Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2018

Design of the Satellite Communication System for Data Transmission of the Nuclear Black Box

Seok Boong Hong*, Duck Hyun Kim, Chang Hwoi Kim
Korea Atomic Energy Research Institute
**Corresponding author: boong@kaeri.re.kr*

1. Introduction

The Nuclear Power Plant (NPP) satellite communication system serves as the link between the Nuclear Black Box and the Mobile Remote Control Station (MRCS) in a potential severe accident situation, allowing continued monitoring of critical variables in the nuclear reactor as well as continued delivery of control inputs [1].

In the NPP satellite communication system, communication is achieved with an FDD (Full duplex) bi-directional satellite transmission link. The Status Link transmits traffic data (i.e., video feed and monitoring variable status) from the NPP to the MRCS. The M&C Link transmits control inputs from the MRCS to the NPP using the FDMA method [2,3].

The NPP satellite communication system is installed independently in each reactor and can expand to include up to 12 nodes in total to communicate with a single MRCS. Fig. 1 is a schematic diagram of the NPP satellite communication system.

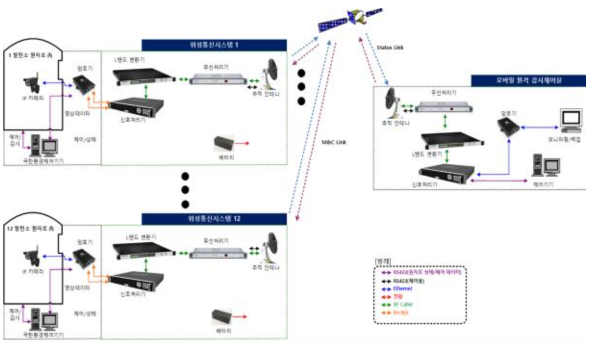

Fig. 1. NPP satellite communication system.

2. NPP satellite communication system.

2.1 Nuclear emergency communication system

The Nuclear emergency communication system receives data from the Nuclear Black Box and designated IP camera, encrypts it with the ARIA algorithm, multiplexes data and applies the AES-256 encryption process [4], performs error correction as well as modulation and signal conversion, and transmits the data to the MRCS via satellite links. The system also receives control data from the MRCS and supplies it to the Nuclear Black Box and designated IP camera using the same methodology.

The overall system consists of an encoder/decoder, a signal processor, an L-band translator, a radio processor, a tracking antenna, a control device and a battery.

The encoder/decoder receives the signal from the IP camera and the Nuclear Black Box, encrypts it with the ARIA algorithm, and passes it to the signal processor. The signal gets transmitted to the MRCS via a satellite, where the counter encoder/decoder then decodes and passes it to the control unit of the MRCS. The control signals from the MRCS travels to the Nuclear Black Box and the IP camera the same way.

The signal processor multiplexes video data from the Ethernet traffic passed on by the encoder/decoder and the encrypted RS-422 serial data. The signal processor then applies error correction and modulation, and transfers the signal to the wireless processor. The AES-256 standard encryption is applied prior to signal processing in order to increase the reliability and security of the system.

The L-band converter up-converts the IF 70MHz signal supplied by the signal processor to the L band and transmits to the wireless processor. In reverse, the L-band converter down-converts the L band frequency signal supplied by the wireless processor to IF 70MHz.

The wireless processor receives the signal from the L band converter, up-converts the Ka band frequency through signal HPA, and transmits it to the tracking antenna. In reverse, the wireless processor receives M&C Link Ka signal from the antenna, down-converts it through the LNB, and transmits to the L band converter.

The tracking antenna transmits the signal supplied by the wireless processor to the satellite by radio. In reverse, the antenna receives radio from the satellite and supplies it to the wireless processor. The automatic satellite alignment function must be incorporated to ensure viewing of the satellite in extreme environmental conditions.

The battery supplies power required by the transmitter system for up to 72 hours during a power outage to allow continued system operation in severe accidents.

