Implementation of In-core Movable Detector Program for Flux Mapping System

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1. Introduction

The Flux Mapping System(FMS) provides a three-dimensional measurement of the reactor core power profile which is an accurate measure of the relative power sharing within the reactor core[1]. This data is used to detect fine-structure power peaking and gives a basis for fuel management[1]. A flux map in the form of detector current magnitude versus axial position is the measure of the neutron intensity of many areas of the reactor core. The FMS is composed of a detector drive system and a control system including operator console[2]. As a part of a FMS retrofit project for kori unit, we implemented the in-core movable detector program on the operator console for kori 2 and 4 unit. In this paper, FMS overview is introduced, and in-core movable detector(IMD) program implemented by KEPRI is described.

2. FMS Overview

The pressurized water reactor(PWR) power plant with a movable detector type neutron flux mapping system normally has thirty six to fifty thimbles depending on its power capacity, but a typical FMS has only four detector drives. So, multiple-path selectors are needed to route the detectors into all of the thimbles.

The FMS developed by KEPRI(Korea Electric Power Research Institute) has double indexing path selector (Dips®) architecture which is composed of four inner path selectors and an outer path selector as shown in Figure 1[2]. The inner path selectors are evenly allocated in a circular manner on the rotatable table of outer path selector which can be rotated 0 to 270 degrees at 90 degrees intervals. Due to this structure, any inner path selector can be rotated to substitute for the bad one. The FMS has 5 operation modes as shown in Table 1. Table 1 means that the FMS can work well even though three inner path selectors don't work.

Op Mode	Det. A	Det. B	Det. C	Det. D
Normal	A Group	B Group	C Group	D Group
Cal	Cal Path	Cal Path	Cal Path	Cal Path
Alt-1	B Group	C Group	D Group	A Group
Alt-2	C Group	D Group	A Group	B Group
Alt-3	D Group	A Group	B Group	C Group

Table 1. Operation Modes in FMS. In table, Cal is abbreviation of calibration, Alt is abbreviation of alternative, Det is abbreviation of detector.

The FMS are controlled by programmable logic controller(PLC) based digital controller with Windows® based operator console which provides fully automated and user-friendly operation and maintenance support means[3]. The operator console is equipped with various kinds of utility functions which provide detailed information about system operating status for the operator and maintenance personnel[3].

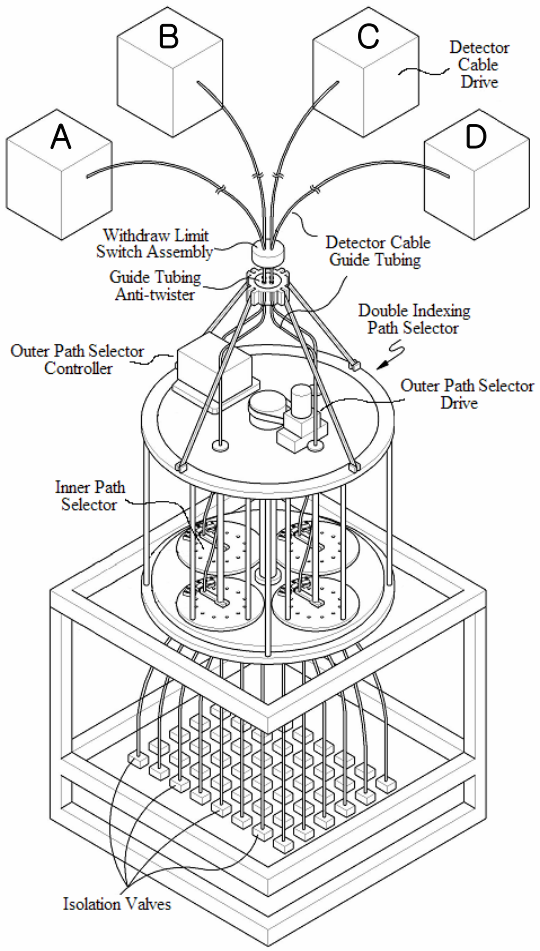

Figure 1. FMS with Dips® architecture

3. In-core Movable Detector program

In-core movable detector(IMD) program works on the operator console. IMD program collects the data on neutron flux map, saves the flux map data file, displays the flux map data including historical data, corrects the acquired flux map data via interpolation using adjacent data and recommends the voltage that is applied to detectors for measuring neutron flux. The implemented IMD program data and control flow is shown in Figure 2. PLC system controls FMS via hardwiring with I/O points. IMD program acquires the flux map data and

control commands via OPC(OLE for Process Control) interface with PLC control program. OPC is a standard interface in industrial control systems, with especially control operator console.

