# A Reliable Bistable Board Implementation through I/O Redundancy

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## 1. Introduction

Nuclear power plant safety systems and related equipment used in the design, including an accident in all driving conditions that must be proven In addition, the safety-related equipment that is derived according to the digitization of the safety equipment is the most important factors [1] [2]. Therefore, it is necessary to prove that the device was satisfied the requirements for a given performance for safety-related digital equipment for the life of the installation[3]. These proven is done through the process, design verification of the equipment, production management, such as installation and maintenance. Among other things, it is most important to implement of the performance and reliability features the safety-related equipment in the design phase. In this paper, Bistable Board implemented to generate a ESF sign-on signal throughout the signal processing of input signal from sensors. Also, for the reliable signal input and output, I/O Module that implements the redundancy increases the reliability of the Bistable Board , to verify the performance of safety-related equipment[1].

## 2. Methods and Results

Several safety-related equipment assoiciated with the processing of the input singal from the detector is important tip in the long-time operation of nuclear power plants. In this paper, presented in a Bistable Board that monitors radiation in the sensor signal processing unit 4~20m A current signal is transmitted through the radiation to determine the integrity of the value. Bistable Board using the input signal to the I/O Module, redundant design and testing through a variety of conditions designed to verify the performance of the unit

### *2.1 Bistable Boards*

Bistable Board is consist of Signal Pre-processing Module, Signal Processing Module, Analog Signal Output Module. Digital Signal Output Module and overall configuration of the unit is equal to Fig. 1. For use in safety-related equipment to carry out reliable Bistable function of input signal processing module was redundant. Especially, Output Modules are made analog signal(current) and digital signal(realy contact) output, and relay output signal is used to the sign the associated signal of the ESF

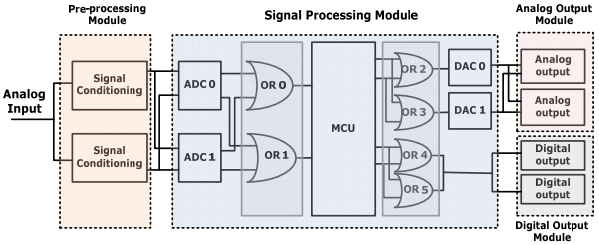


Fig. 1 the overall configuration of Bistable Board

### *2.2 Pre-processing Module*

Signal Pre-processing Module was composed of Current to Voltage conversion, Signal Conditioning, Phase change, Buffer and signal are processed front of AD Conversion, input signal is 4~20Ma(Voltage Range : 0~5V) current source, current is converted in to a voltage signal and is processed[4]. Part of the configuration of the Signal Pre-processing Module is Composed with Fig. 2.

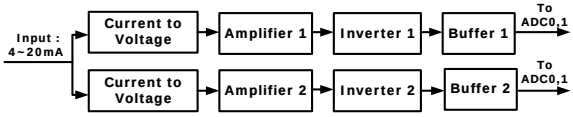


Fig. 2 Pre-processing module

### *2.3 Signal Processing Module*

Part of the configuration of the Signal Processing Module is composed with Fig. 3. Microcontroller was used MSC1211Y5 by Texas Instrument[5]. Input signal which passed through the ADC0, ADC.1 is performed redundant OR operation at the Logic-EPLD. Logic-EPLD perform signal processing of the redundant. Bistable operation is performed to compare with setpoint from input signal at the Microcontroller. After the operation, the DO, DAC0, DAC1 outputs through Port P0, P1.

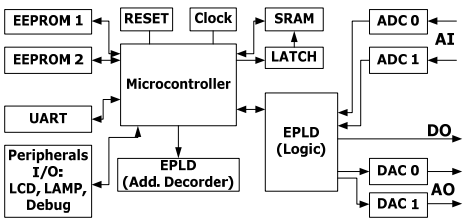


Fig. 3 Signal Processing module

### *2.4 Analog Output Module*

Analog Output Module was perform voltage to current function and output 4~20Ma current signal. The signal which passed through DAC0, DAC1 goes through adjustments in the Input Range Set. After, the signal and power makes isolation former stage[4]. Analog Output Module for Voltage to Current is composed with Fig. 4.

