PPS Automatic Logic Test for SUN 1&2

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1. Introduction

Periodic testing of the Plant Protection System (PPS) can be performed during power operation or shutdown of the plant. The tests consist of Automatic Test and Manual Test. The two tests complement each other and provide complete testing of the PPS. These test function meets the criteria of Reg. Guide 1.22 [1], IEEE Std. 338 [2] and IEEE Std. 603 [3].

2. Methods and Results

2.1 Testing Concept

The Automatic Logic Test and Manual Test are designed not to interfere with safety functions and can be initiated during plant operation as well as plant shut down. Automatic Logic Test and Manual Test are overlapped to demonstrate complete verification of the safety functions. The test input signals will be injected just before the monitoring point used for a previous test. Automatic Logic Test is applied from analog input module to the contact of initiation circuits for RPS function and the output of initiation logic in CP for ESFAS function. Automatic Logic Test is initiated manually.
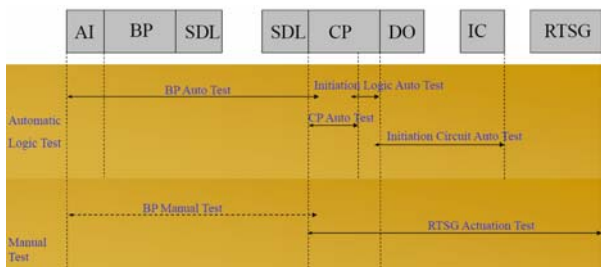

Fig. 1. PPS Testing Overlap

2.2 Automatic Logic Test

Automatic Logic Test consists of automatic bistable logic test, coincidence logic test, initiation logic test and initiation circuit test.

Bistable logic test injects test input signals into the test channel of analog input module in BP (Bistable Processor) rack and confirms operation of A/D converter, BP setpoint comparator, BP logic functions and signal path to the CP. The test is initiated via MTP display after bypassing the channel output per administrative procedure for all parameters in BP to be tested. As shown in Figure 2, the ITP applies a test signal value that is 0.1% less for a decreasing trip function (0.1% more for an increasing trip function) than the trip setpoint via hardwired cable. Injected test value is determined considering the uncertainty of analog input module.

This condition will force the pretrip and trip algorithms to produce pretrip and trip states. For BP test initiation, the test inputs will be injected so that it can only drive the bistable function in the direction of pretrip and trip condition in consecutive order for all parameters. A monitoring point is provided at the input of the CP which can be observed by ITP for the BP logic test. Removal of the channel bypass can be confirmed when CP Automatic Test is performed.
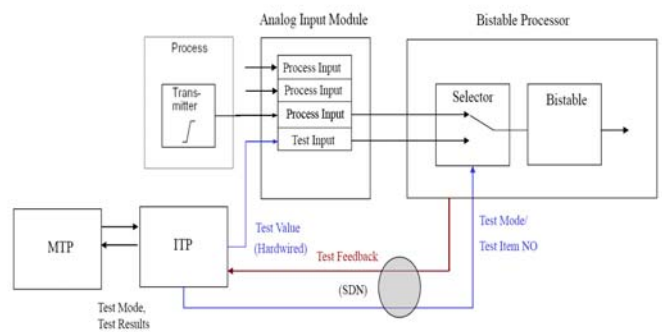

Fig. 2. Bistable Logic Test

Once coincidence logic test, initiation logic test and initiation circuit test are initiated for each CP on MTP display, those tests will be performed in consecutive order.
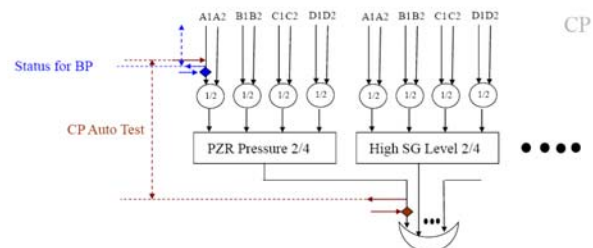

Fig. 3. Coincidence Logic Test

Coincidence logic in CP will use both bistable signals in a channel, which are arranged in a 1-out-of-2 logic prior to the 2-out-of-4 logic. Test values are injected into the coincidence logic (1-out-of-2 and 2-out-of-4) in order for coincidence logic test. A test signal is injected into the step prior to the monitoring point for the BP test in the CP.

