Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 30-31, 2008

Expert System Interfaced ASSA Module for Fault Diagnosis for Instrumentation of Accident Conditions

Kil-Mo Koo, Yeon-Sik Kim, Won-Pil Beak, Hee-Yong Kang

Thermal-Hydrauric Safety Research Center, KAERI, 150 Dukjin-dong, Yuseong, Daejeon, 305-353, Korea, : kmkoo@kaeri.re.kr

1. Introduction

To keep the system safety, we have to increase two important parameters. The first parameter is the reliability of both system safety and system operators. The second is the availability of safety systems. The improvement of system reliability is the subject in this content. One of the major factors in reliability improvement needs a diagnosis system for the quick action item. This is offered by developing an export system that helps the operator to deduce the failed component in the control and safety system in case of emergency. Meanwhile, it also aids in an action the failed component immediately since the operator has already recognized it. Thus, using this export system, the reliability of both the operator and the system will be increased. This paper uses an new expert system interfaced ASSA (abnormal signal simulation analysis)[1] module for fault diagnosis of an instrumentation control systems. The ASSA module was developed by KAERI Lab lately. Therefore, our expert system could obtain enhanced signal patterns from the abnormal signals using an ASSA function instead of an old expert system [2-3].

2. Control System Description

This system starts by the emergency indication and as a result of some questions to the operator, who can arrive to the failed component. In some cases, it gives abnormal signal patterns and some advise for action information. It is difficult to analysis for the abnormal signals to be generated from the some transition condition in the facility. The main system is controlled by nine control rods; 3 safety rods, 4 manual rods, one automatic rod and one precise rod. The main system power is measured by seven ionization chambers, each connected to a measuring channel. Three channels are used to monitor the main system power. Three channels are used to monitor the main system period during the start up. One channel is connected to the automatic loop to operate the main system in automatic mode.

3. Basic logic for Expert System

The failure diagnosis starts from the alarm signal which is considered as the upper node of a tree. The end node of which is the cause of the alarm signal. This signal may be either actual or false. It is actual response when it comes from actual fail as indicated by the signal, while it is false when it comes due to a failure in the signaling system itself or the connection between the different circuits. As indicated in this logic, there will be an interaction between the operator and the expert system, beginning by the alarm or emergency signals and ending by a prescribed procedure for different errors according to the operator answer. There are three main knowledge base schemes that have found favor with expert systems designers: production rules, structured objects, and predicate logic [2]. Expert system uses the first scheme to represent knowledge; namely the production rules. Production rules, sometimes called condition-action rules, consist of a rule set, a rule interpreter or inference engine that decides how and when to apply which rule, and a working memory that can hold data. A rule is made of a list of IF conditions and lists of THEN and optionally ELSE conditions. If all the IF conditions in a rule are found to be true, then all the conditions in the THEN part are considered true. If any of the IF conditions is false, the rule fails and the ELSE conditions, if present, are considered true. If all the IF conditions is false, the rule fails and the ELSE conditions, if present, are considered true. Export system rules have two other optional parts, the NOTE and the REFERENCE parts. The NOTE part is used if it is required to point out something to the user when this rule is fired and displayed to it. The REFERENCE part is used if it is required to know the source of the knowledge represented in the rule (e.g. personal observation, page number of a book, etc.,) During the process of building the expert system, each rule added to the system, is checked for the consistency of it with other existing rules. The system then gives the user a listing of the rules which will be affected with the new rule. The user may determine whether the new rule will affect the system as required or it may modify the added rule to become as required.

4. Logic Diagram of the Control and Emergency Systems

The relation between the control circuits and the emergency circuit can be illustrated as follows: The three safety channels are connected to the emergency circuit through a two out of three relay system. If two channels measure a power increase of 20% of required power, the emergency circuit drops the control rods. Moreover if two channels fail to operate whether due to any component failure, the emergency circuit drops the control rod as shown in figure 1. The three period channels are also connected to the emergency circuit through a two out of three relay system.. If two channels measure a reactor period less than 15 sec., the emergency circuit drops the control rod. On the other hand if two channels fail to operate due to failure of any of its components, the emergency circuit drops the control rods. In addition to the previous two cases, the emergency circuit shutdown the reactor if the following events take place. The automatic rod reaches its down position during automatic mode of operation. The primary circuit flow or primary circuit pressure reduction by 20%. The electric power supplied whether AC or DC failure. Besides, there are over 40 warning signals coming directly from instrumentation to the signaling system to indicate abnormal situation of the different systems. Thus, we can imagine the tremendous amount of components inside the circuits that must be checked in case of abnormal patterns by any other condition occurrences. In this case, ASSA module could be applied to additional diagnosis methods when abnormal signals were generated from any conditional malfunction.

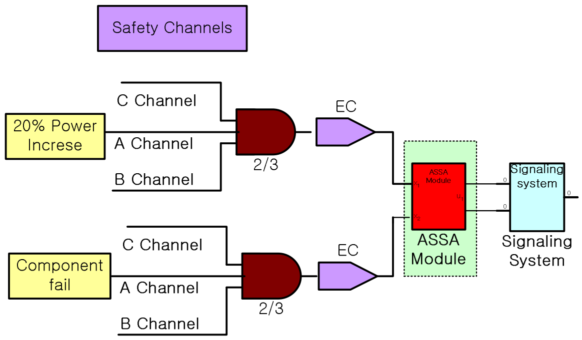

Fig. 1 Three safety channels connected to the emergency circuit of three relay system including ASSA module.

4.1 Aid ASSA Module

There are two sorts of programs which consist of the engine code and the tool code, that can work as a one body order system for this module. The overall result data can be used by one operation system as a one order command. Figure 2 shows detailed block diagrams for the signal processing and analysis from the ASSA module system. So that programs could be operated quickly and conveniently as an onsite instrument, in this simulation, we changed the element value in the circuit which is possible by directly changing the resistance-capacitance components in the initial screen menu of the tool code, so we do not need use the functions of the engine code. As a result, it is also possible to change the output signal patterns according to the changing element value in the tool code menu functions under any accident conditions. It is also easy and convenient for a signal analysis for some kinds of abnormal signal patterns and noise patterns. The output results can be extended and analyzed for response characteristics by the tool code, because the LabVIEW code has powerful analyzing functions. It also includes voltage or current sources that can be varied through the circuit simulation code to obtain realistic circuit response characteristics from environmental changes in the containment. A specific parameter includes: an input leakage (shunt) resistance that is affected by damages to an interconnecting cable. Input series resistance to represent the spliced connections that might be affected by a corrosion and whiskers phenomenon.

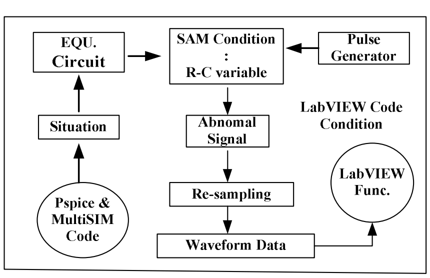

Fig. 2 Block diagrams for an ASSA module system

Using the ASSA module system, we could obtain the response characteristics from the output voltage levels of a pulse parameter according to a change of the resistance for each of resistance in the circuit, and the response characteristic from the output voltage level data and time constant of the pulse parameter according to a change of the capacitance for each of capacitance in the circuit. For the case of the pulse parameter following a change of the resistance, we obtained good response characteristics for the output voltage level data.

5. Conclusion

It is no doubt that the proposed expert system shall increase the system and operator reliability since it will help the operator to define and consequently to repair the system failure. The dialogue between the operator and the export system has benefits: It helps the operator to concentrate and derives his attention in the correct way. The unexperienced operator can learn much from the experience existed in the new expert system of the experienced previous operators. This expert system can be interfaced ASSA module, which has the following advantage: The dialogue is so simple and clear. The operator can add any new experience to this expert system. Operators can use this system efficiently and safely specially during emergency situations. The ASSA module system has been designed through a realization of a one body order system of one program linked to signal analysis tool programs and to an abnormal signal simulation engine as a one order command. The aforementioned 'one order command' means a non stop processing command to import the simulation data from the output of the engine code to the input of the main analysis tool program. The resulting data can also be taken by one operational system. As a result, it is also easy and convenient for a signal analysis for some kinds of abnormal signal patterns and noise patterns. Meanwhile, one of the major factors in reliability improvement will be possible as a diagnosis system for the quick action item through this new expert system interfaced ASSA module.

ACKNOWLEDGEMENT

This study has been carried out under the nuclear R&D program by the Korean Ministry of Science and Technology.

REFERENCES

[1] K. M. Koo, et, al., "Assessment of Existing Ul-Jin 3~4 Plants Instrumentation for Severe Accident Management" KSNP Fall Conference, 2004.

[2] "EXSYS Expert system Development Package, " EXSYS, Inc., 1985.

[3] Peter Jackson, "Introduction to export systems," Addison Wesley publishing company, 1986.

[4] M. E. Yancey, and R, C. Strahm, "Examination and Evaluation of THI-2 Transmitters CF-1-PT4 and CF-2-LT$", GEND-INF-029 Vol. III, 1985.

[5] A. J. Horn, R. W. James, D. E. True, "Assement of Existing Plant Instrumentation for Severe Accident Management" EPRI TR-103412 . [report], 1993.