High-Precision Current Comparator for Current Transformer Calibrations

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***Abstract* — The development and testing of a current comparator (CC) is described. It is intended for ac low frequency applications, such as calibration of instrument current transformers (CT). The CC can be self-calibrated comparing its different inputs between them, without need of an external reference standard. This device was developed to sustain the self-traceability of calibration of CT at UTE (delegated National Metrology Institute of Uruguay).**

Keywords — current transformer, current comparator, high precision measurement, uncertainty, self-calibration, traceability.

I. Introduction

CURRENT comparators are usually used for current transformer calibrations. This type of instrument transformer is an important component in energy measurements. They reduce high current values that exist in power networks to small ones required by measuring devices, usually 5A. They are part of the energy metrological chain. Present regulations in the electric market establish rules in the accuracy of all parts of this chain: energy meters, voltage transformers, and current transformers. To assure that these equipments are in accordance with the regulations, periodicals calibrations must be done. As the accuracy of energy measurements is increasing, all components of the measuring system must follow this trend. Commercial watt-hour meters with accuracies of 0.1% are usually used nowadays. This leads to similar accuracy for the instrument transformers that work with them. In case of high voltage CTs, a transportable calibration system is needed with standard CTs in the order of 200 parts in 10^6. These last CTs must also be calibrated with uncertainties around 50 parts in 10^6. At last, a National Standard CT is needed to be the base of the system, with uncertainties lower than 10 parts in 10^6 [1].

Many different self-calibrating methods were proposed to achieve that goal. Some of them use CC [2, 3]. This device can be based on two-stage method [4], and others on electrical assistance [5]. However, many of them need a calibration procedure that requires an external standard, mostly for ratios different than 1:1. However, as the current ratio is a dimensionless quantity, from a theoretical point of view, it is not necessary a standard artifact to be the base of the calibration pyramid.

The description of a proposed CC with many different ratios, that allows self calibration procedures, is described in the following paragraphs.

II. Description

The main component of the CC is a toroidal transformer with 6 primary windings. Four of them have 25 turns (5 groups of 5 turns connected in series). The other two windings have 5 turns each (5 groups of 5 turns connected in parallel). In this way, all windings are formed by the same turn numbers, which allows to use a rope winding, that distribute the stray magnetic flux in similar way between each individual winding, with similar values of coupling coefficient to the secondary. For the secondary, a single winging, directly on the core, is used. It has 210 turns, uniformly distributed around the core. Over this winding, an electrostatic shield separates primary and secondary windings to eliminate the influence of stray capacitances between them. Over all, a magnetic shied made with Mumetal, reduces external magnetic fields. Fig. 1 and 2 shows details of the construction.

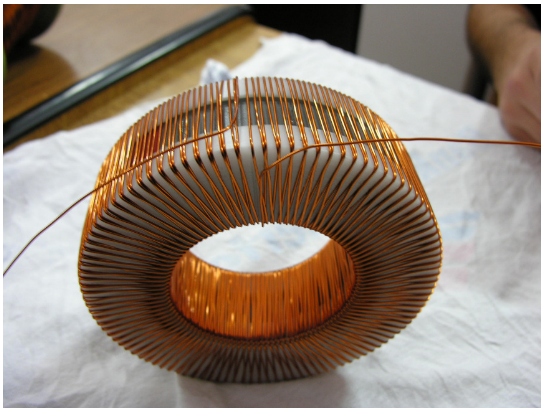

Fig. 1. Secondary winnding.

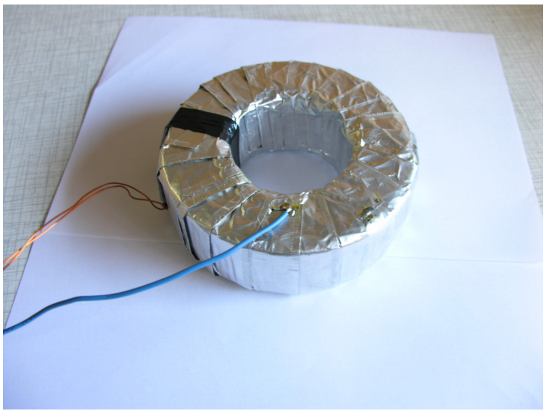

Fig. 2. Electrostatic shield.

The output of the secondary winding is connected to a transimpedance amplifier that imposes a very low voltage at its input, and generates an output voltage proportional to the input current. In this way, the magnetic flux of the core is low, which leads to low errors in the CC. Fig. 3 shows a general view to the device.

Fig. 3. General view of the proposed CC.

The windings are arranged in 6 groups. The first 4, have 25 turns each. The other 2, have 5 turn each. In this way, many different ratios can be used: 1, 2, 2.5, 3, 5, 10 and 20, with parallel or series connections. These changes are done from the front panel with copper bars.

The device can admit a self-calibration procedure. For 25 turn windings, the calibration procedure compares winding with equal turn numbers. For 5 turns windings, the comparison needs to change the parallel connection to a series one to get 25 turns. Tests show errors in the order of 0.3 parts in 10^6, for in-phase and quadrature errors, with uncertainties in the order of 10^{-7}. Details on self-calibration results will be added in the final paper.

ACKNOWLEDGEMENT

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