Architecture of Process Instrumentation and Monitoring Systems in KNICS

C. K. Lee, S. Hur, D.H. KIM, I. S. Oh, J. C. Park
Korea Atomic Energy Research Institute
cklee1@kaeri.re.kr

1. Introduction

The function of the process instrumentation and monitoring systems in KNICS (Korea Nuclear Instrumentation and Control System) is to monitor the ex-core and in-core neutron flux, the NSSS integrity, the radiation, the inadequate core cooling and post accident monitoring variables, the containment integrity as well as the plant process variables.[1] The system architecture is categorized three as an analog-based mixed type, a digital-based mixed type and a smart type. The three categories above are itemized into seven and reviewed qualitatively on the licensing and reliability aspect and the maintenance and economy aspect.

2. System Architecture

2.1 Analog-based mixed type

The information on the analog indicators and recorders are essential for plant operation, and the digital displays and computers are the second information sources to MCR operators.

2.2 Digital-based mixed type

While the CRT and FPD are used as the main information sources for plant operation, the analog technology is still used for the signal transmission and interfaces between systems. For the analysis this type is subdivided into four such as an analog/digital conversion (ADC) separation type, an ADC integration type, the hybrid I and II types mixing the previous two types.[2]

2.3 Smart type

The communication network like a fieldbus is used for the transmission of sensor signals to other I&C systems. And the analog sensor signals are converted in the field level to the digital signals for use in digital devices and computers. This type is subdivided for the analysis into two, a multiplexing type and a smart transmitting type. The remote multiplexing type is a formal smart type, which is same as the ADC integration type except that the analog to digital conversion is executed in the field. The smart transmitting type can be regarded as a smart sensor.

The tables as following show the interfacing means between the process instrumentation and monitoring system and other systems.

	RPS	**CPC**	**QIAS-P&N**
Analog-based mixed type	Hardwired	hardwired	N/A
ADC separation type	Hardwired	Hardwired	Network
ADC integration type	Network	Network	Network
Hybrid (I) type	Hardwired	Hardwired	Network
Hybrid (II) type	Network	Network	Network
Multiplexing type	Network	Network	Network
Smart transmitting type	Network	Network	Network

	Control Sys.	**DPS**	**IPS**
Analog-based mixed type	Hardwired	Hardwired	Network
ADC separation type	Hardwired	Hardwired	Network
ADC integration type	Network	Network	Network
Hybrid (I) type	Network	Network	Network
Hybrid (II) type	Network	Network	Network
Multiplexing type	Network	Network	Network
Smart transmitting type	Network	Network	Network

3. Analysis of Architectures

The licensing and reliability aspect and the maintenance and economy aspect are reviewed qualitatively.

3.1 Licensing and Reliability

The concept of defense-in-depth in I&C, the defense against common mode failures, the equipment qualification method, the method for software verification and validation, etc. are reviewed for each architecture.

3.2 Maintainability and Economy

The qualitative analysis includes the testability, the degree of easy calibration, the number of cables and the number of cabinets inside electrical equipment room (EER) in the nuclear power plant.

4. Proposed Architecture of Process Instrumentation and Monitoring Systems

4.1 Design Principles[3]

- The interface systems with the process instrumentation and monitoring systems are the protection systems, the control systems, the diverse protection system, the alarm and indication system, and the information processing system.
- In case that the sensor signals are simultaneously used in several systems, the ADC is performed at one common device.
- The sensor signals for monitoring only, are analog to digital converted in the process instrumentation and monitoring systems.
- The signals each in the control systems and the protection systems are conditioned and converted in the associated system.
- The proven technology is used, and the use of digital technology in the harsh environments is avoided.
- The number of cabinets and cables within the EER is to be minimized.
- The design is in compliance with the related regulatory requirements.

4.2 Proposed Architecture

4.2.1 Realistic Architecture

The figure 1 is a proposed architecture of the process instrumentation and monitoring systems in the KNICS. The safety related measuring and monitoring signals are processed within the safety-grade auxiliary process cabinets (APC-S). The signals that protection systems and monitoring systems require simultaneously are processed in the protection systems, and then transmitted to the information processing systems. The ex-core neutron flux signals are transmitted to other systems via the signal splitter. The signals that are for monitoring only and not used in the control systems, are processed within the nonsafety-grade auxiliary process cabinets (APC-N), and then transmitted to the information processing systems.

4.2.2 Future Architecture

In this architecture, the smart transmitter is widely installed in the field and those are interconnected with the group field networks for communication between the EER equipment and the sensors. The field networks are directly connected to the system cabinets within the EER and it can reduce the number of cabinets and the length of cables. It therefore promotes the economic efficiency. Adding automatic test function to the devices improves the accuracy of measurement, which lessens the uncertainty of I&C system.

5. Conclusions

It is concluded that the results of analysis in the aspect of licensing and reliability is in conflict with them in the aspect of maintenance and economy. The smart type can be expected to provide the advantages in maintenance and economy. But the review shows that it still has some technical problems in the equipment qualification and this will violate the licensing requirements. However a realistic architecture is proposed through compromising, which can be expected not only to resolve the problems but also to maintain the advantages.

Acknowledgements

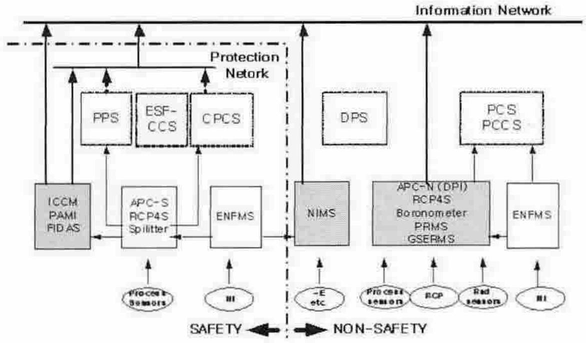
This study has been carried out under the Nuclear R&D Program by MOST in Korea.

References

[1] C.K. Lee et al, Functional descriptions of I&C Systems in the nuclear power plant, KAERI/TR-2459/2003, KAERI, 2003.

[2] S. Hur et al, "Design concepts of KNICS", The 3rd KNS-KIEE Joint Workshop on I&C Technology, Nov., 2003

[3] S. Hur et al, Analyses of measurement technology in SMART, KAERI/TR-1028/98, KAERI, 1998.



Notes (1) Rectangular boxes and circles with solid lines are scope of Instrumentation & monitoring systems.
(2) Gray boxes represent digital based systems, while white boxes are analog based systems.
(3) Thin lines represent the analog point-to-point connection, while thick lines are the digital communication lines.

Fig. 1. Architecture of the process instrumentation and monitoring systems in KNICS