Communication board design to satisfy the communication independence in safety I&C system

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1. Introduction

SMART MMIS has been designed using a fully digitalized system. The safety I&C systems of SMART MMIS are designed using a new platform, which was developed and validated by KAERI [1]. Safety I&C systems are modularized using a platform and communicate with each other using a communication board (CMB) and network switching device (NSD)[2]. The CMB in this paper provides a connection point to other platforms. In this paper, we propose the structure and design of the CMB to comply with communication independence of IEEE Std. 7-4.3.2-2009 and present the test results of the CMB in terms of the communication independence described in IEEE Std. 7-4.3.2-2009.

2. Development of the Communication Board

The CMB provides a communication interface between the DSP-based platforms for the SMART MMIS safety system. The CMB has two ports, TX(transmit) port and RX(receive) port. Each port has a 10-Mbps transmission speed.

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The CMB has the following characteristics:

- Support one-way(unidirectional) and two-way(bidirectional) communication
- Deterministic data communication
- Self-diagnostics (internal loopback test)
- Use optical cable as communication media
- No handshaking
- No flow control and no error control
- Non-interruptible to function processor
- Use fixed data frame size(512bytes)

The CMB is used to communicate with platforms on the same channel as well as those on different channels. Therefore, the CMB shall satisfy the requirement for communication independence described by IEEE Std. 7-4.3.2. It outlines that communications independence between redundant divisions(channels) of a safety system and communication independence of the safety system from non-safety systems is required to mitigate the risk of safety system failure during a design basis event. Also it describes several one-way communication and two-way communication structures between safety channels and between safety and non-safety computers.

The CMB presented in this paper is designed to satisfy the requirement of communication independence. The first prototype CMB developed is shown in Figure 1. But this one cannot satisfy the communication independence due to two ports being available at all times and it can only be used on same channels in safety systems. To satisfy the communication independence between safety channels, and between safety channels to non-safety channels, a second prototype CMB supporting one-way communication as shown in Figure 2 has been designed. The second prototype CMB uses a one-way mode DIP switch to setup the one-way communication mode. When one-way mode DIP switch is 'off', the second prototype CMB communicate via two-way communication mode like the first prototype of the CMB using two optical fiber cables. When the one-way mode DIP switch is 'on', the second prototype CMB cannot receive data frames physically and can only transmit data .

The one-way communication mode provides communication isolation. An optical fiber interface and an optical fiber cable provide electrical isolation. As the protocol of the CMB has no handshaking, no flow control, and no error control, the transmitting platform transmits data regardless of whether the receiving platform (or non-safety computer) is physically connected or disconnected and whether the receiving platform (or non-safety computer) is erroneous

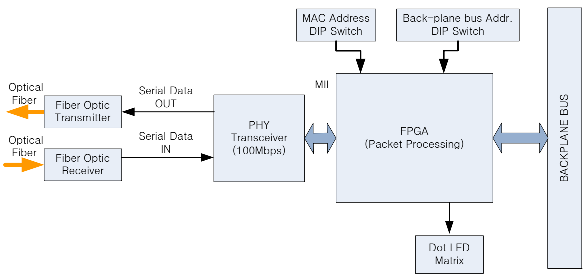


Fig. 1. The first prototype CMB

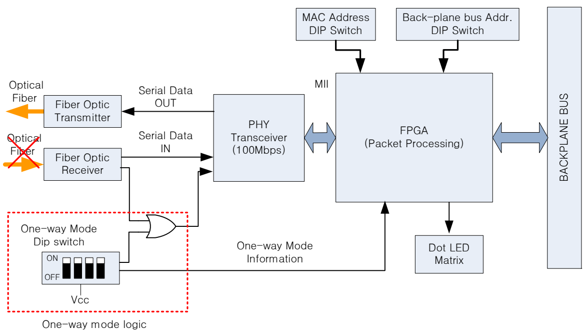


Fig. 2. The second prototype CMB

3. Test Results of the CMB

2.1 Test items and environment

The second prototype CMB is required to test its function and the conformance of the communication independence. The test items are selected based on its functions and reference [3]. The test items of the second prototype CMB are as follows:

- Transmission speed
- Frame loss rate
- One-way communication
- Two-way communication

The test environment consists of two platforms, which are a high-speed DSP (digital signal processor)-based control units; debugging tools (Code Composer Studio (CCS) 3.3 and DSP emulator. The platform consists of the CPB(cpu Board), CMB, AIB(analog input board), AOB(analog output board), CIB(contact input board), COB(contact output board), and SPM(subrack power module) as shown in Figure 3[4]. Normally the platform uses several CMBs to communicate other platforms. In test environments shown in Figure 4, the CMB1 of platform 1 are connected with the CMB1 of platform 2 for one-way communication and two-way communication test respectively.

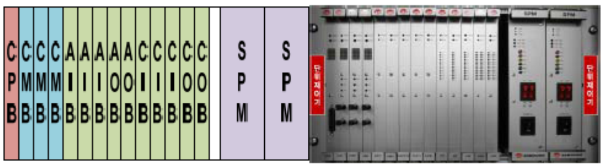
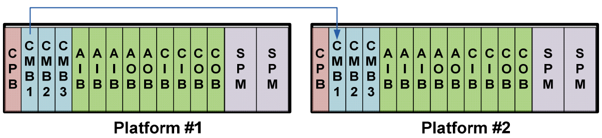
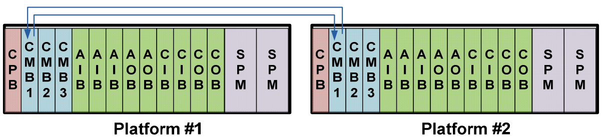


Fig. 3. A Typical configuration of the platform



(a) One-way communication test



(b) Two-way communication test

Fig. 4. Test environment

2.2 Test Results

The transmission speed of a CMB was tested whether it satisfy the performance requirement. The acceptance criterion is that the CMB should transmit 2,442 data frames within 1s (second). Test results show that the CMB transmits 2,442 data frames about 0.7416s. Thus the CMB satisfies the acceptance criterion of this test.

The frame loss rate test of the CMB was performed. The acceptance criterion of this test is that there should be less than one lost data frame of 244,140 data frames transmitted. The frame loss rate of this test is 0%, namely, all the transmitted frames from the sending platform are received at the receiving platform. Test results show that the CMB satisfies the acceptance criterion of this test.

The test of one-way communication and two-way communication were performed. In one-way communication test in Fig. 4(a), the sending platform (platform 1) does not interfere with its function regardless of the failure or fault of the receiving platform (platform 2) and the disconnection between platforms. In two-way communication test in Fig. 4(b), the CMBs of two platforms communicate each other. Test results show that the transmission speed and the frame loss rate is the same as described above.

4. Conclusions

In this study, the CMB is designed and developed for a safety I&C system, and the CMB prototype is tested to validate its function and its communication independence characteristics. To satisfy the communication independence between safety channels and between safety channels to non-safety channel, the second prototype CMB is designed and developed to support the one-way communication by setting up the one-way mode DIP switch. A functional and performance test such as a transmission speed test, frame loss rate test, one-way communication and two-way communication test are performed to validate the feasibility of the CMB. The test results show that the CMB is capable of providing a communication interface for DSP-based platform. Moreover it satisfies the communication independence requirement of IEEE Std. 7-4.3.2-2009 so that a failure or fault of one channel (including non-safety channel) does not interfere with the function of other safety channels.

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