Metrological Support of Electronic Energy Meters Production

Bozidar B. Dimitrijevic[1], Ivana S. Randjelovic[2] and Milica P. Rancic[3]

Abstract - **An automated calibration procedure developed for metrological assurance of the gauging procedure in electronic energy meters production is described in this paper. In the framework of the project sponsored by the Ministry of science and technology in Serbia, mentioned gauging procedure is developed using a PC control software tool LabVIEW and 8-channel acquisition card PCI-NI 6713. Advantages of virtual instrumentation software opposite to standard programming methods are used for evaluation of measuring uncertainty, especially the component introduced by the DAQ card, which is specifically analyzed. Controlled performance of each function and component of the system is provided, as well as their analyzed influence on the accuracy of the whole system.**

Keywords - **automated calibration, virtual instrumentation, gauging energy meters**

I. Introduction

Rapid growth in key technologies, such as information technologies, involves more accurate measurements over much wider value and parameters range, as well as reduction of time needed for measurement procedure to be fulfilled. Improvement of calibration systems in electric energy meter production is especially important for industry as well as for energy traffic manager centers. Investment in development of these systems is economically reasonable because of falling costs in quality control procedure during the production process.

Besides all advantages that automation calibration procedure offers, many known designed calibration systems use expensive etalon energy meters regardless to the applied level of automation [1]. In that case, employed computer is not shared for attaining adequate accuracy class of the produced energy meters under test. A recalibration system without etalon energy meter that involves a computer becomes an intelligent measurement station in the production process that scopes automated test procedures and higher throughput and capacity.

Various systems of this kind are employed worldwide, with a final goal of complete automation. Automated process, based on application of the PC computer and virtual instrumentation software would significantly save time needed for calibration and presentation of results obtained during that process. There are already few completely automated systems employed in the world, and in our country, with similar characteristics [2,3]. For example, the System Century Controls Company from India now offers a fully automatic energy meter calibration [4].

In the framework of our project an automated system for gauging of new type of kWh meters, which are produced in the Ei - "Professional Electronics" factory in Niš, is being developed. The principal goal of our project is to develop a new traceability/calibration procedure for metrological assurance of the automated gauging system in the production of a new type of electronic kWh meters.

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II. Preliminary Requirements and Technical Characteristics

Necessary conditions for rising technological quality of kWh meters to a higher level are accomplished by designing and realizing of the automated gauger using modern information technologies in the field of measurements. In addition, optimization regarding the needed time and testing expenses in accordance with up-to-date requirements of domestic and foreign market is also provided. Use of the PC computer and virtual instrumentation software significantly saves time needed for calibration and presentation of results obtained during that process, as well as it provides secure level of quality, reliability, and accuracy appointed by the corresponding standards for measuring of electrical energy.

Fig. 1 depicts symbolic logic connection of IBM PC and its needed peripheral hardware devices (PCI-NI 6713, SCB-68) as a constituent part of automated calibration system. The Calibrator Metratop53 is used periodically according to issued rules for the legal traceability. Using a software procedure further described in the paper, calibrated voltages as references for energy meters gauging are obtained at six analogue outputs of the 68-Pin Shielded Connector Block (SCB-68). The accuracy of calibrated voltage and current references is reduced due to subsequent analogue processing in the gauger. Correction of the reduced accuracy of set magnitude and phase of three-phase voltages and currents that are brought to energy meters under test is achieved by embedded self-calibration technique.

A global functional scheme of the automated gauger and its working principle are shown in Fig.2. Preliminary requirements, which concrete modules should fulfill, are defined and are as follows:

The gauger is designed for automated and semiautomatic simultaneous calibration and gauging up to twenty kWh meters of following types:

- Direct mono-phase kWh meters for reactive and active electrical energy measurement;
- Direct three-phase kWh meters for reactive and active electrical energy measurement;
- Indirect kWh meters for reactive and active electrical energy measurement;

There is a possibility of simultaneous calibration of kWh meters with same characteristics and of different type, e.g.:

- Mechanical kWh meters which obtain the information about the measured energy using optical reading head;
- Electronic kWh meters which obtain the information about the measured energy at the test output;
- Digital kWh meters, which obtain the information about the measured energy at the optical port.

