The Device for Simultaneously Accuracy Testing of Current Transformers

D.Naumovic-Vukovic, S.Skundric, A.Zigic
1 Electrical Engineering Institute Nikola Tesla, Koste Glavinica 8a, Belgrade

E-mail: dragan anv@ieent.org

Abstract. This paper presents a three-channel device for simultaneous accuracy testing of three current transformers. The concept of multichannel device is one of the possible good solutions for accuracy testing in the process of automated or robotized manufacturing of low voltage current transformers. The paper presents a short description of the overview of calibration results.

1. Introduction
Modern manufacturing of low voltage current transformers is mainly automated or robotized, because this is the way to make the price of current transformer competitive on the world market. Individual testing of current transformers with standard measurement equipment requires a lot of human work and is therefore both technically and economically unacceptable for manufacturers, especially in mass and automated production. For these reasons this topic provokes justified professional interest. Several functional solutions of automated current transformer testing have been developed at Electrical Institute (EEINT) [1]. The technology development in the areas of microelectronics and computers opened wide possibilities for improving accuracy and efficiency of current accuracy testing. For the needs of automated or robotized manufacturing process two possible concepts of current transformer accuracy testing were considered: the concept of multiplexing of tested current transformers and the concept of multiplexing of measuring channels [1]. As the result of these investigations a three-channel measuring device was developed for the needs of the Factory for Instrument Transformers FMT “Zajecar” in Serbia, using the second of the above mentioned concepts and is described in this paper.

2. Description of the Device
The measuring systems for current transformers accuracy testing consists of: reference current transformer, device under test, current burden and corresponding primary current source. The measuring system in FMT Zajecar, apart from three-channel measuring device includes reference current transformer which is the same for all three measurement channels, a unique current source and three reference current burdens for each of the channels individually. This measuring system can also include a computer which allows acquisition, processing and printing of measurement results. Figure 1 shows a photo of the whole measurement system installed in the factory FMT Zajecar.
2.1. Measuring Method

The measuring device was developed using a specific differential measuring method, which allows measurement of reference secondary current and corresponding differential current of current transformers under test. By transforming these relevant currents to corresponding voltage signals, their further analog and digital processing according to the given mathematical model, the individual values of ratio and phase errors for each tested current transformer are obtained [2]. The electronic processing of measurement signals can be observed on the structural model of the measuring device shown in Figure 2. The well known solution of splitting the differential voltage to its orthogonal components as the measure of ratio and phase errors of the tested current transformer [2].

Figure 1. The whole measurement system installed in the factory FMT Zajecar, Serbia.

Figure 2. The block diagram of the three channel device for current transformer accuracy testing.

2.2. Hardware

The block diagram, Figure 2, shows also the relative complexity of the device hardware. The particularity of the applied solution are two-stage differential transformers which allows the multiplication of ratio and phase errors measurements on several measuring channels. This solution requires each measurement channel to have a separate reference burden, which increases the price of the system. In this device, the reference current $I_R$ of the reference transformer is common, so that only one reference transformer is sufficient for all three channels, which considerably reduces the price of the system. Savings are also accomplished by using the same electronic modules for all measurement channels such as: absolute value module (abs), multiplexer (MUX), analog-to-digital converter (A/D), microcontroller (µP), keyboard, display, protection and signalization power supply module. Other electronic modules, such as current-to-voltage converter (I/U), 6-order low-pass filters (F), phase detectors (FD) are identical for all measurement channels. The entire measuring device is placed in a metal box of the size of double 17-inch rack. The device can be used for both laboratory and field measurements.

2.3. Software

The three-channel measuring device a dedicated software was installed. The role of this software is: to manage and control all functionalities of the device, to perform digital processing of measurement signals according to the given mathematical model, to conduct statistical processing of measurement results in order to reduce the effects of random errors, to manage and carry out calibration, i.e. correction of results to reduce systematic errors, to show final results on LCD display in the
corresponding given format, to enable serial connection and the transfer of measurement results to the PC. As this multi-channel measuring device was developed for the needs of efficient serial accuracy testing of current transformers, the developed software of the measuring device is only a part of the software of the whole measuring system which is controlled by an industrial computer. The software of the system together with its hardware can make it possible to automate and robotize the whole process of current transformers testing. In practice, that would mean the automated selection and adjustment of test currents, selection of reference burden values, measurement, acquisition of measurements results, archiving and printing of test protocols.

