Computer Based System for Sources Automated Calibration

VLADISLAV SLAVOV, TASHO TASHEV
Faculty of Automation, English Language Faculty of Engineering
Technical University - Sofia
Bul. Kliment Ohridski 8
BULGARIA
v-slavov@tu-sofia.bg , t_tashev@tu-sofia.bg, http://elfe.tu-sofia.bg

Abstract: - The recent developments in the computer based systems are more and more applicable in different metrology related systems. This paper is an extension of our efforts to implement the modern technologies and trends into the measurement processes. An algorithm for calibration and verification of electrical quantity sources was created and applied in a particular system using the bases of the closed-loop system concept.

Key-Words: - Algorithm, Automation, Calibration, LabVIEW, Measurement, Metrology, Source, Verification

1 Introduction
Computing and technology development in the last years created high-quality technology solutions for automation of the measuring process as well as the metrological activities - verification and calibration of measuring devices and sources. Classical metrological operations calibration and verification of measuring devices take plenty of time consuming and requiring high qualified personnel and it does not exclude admission of subjective errors. Subsequent of data measurement processing also requires a significant resource of time.

Automation of the verification activities and calibration of measuring devices is useful because the possibility of reducing the timing of the measurements, the computer processing of the results, reduction of operator participation to minimum and the exclusion of subjective error, respectively that would significantly improve the quality of the processes without increasing costs though.

At present time, a large range of computer-based technologies are offered to automate the measuring process. These are the products offered by National Instruments, Agilent Technologies, Keithley and others. However, these computer technologies have negligible presence in the laboratory practices of universities in Bulgaria, which leads to retardation of the education regarding to the requirements of the industry.

2 Problem Formulation
In our previous work the automated process of the calibration of DMMs was developed and published. The block diagram of such a process was explained. Some algorithms for creating software products were proposed. Those algorithms were applied in solving particular tasks successfully. As it was mentioned in [1] the calibration and verification process regarding measuring quantities like voltage, current and resistance can be separated into two sub-problems namely verification and calibration of measuring devices as DMMs and verification and calibration of sources such as DC voltage generators, function generators and others. As extension of our previous efforts to improve and facilitate the processes of verification and calibration with achieving better precision, higher accuracy and significantly decreased time the task to develop algorithm for verification and calibration of different sources was put on the table. In this paper the results from our efforts for solving the problem using DC voltage variable source will be presented.

2.1 Bases
Before solving the problem some basic concepts should be mentioned that are used in our work.

2.1.1 Calibration
The International Vocabulary of Metrology, Basic and General Concepts and Associated Terms—VIM 3 [2], defines calibration as:

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication.

NOTE 1 A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.
NOTE 2 Calibration should not be confused with adjustment of a measuring system, often mistakenly called “self-calibration”, nor with verification of calibration.

NOTE 3 Often, the first step alone in the above definition is perceived as being calibration.

It is evident from this definition that the calibration process transfers a reference value, normally a unit from International System SI, to the instrument under calibration to ensure traceability and reproducibility of measurements. This process typically involves many activities with technical, documentary administrative and procedural nature. The paper will be focused on automation of the technical (and documentary) part of activities, which can be done perfectly using modern technologies.

2.1.2 Closed-loop calibration

The calibration of microprocessor controlled, IEEE-488 bus or RS232 communicating DMMs has been simplified by automation. The DMM itself may provide a great deal of the automated capabilities. However, external software, running in a PC, provides even more advanced calibration automation. Closed-case calibration, along with the advent of IEEE-488 bus controllers and calibration instruments controlled by the IEEE-488 bus, revolutionized the traditional DMM calibration by fully automating it. This automated process is often referred to as closed-loop calibration. Closed-loop calibration is one of the most Significant instrumentation developments in recent years. The loop is the connection between the measurement of an instrument's performance and the actual readjustment of its operating characteristics. Closed-loop calibration eliminates the need for any kind of arm in the loop for a DMM calibrator, the system can send the correct range and function over the IEEE-488 bus, apply the desired stimulus to the analog inputs, take the resultant reading back over the bus, and command a change in the digitally-stored correction. The loop is closed by the system CPU. A block-diagram of such a system used for DMM calibration was proposed in [3] and look like shown on figure 1.

3 Problem Solution

To solve the problem explained above our work was divided into three simple steps:

1) To consider a block diagram using the closed-loop concept
2) To develop an algorithm based on the block diagram from 1) and as versatile as possible
3) To apply the algorithm into a particular calibration and verification process

Obviously, to solve the first task is not a challenge because we only have to consider that we have to solve the opposite problem. It means that the Calibrator in fig. 1 will be the source that we verify and calibrate and the DMM will be the calibrator that will measure the true value. This idea can be presented with the following block-diagram:

![Fig. 2 Closed-loop system for sources calibration](image)

As it can be seen all the process is controlled by the PC that is equipped with suitable set of hardware and software. Usually to control the instruments IEEE 488 interface is used (known as GPIB). So to control the devices a program called driver should run on the computer. To develop such a driver is possible with different programming products and environments. As before, in our particular work we use National Instrument’s LabVIEW to develop Plug&Play driver [4]. Based on the concept of the Plug&Play driver and the specification of the programming environment the algorithm shown on figure 3 was created.

In our algorithm we presume the user to have a choice between two different modes – automated and semi-automated. The automated mode controls the generated values of the quantity fully. It means that the user can not change that values and he only observes the process. This mode is suitable for calibration because the values of the generated quantities are usually strictly defined (these are the maximum values of the range). Also to calculate the uncertainty the procedure requires strictly defined values according to the international metrology standards.
The semi-automated mode gives more “freedom” to the user. The range, the initial value and the step can be chosen. The program prompts the user to enter that value and generates the calculated ones. This mode is more appropriate for calculating different types of errors (absolute, reduced, relative) and not so much for calculating the uncertainty since the values entered by the user can be different than the required by the standards.

Another specification of the algorithm is that it presumes the number of the generations and the measurements in one point to be 10. After that the program calculates the mean value of those 10 measurements in one point and passes it for further calculations and visualization.

Each measurement is done 10 times in the same point and the result is the mean value of all those measurements. That is N in the algorithm.

To apply the algorithm into a real process system of the following devices was created:

1) National Instruments’ work station ELVIS II[5] was used as a quantity source. More particularly the DC variable power supply source was used.

2) The measuring options of METRIX1651 was used as a calibrator

3) A PC equipped with LabVIEW controlled the process

To put all this together a Plug&Play LabVIEW driver had to be created. Running on the PC it controls the work of the two devices. To control the functions of ELVIS II LabVIEW gives ready to use Vis. The challenge use to create such a driver for controlling the measuring functions of METRIX1651. Since it uses IEEE 488.2 which is a defined protocol that task was completed significantly fast and successfully using the procedures and methods described in [3]. The system was tested and the results were satisfactory.

4 Conclusions

The computer based systems used to automate the process of calibration and verification are one of the most significant developments during the past years. Our purpose in developing such systems is to improve that process and to apply the results in the certificate metrology laboratories as well as in the educational process.

The algorithm and the methods used to create such a system were tested and approved. A future work for development and optimization challenges us to continue putting efforts on developing different computer based systems using different kind of devices and quantities.

References:


