Test Results of a Network Switch Device for SMART MMIS

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1. Introduction

SMART MMIS has been designed using fully digitalized systems. Non-safety instrumentation and control (I&C) systems are designed based on commercially distributed control systems. The safety I&C systems are designed using a new platform, which was developed and validated by KAERI [2]. Safety I&C systems are modularized using the platform and communicate with each other using a communication board (CMB) and network switching device (NSD). The NSD of this paper has a deterministic behavior for industrial or nuclear application, where process data or control data has to be delivered within a certain time limit. The NSD has been developed and tested at KAERI since 2009 [1]. This paper presents the development and test results of the NSD.

2. Development of the Network Switching Device

The NSD plays the role of data communication between the DSP-based platforms for the SMART MMIS. The NSD provides a link through which a group of platforms are connected and operates as a central connection point in the star topology. The NSD has 32 line interfaces (32 ports) to connect to other nodes. Each port has a physical 100-Mbps transmission speed.

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The NSD has the following characteristics:

- Support unidirectional and bidirectional communication
- Deterministic communication
- Self-diagnostics (internal loopback on individual port)
- Electrical isolation using optical fiber
- No handshaking, flow control, and error control
- Minimum BER < 1.00E-9 (FLR < 4.096E-06)
- Access control (access control list)

BER means the bit-error rate and FLR means the frame-loss rate.

The NSD prototype consists of 4 link boards, a switching board, backplane board, and panel board, as shown in Fig. 1. A part of the link board receives and transmits an optic signal, converts an optic signal to an electrical data or vice versa, and stores the electrical data in the buffer of each port. The switching board reads the electrical data, which is called a data frame, in the buffer, inspects the destination address in the header of a data frame, and forwards it to the designated port. The backplane board provides an interface of the switching board and link board. The panel board indicates the status and provides alarm information of the NSD.

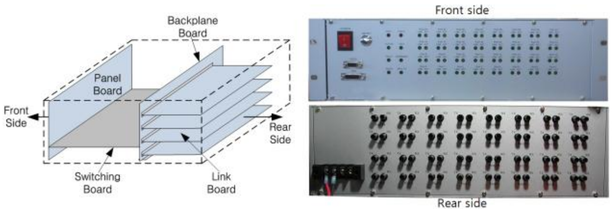

Fig. 1. The NSD prototype

3. Test Results of the NSD

2.1 Test items and environment

The NSD prototype is required to test its function and performance for validating safety and integrity. The test items are selected based on the reference [2-3]. The test items of the NSD prototype are as follows:

- Traffic Distribution (switching function)
- Transmission Speed
- Transmission Delay
- FLR (Frame Loss Rate)
- Broadcasting Performance

The definitions of each test item are described in Table 1.

Table 1. The definition of test items

Test Item	Definition
Traffic Distribution	The process or function of selecting paths in a network along which to send a data frame
Transmission Speed	The number of bits or frames that are transmitted per unit of time
Transmission Delay	The amount of time required to transmit a data frame from input buffer to output buffer
FLR(Frame Loss Rate)	The number of lost data frames divided by the total number of transmitted data frames
Broadcasting Performance	The performance of delivering a data frame to all nodes in the network

The test environment consists of a NSD; platforms, which are a high-speed DSP (digital signal processor)-based control units; debugging tools (Code Composer Studio (CCS) 3.3 and DSP emulator); and NSD monitoring device, which indicates internal traffic information and the result of the self-diagnostics of the NSD.

All ports of the NSD are connected with the CMBs of the platform for full-duplex and uni-directional data transmission.

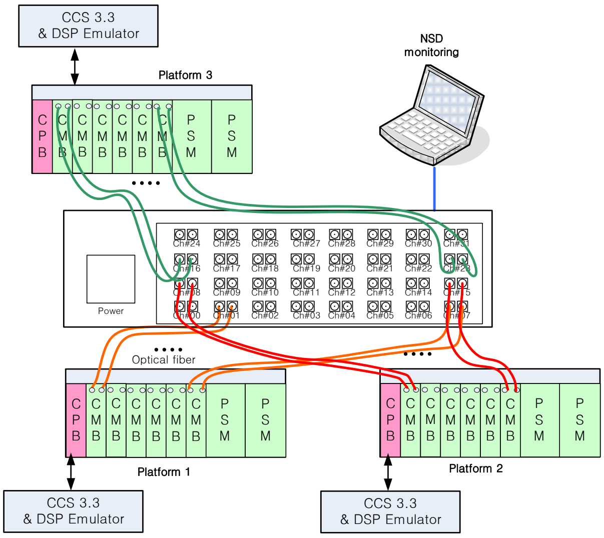

Fig. 2. The test environment of the NSD prototype.

2.2 Test Results

The distribution function of the NSD was tested to validate the routing function. Test results show that the NSD transmits all the data frames from the source node to the destination node based on the data frame's destination address.

The transmission speed of the NSD was tested to measure the processing speed of the data frames. The acceptance criterion is that the NSD should transmit 2,442 data frames within 1s (second). Test results show that the NSD transmits 2,442 data frames within 0.9765s (mean), 0.9763s (min) and 0.9766s (max). Thus the NSD satisfies the acceptance criterion of this test.

A transmission delay test of the NSD was performed. The acceptance criterion of this test is that the NSD should transmit a data frame within 96 *us* - 1,366*us* (micro-second). As shown in Table 2, the NSD satisfies the acceptance criterion of this test.

Table 2. Ttransmission delay test result

	Transmission delay		
	Mean	Min.	Max.
Background Traffic	120.82 *us*	101.87 *us*	145.27 *us*
No Background Traffic	107.89 *us*	96.67*us*	334.23 *us*

A broadcasting performance test and frame loss rate test of the NSD were performed. The broadcasting performance results of the NSD are shown in Table 3. 10,000 data frames (tx_frame) from all the NSD ports were broadcasted respectively, and each port of the NSD received 320,000 data frames (rx_frame). Thus the NSD satisfies the required broadcasting function and performance. The acceptance criterion of the FLR test is that the minimum FLR should be less than 4.096E-06. As shown in Table 3, the numbers of the error frame s (Err_frame) in Table 3 of each port are all '0's. This means that none of the data frames were lost and that the FLR is '0'. Thus, the test results show that the NSD satisfies the acceptance criterion of this FLR test.

Table 3. Broadcasting performance and FLR test result

Port No.	24	25	26	27	28	29	30	31
tx_frame	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Err_frame	0	0	0	0	0	0	0	0
rx_frame	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000
FLR	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Port No.	16	17	18	19	20	21	22	23
tx_frame	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Err_frame	0	0	0	0	0	0	0	0
rx_frame	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000
FLR	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Port No.	8	9	10	11	12	13	14	15
tx_frame	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Err_frame	0	0	0	0	0	0	0	0
rx_frame	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000
FLR	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Port No.	0	1	2	3	4	5	6	7
tx_frame	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Err_frame	0	0	0	0	0	0	0	0
rx_frame	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000
FLR	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

4. Conclusions

In this study, an NSD is designed and developed for a safety I&C system, and an NSD prototype is tested for its validity. The NSD plays the role of data communication between the DSP-based platforms. A function test such as a distribution test and broadcast test; and performance tests, such as transmission speed test, transmission delay test, and frame loss rate test are performed to validate the feasibility of the NSD. The results of these tests show that the NSD satisfies the function and performance requirements. The test results show that the NSD is capable of providing a communication path between DSP-based platforms and is applicable in the test facility to validate the design of a SMART MMIS.

REFERENCES

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