Simulation Approach for Safety Evaluation of Smart Transmitters in NPPs

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1. Introduction

Smart transmitters which are microprocessor-based device including software have been used for various industry. Recently Instrumentation and Control (I&C) equipment is applied to nuclear safety systems due to the improvement of digital technology. Even though the smart transmitters have the superior functionality to conventional transmitters, the insufficient and stringent regulatory guide allows the smart transmitters to be used for only monitoring on safety systems in Shin-Kori Unit 3 and 4 Nuclear Power Plants.

The necessity of preparing the regulatory guide or safety review plan for the smart transmitter is increased before using the smart transmitter for safety function. So the two year simulated approach study plan to extract some generic characteristics not limited typical smart transmitter was setup in Dec. 2014 to safety evaluation of safety grade smart transmitter. This paper addresses the considerations on safety evaluation and simulated approach for smart transmitter of the first year and middle of the second year study.

2. Analysis of hardware configuration

Disassembling some of the smart transmitters, review the manuals and comparison the components with some models of smart transmitter were done to know the typical hardware configuration and extracted the typical electric block diagram as like the figure 1. The output signal of the digitalized HART module is added to the analog output signal (current, A) using the phase shift key (PSK) modulation.

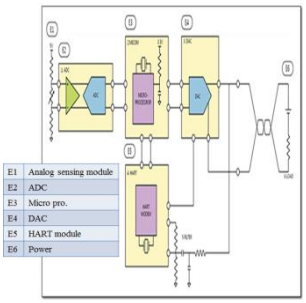

Figure 1. Typical electric block diagram of smart transmitter

3. Analysis of software configuration by HART protocol

The smart transmitters are provided with HART protocol interface to transmit the sensed process signal can be controlled the setup. The HART protocol is standard and simple protocol to connect the sensor so the HART protocol packet could be analyzed by transmitted HART command code and response message. The used and unused HART commands in the HART standard were analyzed by the response message. In addition, the software functional block and flow of smart transmitter are able to analyze the data packet using the backward tracing method with the HART/USB convertor.

4. Development of hart protocol based pc-smart transmitter test bed

The testbed for the analysis has to be developed to know the failure-effect to system as well as the smart transmitter itself. The test bed for PC-smart transmitter based HART protocol was development to analyze dynamic response of the smart transmitter. As shown in figure 2, the configuration of the test bed is simply consisted of several components. The special program run in PC was developed to interpret an input HART command packet and monitor the return packet in conjunction with the HART/USB convertor. Changes of input signal through the input device as like pressure were sensed by a smart transmitter and simultaneously be supplied to host PC for reference. The sensed analog data was converted to digital data and transmitted to HART/USB and host PC by HART protocol packet. The digital data by HART protocol and analog output signal by the DAQ board were compared by the PC program.

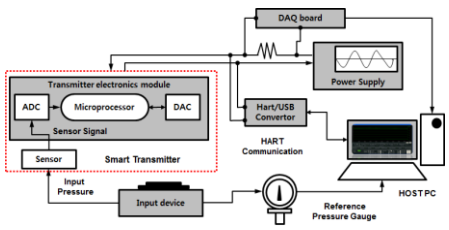

Figure 2. Conceptual design of the test bed for PC-smart transmitter

To check the test bed functional ability and smart transmitter behavior, some test input to the smart transmitter were introduced, and the transferred HART packet data and analog output were then compared with reference.

7. Development of simulation test case using the test bed

To establish the simulation test case, the review of the EPRI 1001468 report was done [1] [2]. The test cases were categorized into three categories on the basis of the following factors:

1) The originated function and performance of the transmitter
2) The unique function of the smart transmitter
3) The function with failure mode

The categorized simulation test cases and test procedures were developed and some test cases were done to extract some generic characteristics not limited typical smart transmitter as shown in table 1.

Table 1. Categorized simulation test case

Category	Test case
Originated function and performance	-Reference Accuracy -Ambient Temperature Effect -Static Pressure Effect & limit -Dynamic Performance Dead Time -Mounting Position Effect -Power Supply Effect & limit -Overpressure Effect -Minimum Span limit -Damping
Unique function of Smart Transmitter	-Behavior during Turn on Time -HART Minimum Communication Rate -Diagnostic function -etc.
Function with Failure mode	-H/W FMEA -S/W FMEA -Communication Error -etc.

8. Conclusions and future work

This paper showed the first year and the middle of the second year activity for the smart transmitter safety evaluation and simulated approach. The PC-smart transmitter test bed was setup and the test case for confirming the characteristics of the smart transmitter has been established. The simulations, setup of the Safety PLC platform-smart transmitter test bed and the system level concerns (potential software common cause failure, data network problem, etc.) prepared regulatory guide from the study results are plan in second year.

9. Acknowledgments

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[1] EPRI-1001468, “Generic Qualification of the Rosemount 3051N Pressure Transmitter: Summary of Activities and Results”, June 2001

[2] Hyung Tae Kim and Choong heui Jeong, “Considerations on Safety Evaluation of Safety grade Smart Transmitter in Nuclear Power Plants” Transactions of the Korean Nuclear Society Spring Meeting, Korea, May 7-8, 2015