

SOFTWARE CONTROLLED PROCEDURE FOR VERIFICATION OF THE VOLTAGE MEASURING TRANSFORMER ACCURACY

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Abstract

Solution of the experimental measurement and data acquisition system, designed for verification of the voltage measuring transformer accuracy in the laboratory conditions, is presented in this paper. Functional basis of developed solution is provided by virtual instrumentation software package LabVIEW 8.0. Described acquisition system includes standard PC configuration platform with application software, multifunctional calibration instrument Fluke 5100B for generation of the reference voltage signals and data acquisition card PCI NI 6251. Software application developed in LabVIEW programming environment, performs measurement, recording, presentation and statistical processing of transformer output voltage basic parameters. Statistical analysis of the obtained measuring results, with possibility for graphical presentation of recorded time diagrams for measured voltage parameter values, provides estimation of the mean measured parameter values and measuring uncertainty components, according to the relevant documents for estimation and expression of the uncertainty in measurement.

Keywords: voltage measuring transformer, LabVIEW virtual instrumentation software, measuring uncertainty.

INTRODUCTION

With rapid growth of the electrical energy consumption and limited natural resources for energy production, basic demand is increasing of the total efficiency level in electrical energy production, distribution and consumption. In a globally widespread processes of liberalization on the electrical energy world market, within the last ten years are created new technological demands for research and developing facilities and institutions. Significant characteristics of this processes are involving and integration of wide geographic areas in the electrical energy trading operations. This includes the increased number of the participants on electrical energy market, much greater amount of the business transactions and significantly higher number of information for exchanging and processing.

Important segment in mentioned process of the total energy efficiency level increasing, is measurement and analysis of basic parameters related to quality of electrical energy delivered to the individual customers. Measurement of voltage, current, power and energy parameters involves measuring transformers applied in the various types of regulation and control energy facilities. Measuring accuracy of voltage and

current transformers affects on accuracy of the complete measurement process. Especially are important measurements performed for precise determination of individual customers energy consumption level, which demands measuring transformers having high accuracy classes [1].

Procedures used for investigation of voltage measuring transformer accuracy and condition diagnostic must be performed in the accredited metrological laboratories or directly on remote locations of measuring transformer facilities, periodically at exactly specified time intervals. Such accuracy verification procedure requires combination of sophisticated measurement and control devices and appropriate measurement methods, having the high accuracy levels. This equipment includes calibration instruments for generation of the reference voltage parameter values prescribed by relevant quality standards and control instruments used for measurement of the transformer output voltage parameters.

Experimental measurement and acquisition system, presented in this paper, developed for verification of voltage measuring transformer accuracy, functionally is based on 16-channel acquisition PCI card NI 6251 [2], supported by programming application in LabVIEW graphic

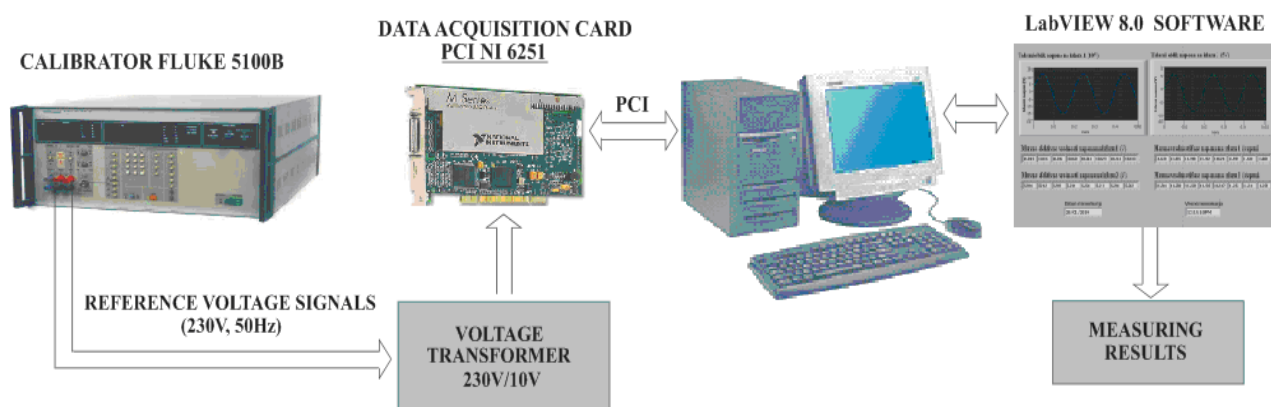


Fig. 1. Hardware configuration of the experimental measurement and data acquisition system

software package [3]. Reference instrument for providing input transformer standard signals of 230V RMS voltage value and 50Hz frequency, is multifunctional calibrator Fluke 5100B [4]. Developed programming application performs measurement, continuous recording, graphical presentation and statistical analysis of voltage parameter values, measured on the transformer outputs. Software processing of the measured values is performed according to the relevant standards and recommendations for calculation and presentation of the measuring uncertainty.