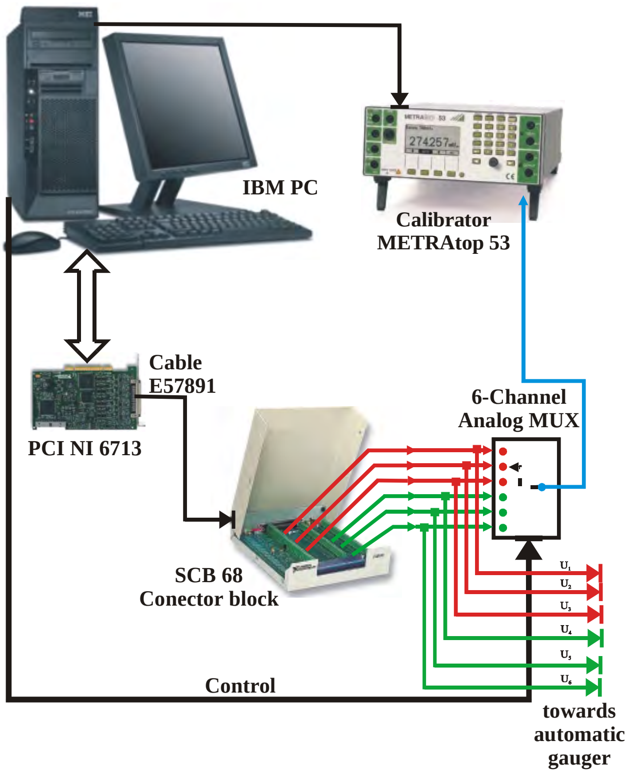

Fig. 1. Virtual instrument with programmable generator

The gauger consists of:

- PC computer, which provides communication between the user and the system, pools and controls parts of the whole system and makes a database of obtained results during the gauging. Based on those results, daily and monthly reports are presented and filed for each of the tested energy meters in all points of the protocol.
- Programmable generator of voltage and current (distributive electrical network simulator) which generates three voltage outputs (U_R, U_S, U_T) and three current outputs (I_R, I_S, I_T);
- Data logger that simultaneously and precisely gathers information about the measured energy from the tested kWh meters and voltage and current references (AC dividers outputs and current shunts). Gathered data are sent to the PC computer, where performance accuracy of tested energy meters is evaluated and all necessary corrections are performed.
- A rack with (20 + 20) locations for linking and testing of kWh meters of different type and floor plan, whereas each tested spot is equipped with a mechanism for maintaining and controlling the optical reading head, local error indicator and connector through which a RS 232 interface can be realized between the tested energy meter and the PC computer.

TABLE I

Voltage sources	
Nominal voltage	$U_{n1} = 57.73\,V$ $U_{n2} = 230\,V$, $50\,Hz$
Programmable adjustment	2-120% U_n
Voltage stability	$\leq \pm 1\%$
Voltage phase difference	0-120^0
Phase error	$\leq \pm 1\%$
Maximal output load/phase	200 VA
Current sources	
Programmable current adjustment	20 mA-120 A
Current stability	$\leq \pm 1\%$
Current phase difference	0-120^0
Phase error	$\leq \pm 1\%$
Maximal output load/phase	1 kVA
Phase angle between U and I	
Adjustment of the Phase angle between U and I	$0 - \pm 180^0$
Phase angle stability	$\leq 2^0$
Frequency adjustment	
Frequency band	45-65 Hz
Stability of the set frequency	±2%

Standard technical requirements of the gauging system that must be met are listed in Table I. In accordance with technical specifications, an automated system for gauging, which contains a PC computer in the feedback circuit, is being developed. Output information from the current shunt as well as those from AC dividers, across the ADC converter, are returned to the PC computer where the kWh parameter correction is done. Using a multi-channel microcomputer card PCI-NI 6713 [9], for referent voltage and current generating, eight digital/analogue output channels are provided. DAQ card outputs are connected to the system through SCB-68 (68-Pin Shielded Connector Block).

