Development and Test of Satellite Modem for Severe Accident Response System in NPPs

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1. Introduction

When severe accidents happen in NPPs, an advanced severe accident response system is needed in order to monitor status of NPPs and control the safety equipment at a remote control station using a wireless communication system. In this paper, we introduce the severe accident response system (SARS) consisting of the nuclear black box, mobile remote control station (MRCS) and satellite communication system as shown in Fig. 1 [1].

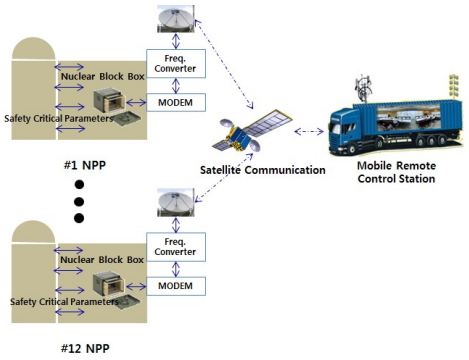

Fig. 1. SARS configuration

The nuclear black box collects the safety status information including safety critical parameters and video information in NPPs at the harsh environment such as high temperature, pressure, humidity, and radiation level and then transmits the information to the MRCS through a satellite communication system.

In this paper, we also describe the concept of satellite communication system. The function, performance and test results of the satellite modem is presented that is a key component of satellite communication system

2. Satellite Modem

2.1 Satellite communication system overview

The satellite communication system consists of a modem, frequency converter, amplifier and battery. The modem receives signals from the nuclear black box and IP camera and encrypts the data. The frequency converter translates the output frequency of modem to the corresponding frequency to the satellite which is the Chollian used in this paper. The battery supplies the power to the satellite communication system during 72 hours [2].

2.2 Function and Architecture of Modem

The satellite modem modulates and demodulates signals from the nuclear black box and MRCS also encrypts the signals based on the AES-256. The hardware configuration of modem is shown in Fig. 2.

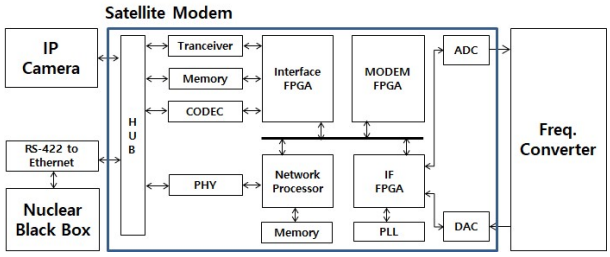

Fig. 2. Hardware configuration of mode

The interface FPGA performs the interfacing function to IP camera and nuclear black box and adjusting function to Time Division Multiplexing (TMD) velocity. The Network processor controls the satellite modem and translates Ethernet over high-level data link control (HDLC). The Modem FPGA modulates and demodulates data and videos signals also controls the traffic. Finally, the IF FPGA performs the interfacing function to the frequency converter and translates digital to analog signals and vice versa.

The required specification of satellite model is as follows [3]:

- Modulating and demodulating the signal at the level of 45Mbps.
- Tranceivering the Ethernet packet.
- Encrypting signals.
- Interfacing the intermediate frequency, 70MHz.
- Interfacing the nuclear black box, IP camera and frequency converter.

3. Test

3.1 Module Test

The main performance of satellite modem is tested as follows:

- Bandwidth for various transmission rate
- Transmission rate

The configuration for module test is shown in Fig. 3. The test results are depicted in Table I and II.

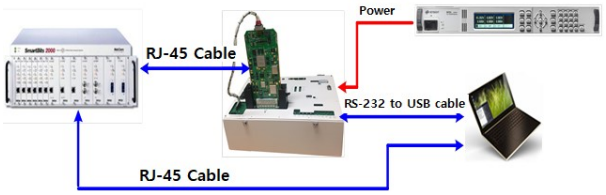

Fig. 3. Module test configuration

Table I Test results for bandwidth on various transmission rate

Specification		Test Results	
Trans. rate	**Bandwidth**	**Modem #1**	**Modem #2**
64Kbps	BW≤ 200KHz	179.96KHz	179.73KHz
2.048Mbps	BW≤ 2.3MHz	2.21MHz	2.21 MHz
4.096Mbps	BW≤ 4.5MHz	4.32MHz	4.32 MHz
8.192Mbps	BW≤ 3.0MHz	2.89MHz	2.89 MHz
16.384Mbps	BW≤ 6.0MHz	5.76MHz	5.76 MHz
34.368Mbps	BW≤ 12.0MHz	11.46MHz	11.46 MHz
44.736Mbps	BW≤ 14.5MHz	13.75MHz	13.76 MHz