The ITP performs active testing, as shown in Figure 3, of coincidence functions within its channel. The ITP generates all valid trip combinations per coincidence. Valid test trip combinations are AB, AC, AD, BC, BC and CD causing trip output. These test combinations confirm the operability of coincidence logic and can minimize testing time.

A blocking signal is requested by the ITP and inserted by the CP prior to commencement of this test. The blocking signals are mutually exclusive such that only one CP at a time can accept a blocking signal. Upon completion of coincidence logic test, the blocking signal will be automatically removed. Removal of the blocking signal is confirmed when initiation logic test is performed.

Initiation logic combines the outputs of coincidence logic with logical "OR" for each RPS and ESFAS function. Initiation logic test is initiated automatically after the completion of coincidence logic test. During this test, the output of initiation logic is blocked. A test signal is injected into the CP just before the monitoring point provided for coincidence test.
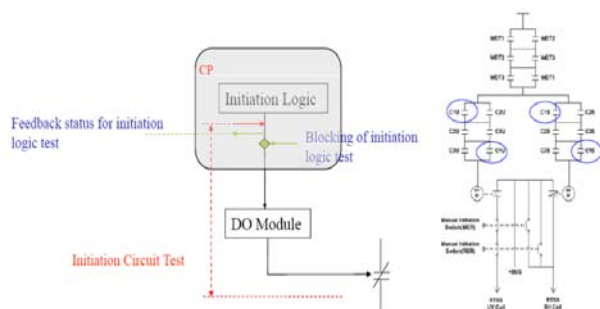

Fig. 4. Initiation Logic Test

Initiation circuit test is initiated automatically after the completion of initiation logic test. A test signal is injected into the CP just before the monitoring point provided for initiation logic test. Initiation circuit test opens the contacts of initiation circuit. The ITP compares this with expected results and Automatic logic test is completed.

2.3 Recommended Periodic Surveillance Test

The majority of Surveillance Requirements in Technical Specification can be met by PPS Automatic

Test. Manual Test will be performed for the parts which were not covered by Automatic Test. Manual Test includes rate limited variable setpoint test, manual reset variable setpoint, manual actuation test and manual actuation switch test.

Test Items	UCN 5&6DPPS	PPS Surveillance Testing Applying Automatic Logic Test for SUN1&2
Bistable Logic Test (Including Manual Test)	205 minutes/Channel	147 minutes/Channel (Auto Logic Test: 27 minutes, Manual Test: 120 minutes)
Coincidence Logic Test (Including Manual Test)	370 minutes/Channel	96 minutes/Channel (Auto Logic Test: 96 minutes, Manual Test: N/A)
Manual Actuation Test	40 minutes/Channel	40 minutes/Channel
Total Testing Time for Periodic Test	615 minute/Channel (41 hours)	283 minutes/Channel 1,132 minutes for four channels (About 19 hours)

Table 1. Expected Testing Time for Periodic Test

Table 1 shows expected testing time for periodic test compared with that of UCN 5&6 DPPS.

3. Conclusions

PPS Automatic Test covers the hardware tests from Analog Input Module to the contacts of initiation circuits for the RPS function and to the output of initiation logic in the CP for the ESFAS function as well as software logic tests in the BP and the CP. The majority of Surveillance Requirements in Technical Specification can be met by PPS Automatic Test. Manual Test will be performed for the parts which were not covered by Automatic Test. The Surveillance Test applying Automatic Logic Test will minimize the operator burden as well as reduce testing time because Automatic Logic Test does not require frequent manual actions.

REFERENCES

[1] USNRC Reg. Guide 1.22, "Periodic Testing of Protection System Actuation Functions (Safety Guide 22)", Rev.00, February 1972.
[2] IEEE338-1987, "IEEE Standard Criteria for the Periodic Testing of Nuclear Power Generating Station Safety Systems".
[3] IEEE603-1998, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations".