A Development of the Calibration Tool Applied on Analog I/O Modules for Safety-related Controller

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1. Introduction

The purpose of this paper is to develop the calibration tool for analog input/output(I/O) modules. Those modules are components in POSAFE-Q which is a programmable logic controller(PLC) that has been developed for the evaluation of safety-related.

Analog I/O modules in POSAFE-Q play a role to monitor the voltage, current, temperature of the object. In order to measure accurately, the module calibration is needed.

In this paper, performance improvement of analog I/O modules is presented by developing and applying the calibration tool for each channel in analog I/O modules. With this tool, the input signal to an analog input module and the output signal from an analog output module are able to be satisfied with a reference value of sensor type and an accuracy of all modules.

2. Analog I/O Module in POSAFE-Q PLC

POSAFE-Q, which meets international standards such as IEEE 7-4.32 and EPRI TR-107330, is a safety grade Q Class 1E PLC for application to the safety-related system in a nuclear power plant(NPP). It is applied to the comparative logic processor, simultaneous logic processor, and automatic cycle test processor in the reactor protection system. It is also used in group and logic controller for engineered safety feature (ESF).

Fig. 1. The Structure of POSAFE-Q.

The structure of POSAFE-Q is shown in Fig. 1. POSAFE-Q has input/output modules that handle various input/output signals in both analog (voltage, current and temperature) and digital (AC, DC and pulse) form. In particular, the loop back self-diagnosis for the input/output channels, the hot swap function, and the plug-in terminal blocks allow the user to service and maintain the system easily and conveniently even online. POSAFE-Q also has special function modules, including a redundant power supply module, a processor module and a bus extension module.

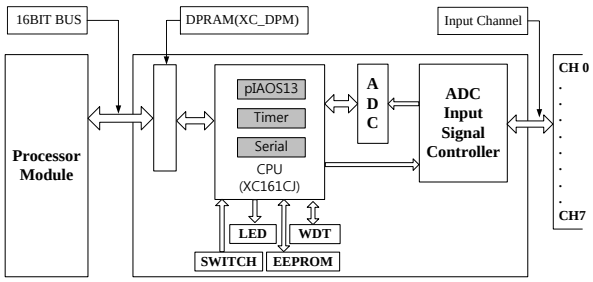

Fig. 2. Analog Input Module Sequence

There are five Analog I/O modules in POSAFE-Q, an analog voltage & current input module(NAD8-3Q)(Fig. 2), an analog voltage & current output module(NDA8-2Q), an analog RTD input module(NRD8-1Q), an analog TC input module(NTC8-1Q), an analog voltage input module(NADF-1Q).

These modules operate by receiving DC power 5V from power supply module. Analog Input modules send a data which is changed an input value from analog to digital signal to a processor module(NCPU-2Q). Also analog output module receives a digital data from a processor module and converts an output value into analog signal(voltage or current).

3. Development and Application of Calibration Tool

3.1 Calibration Sequence

The environmental difference where POSAFE-Q PLC is used occurs, and all elements included in analog I/O modules have a little different tolerance. So a calibration function is needed for analog I/O modules to measure an input value precisely.

The calibration sequence is as follows(Fig. 3).

- As can be seen in Fig. 4, setting the PC, modules, cables and a calibrator for using the calibration tool and application program is necessary.
- Using the calibrator, input the voltage/current value corresponding an offset and gain of each channel through the RS-232 communication.

- The input voltage/current is converted to digital(Hex) value going through with analog-to-digital converter(ADC). The converting data is saved in electrically erasable and programmable read only memory(EEPROM).
- If an analog signal inputs after calibration sequence is over, the calculation will be proceeded with a input data and a calibration data in a micro-controller unit(MCU). And calculated data is transmitted to the processor module.
- After that, the processor module keeps a watch on the transmitted data from analog I/O modules whether a problem comes up with it.

