Design of Alarm and Indication System for SMART

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1. Introduction

The SMART control room is a digital control room based on computer-based technologies. While existing analog-based control rooms include a thousand of alarm tiles, indicators, and controllers, the SMART control room is a compact control room with the adoption of Visual Display Unit (VDU)-based monitoring and control equipment. The SMART Alarm and Indication System (AIS) adopts the computer-based alarm processing and VDU-based indication technologies so that the operators are able to focus on the important alarms by suppressing the minor alarms. The AIS preforms following functions as the digital technology-based monitoring system which processes and displays the alarm and indication information.

- The AIS provide (1) the system or process abnormalities, (2) the priority and characteristics of the abnormality, (3) a guideline as to the initial response required by the operators, and (4) the function to identify whether the operators have resolved the abnormality in a proper time.
- The AIS express the process status on the VDU-based alarm tile and alarm list and notify abnormal process status to the operator using auditory device In addition, the alarms perform VDU-based control functions for silence, acknowledgement, reset, and test.
- The alarm function applies enhanced alarm processing algorithms to ensure the nuisance alarm avoidance, suppression of minor alarms when redundant alarms are triggered simultaneously, and prioritization according to the importance of triggered alarms to provide reliable alarm information to the operators.
- The indication function provides the information of Bypassed and Inoperable Status Indication (BISI) and the indication of parameters of Post Accident Monitoring (PAM) type A, B, C, D and E variables specified in References [1] and [2] and important operating parameters. It also provides indication information needed for the safety shutdown in the Main Control Room (MCR) and Remote Shutdown Room (RSR).

In this paper, system description for SMART AIS is introduced in detail to understand its design feature, system configuration, and system functions.

2. Design Features

The alarms and indications of the AIS are designed to be Nuclear Non-Safety, Non-Class 1E, and seismic category I. The availability of the alarms and indications of the AIS is 99% under all power conditions and transients of the power plant.

The AIS is independently operated by two AIS servers to secure the redundancy. Although one of the AIS servers failed, the other remaining AIS server is able to perform its function. Each of the redundant systems monitors the operation of the other to alert either side fail. The AIS secures independence through physical separation, electrical isolation, and communication isolation to satisfy References [3] and [4].

The AIS and Information Processing System (IPS) independently calculate and display the same process parameters and alarms by using different hardware and software in order to satisfy the diversity function of the alarm.

The AIS has the continuous self-diagnostic capability during operation for integrity testing of hardware. Self-diagnostic is performed periodically to identify the system failures in early stage. The failure detection in AIS is provided to the operators in the Main Monitoring and Control Workstation (MMCW).

The AIS is designed to endure electrical surges, electromagnetic interference (EMI), electrostatic discharge (ESD) and radio frequency interference (RFI). In addition, the AIS hardware is designed to satisfy the environmental requirements to perform its function under normal operating conditions and Anticipated Operational Occurrences (AOO) conditions. Moreover, equipment and devices are shielded and isolated to prevent electronic interference. The AIS software is classified as a software class that is important to safety.

3. System Configuration

The system configuration of the AIS are shown in Figure 1. The AIS receives digital signals AIS Interface and Test Processor (ITP), AIS Maintenance and Test Panel (MTP), and Hardwired connection from both safety and non-safety systems which interface with the AIS. These signals are continuously transmitted to the AIS at rates. The AIS processor performs input data processing, determination of representative value, and signal validation on input signals. Then, these data from

the safety and non-safety system are broadcasted on the AIS network.

The AIS servers capture the data from the AIS network and update the AIS process database. There are two AIS servers to perform alarm and indication processing: Primary and Secondary servers. Primary AIS server is the main server in which its functions are performed, while secondary AIS server is the backup server. Even though both primary and secondary AIS server process same inputs, output from primary AIS server is dominantly transmitted to corresponding display processor and interface system in case of normal state. Only when the failure of primary AIS server is detected, output from primary AIS server is cut off by fail over function and that from secondary AIS server is transmitted to display processor and interface system.

