

An Early Development of Software for Automatic Measurement of Multifunction Calibrator

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Abstract – This paper describes an early development of software for automatic measurement of the multifunction calibrator using direct measurement method with the reference multimeter. The software is developed to control the multifunction calibrator and the reference multimeter using GPIB interface. The developed software can do single point measurement and multi points measurement by configuring the instruments automatically. For the security reasons against the instruments, it is equipped with a pop-up alert to indicate that a connection change is required before the measurement begin, because the multifunction calibrator commonly has three electrical measuring quantities (voltage, current, and resistance) that have different connection for each of the quantity. The measurements can be made with some repeatability to reduce the type A uncertainty and the measurement results then tabulated as raw data. The results can be saved as a certificate of calibration automatically from the template in which the correction and the expanded uncertainty are calculated. Therefore, the accurate and precision measurements for calibrating and testing the electrical equipment can be performed with easy, safe and fast.

Keywords – Software Development, Automatic Measurement, Multifunction Calibrator, Reference Multimeter, Direct Measurement Method.

I. INTRODUCTION

The role of the testing laboratory is very important in quality assurance of energy sector. The common standard instruments used for energy testing are multifunction calibrator and reference multimeter, which can calibrate the voltage, current, and resistance quantities. However, the problem faced by the testing laboratory is the manual calibration of these instruments.

In practice, this kind of measurement is long, tiresome, and very hard to be performed manually by hand. Fortunately, almost all standard instruments used in testing laboratory have General Purpose Interfacing Bus (GPIB) interface option to connect and control these instruments by computer, named as automatic measurement [1].

Some industries in the worldwide have developed methods to change from manual to automatic measurement through display software, such as Fluke [2]. Since 2011, National Measurement Standards – National Standardization Agency of Indonesia (SNSU-BSN), as the National Metrology Institute of Indonesia, has improved the measurement process from manual to automatic measurement using commercial software Met/Cal [3]. In practice, even though the software has been implemented for measurement, fully automatic measurement is still impossible to be realized since it still requires changing the connection manually.

Before fully automatic measurement is achieved, it is necessary to develop new software so that in the future integration with all developed hardware system can be controlled easily. Therefore, this paper describes the new software that has been developed for semi-automatic measurement.

II. MEASUREMENT SYSTEM

The measurement system consists of hardware and software. The hardware used for this system are multifunction calibrator as unit under test (UUT), reference multimeter as standard, and cable connector that supported the measurement system [4,5,6].

The supporting equipment are the Personal Computer (PC) and the General Purpose Interface Bus (GPIB) IEEE-488. In this research, GPIB is used to send commands from the PC to the multifunction calibrator and reference multimeter, as well as transfer the data from the reference multimeter to the PC. Figure 1 illustrates block diagram of

the measurement system consisting of the PC connected using a GPIB cable to the multifunction calibrator then to reference multimeter.

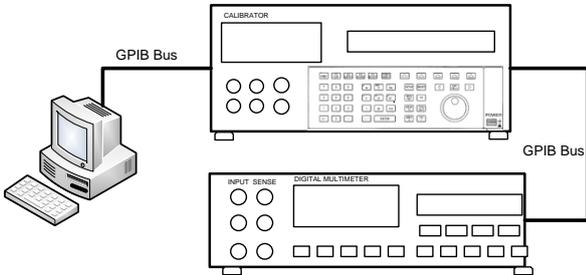


Fig 1. Block Diagram of Measurement System

The programming language used in the measurement system to operate the equipment is the open source Visual Studio Community software, namely Visual Basic. The Graphic User Interface (GUI) of the software can make measurements easier and faster than manual measurement systems. This software provides convenience of being able to set single point or multi points measurement, adjusting configuration, measuring ranges automatically both on the multifunction calibrator and reference multimeter. It also can automatically record the measurement in the form of a spreadsheet.

