Development software for DMM calibration

from remote set point until automated reporting

Mochammad Rameli
Electrical Engineering Department
Institute Technology Sepuluh Nopember
Surabaya, Indonesia
rameli@ee.its.ac.id

Eka Iskandar
Electrical Engineering Department
Institute Technology Sepuluh Nopember
Surabaya, Indonesia
iskandar@elect-eng.its.ac.id

Abstract--**Measurement of electrical quantities such as voltage, current, resistance becomes a part in checking the electrical equipment both for industry and households. Digital Multimeter (DMM) can be used as a measurement of electrical quantities. Sometimes the operator can make mistakes such as connecting cable at wrong place, or forgot to change the measurement range so it can break the DMM fuse. Frequent use of calibrator can make text on function button indistinct. DMM calibration should be performed periodically to guarantee the truth values of the results from measurement of electrical quantities. Truth values can be achieved by adding correction value read on DMM. Calculating correction values can be easily done by software and written automatically on certificate of calibration. By involving software in calibration procedure, we can remind the operator when the operator connect the cables at wrong place or forget to change the electrical quantities range with pop up menu that appears on the software. We can generate certificate of calibration automatically from template in which the correction values are calculated.**

DMM; measurement; calibration; automatic; calibration certificate;

I. INTRODUCTION

Nowadays the electrical calibrator has the ability to receive commands from the host computer and sends the requested data to the host computer via the GPIB communication port or serial port. Previous research[10] have been sucessfully integrating labVIEW with Fluke 5500 callibrator. One of our research objective is to prevent damaging DMM during callibration process by using labVIEW software to warn the operator to do the correct procedure. By sending set value via commands, the text of the function button can be preserved because it rarely comes into contact, and the buttons also have longer live because the mechanical parts of the buttons rarely move. Command sent are recorded in the log. Tracking command sent by operator that is possible damaging the multimeter or calibrator can be easily done by viewing log file. This can help investigating case that damage the DMM or calibrator. Notification will appear to warn the operator before setting new point sent to DMM. Before doing calibration, a measurement uncertainty of type B (from environment), and standard specifications inputted previously so that the calculation of the uncertainty on the worksheets can all be done by the software. Validation is done by comparing the calibration used with computer and calibration without computer. Both have similar result.

II. HARDWARE

The equipments used in this experiment are laptop with usb port, fluke 5500A multifunction calibrator, constan 50 DMM, usb to serial converter, and RS232 serial cable. The laptop is connected to calibrator via serial to usb converter and RS232 serial cable. Then the DMM is connected to the calibrator.

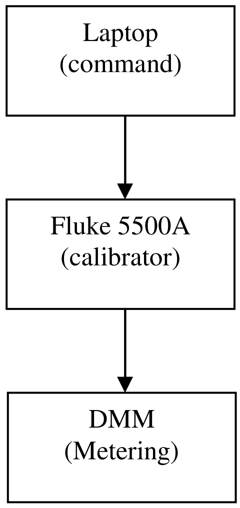

Figure 1. Block diagram of the calibration system

III. SOFTWARE

A. *Existing Procedure Calibration for Voltage Function*

To test DC voltage function for example, the steps are as follow [9] :

- Turn on the DMM and set its function switch to V
- Set the warmed up calibrator to 3.5 V dc. Press OPR
- Use the output adjustment controls to adjust the calibrator output for a reading of +3.5000 on the DMM display

