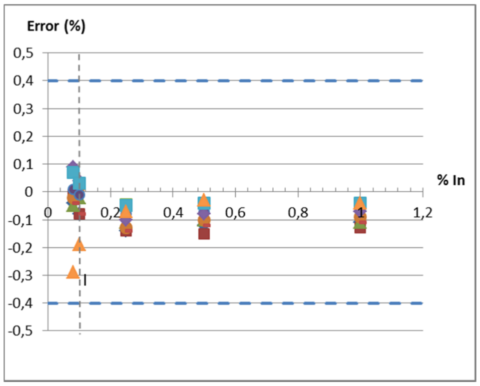

Fig. 1. Errors of meters of group I (class 0.2 S).

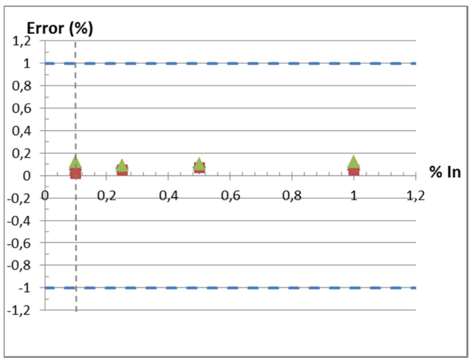

Fig. 2. Errors of meters of group II (class 0.5 S).

Below these minimum currents, there is no requirement in the standard, neither manufacturer specifications. To get information on typical behaviors, several calibrations were done on eight different CTs. Their nominal voltages were between 7.2 kV and 150 kV, and currents between 100 A and 1000 A. As reference standard, a Zera WM-3000I bridge with a Tettex 4713 CT was used. This measuring system was calibrated at low currents against a high precision standard CT (Conimed TN 1205). Fig. 3 and 4 shows the results for class 0.5, from 0.1% to 1% of In. Dashed lines indicate the error limits at 5% of I_n, which is the minimum current stated by the standard. The error depends on the current but also on the burden. Although burden was varied between 0% and 100%, only results at 25% are shown because of lack of space. More results will be presented at the conference.

A CT class 0.5 S, 100-A/5-A, 10 VA, 17.5 kV was tested. Between 0.1% and 1% of I_n, the errors varied between 0.34% and 0.48% in ratio, and between 2 min and 6 min, for all burdens from 0 to 100% of its nominal value. For this class, the limits at 1% of I_n are 1.5% and 93 min. This class of CT, generally has Mumetal cores, which justify this excellent behavior at low currents.

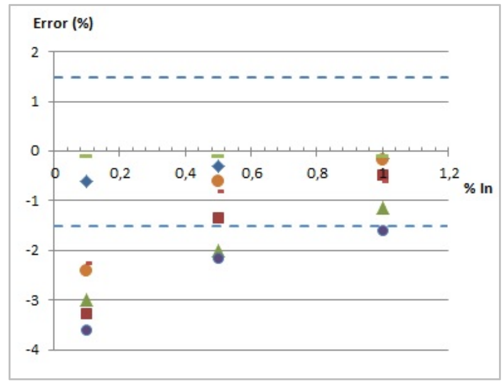

Fig. 3. Ratio error of CTs class 0.5 at 25% of nominal burden.

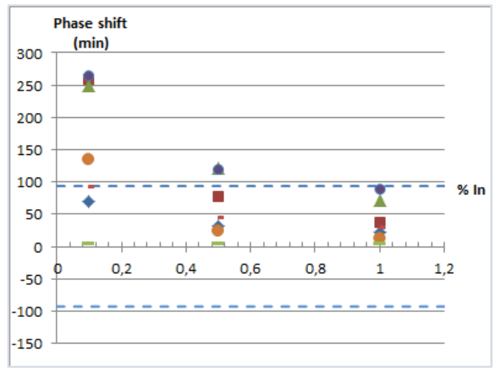

Fig. 4. Phase shift of CTs class 0.5 at 25% of nominal burden

IV. Conclusions

A sample of electronic watthour meters and current transformers were calibrated at currents below the minimum values stated by the standards, starting in 0.1% of I_n. In the sample of watthour meters class 0.2 S and 0.5 S, all had errors lower than those stated by the standard for 1% of I_n.

In CTs of class 0.5, almost all units have errors at 1% of I_n inside the limits for 5% (minimum current for this type of CT). At 0.1% of I_n, the errors reaches 2.5 times the standard limits, but still could be useful for the mentioned application. A CT of class 0.5 S had errors inside the limits for 1% of I_n, at all currents and burdens, down to currents of 0.1% of I_n.

References

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[2] IEC Standard 62053-22, "Electricity metering equipment (a.c.) – Particular requirements – Part 22: Static meters for active energy (classes 0.2 S and 0.5 S), 2003.

[3] IEC Standard 61869-2, "Instrument transformers - Part 2: Additional requirements for current transformers," 2012.