This software has been implemented with a pop-up alert about the connection of the measuring cable at each parameter so that it can prevent damage to the equipment due to incorrect connection of the cable to the instrument. This is because each measuring parameter has a different type of connection. Through this software, calibration operator can manage a large number of repeated measurements, thereby minimizing the uncertainty of random measurements, known as type A uncertainty [7]. Moreover, the use of this software can reduce human error in the measurement or calibration process.

III. IMPLEMENTATION ON SOFTWARE

The software is written in Visual Basic and run on the PC with GPIB interface. It consists of several panels and menus guiding the operator through the measurement procedure consisting of pre-measurement stage, the measurement stage, and the reporting stage.

A. Pre-measurement Stage

First, the operator has to define the procedure to run by selecting multifunction calibrator and reference multimeter on the "Instrument Setup" panel. In addition, the interface configuration is also defined by determining the bus address of multifunction calibrator and reference multimeter. To determine the time configuration for adjusting the delay of measurement, there is a "Delay to start" menu to give the time for the measurement

application to run, usually applied as the warm-up time by the user.

The "Delay between 2 points" menu gives the time lag between two measurement points, while the "Delay between 2 parameters" menu provides time lag between two measurement parameters as shown in Figure 2.

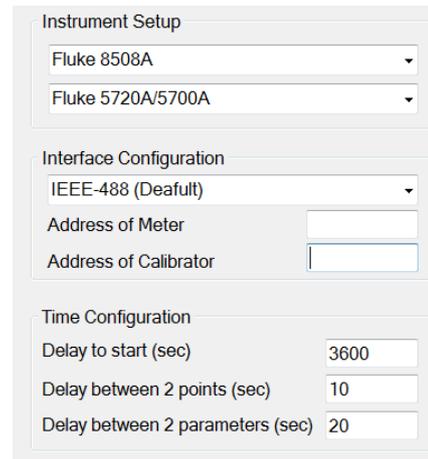


Fig 2. Instrument Setup, Interface Configuration, and Time Configuration Panel

The "Measuring Setting" menu provides configuration setting of measurement parameter such as resolution, sampling time, filter, zero offset, mode, and guard mode. The example of resolution setting is shown in Figure 3.

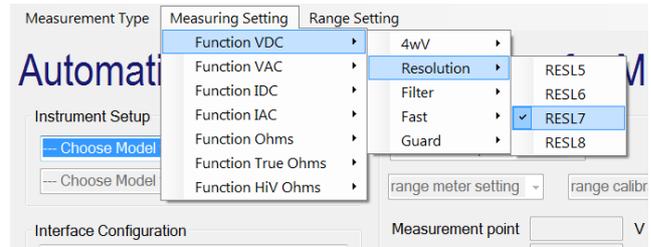


Fig 3. Measurement Parameter Configuration Menu

B. The Measurement Stage

At this measurement stage, the range setting is determining whether the measurement is in lock or unlock mode as shown in Figure 4. The lock mode locks the measuring point in the desired range while the unlocked mode lets the measuring point in the auto range.

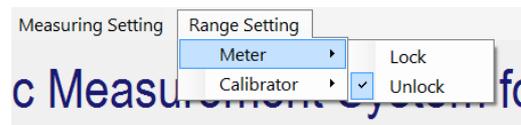


Fig 4. Range Setting Menu

There are several menus to configure the measuring points such as "choose a parameter", "range calibrator

setting”, “range meter setting”, “measurement point” and “frequency”. These menus are for setting the parameter to be measured, choosing the range on the multifunction calibrator and reference multimeter, entering the measuring point and inserting the frequency value, especially for AC parameters.

Retrieving measuring points and their configuration from spreadsheet can be done using "Load Measurement Points from file" panel. These features is shown in Figure 5.

