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A Mock-up Development for Verifying Digital Upgrades of I&C Systems in Korean Standard Nuclear Power Plants

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1. Introduction

A verification mock-up is being developed for digital upgrades of I&C systems employed in KSNP type plants. The purpose of the mock-up development is to verify the operation under an environment where analog systems and digital systems will interact with each other. The mock-up includes a DCS and PLC as digital systems, and indicators, hand switches, and M/A stations as analog systems. The test scenario for verification involves the control of steam generator levels.

It is anticipated that a hybrid type operation involving old analog systems and new digital systems may be employed while upgrades are progressing. The main reason for this is that upgrades are mainly conducted during the several overhauls. Therefore, before completion of the full scope of upgrades, there may be some operational phases. After each completion of each phase, the plant operation should be performed with old analog systems and new digital systems. The mock-up that we are developing is for verifying and testing the interaction or the compatibility of the operation between analog systems and digital systems.

2. Mock-up structure

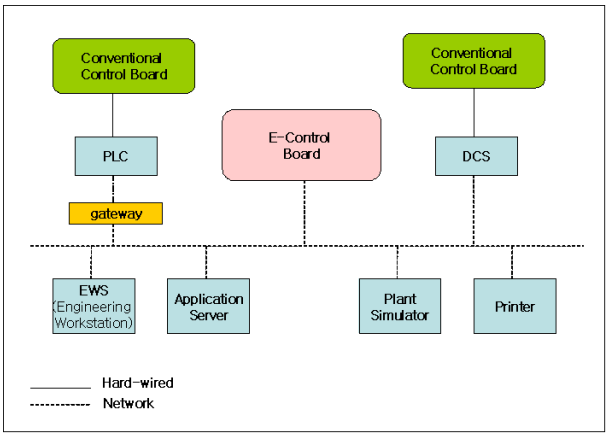

Fig. 1. Mock-up Structure

The mock-up consists of a conventional control board, an e-control board, a PLC, a DCS and others, as illustrated in fig.1. The conventional control board is hard-wired into the PLC and DCS, respectively, and other components in the mock-up are linked by means of network communication.

2.1. Conventional Control Board (CCB)

The CCB is composed of indicators, legendary hand switches, and M/A stations for PID control. The size of the CCB is made much smaller than original plant's CCB. The CCB we are making is for testing partial functions of plant operations such as control of steam generator levels. The CCB is hard-wired to the DCS and PLC. Control signals from the CCB are sent to the DCS or PLC, and finally arrive at the plant simulator. Feedback from the plant simulator is sent to all components in the mock-up.

2.2. E-Control Board (ECB)

The ECB means an electronic control board that has controllers and indicators on the monitor or LDP (Large Display Panel) linked to computers instead of physical equipment such as switches and indicators to control valves or pumps.

The ECB includes an LDP and a workstation for operators. The workstation consists of 3 displays and 3 computers on the table. The LDP is a 48 ″ LCD display and shows operating information including dynamic data. The ECB has monitoring functions that watch the health status of alarms, the PLC, the DCS, and network communications. The ECB can also generate control signals for controlling instruments.

2.3. PLC (Programmable Logic Controller)

The PLC sends signals to indicators in the CCB or receives signals from controllers in the CCB and in the ECB. The PLC controls systems related to safety such as ESFAS. The actuation signals from the PLC are transferred to the plant simulator by means of Ethernet in the mock-up. The PLC is connected with Ethernet through a gateway for maintaining the independence of the network protocol.

2.4. DCS (Distributed Control System)

Like the PLC, the DCS also sends signals to indicators in the CCB or receives signals from controllers in the CCB and in the ECB. Because it should receive input signals from the CCB and ECB, the DCS includes control logics to process the priority of the signals. The DCS controls non-safety systems such as the steam generator level control system and is linked to other components with Ethernet. The actuation

signals from the DCS are also transferred to the plant simulator.

2.5. Other Components

EWS (Engineering Workstation): The EWS plays the role of inserting control logics to process the priority of the PLC and DCS. The EWS can add/delete points, manage the database, and update automatically information displays in ECB.

Application Server (AS): AS performs calculation of derivative variables and stores process variables. AS provides the data recorded on the database to other components when requested. Also, AS carries out alarm processing and SOE (Sequence of Event).

Plant Simulator: This simulator is for Ulchin (UCN) units 3&4. The control signals from the PLC and DCS arrive at the simulator and the resulting information processed by the simulator is sent to all components.

3. Test scenario

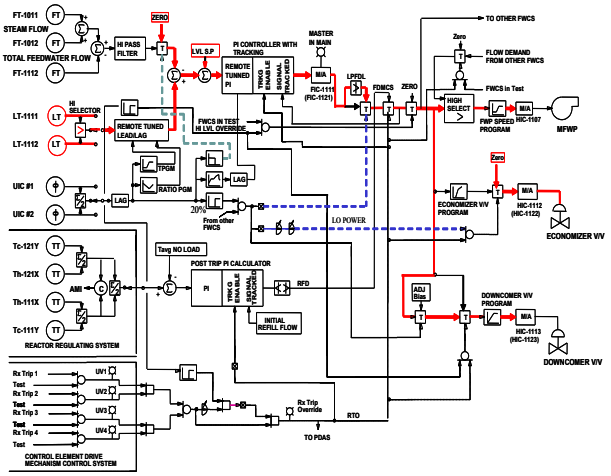

Fig. 2. S/G level control logic diagram

The mock-up uses the steam generator level control system as a test scenario. Fig.2 shows a control loop diagram for developing the scenario. Switches, indicators and M/A stations in the CCB are used for performing steam generator level control. The functions of valves and pumps in fig.2 are implemented by the simulator. A detailed version of the test scenario has not been determined but the test scenario is sufficient for the purpose of the mock-up development.

4. Conclusions

Generally, the upgrade of I&C systems in nuclear power plants is a long-term project. In the case where the upgrade entails several phases, a hybrid type operation involving interaction between old systems and new systems may be inevitable. The purpose of the mock-up currently under development is verification of this type of plant operation. After developing this mock-up, several types of test scenarios will be applied to the mock-up. The results obtained from performing the scenarios will provide informative data for upgrading I&C systems with new digital equipment in nuclear power plants.

REFERENCES

[1] Y. S. JUNG, C. H. SUNG, The Development Plan of the Mock-up for Upgrading I&C Systems in KSNP, KHNP Report, June 2008.