- Complete the following procedure to set a dc voltage output at the 5500A front panel NORMAL terminals. If you make an entry error, press CE to clear the display, then reenter the value. Verify the applied voltage to the DMM does not exceed the rating of the DMM insulation.
- Press RESET to clear any output from the 5500A
- Connect the DMM to 5500A
- Set the DMM to measure DC voltage on the desired range.
- Press the numeric keys and decimal point key to enter the desired voltage output. (maximum seven numeric keys).For example, 123.4567
- At voltage output of 100 volts and above (nominal), you may notice a slight high-pitched sound. This is normal.
- Press +/- to select the polarity of the voltage (default is +).
- Press a multiplier key, if necessary. For example, press m.
- Press V
- The control display now show the amplitude of your entry. For example, 123.4567 mV.
- Press ENTER. The calibrator clears your entry from the Control Display and copies it into the Output Display.
- Press OPR to activate the calibrator output
- A softkey label for range appears on the Control Display in the dc voltage function.
- Verify that the error shown on the control display is less than the specification ftom DMM its users Manual.
- Check the DMM error at 35.0 V, -35.0 V, 350.0 V. Hint:use the MULT X. Verify the errors are within specification. When MULT X causes the output to go over 33 V, the calibrator goes into standby. When this happens, press OPR to operate.
- Check the DMM error at 1000 V to verify it is within specification.
- Set the output of the calibrator to 350 mV and press OPR. Verify the error are within specifications.
- All DMM reading written on worksheet paper for all possible range DMM.
- After completion of the data collection process uncertainty calculation is done manually. Calculation uncertainties include uncertainties type A are derived from statistical calculation data and the uncertainty of type B derived from gauges, calibrators, temperature, humidity, etc. The combined uncertainty is equal to the root sum of the squares of all the uncertainty contributions. Expanded uncertainty obtained by multiplying the combined uncertainty with the coverage factor "k". Values provide coverage factor of the level of confidence for the expanded uncertainty. Most commonly, the overall uncertainty is the scale by using the coverage factor k = 2, to give approximately 95% confidence level. The value of the overall uncertainty is also a correction value of DMM [6,7].
- All the set point value, the value DMM readings, and the overall uncertainty value / correction displayed on certificate calibration.

Software used is LabVIEW that act as an interface between the operator and calibrator. LabVIEW command buttons display same function buttons on the calibrator. Pressing a button on the software will send a command via the serial port to the calibrator. Recognized command will be displayed on the calibrator screen.

Figure 2. Fluke 5500A Multifunction Calibrator

Commands sent from laptop as set value source to calibrator. Then calibrator sent out the corresponding set value sourcing to DMM. The DMM display the value measured.

The reading from DMM by the operator is written to worksheet file. The worksheet file automatically processed to generate calibration certificate. Environmental information such as temperature and humidity, calibration certificate from the calibrator, the technical specifications of measuring instruments help calculate uncertainty value or correction value that will be listed on the certificate of calibration.

B. *Calibration Procedure with LabVIEW*

Here are calibration procedure with Software as follows:

- Turn on calibrator and wait a while until the condition is stable. Usually an hour waiting is stable enough.
- Connect the USB to serial converter between laptops and calibrator.
- Run the LabVIEW software made for sending the set point value to the calibrator. Also check the serial port setting on a laptop with a serial port settings at the calibrator.

- Connect the test leads from the DMM to the calibrator and change the range DMM to the smallest range.
- Through the software sends a setpoint by typing commands OUT and the set point value and then press the virtual button ENTER. Via usb to serial converter the command is sent to the calibrator. On the calibrator screen will appear set point value for calibrator as in software.
- In the software will display a popup confirmation window that reminds change the measurement range on the DMM above the set point value and proceed to the next procedure by pressing YES and NO will stop the software.
- In the software will display a popup confirmation window that reminds change the cable configuration and proceed to the next procedure by pressing YES, and NO will stop the software.
- To apply the set point, press the virtual button OPR on the software. Through usb to serial converter command is sent to the calibrator. On the calibrator screen STBY status will change to the OPR status. The set point value will come out of the calibrator and measured by the DMM also display it on display DMM.
- Write DMM reading to the worksheet. the calibrator status changed to STBY by pressing a virtual button STBY on the LabVIEW software. Via usb to serial converter command is sent to the calibrator. On the screen calibrator OPR status will be renamed STBY. DMM will show a reading of zero value.
- Collecting measurement data that is displayed by DMM to worksheet file that was created in Excel template. Repeat the process to change the set point in LabVIEW for all DMM range and reconfigure cable for corresponding range. Until all DMM range is completed calibrated.
- After completion of the data collection process uncertainty calculation is done automatically by embedding formulas in excel. Calculation uncertainties include uncertainties type A are derived from statistical calculation data and the uncertainty of type B derived from gauges, calibrators, temperature, humidity, etc. The combined uncertainty is equal to the root sum of the squares of all the uncertainty contributions. Expanded uncertainty obtained by multiplying the combined uncertainty with the coverage factor "k". Values provide coverage factor of the level of confidence for the expanded uncertainty. Most commonly, the overall uncertainty is the scale by using the coverage factor $k = 2$, to give approximately 95% confidence level. The value of the overall uncertainty is also a correction value of DMM [6,7].
- All the set point value, the value DMM readings, and the overall uncertainty value / correction displayed automatically on Excel templates that have been made and can be printed as certificate callibration.

