

A Study on the Periodic Surveillance Algorithm for the Nuclear Power Plant Protection System

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Abstract - Safety is emphasized in nuclear power plant system for its characteristic. One of the most important systems to guarantee the safety of nuclear power plant is the PPS (Power protection system). The measurement control system includes PPS, which is similar to the human nervous system, is very important factor not only for the safety but also for the operation. Therefore, developing a technology to level up the performance of measurement system and reliability of the plant will bring cost-effective and safe generation of nuclear power. In this study, I researched composition of digitized PPS and algorithm for cyclic inspection

1. Interoduction

Recently, electricity required for factories, houses and offices, is continuously increasing directly proportional to the development of industry and civilization. But facility expansion for electricity generation is restricted by the long term plan for its large scale. So, smooth supply of electricity depends on maximized use of present power generation facilities. Relative importance of the nuclear power plant is getting higher and higher in the aspect of environment and resource protection and it plays a great part in stable electricity supply as a base load. Safety is emphasized especially in nuclear power plant system for its characteristic. One of the most important systems to guarantee the safety of nuclear power plant is the PPS. The measurement control system includes PPS, which is similar to the human nervous system, is very important factor not only for the safety but also for the operation. Therefore, developing a technique to level up the performance of measurement system and reliability of the plant will bring cost-effective and safe generation of nuclear power. Safety is emphasized especially in nuclear power plant system for its characteristic. One of the most important systems to guarantee the safety of nuclear power plant is the PPS. The measurement control system includes PPS, which is similar to the human nervous system, is very important factor not only for the safety but also for the operation. Therefore, developing a technique to level up the performance of measurement system and reliability of the plant will bring cost-effective and safe generation of nuclear power. The contents of this study are

as follows:

In the chapter 2: Brief explanation on the protection system of nuclear power plant.

In the chapter 3: Suggested PPS design using PLC.

In the chapter 4: Experiment to prove the performance ability of the designed PPS and PSA. For this purpose, the researcher has realized one channel of PPS for nuclear power plant using PLC directly.

In the chapter 5: Summary of this chapter. The reseacher drew conclusion by summarizing the results discussed in each chapter.

2. Plant Protection System

2.1 Plant Protection System Overview

The PPS shall continuously monitor selected safety-related plant parameters to assure, at all times, that a safe plant status is maintained. The PPS shall automatically initiate plant protective action in the form of initiation of the appropriate protective function(Reactor Trip and Engineered Safety Features Actuation) whenever the monitored plant parameters reach a predetermined level. This function protects the pressure boundary of core fuel design limit and reactor coolant system at the time of occurrence of moderate frequency event or infrequent frequency event and helps the accident mitigation at the time of limiting accident.

The protection system of power plant offers 4 measurement channels isolated electrically and physically about each variable except the channel of position measurement of control element assembly. It offers 1 preliminary channel to enable 2-out-of-3 logic to be maintained by bypassing one channel out of 4 channels. If 2 channels or more reach trip-setting-value out of 4 measurement channels, it gives trip signal. Trip signal doesn't excite the coil of control element drive mechanism by intercepting electric source from motor-generator set and makes all the control rods fall at the lower part of core by gravity.

2.2 Plant Protection System Trip Signal Parameter

The PPS consists of measurement channels, processors, logics, and other circuits necessary to ensure a reliable and rapid reactor shutdown (reactor trip) if the like process parameter in two or more channels reaches a limiting of the safety system setting. The system's primary

function is to protect the reactor core and reactor coolant system pressure boundary and to assist the Engineered Safety Features Actuation System in limiting the consequences of certain accident conditions. The system's secondary function is to provide equipment protection, alarms, and limiting signals. The PPS initiate a reactor trip for the conditions stated below. Pretrip alarm is initiated prior the trip value to provide audible and visual indication of an approach to a trip condition. The trip sign and function of PPS are as follows:

- Variable Overpower Trip Signal
- High Logarithmic Power Level Trip Signal
- High Local Power Density(LPD) Trip Signal
- Low Departure From Nucleate Boiling Ratio (DNBR) Trip Signal
- High Pressurizer Pressure Trip Signal
- Low Pressurizer Pressure Trip Signal
- Low Steam Generator Water Level Trip Signal
- High Steam Generator Water Level Trip Signal
- Low Steam Generator Pressure Trip Signal
- High Containment Pressure Trip Signal
- Low Reactor Coolant Flow Trip Signal
- Manual Trip Signal

3. Design of Plant Protection System to using PLC

This researcher limits the structure of protection system of nuclear power plant to use digitized PLC on the basis of the contents examined in the summary and composition of protection system of nuclear power plant in the chapter 2. As is in Fig1. When this limit is digitized, design should be made, so that the requisites of H/W and S/W which are usable in the safety grade of nuclear power plant may be satisfied. And, the compositions suggested in this thesis should be designed, so that they may satisfy requisites.

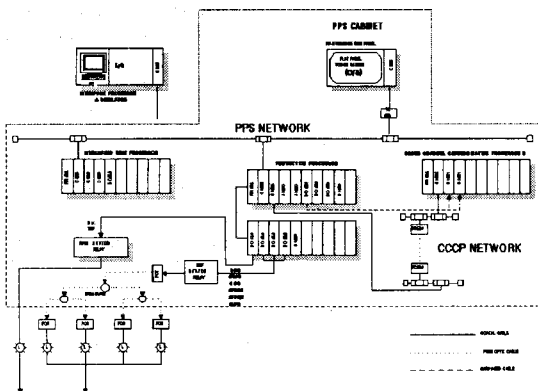


Fig1 Composition of Plant Protection System

4. Experiments and Results

For the experiment of suggested PPS composition chart and PST(Periodic Surveillance Test) algorithm, this researcher manufactured the experiment device to be able to realize the function like real spot. By being input about the process variable signal from simulator station, sending this to PTP and ITP(Integrated Test Processor) and using it in cyclic inspection test, this researcher tried to judge the existence or non-existence of abnormality of PPS system. PLC hardware used in experiment device is composed of 32bit Motorola processor, analog input and output module, digital input and output module and data communication module as the Master Advant Controller 110 Series of ABB company. Besides, as for software used in experiment device, functional block diagram that the verification and validation of software are easy was used. And, suggested algorithm was attached to the appendix of this thesis. These results of cyclic inspection test that hardware and software were used were indicated on MTP picture.

4.1 Devices used the Experiment

Firstly performed contents by using experiment device is to confirm whether the performance of suggested composition logics is performed properly. This minimum performance test is as follows:

- Realization of automatic test of manual initiation.
- Pretrip/Trip performance about the variables by each type.
- Bypass performance at the time of test.
- Confirmation of connection to other processor.

Photo1 is showing the real photo of simulator station.

4.2 Devices used the Experiment

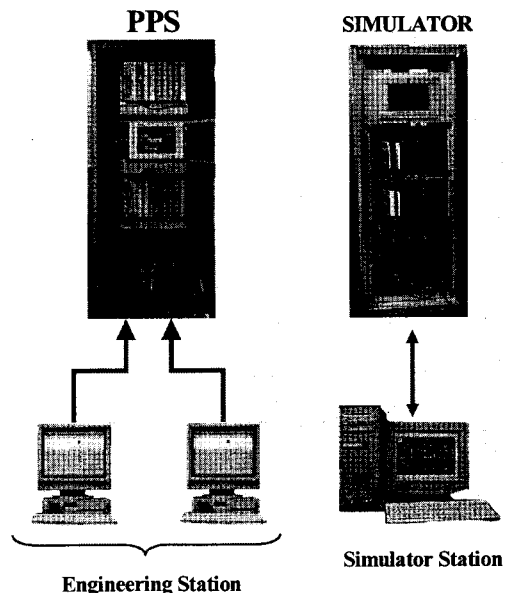


Photo 1 Simulator Station

4.2.1 Result and Study of Experiment

Suggested composition diagram and the experiment of PSA were executed by classifying into 2 kinds greatly. It was classified into Hardware test of experiment device and PST to be performed at ITP after being initiated at MTP. Hardware test means one basic performance test of experiment device, and Photo 2 is showing the form to do hardware test. That PST test is performed means that the communication and the algorithm suggested in each process were installed basically, and we may judge whether the transmission of signal was performed properly.

A. Rate limited variable trip

Rate limited variable trip permits the automatic



Photo 2 Hardware Test Form

increase and automatic decrease of set value to be caused by the operation of bistable input variable. This researcher made out algorithm, so that constant difference may be always maintained between bistable input value and set value. If input signal changed beyond the change rate of set value, in case that the difference between two values approaches zero, pretrip operates. And, in case that input signal is zero, trip appears. Once trip appears, set value doesn't change until trip signal is removed. Fig 2 is showing the result of Rate limited variable trip.

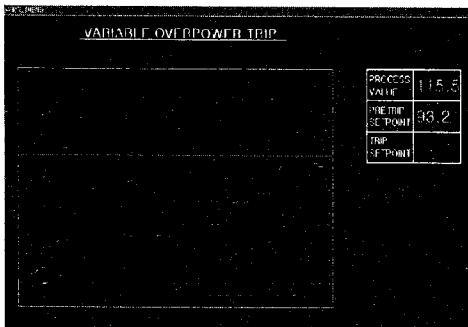


Fig 2 Variable Overpower Trip

B. Variable trip with manual reset

Variable trip with manual reset is the function

of input signal about bistable. This design concept is being made into the form to decrease the set value as much as a certain quantity automatically in resetting manually. When signal decreases, it decreases by resetting the set value below constant value than real input signal to exist at that time. Whenever the arrival at pretrip is made, nuclear power plant may be cooled without the operation of a certain unnecessary protection motion, as the operator resets the set value continuously. If input signal gets to increase beyond the value reset lastly, suggested algorithm is being programmed, so that set value may rise automatically, maintaining the constant value with input signal. Besides, it was designed, so that reset may be made again after the lapse as much as predetermined time interval after resetting.

C. Fixed trip

Fixed trip shows trip signal, when it is beyond already set value or below it. And, this is classified into rise trip and descent trip. For example, in case that real input signal is greater than pretrip, setpoint at the time of descent trip, design was made, so that alarm may be given. And, in case that real input signal is greater than trip setpoint, it gives trip signal. This result is showing the test result of high containment pressure out of high containment pressure, high logarithmic power level, High PZR pressure, Low SG level, and High SG level.

5. Conclusions

In this study, I presented the composition of digitized PPS, having operated on analogue base, using PLC, and PSA used for cyclic surveillance test, which is automatically performed after manual-initiation by an operator. In order to verify performance of the suggested composition and PSA, the researcher simulated the actual field by linking the miniature to the simulator of existing power plant. We designed the system to be operated automatically after initiation by an operator. The system was constituted to judge whether the test is possible or not by the status information from the channel. The results were satisfactory but only a part of variables were tested. So, study has to be continued using PLC model having greater capacity and faster PLC CUP considering of digitized conditions such as signal and communication with other systems.

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