BLOCK CONFIGURATION OF THE MEASUREMENT SYSTEM

Hardware configuration of the experimental measurement and data acquisition system used for measuring transformer accuracy checking, developed at Department of Measurement on the Faculty of Electronic Engineering in Niš, is presented on the Fig 1. Block configuration of designed system includes reference calibration instrument Fluke 5100B, data acquisition PCI card NI 6251 and LabVIEW 8.0 application software, installed on a standard PC hardware platform. Calibration instrument Fluke 5100B is microprocessor based device, programmable from instrument front panel. Depending on the current requirements, this instrument provides generation of reference AC voltage waveforms with RMS values within the range from 1mV to 1100V and signal frequency from 50Hz to 1KHz. For this specific application, calibration instrument generates reference voltage signals for measuring transformer inputs, having basic parameters 230V RMS value and 50Hz signal frequency according to the recommendation of European power quality standard - EN 50160.

This standard prescribes voltage characteristics of electricity supplied using public distribution systems [5]. Reference waveform generated on calibration device output are transferring using standard BNC connectors directly to inputs of voltage measuring transformer, which accuracy need to be verified. In the next segment of this procedure, voltage waveforms obtained from measuring transformer outputs, within a range of $\pm 10V$, must be transferred to inputs of data acquisition card A/D converter, having 16-bit resolution [2]. Multichannel acquisition card NI 6251 from american manufacturer National Instruments Corporation, for this application purpose uses two analog input channels, which receive signals from measuring transformer voltage outputs, with specified 10V and 5V nominal RMS values. Internal communication and two-way data interchange between data acquisition card and PC computer is provided using standard PCI communication interface. Described procedure for verification of voltage measuring transformer accuracy is supported using programming application developed in LabVIEW 8.0 software package, which will be described in a following segment of this paper.

LABVIEW SUPPORT OF THE SYSTEM

Virtual instrumentation concept is a method for development of the measuring instruments, based on the standard PC computers, hardware components for data acquisition and packages specialized for software analysis and graphical presentation of the obtained measuring results. Most important advantage of virtual measuring instruments is possibility of performing simple and fast corrections of the software algorithm, which controls performing of the PC supported

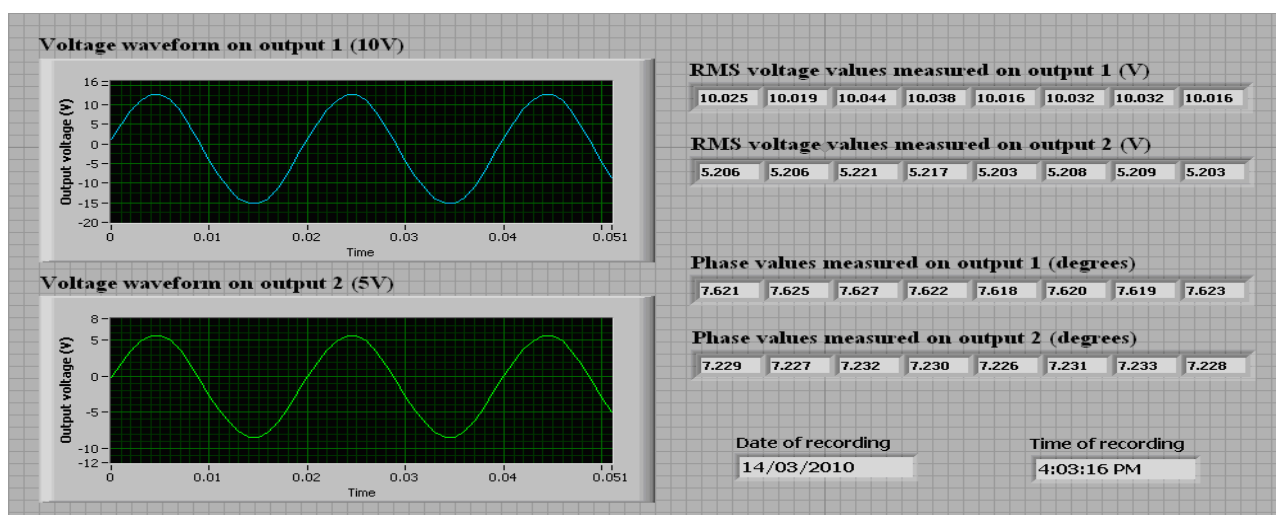


Fig. 2. Virtual instrument for presentation of the voltage waveforms and measured voltage parameters

