The Calculation Process of Channel Uncertainty on Digital System for Integral Reactor

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1. Introduction

The Channel Uncertainty is very important factor on the Safety Analysis input data because the channel uncertainty is the input data for calculating the trip setpoint and verify the hardware accuracy. But, the instrumentation system is changed to digital system due to technical improvement in these days. So, there are occurred to problems when digital system adopt directly the calculation method of uncertainty on analog system. This paper shows that the difference of the calculation process between analog system and digital system. And also, it presents consideration for calculating the uncertainty on digital system and the calculation process of uncertainty on digital system for Integral Reactor.

2. The Calculation Process of Channel Uncertainty on Analog System.

The uncertainty is determined by the calculation process, which is described on reference [1]. The typical process of uncertainty calculation followes as the instrument research, uncertainty classification, obtain from manufacture manual & qualification report, research of the uncertainty source, operating mode research for each instrument, consider to environmental factor in normal and accident condition and finally calculate about channel uncertainty. To calculate the channel uncertainty, investigate the details of the allowable errors about the transmitter, rack, indicator, and environmental factor. The source of uncertainty are composed of reference accuracy, drift, ambient temperature effect, power supply effect, M&TE, seismic effect, radiation effect and so on. The considerations of environmental factor are reference accuracy, drift, M&TE, power supply effect, temperature effect, relative humidity effect, background radiation effect in normal condition. In accident condition, the environmental factors are based on uncertainties under normal condition and add on seismic effect, HELB and accident effect. The calculation method is used usually SRSS method. In addition to, it is decided by engineering judgment with conservatism because it is a right way that final setpoint become a conservative value.
The typical calculation model of channel uncertainty on analog system is shown in the figure 1.

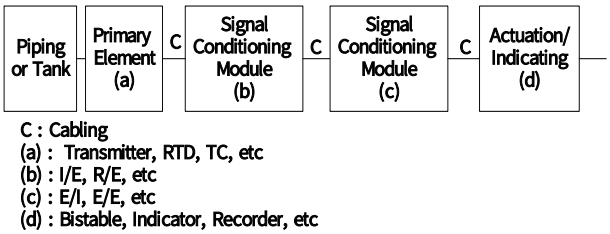

Figure 1. Typical calculation model of channel uncertainty on analog system

3. The Difference of Uncertainty Calculation between Analog System and Digital System.

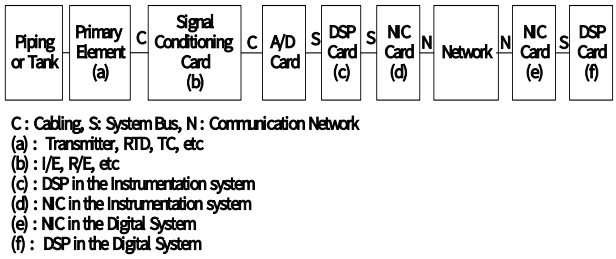

Figure 2. Typical calculation model of channel uncertainty on digital system

There are occurred to differences of uncertainty calculation between analog system and digital system due to system intrinsic characteristics. The calculation model of channel uncertainty on digital system is shown in the figure 2. This model also considers to apply the calculation process of uncertainty on analog system to uncertainty calculation on digital system. The uncertainty value is accumulated by sensor, signal conditioning modules on analog system. But it is a meaningless on digital system because the digital system executes the program to generate output signal that is independent of input signal error. That means the output signal of digital system portion is not related to the error range of the input signal. And the error of A/D converter is already calculated on analog system. The errors of A/D converter are consist of LSB error, linearity error, gain error, offset error, missing code, etc. [2]. This factor is already reflected on calculation for digital system uncertainty. As

there is no possibility to generate the error of digital wordlength after A/D conversion. The error of digital system is the recognition error when read the digital bit from NIC due to the error of input resistor and wordlength error in calculation process. The chance to generate recognition error and wordlength error is very little probibility and take consider to input range of the DSP. The digital system is important not only hardware function but also software function. So, the uncertainty value take considers the software uncertainty and hardware uncertainty at the same time. But the chance of software error is not considered in this paper because this paper assumed that software is fully verified through the process of the development, test and V&V procedure.

4. The Assumption and Calculation Process of Channel Uncertainty on Digital System.

The error of digital system is already described as the recognition error, wordlength error of the calculation process as described above. The recognition error and wordlength error mean malfunction of the digital system rather than error. So, the calculation process of uncertainty is applied to failure rate after A/D conversion. And it is the assumption that error magnification in the accident condition is calculated based on the change rate of the component failure rate in the environmental condition. The used standard for this process is the part stress in reference [3]. It is used for the temperature factor as the main factor. The uncertainty using calculation process based on failure rate is calculated by following assumptions, for example, on the Plant Protection System(PPS) of integral reactor.

1) The input signal for BSM in the PPS after A/D conversion in Instrumentation system.
2) The failure rate is based on the revised failure rate of NIC and DSP card during the component design.

The failure rate of component is shown in the table 1.

Condition	Component	Failure rate(E-06)
Normal	DSP	2.75
	NIC	1.76
Accident	DSP	9.54
	NIC	4.61

Table 1. The failure rate of component on digital system

3) The signal connection is ;
DSP of instrumentation system → NIC of the instrumentation system → Network → NIC of SCOPS → DSP of SCOPS → NIC of SCOPS → Network → NIC of PPS BSM → DSP of PPS BSM

4) The estimative error of network is 1E-12. The estimative failure rate of power supply is 6.78E-06.
5) When the accident condition is 50℃ on the board as ambient temperature, the failure rate is calculated. And the local equipment condition is GF(Ground, Fixed). The failure probability of channel is 3.56E-05 in normal condition and 6.74E-05 in accident condition. This calculation process from table 1 to result value is based on reference [4].

5. Conclusion

There are not the specified uncertainty calculation requirements about digital system. By intuition, the form of digital channel uncertainty is not same as % of FS in the analog system because digital system output is digital bit such as 0,1.
This paper presents the new calculation process of channel uncertainty using the failure rate on digital system. The process which is described this paper will be a kind of calculation process for channel uncertainty on digital system. In the future, the more details of digital system uncertainty will be presented and take consider the software uncertainty.

REFERENCES

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