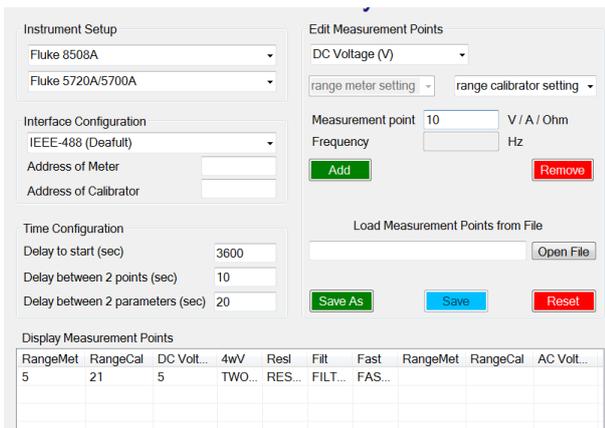


Fig. 5 Edit Measurement Point and Load measurement Point form file panel

Before and after running the calibration process, record the environment temperature and humidity in the “Initial room condition” and “Final room condition” fields. The calibration process begins by pressing the “Start” button and then a pop-up alert appears to remind the operator to check the cable connections before the measurement running. This pop-up alert will appear again when the measurement parameter changed to make sure the connection is fit for the measurement. The pop-up alert is shown in Figure 6.

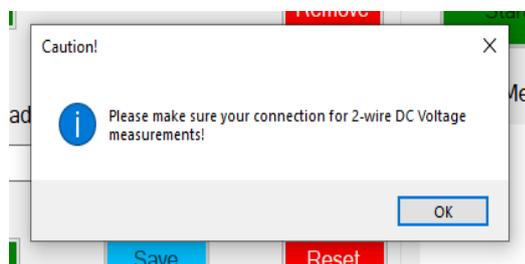


Fig 6. The Pop-up Alert Display for 2-wire DC Voltage

During measurement process, the software will display updated results in the related fields. The obtained measurement results by default are tabulated as raw data. These results also can be saved as a certificate of calibration automatically from the template in which the correction and the expanded uncertainty are calculated. This option is shown in Figure 7.

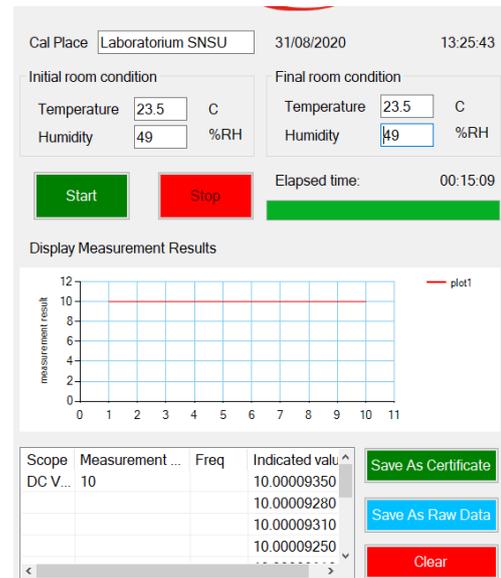


Fig 7. The Display of Updated Result in Related Fields

C. The Report Stage

At the reporting stage, the correction and uncertainty of multifunction calibrator measurement results were evaluated based on the JCGM guidelines with a 95% confidence level and a coverage factor of $k = 2$. The correction from the certificate of standard is then added mathematically into the reference multimeter reading to get the multifunction calibrator correction.

IV. PERFORMANCE

The early software has been performed in both 5 times measurement repeatability and 10 times measurement repeatability for all functions (voltage, current and resistance). For instance, the number of repeatability for 5 times and 10 times measurements in DC voltage quantity at the point of 100 V, in AC voltage quantity at the point of 100 V at 50 Hz, in DC current quantity at the point of 1 A, in AC current quantity at the point of 1 A at 50 Hz, and in resistance quantity at the point of 1 kΩ. The measurements in both 5 times and 10 times repeatability are then evaluated and compared by performing under the same configuration, auxiliary hardware, and environmental conditions. The repeatability evaluated as a type A uncertainty [7]. Sample of these average results and the type A uncertainty evaluation illustrated as error bar are shown in the Figures 8 to 12.