It should be mentioned that the Commission of the European Communities has published *Directive 2004/22/EC of the European Parliament and of the Council on measuring instruments* [5]. Our future work should consider complete accordance with requirements proposed by this Commission.

III. METHOD FUNDAMENTALS

Using a software package LabVIEW [6], based on virtual instrumentation, amplitude and phase corrections of current/voltage channels are performed, which fulfills requirements and technical characteristics of the programmable voltage and current generator. A program sequence developed using a graphical program language LabVIEW, is shown in Fig.3. A program provides a possibility for changing amplitude and phase of all voltage and current channels. Using a portable calibrator METRAtop 53 [7], metrologically verified using a technique given in [8],

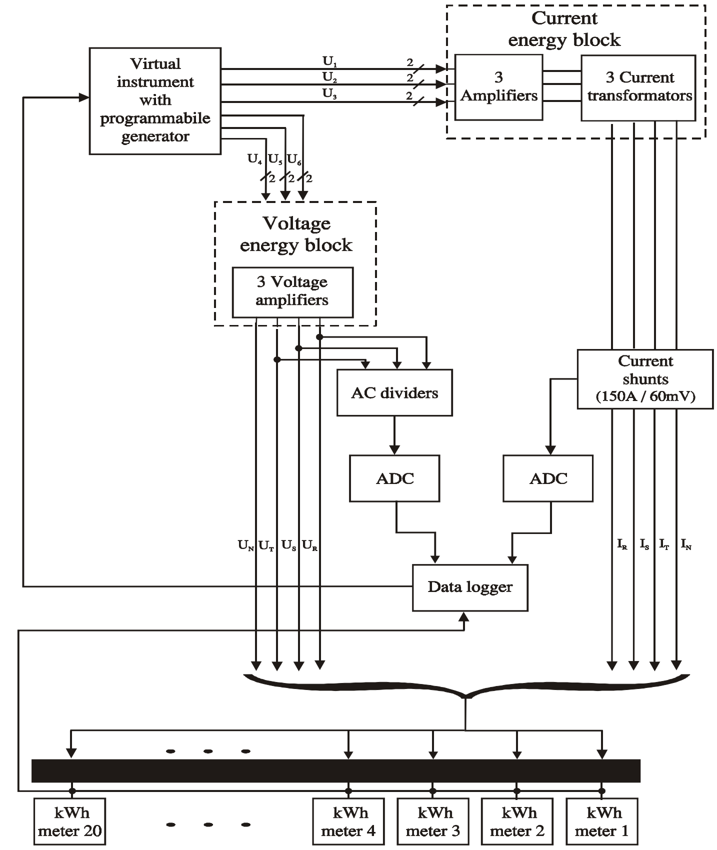

Fig.2. Block scheme of the measuring system

which is connected to the PC computer through the RS-232 interface, output levels are measured and then returned to the computer for further analyzing. Based on obtained results, any of known methods for uncertainty evaluation can be applied, such as Monte Carlo method that considers the following procedure, [10]:

The first step is characterization of metrological performance featured by each component of the measuring system. The information concerning the uncertainties can be achieved by means of either statistical methods applied to experimental tests (type A evaluation, according to [10]) or, more frequently, by exploiting accuracy specifications provided by the manufacturer (type B evaluation), for any device included in the system [12,13]. Both kinds of uncertainty evaluations are based on probability distributions. If the evaluation of type B is applied and there is not any available information on distribution, each contribution to uncertainty is considered a random variable. It has a uniform distribution on an interval centered at zero, whose lower and higher limits are defined by accuracy specifications given in data sheets.

Since the distribution function is defined, the Monte Carlo procedure can be applied in order to determine standard uncertainty. The procedure can be generalized and automated using a program sequence developed under the software package LabVIEW. Generalization considers a possibility to generate sets of random variables of desired statistical parameters. As a result, a large number of variable sets is obtained. Now, different types of tests can be performed on these variables. In each test, values of input data are being changed and, for known relationship between the input and the output quantities, corresponding sets of output data are obtained. Statistical parameters that describe obtained output data, such as mean, standard deviation, mean square value, etc, are calculated.