C. Functional Specifications system

The formulation of the system specifications prepared starting from the search for the cause of the calibration process failed. We find the causes then find the solution. Calibration system proposed giving added value to the existing calibration system. Calibration system proposed expected to minimize failure derived from the operator, such as wrong measurement range, wrong configuration test leads, frequent use function button, wrong order procedure, or granting wrong set point. If something happens due to negligience a notification will appear to notify or alert the operator before proceeding to the next procedure. All the requirements to be made is poured on a functional specification prepared calibration system. Functional specification system made include [8]:

- Hardware and software.
- A description of its function.
- Data obtained and produced.
- Interface system.
- Limitations on the system.
- Management software.

The success of the new calibration system upon completion is tested and implemented on the actual calibration process.

D. Software Design

Software design starts from the functional specifications of the system. From here every problems are solved using the software, while the hardware is not much different from the calibration system generally. The solution to the problem of preserving text on the calibrators function button is by creating virtual button in labVIEW that replicate function of the physical button on the calibrator. Any issues regarding action taken in calibration procedure can be checked on the log file that consist of commands sent to the calibrator, while notifications act as warning to the operator while configuring the wires and selecting the correct range at DMM. The issue of making calibration certificate is done automatically by software.

E. Implementation and Testing

First LabVIEW software must be able to send commands to the calibrator via serial communication lines from laptop to calibrators. Then, configuring the labVIEW software so that it can send ASCII characters between laptop and calibrator. Furthermore, more configurations are done so the program can send commands from the virtual buttons to calibrator as though the command come from the physical button on calibrator. Then a log file will record every stroke made in the virtual buttons. The dialog box for notification and confirmation appears after submitting set point to calibrator. Then, a callibration result is made from an excel worksheet template. Connecting calibration result with formulas that calculate the uncertainty both statistically from environment and also from equipment, thus it can be produced as a result of its calibration certificate. Each part of the program was made and tested individually and then combined to produce the overall program that meets the functional specifications. Once merged, the program is tested and involved in the calibration process.

F. LabVIEW front panel and block diagram

Programming in LabVIEW includes two parts, namely the Front Panel and Block Diagram. Front panel section on the calibration software created is used for interaction between the operator calibration with calibrator form of communication settings, date and time begin the calibration process, the value of the set point, the emphasis commands, start and stop the program. The block diagram contains the commands in the form of blocks of successive can be parallel or series, which is structured in order to produce certain functions, such as sending data serially, sent log command and notifications in loop condition.