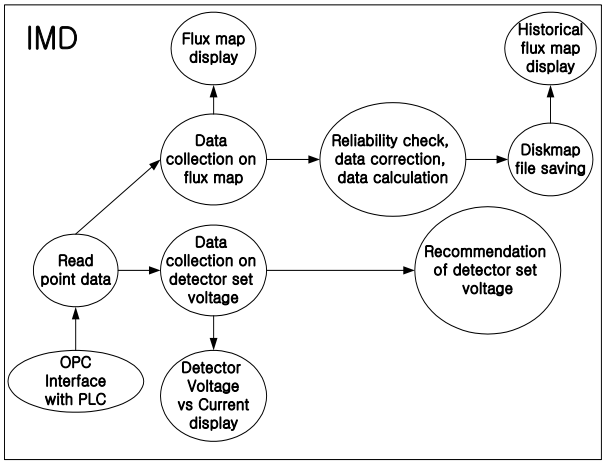

Figure 2. Data and control flow in IMD program

IMD program configuration is shown in Figure 3. IMD program has many subroutines. Some routines work every 200ms, others work asynchronously, for example, upon clicking mouse buttons. OPC interface with PLC occurs every 200ms. IMD program provides the operator with data files such as a disk map file, a summary file, a pass map file which can be used as inputs to incore program that verifies the reactor core design parameters, determines the fission power distribution in the core, and calculates the factors related to plant safety off-line. Subroutines shown in Figure 3 perform the functions described in Figure 2.

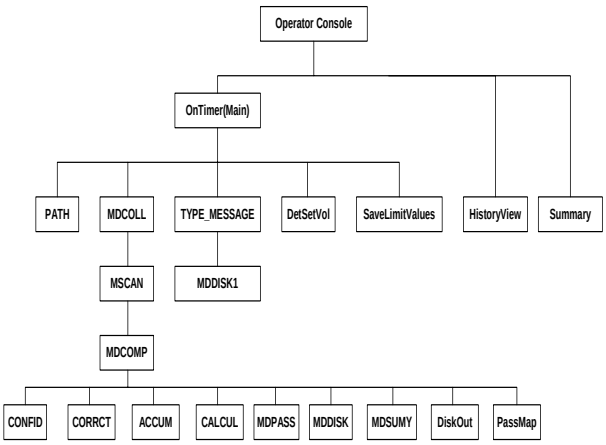

Figure 3. IMD program configuration

Figure 4 shows a IMD program display. IMD program display is largely composed of map display, plateau display and historical data display. Map display shows the operator the map data on-line. Map display can be used for measuring flux map data and setting top of fuel limit. Plateau display shows the plot of detector current magnitude versus the voltage applied to detector. Plateau also recommends the detector set voltage using center of gravity algorithm. Historical data display shows the historical flux map data, so previously measured flux map data can be retrieved on the display.

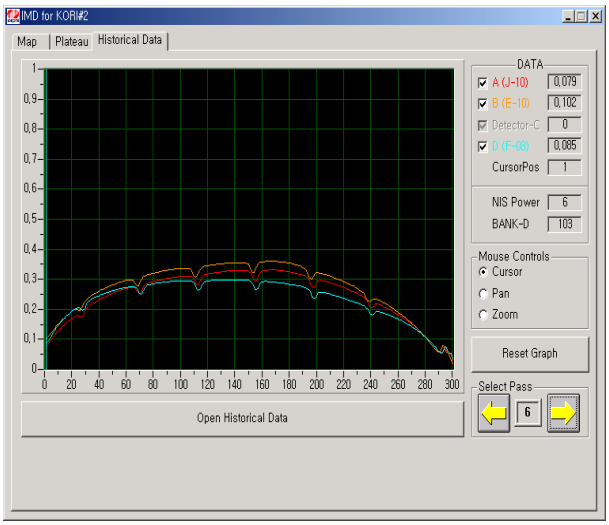

Figure 4. IMD program display

The implemented IMD programs were installed on the operator console for Kori units 4 and 2 in October 2004 and in January 2005 respectively, and have successfully worked. Historical data shown in Figure 4 are the distribution data of neutron flux at 5% reactor power of Kori unit 2.

4. Conclusion

IMD program that works in Windows® based operator console is implemented. The implemented IMD program has various kinds of functions that display real-time flux map data, plateau data, and historical flux map data, save the disk map file, pass map file and summary map file, recommend detector set voltage, and correct the acquired map data. Upgraded version of IMD program that has additional data abstraction function will be applied to Kori unit 3 in June 2005.

REFERENCES

[1] Flux Mapping System Technical Manual for Korea Electric Company Korea Units No. 5 and 6, Volume 1, Westinghouse Nuclear Energy Systems.
[2] Cho, Byung-Hak, et al., March 2003. The Development of an Advanced In-core Instrumentation Drive System for Kori Unit 1, KEPRI, Final Report of 99NS03.
[3] Shin, Chang-Hoon, et al., February 2002. The Development of Control Equipment of In-core Flux Mapping System, KEPRI, Final Report of 97SS10