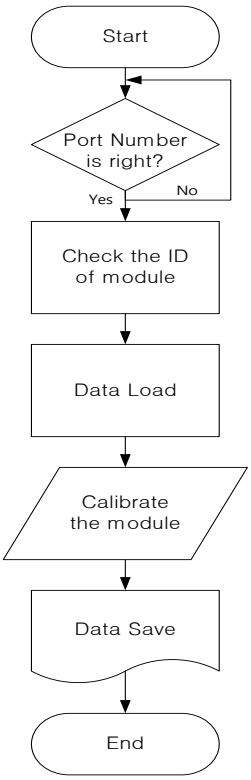

Fig. 3. The Calibration Sequence

Fig. 4. Equipment Setting for Using the Calibration Tool

3.2 Development and Application of Calibration Tool on Analog I/O Modules

The calibration tool is applicable in analog I/O module of up-to-date version as well as of existing version. Granted that the unique ID per each module is designated, connect to USB port of PC through the RS-232 communication and click the open button with the adapted port number. Then, the tool sets up the calibration mode in accordance with the type of module and version thereby reading the ID information.

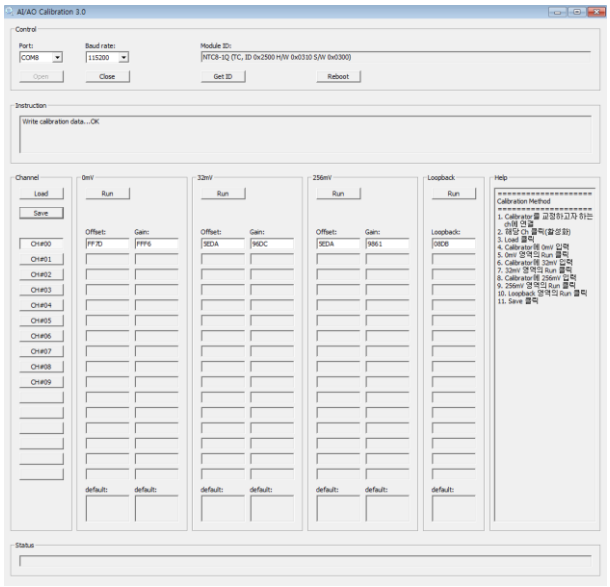

Fig. 5. The Form of Calibration Tool for NTC8-1Q of up-to-date version

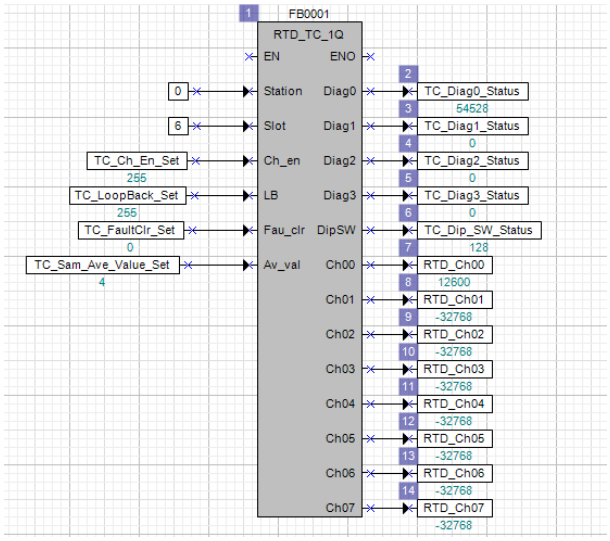

Fig. 6. Verification of the calibration result using an application program

It is assured that the input data is shown a valid value through POSAFE-Q Software Engineering Tool II(pSET-II) which supports an integrated environment

for develop an application program of POSAFE-Q. In Fig. 5 and 6, converted data, 12600(digit) value, is displayed on pSET-II when 51mV is inputted by calibrator on Ch.0 with setting the sensor type to K-type after calibrating NTC8-1Q module of up-to-date version.

4. Conclusions

With RS-232 communication, the manual calibration tool is developed for analog I/O modules of an existing and up-to-date version in POSAFE-Q PLC. As a result of applying this tool, the converted value is performant for a type of input sensor and an accuracy of analog I/O modules.

REFERENCES

[1] EPRI TR-107330, Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants.

[2] Jong-Kyun Kim, Dong-Hwa Yun, Sung-Jae Hwang, Myeong-Kyun Lee and Kwan-Woo Yoo, A Performance Improvement of Power Supply Module for Safety-related Controller, Transactions of the Korean Nuclear Society Autumn Meeting poster, 2015.