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Design of High Reliable Safety Data Link(HR-SDL) For Safety Grade PLC for Nuclear Power Plants

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Abstract: This paper is concerned with a Safety Data Link communication for Safety Grade PLC. Safety Data Link provides peer-to-peer communication between PLCs. The link transmits a safety control signals such as a trip signals to other channels. This link uses Profibus-FDL protocol based on SDN(Send Data with No acknowledge) in order to prevent handhsaking.

1. INTRODUCTION

High Reliable Safety Data Link(HR-SDL) of Safety Grade PLC(POSAFE-Q) uses deterministic, bi-direction, and broadcasting methods. The HR-SDL protocol uses Profibus FDL(Fieldbus Data Link) based on SDN (Send Data with No acknowledge) in order to prevent handshaking.

The communication module uses peer-to-peer communi- - cation method that communicates through dedicated link, and fiber-optic cable is used as a physical link for physical isolation. To satisfy quality of data, CRC examination method is used. HR-SDL offers 4 independent communication ports in maximum. All hardware of the communication module satisfies IEEE safety class 1E, and seismic category I. And, the software used in the communication module is classified by safety critical software. The communication module will be used for transmitting a local trip signal from bistable processor to coincidence processor in Reactor Protection System.

2. HARDWARE STRUCTURE OF HR-SDL COMMUNICATION MODULE

Hardware of the HR-SDL communication module consists of a CPB (NCPB-1Q) and a driver board (NDRVOM-4Q) as shown in figure 1, and is combined by piggy back. Software of the CPB(CPB) is called PNMOS4, and software of the DRB(Driver Board) is called PNDOS2.

The communication module is interfaced through 16 bits bus (P16-A Bus) with the processor module. A CPB supports 4 communication ports (Comm Port), and a DRB supports 2 communication ports.

The CPB consists of DPM (Dual Port Memory), CPU, ROM and RAM, and exchanges data with processor module through DPM-CPB.

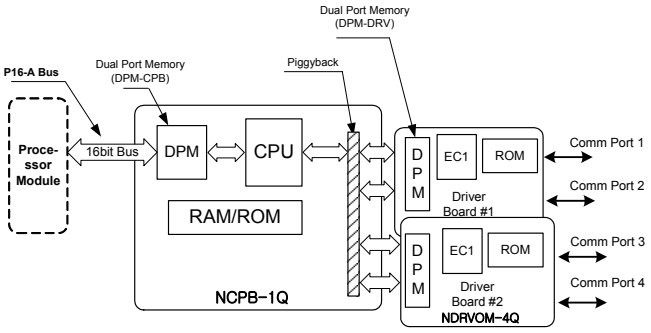

Fig. 1 The H/W Structure of HR-SDL Communication Module

The DRB (Driver Board) consists of DPM, EC1 and ROM, and exchanges data with the CPB through DPM-DRB.

The micro processor in the CPB is SMQ 320C32 PCMM-60M CPU, and the CPB uses 32KWords (we write 32KW hereafter) Dual Port Memory, 512KW Flash Memory, and 512KW SRAM.

The DRB uses 2 EC1 (DSTnI-LX-48M CPU)s that are 16bit processors to support two independent communication ports, and two 8KB Dual Port Memories, 256KW Flash Memory, two 256KW SRAMs.

The dual port memory (DPM-CPB) in the CPB uses 16bit shared memory, with the minimum capacity of 32KW. Local memory is consists of 256KW flash memory for saving parameters and the executive program, 256KW FAST memory in which actuality executive program runs, and 512KW SRAM. Access to these memories is achieved through the bus of 32bits.

Since the data transfer between the CPB and the processor module is achieved through a dual port memory without interrupt, the safety function of the processor module is

performed separatively from communication module. Also, the DRB sends/receives data to/from other PLCs through EC1 separatively from the CPB.

The CPB and DRB have watchdog timer to detect program halt and over run error.

The maximum data transfer rate is 12Mbps, and the rate can be changed through application program tool (pSET).

3. SOFTWARE STRUCTURE OF HR-SDL COMMUNICATION MOUDLE

The CPB software of the HR-SDL can be subdivided into six functions as follows:

- Initialization Software:

  The Initialization is activated on the power on, reset, and hot swap state. This software initializes and performs hardware initialization and self-test.

- ID Check Software:

  This software is used for checking the live status of the CPB and DRB.

- Parameter Set Software:

  This software is used for setting communication environment such as data transmission mode and baudrate.

- Data Send and Receive Software:

  The Data send and receive software is sending the message box of the processor module to DRB. And also, this software performs data receiving from DRB and sends to processor module. In this reason, this software can be divided into send portion and receive portion.

- Error Management Software:

  This software manages an error which is occurred in the CPB and DRB. Thus, this software collects an error and manages properly.

- LED Display Software:

  This software activates a LED display hardware interrupt.

Also, the DRB software of the HR-SDL has the same structure and similar function as CPB. The software can be subdivided into as following functions:

- Initialization Software
- ID Check Software
- Parameter Set Software
- Data (Message) Send Software
- Data (Message) Receive Software
- Error Management Software
- LED Display Software

4. TEST AND RESULTS

To prove the performance of the HR-SDL, several tests were performed. To verify the functionality of the the hardware and software component, the component test (CT) were performed successfully tested.

And also, to verify the functionality and performance according to component integration and integration with processor module, the integration test (IT) were performed and successfully tested.

To prove overall performance of the HR-SDL, the system test (ST) was performed. And the test were performed and successfully tested. The test items are as follows :

- Deterministic performance test

  This test is to verify deterministic capability according to variation of the communication load and CPU load in processor module.

- Data transmission error characteristic test

  This test is to verify fail safe capability when the data transmission error is occurred in communication path.

- Data transfer rate test

  This test is to verify data transmission rate at normal, off-normal, and error operation. The rate will be calculated in bps(bit per second).

5. CONCLUSION

HR-SDL communication module was developed for safety grade PLC. This module uses deterministic, bi-direction, and broadcasting methods, And HR-SDL protocol is Profibus FDL(Fieldbus Data Link) with SDN (Send Data with No acknowledge).

To prove the performance of the HR-SDL, several tests were performed such as CT, IT and ST. The test results are satisfied with requirements and specification. This module will be used for transmitting a local trip signal from bistable processor to coincidence processor in Reactor Protection System.

REFERENCES

EPRI TR-107330, Generic Requirements Specifica-
-tion for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants.

NUREG/CR-6082, Data Communications, 1993.

USNRC Reg. Guide 1.152, Criteria for Programmable Digital Computer System Software in Safety-Related Systems of Nuclear Power Plants, Rev. 01, Jan. 1996.

IEEE Std. 7-4.3.2-2003, Standard Criteria for Digital Computer in Safety Systems of Nuclear Power Generating Stations.

KAERI/TR-2010 General Requirements and Specifications for PLC to be applied to Safety System of Nucler Power Plant, 2002.