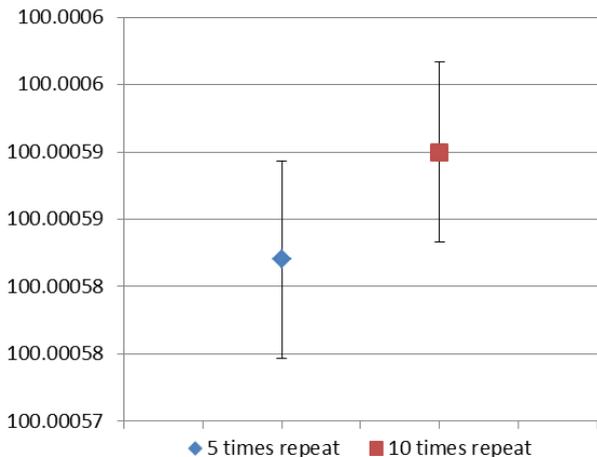


Fig 8. The results of 100 V (DC Voltage) in 5 times and 10 times repeatability

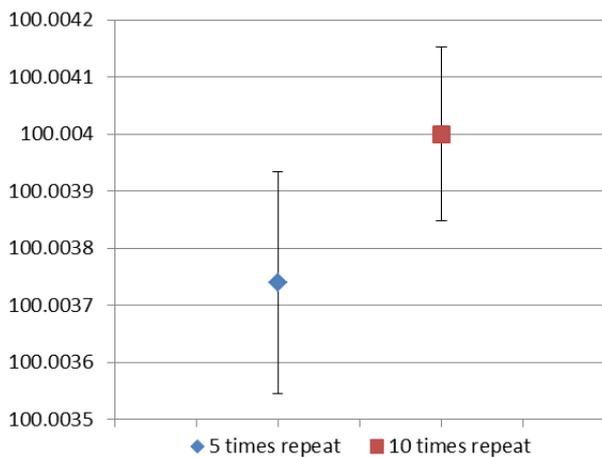


Fig 9. The results of 100 V (AC Voltage) at 50 Hz in 5 times and 10 times repeatability

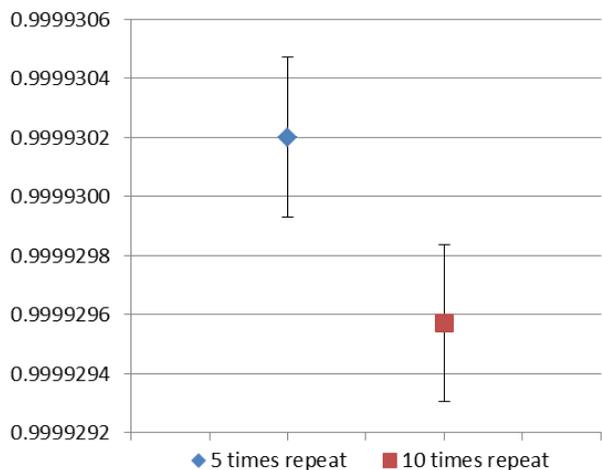


Fig 10. The results of 1 A (DC Current) in 5 times and 10 times repeatability

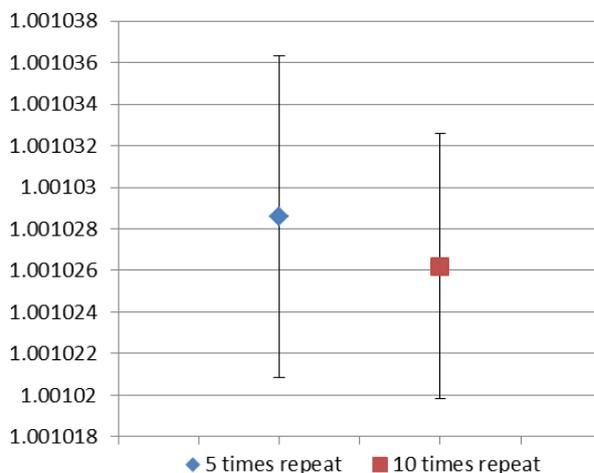


Fig 11. The results of 1 A (AC Current) at 50 Hz in 5 times and 10 times repeatability