Table II Test results for transmission rate

Trans. rate	Test Results (Frame Loss 0%)	
	Modem #1	**Modem #2**
2.048Mbps	2.1Mbps	2.1 Mbps
4.096Mbps	4.2 Mbps	4.2 Mbps
8.192Mbps	8.4 Mbps	8.4 Mbps
16.384Mbps	16.7 Mbps	16.7 Mbps
34.368Mbps	34.8 Mbps	34.8 Mbps
44.736Mbps	45.5 Mbps	45.5 Mbps

3.2 Integration test

In the integration test as shown in Fig. 4, interface functions to nuclear black box, IP camera and MRCS are tested as follows as:

- Interfacing to the nuclear black box and IP camera
- Interfacing to the MRCS

Through the integration test it is checked whether the information data from the nuclear black box is transmitted to MRCS or not and vice versa.

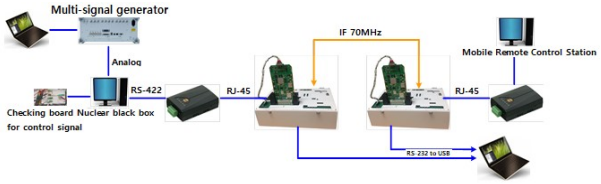

Fig. 4. Integration test configuration

3.3 System test

Based on results of integration test, the entire satellite communication system including the modem is tested using the Chollian satellite as shown in Fig. 5.

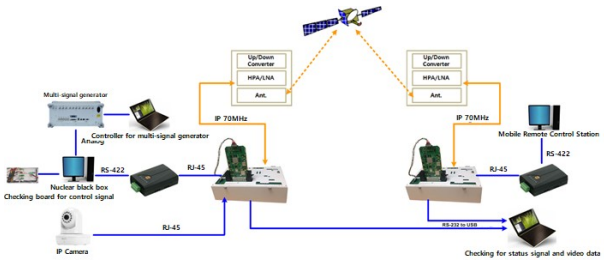

Fig. 5. System test configuration

As shown in Fig. 6, the safety status information data from nuclear black box and video data from IP camera are transmitted to the MRCS without errors and data loss. The control data from the MRCS is also errorlessly sent to the nuclear black box [4].

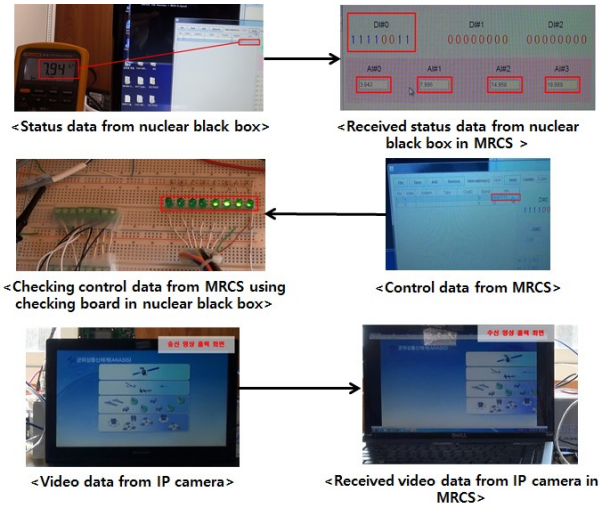

Fig. 6. System test results

3. Conclusions

In order to cope with the severe accidents in NPPs, an advanced SARS is needed and for the effective operation, the satellite communication system should be adopted in that system. In this paper, we introduce the concept of the SARS consisting of the nuclear black box and MRCS. The implementation and test results of satellite modem are presented which is the key component of satellite communication system. The satellite modem performs the function interfacing to subsystem of SARS; transmitting the safety information data from nuclear black and video data in NPPs box to the MRCS and transmitting the control data from MRCS to the nuclear black box. The function and performance of modem is verified and validated through module, integration and system test. This modem can play an important role in the SARS requiring robust and high reliable wireless communication system.

REFERENCES

[1] K. S. Son, C. H. Kim and H.G. Kang, Conceptual design of emergency communication system to cope with sever

accidents in NPPs and its performance evaluation, Annals Nuclear Energy, 76(2015) 367-377.
[2] S. B. Hong, D. H. Kim and C. H. Kim, Design of the satellite communication for data transmission of the nuclear black box, Transaction of the Korean Nuclear Society Spring Meeting, 2018.
[3] S. B. Hong, Design Specification for signal processing unit to transmit a data with high QoS, KAERI, 2017
[4] S. J. Hwang, Test results report for satellite communication system, Comesta, 2017