2.2 Mobile Remote Control Station (MRCS)

The MRCS receives traffic data from up to 12 independent Nuclear Black Box nodes through the Status Link and delivers select data to the operator. The MRCS also transmits the operator's control input to the corresponding Nuclear Black Box through the M&C Link.

The antenna for the MRCS must be designed to allow manual operation, be compact and lightweight such that it can be mounted on a vehicle. A satisfactory commercial product may be chosen.

All other components of the MRCS shall be the same in function and specification to those of the nuclear emergency communication system.

3. System Specifications

3.1 Main functions of components

The main functions of the components of the NPP satellite communication system are the following:

The encoder/decoder provides the encoder/decoder function using the ARIA algorithm. The signal processor provides an interface among 7/16Mbps transmission speed and Ethernet packet transmission and reception, AES-256 self-encryption, error correction and FER reporting, and IF 70MHz L band converter. The wireless processor provides Ka bandwidth up/down conversion and transmit/receive gain adjustment function. The tracking antenna has satellite automatic alignment and position stabilization functions. The battery provides 72 hours of emergency power supply, and shows the remaining operation time and an alert below a pre-set limit.

3.2 Interface

The interface between each component located in a NPP is illustrated in Fig. 2.

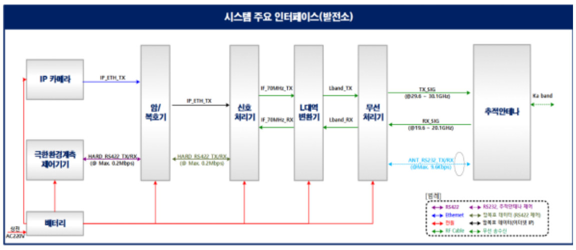

Fig. 2. Interface between components located at NPP

The interface between components located in the MRCS is illustrated in Fig.3.

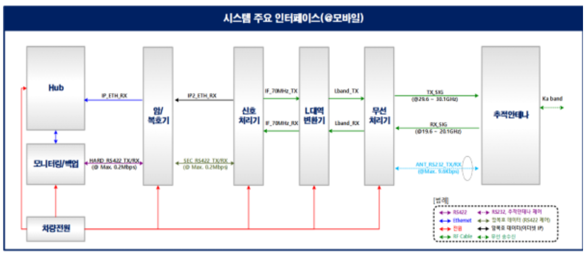

Fig.3. Interface between components located in the Mobile Remote Control Station.

3.3 Algorithm design

In order to protect the NPP satellite communication network from cyber threats imposed by internal or external intruders, it is necessary to combine various cyber security measures found in the IT field. In the proposed satellite communication system, the encoder/decoder provides encryption/decryption through the ARIA algorithm and, additionally, the signal processor employs AES-256 encryption algorithm to help achieve high-reliability data transmission.

3. Conclusion

The NPP satellite communication system provides continued communication between Nuclear Black Box and the operator in the event of a severe accident.

The NPP side communication system multiplexes the video Ethernet traffic data received from the encoder/decoder and the encrypted RS-422 serial data of the monitoring variables received from the Nuclear Black Box, performs signal processing (error correction/ modulation), and delivers data to the wireless processor, which then gets delivered to the MRCS via a satellite. The MRCS side communication system delivers control data from the MRCS to the Nuclear Black Box via the satellite. In order to enhance the reliability and security of the system during the signal processing, it employs the ARIA algorithm and the standard AES-256 encryption.

REFERENCES

[1] COMESTA, “중대사고에 사용되는 원전비상통신 시스템 설계규격”, 2014.

[2] N. Kawai, E. Nakasu, T. Yosimura and A. Ohaya, “ISDB transmission system in the 12GHz band digital satellite broadcasting”, NAB 1992 Broadcast Engineering Conference Proceedings, pp. 43-51, Apr. 1992.

[3] Y. W. Kim, D. S. Kang, H. H Jeon, “The Characteristics of HDTV Transmission Channel via KOREASAT”, ICEIC’95, pp. 139-142, Aug. 1995.

[4] Advanced Encryption Standard (AES), Federal Information Processing Standards Publication 197, Nov. 2001.