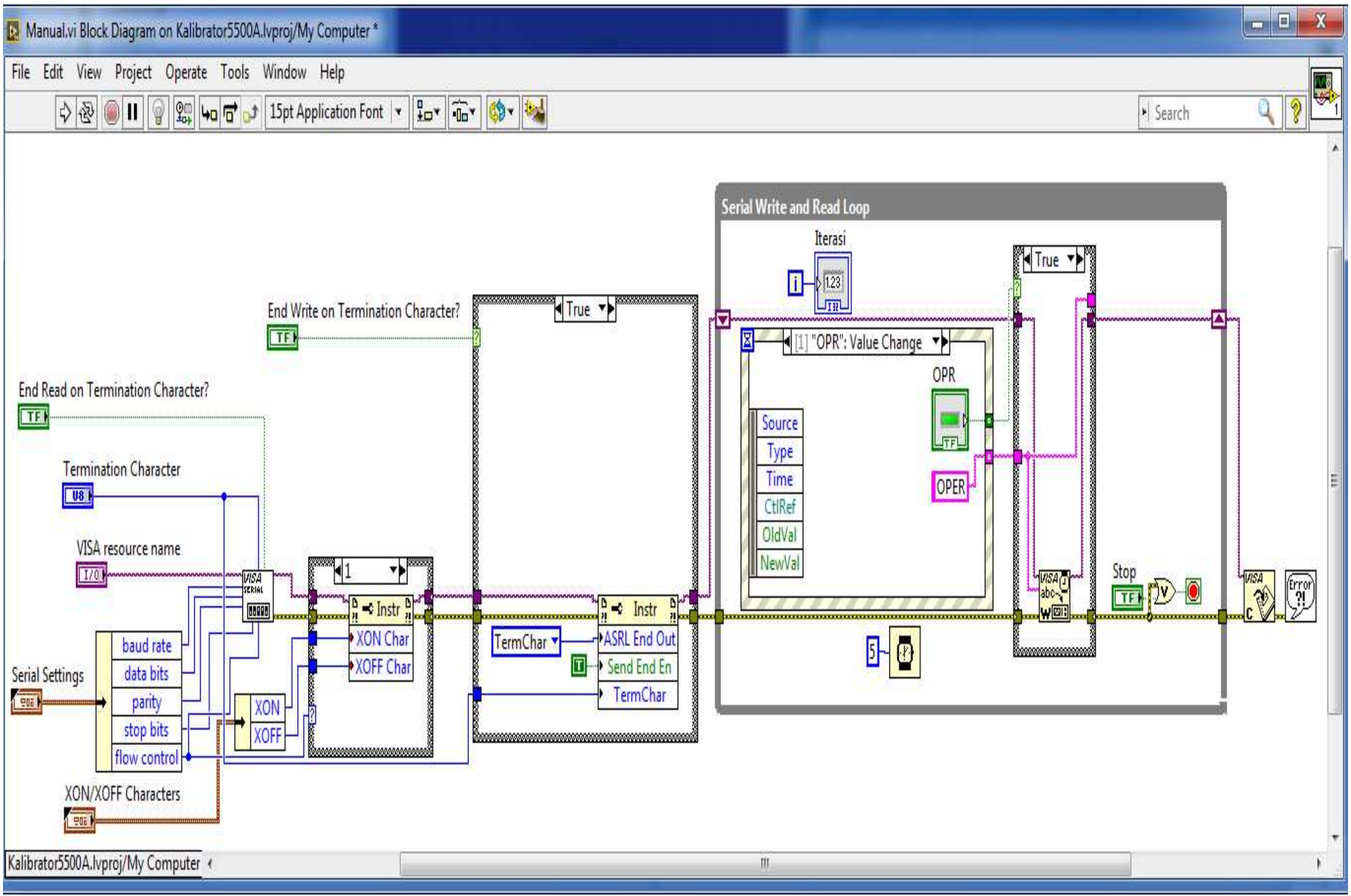

Figure 3. LabVIEW Block Diagram

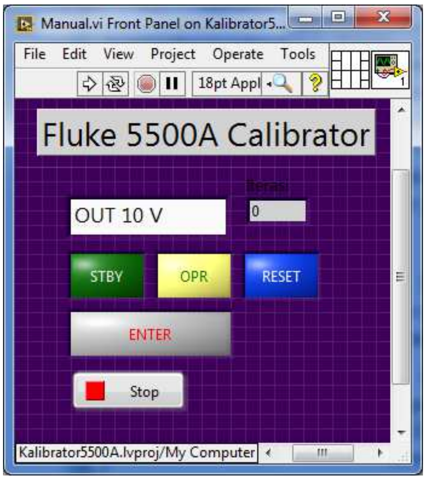

Figure 4. LabVIEW Front Panel

IV. RESULT AND VALIDATION

Virtual Button, and Text Box made in a LabVIEW program can replace the function of the buttons on the Fluke 5500A Multifunction Calibrator. Command log can show every button pressed in software. Dialog box appears suggesting range DMM and check for cabling appropriate range. By filing out the calibrator worksheet with data from experiment, we can get calibration certificate automatically.

V. CONCLUSION

By using virtual button instead of phisical buttons the text on the physical button will be preserved. Log command can be used to check the step-by-step of the procedure have been taken. Warning notifications will alert the operator wherever the operator forgets to change the callibration of the range of measuring instruments or forget to change the position of cables. Values of uncertainty in calibration certificates can be generated automatically from filling the calibration data of electrical quantities.

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