measurement procedure [3]. Process of voltage transformer accuracy verification, described in this paper, functionally is supported by control application realized in LabVIEW 8.0 package. This software enables measurement, recording, graphic presentation and statistical processing of measuring results regarding to RMS values, phase and frequency of output voltage signals. Front panel of the virtual instrument developed in a LabVIEW programming environment, for comparative graphical presentation of voltage waveforms recorded on measuring transformer outputs, is presented on the Fig 2. Besides this presentation of the output voltage waveforms, on front panel are indicated measuring results concerning the RMS voltage values and phases measured on transformer 10V and 5V nominal outputs. Additional information about an exact

date and time of presented voltage waveforms recording are also provided on this front panel.

Software procedure for statistical analysis of the obtained measuring results regarding to RMS values measured on transformer outputs, performed in LabVIEW software environment, is illustrated on Fig 3. Developed application performs comparative graphic presentation of the recorded time diagrams and corresponding statistical histograms of measured RMS values for transformer output signals. On presented instrument panel are also indicated minimum and maximum voltage values obtained during this measuring process on voltage transformer outputs, including calculations and numerical presentation of mean measured voltage values, with the corresponding measuring uncertainty components for both transformer outputs. The

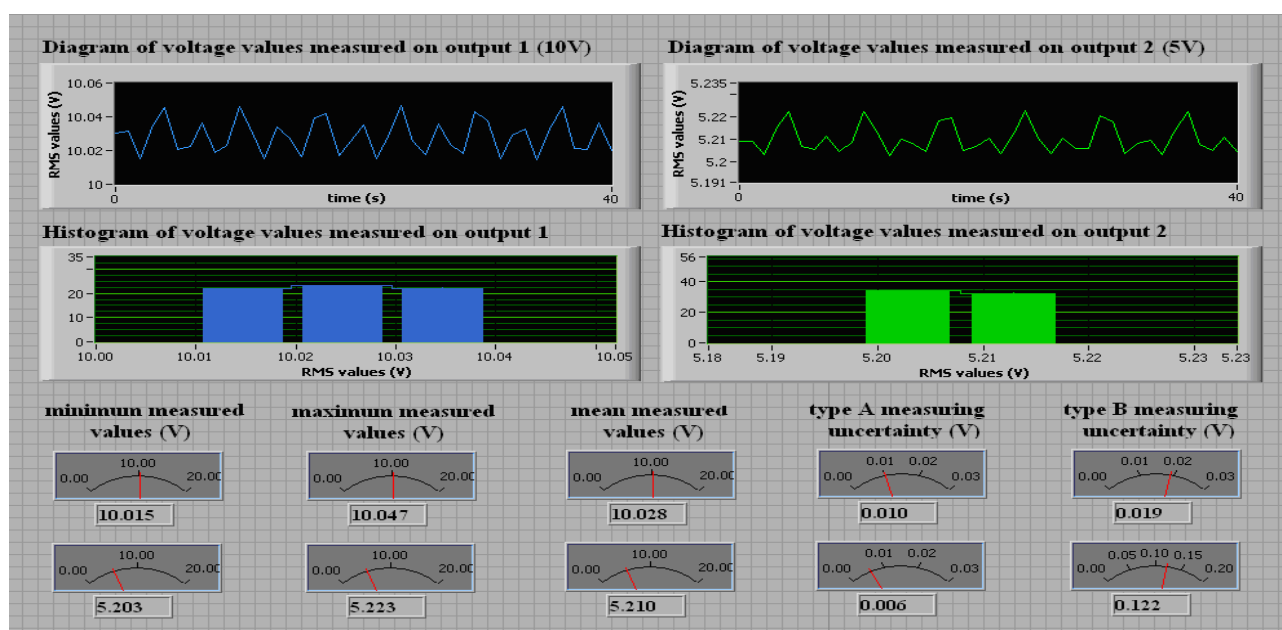


Fig. 3. Statistical processing of the measured RMS voltage values performed in LabVIEW environment