Described method shows that numerical approach can be applied to a large number of practical situations. In the case of analogue signal conditioning systems, the accuracy specifications mainly concern gain, offset, harmonic distortion, slew rate, noise, bandwidth, etc. In the case of sampling and A/D devices, other uncertainty sources also have to be taken under consideration, such as time jitter, nonlinearity, quantization, etc, [10]. In order to fulfill required specifications, this procedure must be repeated a number of times N, [11]. As mentioned above, the A/D conversion system can also be a significant source of uncertainty because of quantization, offset, gain, and nonlinearity errors. Therefore, an evaluation of the uncertainty, which could be introduced by this system part, must be performed using the method described above.

IV. CONCLUSION

The contribution of accurate gauger in production now has a lot preferences and primary among them is to maintain both energy meters quality and optimization costs of the final control of this kind of products. Therefore, it is essential that

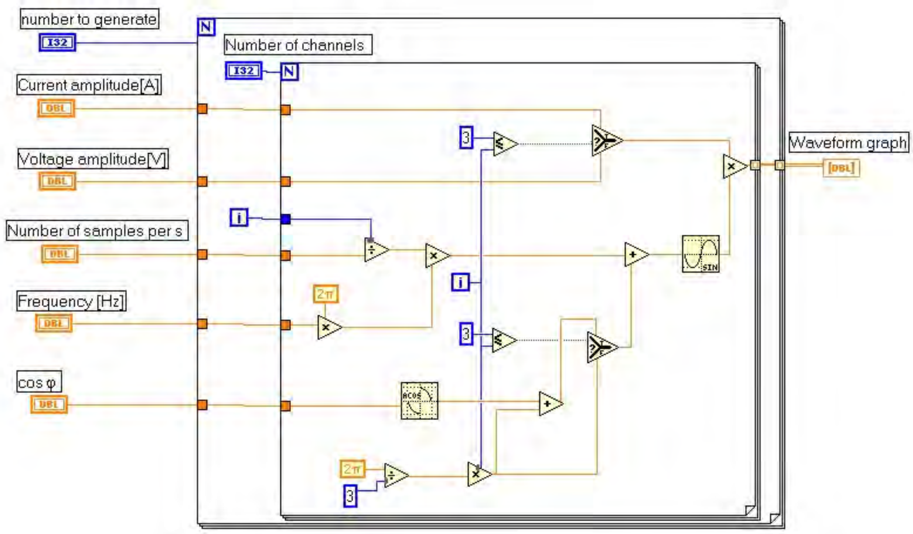

Fig. 3. A program sequence developed using LabVIEW

all subjects concerned with electric energy measurement quality are ensured, and that the right standard for calibration service is obtained in order to achieve and maintain proposed quality requirements.

In the framework of our project an automated calibration system for gauging of new type of kWh meters, which are produced in the Ei - "Professional Electronics" factory in Niš, is being developed. The principal goal of our project was to develop a traceability/calibration procedure for metrological assurance of the automated gauging system in kWh meters production. Based on the preliminary requirements and technical characteristics of a new energy counter, a new solution for the automated calibration procedure is designed using available modern measurement means in our metrological laboratory.

As the traceability for automated systems must be provided by regular re-calibration, which would be based upon an approved procedure including details of how the system software controls the traceability and self-calibration procedure, the proposed laboratory project provides two principal mutual dependence functions: traceability and re-calibration. All known automated systems of gauging use the PC and realized software as a programmable generator and all eventual corrections are done apart from the computer system. In our case, all referent as well as measured values are led to the computer through the feedback, where all necessary corrections are automatically performed. Self-re-calibration of automated gauging equipment within the system is performed under virtual instrumentation control (LabVIEW software), against higher echelon laboratory standards, such as portable calibrator MetraTop53 and the acquisition card PCI-NI 6713.

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