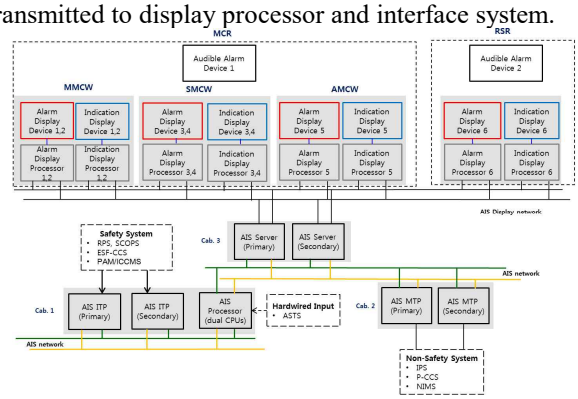

Fig. 1. System configuration of AIS.

The primary and secondary AIS servers that satisfy the independence requirement are located in the I&C equipment room. These AIS servers display the alarms in alarm display device located in MMCW, Safe Shutdown Monitoring and Control Workstation (SMCW), Auxiliary Monitoring and Control Workstation (AMCW) and Remote Shutdown Panel (RSP) and also display the indication information in indication display device located in MMCW, SMCW, AMCW and RSP after performing alarm and indication processing.

4. System Functions

4.1 Alarm Functions

4.1.1 Filtering of Nuisance Alarms by Time Delay

The alarm function filters the number of nuisance alarms activated by chattering or instantaneous violation of setpoints at the time of component actuation. For example, a time delay is applied to eliminate nuisance alarms in the case of 1) an instantaneous alarm being activated when a pump or large capacity valve does not function properly after it is actuated or 2) an alarm activated by an instantaneous process transient state.

4.1.2 Filtering of Nuisance Alarms by application of a dead band

The dead band is applied to filter nuisance alarms by preventing the generation of chattering when the measured values are close to the alarm setpoints.

4.1.3 Alarms suppression by multiple setpoints

Alarm suppression in multi-setpoints is used to suppress the alarms in less importance among the multi-setpoints of identical process parameters. For example, once the Equipment Drain Tank (EDT) low-low level alarm is activated, EDT low level alarm becomes less important and thus is suppressed. Then, if the EDT low-low level alarm is cleared, the suppressed EDT low level alarm shall be activated.

4.1.4 Alarms suppression by prioritization

The alarm function suppresses the priority 3 alarms in static prioritization and avoids application of dynamic prioritization. Suppression of priority 3 alarms is applied only to the alarm display of the AIS. The prioritization of alarms provides distinguishable information to operators and is a useful means of effectively concentrating operator attention.

4.1.5 Alarms suppression by separation of status alarm

Status indications, messages that indicate the status of plant systems but are not intended to alert the operator to the need to take action, generally are not presented via the alarm display because they increase the demands of operators for reading and evaluating alarm system messages. The alarm function suppresses the display of general status, except for safety function-related status alarms and safety function-related failure alarms.

4.2 Indication Functions

The indication function of SMART AIS provides the information if protective action of some part of protection system has been bypassed or deliberately rendered inoperable for any purpose. In addition, indication function also provides main operating parameters of plant including PAM type A, B, C, D and E variables that are available against Common Cause Failures (CCFs) of PAM variable indication in PAM/ICCMS and IPS.

The indication function displays the indication parameters needed for safe shutdown, and if information display of the IPS is not available, the indication of AIS provides information instead of the IPS. And indication displays Control Rod Assembly (CRA) position information, CRA position sensor information and CRA bottom limit contact point information.

5. Conclusions

The AIS performs no direct plant safety function since it strictly monitors and displays data. However, due to its importance, the AIS is designed in accordance with a quality program to assure product quality commensurate with the intended use of the equipment.

REFERENCES

[1] USNRC Reg. Guide 1.97, Rev.04 “Criteria for Accident Monitoring Instrumentation for Nuclear Power Plant”, 2006. 6
[2] KEPIC ENB 6330 (IEEE Std 497-2002), “Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations”, 2005
[3] USNRC Reg. Guide 1.75, “Criteria for Independence of Electrical Safety Systems”, 2005. 2
[4] KEPIC ENB 2000 (IEEE Std 384), “Independence of Class IE Equipment and Circuits”, 2005