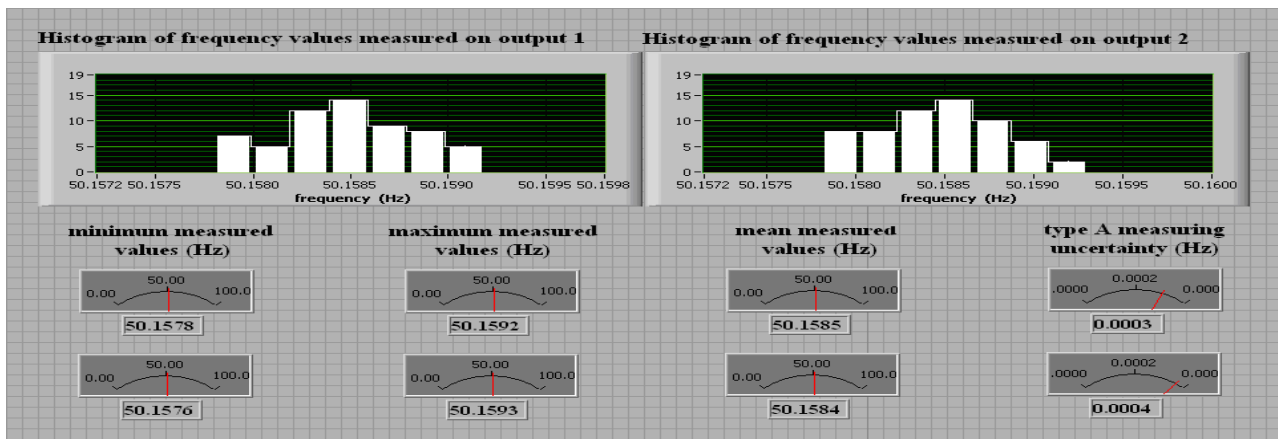


Fig. 4. LabVIEW statistical processing of the frequency values measured on the transformer outputs

mean measured voltage values are calculated as arithmetical mean of the obtained measured values, as it shown with the following relation:

$$V_{mean} = \frac{1}{n} \sum_{i=1}^n V_i \quad (1)$$

Procedure for calculation of the measuring uncertainty values is performed in accordance with the document: Guide to the Expression of Uncertainty in Measurement [6], published by International Organization for Standardization, ISO. Calculations of type A uncertainty values are performed according to statistical methods applied on obtained measurement results, by next equation for statistical standard deviation:

$$u_A(V) = \sqrt{\frac{1}{n(n-1)} \sum_{i=1}^n (V_i - V_{mean})^2} \quad (2)$$

Type B uncertainty values are estimated on the basis of data obtained from specification of reference instrument Fluke 5100B. According to specification for nominal frequency of 50Hz reference voltages are generated with specified accuracy of 0.05% [4]. Considering specified relative accuracy, for type B uncertainty of the measured data are calculated following results:

$$u_{B1}(V) = \frac{1}{\sqrt{3}} \frac{0.05}{100} 10V + \frac{0.028V}{\sqrt{3}} = 0.019V \quad (3)$$

$$u_{B2}(V) = \frac{1}{\sqrt{3}} \frac{0.05}{100} 5V + \frac{0.210V}{\sqrt{3}} = 0.122V \quad (4)$$

Software analysis of the frequency values measured on the first and second transformer output, performed in LabVIEW application, is presented on the Fig 4. Similar with previously described procedure, on shown front panel are illustrated statistical histograms concerning the frequency values measured on the 10V and 5V transformer outputs. Illustrated procedure also

includes indication of minimum and maximum measured frequency, with calculations of mean frequency values and measuring uncertainties.

CONCLUSION

Possibility of using virtual instrumentation software for verification of voltage measuring transformer accuracy, based on analysis of the measured voltage parameters, is presented in this paper. Reference voltage waveforms for measuring transformer inputs are provided by calibrator Fluke 5100B. Hardware section of measurement procedure includes PC computer and acquisition card PCI NI 6251. Software application in LabVIEW 8.0 package performs measurement, presentation and processing of measured RMS output voltage values, phases and frequencies. Software processing includes presentation of recorded diagrams, indication of minimum and maximum measured values, calculations of the mean values and measuring uncertainty. This solution avoids demands for measurements of output voltage for each point of input voltage changing, due to providing an automation of complete measurement process.

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