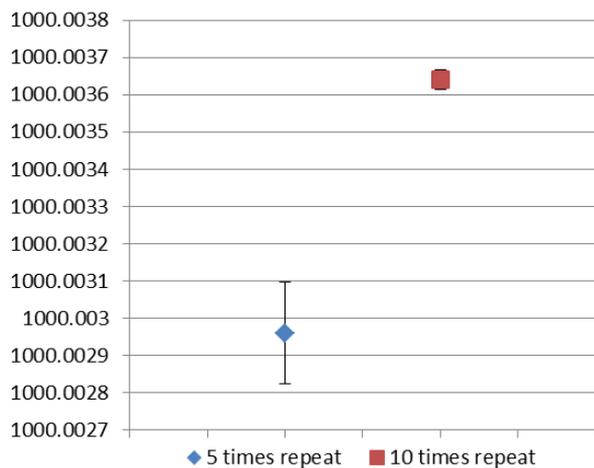


Fig 12. The results of 1 kΩ (Resistance) in 5 times and 10 times repeatability

Almost all results show that the evaluated values in 10 times repeatability have smaller error bar than the 5 times repeatability values. Also, the average values of 10 times repeatability are very close to their corresponding 5 times repeatability results. However, the results of 1 A DC current and 1 kΩ resistance have different average values and do not covered by error bar. It is probably because the settling time in these parameters has not met a suitable time to achieve the true value.

V. CONCLUSIONS

The early developed automatic measurement system has been established at SNSU-BSN for the multifunction calibrator measurement using direct method with the reference multimeter which makes the measurement easier than manual.

The software facilitates the appearance of pop-up alert about the connection of measuring cable which increase

the safety of the measurement.

This software designed to be able to take a lot of repeatability in measurement that will reduce the type A uncertainty. The result of measurement can be saved as raw data or certificate of calibration which produces fast calibration.

With the software, accurate and precise measurements can be performed for calibrating and testing the electrical equipment with easy, safe and fast.

VI. ACKNOWLEDGMENTS

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REFERENCES

- [1] **Hala, M, Abdel Mageed; Ali M, El-Rifaie.**: Automatic Calibration System for Electrical Sourcing and Measuring Instruments, IEEE, 2013.
- [2] **Fluke.**: User Manual Fluke Metrology Software Version 7 MET/CAL 5500/CAL MET/TRACK, *Fluke Corporation*, 2002.
- [3] **Mohamad, Syhadi; Hadi, Sardjono; Lukluk, Khairiyati.**: Verifikasi Sistem Pengukuran Tegangan Standar AC Berbasis Metcal 7, 20 Berketelitian Mencapai 2 PPM (Verification of Measurement System for AC Standard Voltage Based on Metcal 7, 20 with 2 ppm Accuracy), *Jurnal Standardisasi 14 (1)*, 2012, pp 22-33.
- [4] **Mochammad Rameli dan Eka Iskandar.**: Development software for DMM calibration from remote set point until automated reporting, JAVA, *International Journal of Electrical and Electronics Engineering 13*, Volume 14, Number 1, April 2016.
- [5] **Vitawat, Sittakul; Jutarat, Tanarom; Narat, Rujirat and Ajachara, Charoensook.**: A Fully Automatic Multimeter Calibration System Using Programmable Switch, *NIMT Article*, Vol 14 No 67, May-June 2012.
- [6] **EURAMET**; Guidelines on the Calibration of Digital Multimeters, EURAMET cg-15 Version 3.0, 02/2015.
- [7] **JCGM**: JCGM 100 : 2008, Evaluation of measurement data: Guide to the expression of uncertainty in measurement (1st ed.). *JCGM*.
<https://doi.org/10.1373/clinchem.2003.030528>