The Study for method to prevent the Unplanned Trip of Field Equipment From a Wrong Signal of Digital Cards in Nuclear Power Plant

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1. Introduction

NPPs have many facilities where safety is a top priority. It takes a lot of verification time to build such a facility. Because of these times, even if it is the latest equipment, it often becomes an old facility at the time of operation of the facility.

For this reason, it is many cases that power plant control facilities mostly transmit important signals using serials communications. Many techniques have been used to maintain integrity for communications.

Many methods ensure the integrity of communications. However, there are cases where the integrity of the original source data is not guaranteed.

For safety reasons, safety-class facility often stops the NPP when a signal related to safety is detected.

This paper proposes a method to guarantee the integrity of data on Digital Input Cards (analog electronic cards)

2. Existing facility

Various Input/output (I/O) signals, almost contact signal, exist in various systems. The Controller to control signals is composed of various different function electronic cards such as Input, Output, Communication, Arithmetic, and etc.

2.1 I/O electronic card

I/O electronic cards are designed separately or in combination by analog and digital. [3]

Analog I/O electronic card receives input signal through Analog to Digital Convertor (ADC) and sends output signal through Digital to Analog Convertor (DAC). Central Processing Unit (CPU) perform calculation and control in the between two processing.

Digital I/O electronic card receives contact signal and then transfers to a CPU card. And a CPU card combines a received digital data value. And then calculated and operated signals are outputted or stored by CPU card.

There are various data transmission schemes between I/O cards and control card. Serial path is such as RS232, RS485 and etc., and parallel path is as MODBUS, VMEBUS, and etc.

2.2 Problem

In the bus transmission, various methods are used for the integrity of communication. There are various ECC [1] [2] schemes in general buses.

However, in the control equipment, especially the serial path, only the physical method is taken, and various inherent functions are often excluded. One of them is the ECC. The following figure is an example of the serial path currently in use. [3]

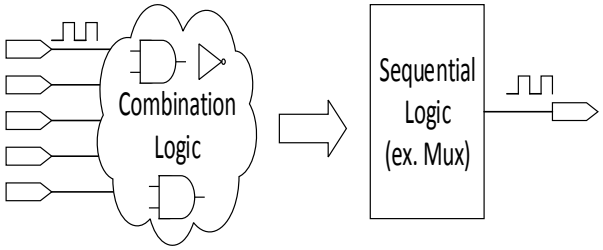

Fig. 1 The block diagram of I/O card circuit

In this way, integrity of the data to the CPU electronic card is ensured, but the data integrity of the input contact signal is not ensured.

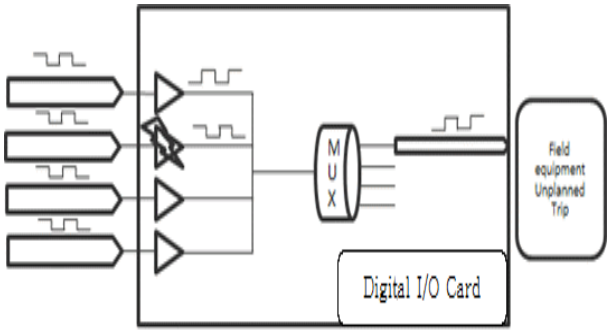

Fig. 2 The block diagram of the I/O card circuit failure

That is, each contact signal is combined to send data to the serial path. If 1 or 2 bits of the signal is changed in the process due to noise, loose connection, device failure and so on, there is no way to verify the error of this data via parity check or hamming code and to return the signal for preventing the unplanned trip of the equipment.

3. IMPROVED ELECTRONIC CARD

3.1 Proposal Structure

In the I/O cards, ECC circuit is applied between the signal input part and the output part to output to the CPU card.

The following figure is a block diagram of ECC circuit application.

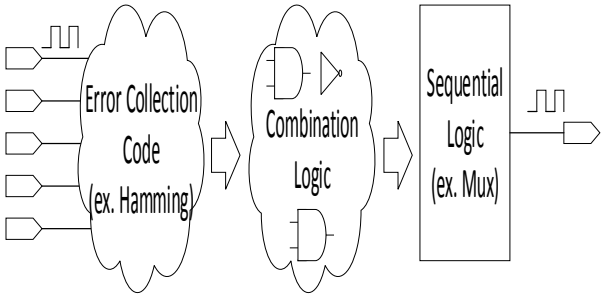

Fig. 3 The proposal structure with ECC

Even if the CPU card receives the data with an error, Implemented ECC is not to make any trouble by the recombination of the contact signal. Both communication integrity and data integrity are able to be checked.

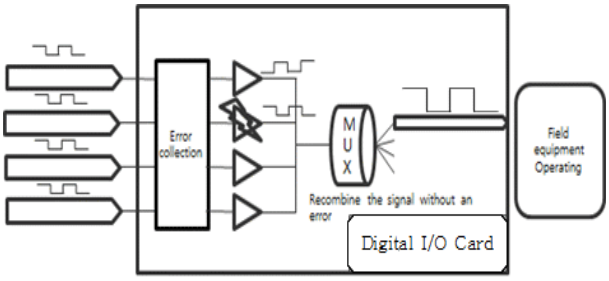

Fig. 4 The block diagram of the applied ECC

3.2 Considerations

Although the transfer data size from the I/O card to the CPU card have to appropriately adjust and optimize as of the data size of the CPU, The added ECC may cause data overflow, thereby increasing the operation time.

When buffering and storing data (for LOG) are required, the cost increases because the memory capacity is increased.

4. CONCLUSION

If the ECC is not applied to the input data, it has a limitation on the performance of the Digital card. This card could be verified only the integrity of the bus. Also it cannot verify the integrity of the corrupted data, resulting in erroneous output (a wrong decision) and it has a serious effect on the control of the NPP.

On the other hands, if ECC is added to the combination of input data like the proposed method for error, it is possible to prevent the malfunction by checking the integrity of the data. In addition, since the error signal is ignored and restored via the Hamming Code, the input signal is recombined regardless of the error of the signal.

REFERENCES

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[2] Todd K. Moon, “Error Correction Coding : Mathematical Methods and Algorithms”, John Wiley, 2005

[3] M. Morris Mano, “Digital design”, Prentice-Hall, 1984