



TWO-STAGE ELECTRONICALLY COMPENSATED CURRENT-TO-VOLTAGE-TRANSDUCER

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Abstract: To fulfill the requirements of very high accuracy wattmeters, a current to voltage transducer was developed. The nominal input currents go from 1 A up to 100 A, and the nominal output voltage is 2 V. The goal is to get uncertainties in the order of 1 part in 10^6 .

Key words: current transformer, compensation, measurement, calibration, power.

1. INTRODUCTION

Very high precision wattmeters have been developed in the National Metrology Institutes. Most of them are based on using two commercial multimeters (HP 3458) [1]. One of them is used to digitalize the voltage, and the other a voltage proportional to the current. As the best range of this model of instrument is 10 V, it is necessary to scale currents that can reach 100 A to voltages of some volts. It is not possible to use a simple resistor shunt, because of the high power dissipated on it. The solution is to reduce the input current to a small value, so that the shunt dissipates a small power with low temperature raise.

The uncertainty of the voltmeters, using special control programs, is in the order of some parts in 10^6 . Then, the current to voltage transducer must have uncertainties around few parts in 10^6 , in order to not degrade the all system. As this transducer comprises a resistor shunt and a current transformer, this last device must have uncertainties around 1 part in 10^6 . To get that, a two-stage transformer with an electronic amplifier is proposed. Although similar circuits have been proposed in the past [2, 3, 4], none of them reaches the total compensation of the internal transformer error sources.

For this type of current transformers, the main source of error is the magnetizing current. This current flows through the magnetizing branch, and does not flow through the output. To get low errors, the magnetic flux must be as low as possible, reducing in this way the magnetizing current. In two stage transformers, one stage provides the power, while the other only supplies an error current, been its magnetic flux very low [5]. The exact value of this flux depends on the load, external burden and the internal series impedance of its secondary winding. The lower the load, the smaller the magnetic flux. Conventional proposals for two-stage current to voltage transducers have two burden resistors, one for the main secondary winding and other (generally of the same value) for the compensating one. As the compensating current is much lower than the main one, the same occurs

for the voltage drops. This allows total errors in the order of 10 parts in 10^6 , if burdens around 10Ω are used. For reducing the errors 10 times, an electronic compensating circuit is proposed.

2. TRANSFORMER DESIGN

The core for both stages is of a high permeability type (mumetal). Both secondary windings (main and compensating stages) have 500 turns. There are two groups of primary windings. The first one is formed by 10 windings of 10 turns each. Connecting in parallel-series sets, it can be arranged from 10 to 100 effective turns (10, 20, 50 and 100). As the nominal secondary current is 200 mA, the nominal input current ranges are 1 A, 2 A, 5 A and 10 A. For the upper ranges, another primary winding group exists. It has 10 windings of 1 turn each. Therefore, using these windings, the nominal primary current goes from 10 A up to 100 A.

Each group of each winding has the same current whichever is the connection. In this way, the stray magnetic flux does not change when different ratios are selected. This property assures that the errors are practically the same for all ratios, allowing a reduction in the calibration work. However, error differences can appear between low and high current windings, because they have different windings. To determine the amount of this variation, there are 10 A ranges in both windings. Connecting both with opposite polarity, the output would be null, so that measuring the actual output, that ratio error difference can be estimated.

3. ELECTRONIC COMPENSATION

The goal of the compensating circuit is to null the magnetic flux in the compensating stage core. For that, a controlled voltage source generates the same value than the voltage drops in the internal and external series impedances of the compensating secondary winding, but with opposite polarity. In this way, no electromagnetic voltage exists around the winding, neither magnetizing current. From a theoretic point of view, there is a complete compensation and null errors. This electronic source supplies only the small power required by the compensating stage of the transformer, so a simple operational amplifier is enough for this application. Fig. 1 shows a schematic circuit. W_m is the main winding of the two-stage transformer and W_c is the

auxiliary one. The objective of the electronic device is to null the electromagnetic force (ε) in W_c . Assuming an internal resistive impedance of this winding r , the following equations apply

$$\varepsilon = I(r + R_1) + V_2 \quad (1)$$

$$V_2 = -R_1 I \left(1 + \frac{R_2}{R_3} \right) \quad (2)$$

which leads to

$$\varepsilon = I \left(r - \frac{R_1 R_2}{R_3} \right) \quad (3)$$

If $r = R_1 R_2 / R_3$, then $\varepsilon = 0$. This shows that it is possible to null the emf on W_c nulling in this way the magnetic flux through the auxiliary core.

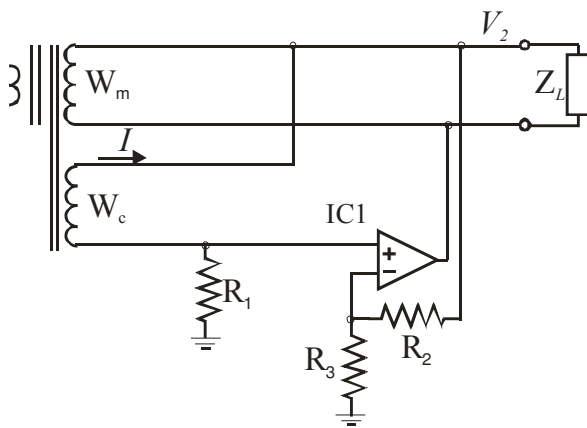


Fig. 1. Schematic circuit of the two-stages electronic compensated transformer

Detailed information on the errors measured in the prototype will be given in the congress. Influence of parasitic capacitance, as a second order error, will also be presented.

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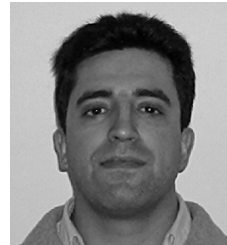
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Biography

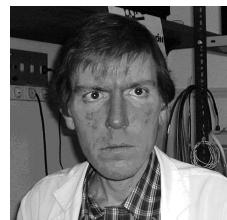


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