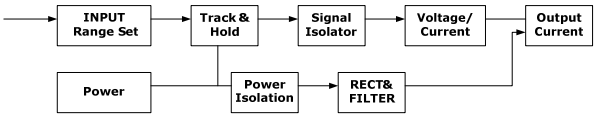


Fig. 4 Analog output module

### *2.5 Digital Output Module*

Digital Output Module is composed with Fig. 5. The digital signal is output through port P1.0, P1.1 and passed Relay Driver1 consisted of Opto-coupler, Relay Driver2 considering the running time for relay with capacitor at the same time. Normally, Relay drive signal is connected the associated circuit with Relay Energized state. When Port P1.0, P1.1 is the High(Active) state, output signal is connected to the associated circuit with De-energized state.

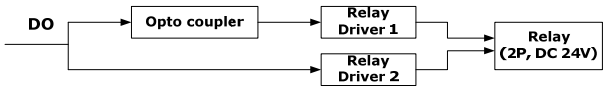


Fig. 5 Digital Output Module

### *2.6 Bistable algorithm*

Microcontroller is perform data conversion from the input signal and voltage values was calculated corresponding with value of the radiation. So, the results of calculation and Setpoint was stored a EEPROM2. Consequently, Successively input voltage value was compared with setpoint at 0.1 second per entered Voltage Value. As Fig. 6, If input voltage value exceed the setpoint, contact signal is generated by driving a relay .

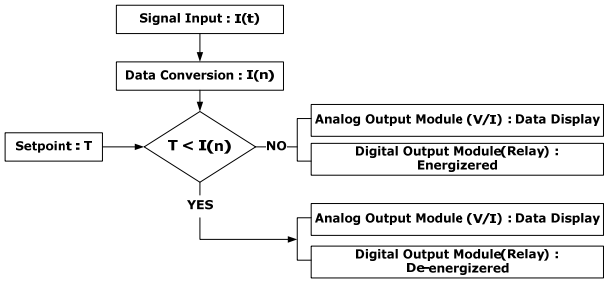


Fig. 6 Bistable algorithm

### *2.7 Functional Test and Verifications*

In order to test the performance of Redundant I/O Module of Bistable Board, selected as Test Items that can affect the safety of the equipment. Current signal was supplied 12mA(= 2.5V) in a Pre-processing Module, Device's function of Selected Test Items was Set up as Table. 1. Setpoint of Bistable Board was set up 1.25V, Analog Output and Digital Output's Test Items test results are shown Table. Through the test results, we can confirm it the Bistable Board's performance through implementation of I/O Module redundancy.

Table. 1 test result of bistable boards (Input=12mA, Setpoint = 1.25V)

| IN | TEST ITEM | | | | | | | | | | OUTPUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ADC - 0 | ADC - 1 | OR - 0 | OR - 1 | OR - 2 | OR - 3 | OR - 4 | OR - 5 | DAC - 0 | DAC - 1 | AO (mA) | DO |
| 12mA | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON | 11.8 | ON |
| | OFF | ON | ON | ON | OFF | ON | OFF | ON | OFF | ON | 11.9 | ON |
| | ON | OFF | ON | ON | ON | OFF | ON | OFF | ON | OFF | 11.8 | ON |
| | ON | ON | OFF | ON | OFF | ON | OFF | ON | OFF | ON | 11.8 | ON |
| | ON | ON | ON | OFF | ON | OFF | ON | OFF | ON | OFF | 11.9 | ON |
| | OFF | ON | ON | OFF | ON | OFF | ON | OFF | ON | OFF | 11.8 | ON |
| | OFF | ON | OFF | ON | OFF | ON | OFF | ON | OFF | ON | 11.9 | ON |
| | ON | OFF | ON | OFF | ON | OFF | ON | OFF | ON | OFF | 11.9 | ON |


Fig. 7 waveform of Analog Output and Digital Output when all TEST ITEM was ON status

## 3. Conclusions

So far, We examined Implementation of the I/O Module redundancy the Bistable Board for the circuit configuration, operation and test methods. In addition, through testing, redundancy of critical elements in improving the reliability of safety-related equipment to provide much influence in both analog and digital outputs was identified. Reliability of safety-related equipment in nuclear power plants, among other things is an important element. Digitized the development of safety-related measurement and control was need many condition at the equipment design, operation, maintenance. The proposed implementation of number of redundant safety-related I/O measurement and control device design is one kind of way. Therefore, how to design the future of safety-realated equipment will be needed for many studies.

## REFERENCES

[1] IEEE Std 603, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations", 1998
[2] IEEE Std 1023, "IEEE Guide for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations", 1988
[3] IEEE Std 7-4.3.2, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations.", 2003
[4] MSC1211 User's manual, " Precision Analog-to-Digital Converter(ADC)and Digital-to-Analog Converters(DACs) with 8051 Microcontroller and Flash memory", TI