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Verification Results of Safety-grade Optical Modem for Core Protection Calculator (CPC) in Korea Standard Nuclear Power Plant (KSNP)

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1. Introduction

This paper describes the test environment, test components and items, a traceability analysis, and system tests as a result of system verification and validation based on Software Requirement Specifications (SRS) for a safety-grade optical modem of a Core Protection Calculator (CPC) in a Korea Standard Nuclear Power Plant (KSNP), and Software Design Specifications (SDS) for a safety-grade optical modem of a CPC in a KSNP.

2. Methods and Results

In this section, the test methods and results are described. Above all, in the case of embedded systems, it is important whether system test results on the host environment are satisfied with the target board have not been performed. Functional tests, performance tests, event tests and scenario tests for safety-grade optical modem. Coverage of the range value, boundary value, and equivalent value were also measured.

2.1 Verification test environment

Application firmware was developed under GNU /Linux Ubuntu 11.10 of AMD64 environments. To build a system test with the host environment, firmware was ported in the target board of an optical modem using USBISP. To measure the embedded software of a safety-grade optical modem, an AVR USBISP V3.0 and avrdude 5.10 utility were used as shown in Figure 1.

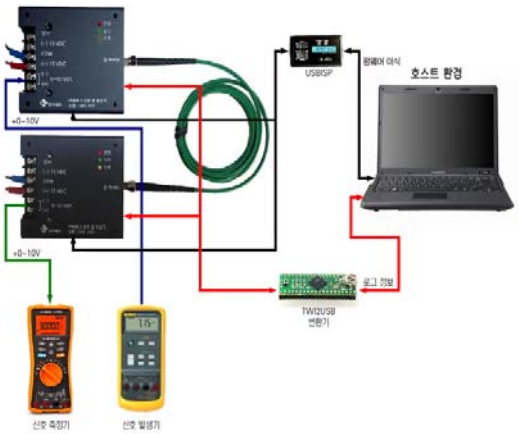

Figure 1 Verification test environments of safety-grade optical modem

2.2 Test components and test items

Test components and items are as shown in Table 1.

Table 1 Test components and items for safety-grade optical modem of CPC

NO	Category	Test Components	Test Items
1.	Functional test	Initial setup	Variable of Hardware and Software - Optical Modem - LED - Timer - WDT etc.
		Optical signal translation	Voltage-Optical signal
			Optical signal - Voltage
		Data communication	Sending Only (Unidirectional)
			Receiving Only (Unidirectional)
		Status indication	POWER
			TX
			RX
			FAULT
		Setup	Gain, Offset
		Protocol	Protocol Analysis (Packet) CRC8
2.	Performance test	Accuracy	Accuracy ±0.05%
		Communication speed	- 4ms - 57600bps
3.	Event test	Fault injection	Power Fail, Abnormal State - Signal short - CRC - Timeout - Frame Error - Buffer overflow
4.	Scenario test	Continuous operation test	About three month burn-in test

In particular, the performance requirements listed above should be satisfied for the purchase order requirements of Korea Hydro and Nuclear Power Co. Ltd (KHNP) as follows.
- Response time should be less than 4ms.
- Full Range Accuracy within ± 0.05% or better should be satisfied.
- Unidirectional buffering and deterministic communication should be satisfied.

2.3 Test results

The initialization setup, optical signal conversion capabilities, communication capabilities and accuracy, display status indication, parameter setup, and protocol were set up in the functional tests.

The Performance tests were carried out as follows:
- Response time : 4ms

- Accuracy of ± 0.05%
- 57600bps transfer rate
- Communication time between ADC (Analog Digital Converter) and MCU (Main Control Unit)
- Communication time between MCU and DAC (Digital to Analog Converter)
- Optical modem transmitter Offset
-Gain adjustment between MCU and DAC
- TWI (Two Wire Interface) communication as an optical transmitter
- TWI communication as an optical receiver
- Communication between MCU of optical modem sender and external clock
- Communication between MCU of optical modem receiver and external clock
- Status of communication tracking between MCU of optical modem receiver and optical receiver's component

The verification results of the performance test for a 57600 bps transfer rate and response time (4ms) among several performance tests are shown in Figure 2 and Figure 3, respectively.

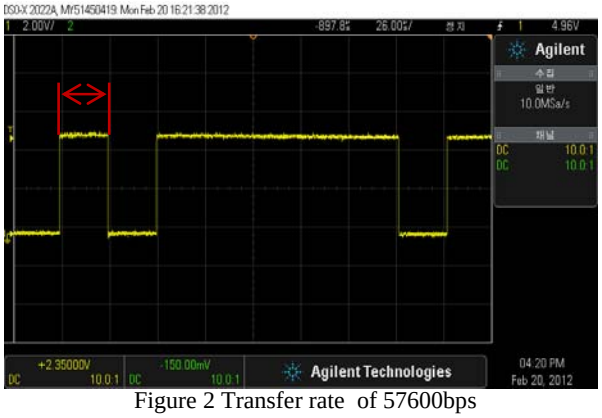

Figure 2 Transfer rate of 57600bps

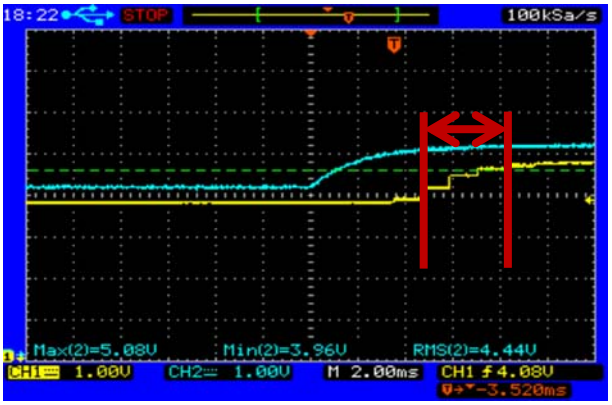

Figure 3. 4ms Response time

Event tests were performed based on the error injection; in particular, signal short-circuit among several error injections was tested successfully.

Signal source of making a triangular wave under the verification test oracle equipment was used as shown in Figure 4. A scenario based burn-in test was carried out during three months and two weeks continuously.

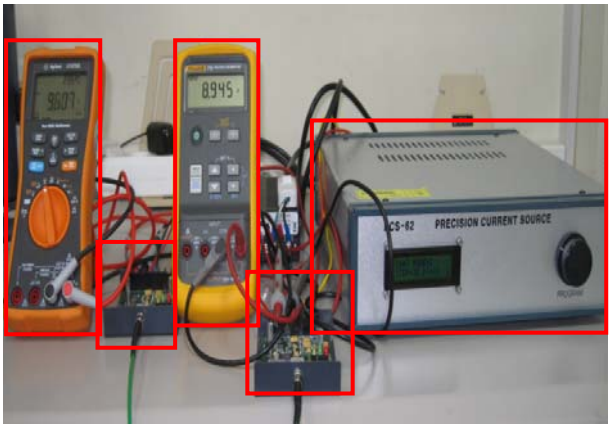

Figure 4 Continuous tests by triangular wave

3. Conclusions

All tests were performed according to the test plan and test procedures. Functional testing, performance testing, event testing, and scenario based testing for a safety-grade optical modem of a Core Protection Calculator in a Korea Standard Nuclear Power Plant as a thirty-party verifier were successfully performed.

We confirmed that the coverage criteria for a safety-grade optical modem of a Core Protection Calculator is satisfactory using a traceability analysis matrix between high-level requirements and lower-level system test case data set.

REFERENCES

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