Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

The Software Testing of PPS for Shin-Ulchin Nuclear Power Plant Units 1 and 2

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1. Introduction

The testing of software (S/W) is the process of analyzing a software item to detect the differences between existing and required conditions to evaluate the features of the software items. This paper introduces the S/W testing of Plant Protection System (PPS), as a safety system which actuate Reactor Trip (RT) and Engineered Safety Features (ESF) for Shin-Ulchin Nuclear Power Plant Units 1 and 2 (SUN 1&2).

2. The Details and Results

In this section, the S/W classes and test levels of PPS testing for SUN 1&2 are described and testing methods for test levels are added.

2.1 PPS S/W

The S/W for PPS consists of multiple units; Bistable Processor (BP), Coincidence Processor (CP), Interface and Test Processor (ITP) and Operators Module / Maintenance and Test Panel (OM/MTP). Among these units, BP S/W and CP S/W shall be classified as the 'Protection' class, while ITP and OM/MTP as the 'Important to Safety (ITS)' class.

2.2 Test beds for testing

The test beds for PPS S/W Testing for SUN 1&2 can be classified to the PPS Development Facility (DF) and a deliverable four channel PPS. The testing for the PPS DF that S/W designer shall perform is described in this paper, and the testing for the deliverable four channel PPS is not described because the Component Designer should perform the related test. Additionally, the I/O simulator for the S/W testing is required to provide inputs and read outputs from the DF via Safety Data Link (SDL). The figure 1 shows the connection of DF which is identical to Channel D of the deliverable PPS and I/O simulator.

2.3 Test levels

Test levels of the testing for PPS can be classified as follows;

Module Test
Unit Test
One Channel Software Test (OCST)

Each test level is progressed with test procedures specifying the set of inputs, execution conditions, and expected results. The test result report is documented for each level, and discrepancies and/or deficiencies, if any, identified as a result of testing are documented also. After these discrepancies are resolved, the re-test (regression test) is performed according to the related procedure.

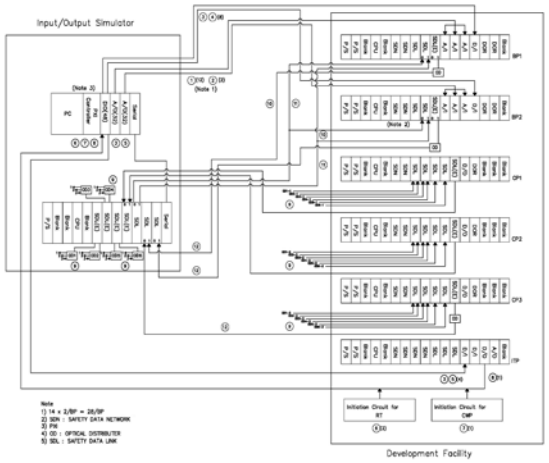

Fig. 1. Connection of DF and I/O simulator

2.4 Module test

The purpose of module testing is to validate each module consisting of custom Function Block (FB) elements against the requirements specified for that module.

The module test is accomplished only to the Protection class S/W, that is BP and CP, because the ITS class need not to perform the module test.

2.4.1 Functional test

For the module testing, test cases are developed to exercise applicable combinations of the test item inputs to determine if the functional requirements are met, and based on the requirements of software design description and/or based on inputs calculated to exercise the branches in the PPS C code. This testing is performed by using an engineering station with the DF which is identical to Channel D of the deliverable PPS, and I/O simulator. These test cases are also used to verify that all necessary branches are executed using an automated test coverage tool.

2.4.2 Coverage test

Code coverage test is to measure the coverage of any code and to present the amount tested as the percentage. Achieving 100% decision coverage (DC) means that the whole conditional expressions in all decision points are tested for the all possible outcomes: True and False. When the coverage is not 100%, more test cases are designed to increase the coverage in order to test missing parts.

The QMTC of SCADE Suite was used to perform code coverage testing of modules composed of custom FB elements for the PPS S/W for SUN 1&2. The test result was made as a report form like figure 2 for each module.

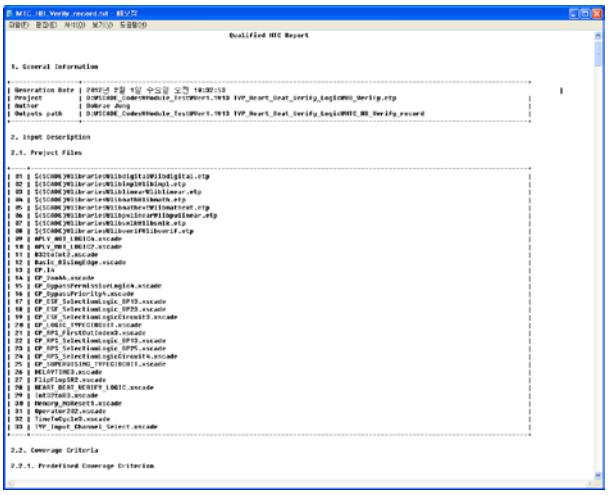

Fig. 2. Coverage test report

2.5 Unit test

The unit testing is performed for a complete software program consisting of multiple modules of PPS; BP, CP, ITP and OM/MTP. Test cases for unit testing are developed to exercise applicable combinations of the test items inputs to determine if the functional requirements are met, and based on the functional and performance requirements of the software requirements specification, and/or the system requirements specification. This testing is also performed using an engineering station with the DF and I/O simulator.

2.6 OCST

In one channel software testing, the various interface and system functions among multiple units (BP, CP, ITP, and OM/MTP) of PPS are tested according to requirements specified in the system requirements specifications for their units. During this test, the I/O simulator is used for generating all analog and digital inputs and incoming SDL links. The test procedure for the OCST includes test cases for the following system modes.

Normal Mode
Test Mode
Failure Mode

3. Conclusions

The testing of S/W is the essential process in order to measure and improve the S/W quality, and the S/W testing of PPS for SUN 1&2 was successfully accomplished for the good quality of the S/W in compliance with the related Code and Standards.

Furthermore, the development process of PPS S/W for SUN 1&2 was performed by using software development tool applying the Integrated Software Develop Environment (ISODE), and the testing was accomplished using the automated test tool. The use of these qualified tools will lead to reduce development time and verification time of the S/W and human error, and to improve the S/W quality.

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