3. Calibration and Evaluation
The realized three-channel measuring device, apart from functional examinations, was also subject to investigations of its metrological characteristics, especially the measurement accuracy of ratio and phase errors.

Functional examinations showed that the work with this measuring device is at least three times more efficient than the work with classical single channel measuring device even with manual adjustments of test currents and burdens.

| Table 1. The zero check of the three channel device for current transformer accuracy testing. |
| --- | --- | --- | --- | --- | --- | --- |
| Channel | 1% In | 5% In | 20% In | 100% In | 120% In | 200% In |
| I | g (%) | 0.0032 | 0.0010 | 0.0007 | 0.0002 | 0.0001 | 0.0001 |
|  | δ (min) | -0.575 | -0.517 | -0.145 | -0.030 | -0.025 | -0.016 |
| II | g (%) | 0.0062 | 0.0013 | -0.0014 | -0.0001 | -0.0001 | -0.0001 |
|  | δ (min) | -0.290 | -0.103 | -0.030 | -0.007 | -0.006 | -0.003 |
| III | g (%) | 0.0066 | 0.0015 | 0.0004 | 0.0001 | 0.0001 | 0.0001 |
|  | δ (min) | 0.196 | -0.087 | -0.027 | -0.007 | -0.006 | -0.005 |

Metrological investigations of the measuring device comprised: zero check of the measuring device and the accuracy tests of ratio and phase measurement errors in the range of test currents from 1% $I_n$ to 200% $I_n$. The zero check was performed in the way that the same reference current flew through all differential transformer coils which correspond to secondary currents of transformers under test and reference transformer currents. The obtained results are shown in Table 1.

The accuracy test of device ratio and phase measurement errors was conducted in the way that the same secondary current of the transformer under test was implemented through all three differential transformers. The current transformer with known ratio and phase errors was used as the transformer under test. In that way the deviations of measured errors for all three measurement channels with respect to the true error values of the transformer under test were found.

Figure 3 and 4 shows differences in the ratio and phase errors measurement of each channel for the set ratio error of the 0.5% and phase displacement of the 30 min. Also figures 3 and 4 shows the ratio and phase errors levels for the current transformer accuracy class 0.2S according to IEC standard [3]. Obtained maximum ratio error discrepancy is 0.015% for the range of primary test currents from 1% $I_n$ to 5% $I_n$. For the range of primary test currents from 10% $I_n$ to 200% $I_n$, ratio error discrepancy is less than 0.001%. Obtained maximum phase displacement discrepancy is 0.45 min for the range of primary test currents from 1% $I_n$ to 5% $I_n$. For the range of primary test currents from 10% $I_n$ to 200% $I_n$, phase displacement discrepancy is less than 0.30 min.

4. Conclusion
Detailed metrological investigations were carried out and their results partially shown in Chapter 3. The analysis of measurement results shows that the estimated measurement ratio and phase errors of the device under test INST-2C is less than 0.5% of the measured value ±75 ppm for the range of
primary test currents from 1 %\(I_n\) to 5 %\(I_n\), i.e. less than 0.5 % from the measured value ±20 ppm for the range of primary test currents from 10 % \(I_n\) to 200 % \(I_n\). It means that this device can be used for serial test of current transformers of accuracy class: 0.1, 0.2, 0.5, 1, 3 as well as of accuracy class with extended current range: 0.1S, 0.2S, 0.5S.

**Figure 3.** Differences in the ratio errors measurement of each channel for the set ratio error of the 0.5% with the ratio errors levels for the class 0.2S current transformers according to IEC 61689-2.

**Figure 4.** Differences in the phase displacement measurement of each channel for the set phase displacement of the 30min with the phase errors levels for the class 0.2S current transformers according to IEC 61689-2.

**References**

[1] Naumovic Vukovic D, Skundric S and Zigic A 2017 Three channels device for current transformer accuracy testing Proc.19th International Symposium POWER ELECTRONICS Ee2017 (Novi Sad, Serbia, 19–21 October 2017), T4.3.2_07919

[2] Skundric S, Kovacevic D, Smak F, Vukovojac S and Korolija M 1994 A computer aided system for automatic testing of instrument current transformers accuracy Proc.13th IMEKO World Congress (Torino, Italy, 05–09 September 1994)

[3] IEC 61869-2 Instrument Transformers - Part2: Additional requirements for current transformers, Edition 1.0, 2012-09