Transactions of the Korean Nuclear Society Autumn Meeting
Busan, Korea, October 27-28, 2005

Instrumentation and Control system of ICRF Test Facility for Fusion Research

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1. Introduction

ICRF (Ion Cyclotron Range of Frequency) test facility[1] for fusion research in KAERI (Korea Atomic Energy Research Institute) includes a few several hundreds kW level of rf sources, dummy loads, impedance matching system, and antenna test chamber with auxiliary cooling systems. These test facility has been served for testing long pulse KSTAR ICRF antenna and other various rf components. All the subsystems are interconnected by rf power transmission lines and signal lines for monitoring, controlling and interlock. For the integration of necessary signals and achieving control goal, EPICS (Experimental Physical and Industrial Control System)[2] has been chosen. EPICS is a set of software tools and applications which provide a software infrastructure for use in building distributed control systems to operate large devices. Such distributed control systems typically comprise tens or even hundreds of computers, networked together to allow communication between them and to provide control and feedback of the various parts of the device from a central control room, or even remotely over the internet.

2. Software configuration

Because the number of components in test facility grew up during the last ten years, computer platforms and operating systems are various such as Windows and Linux for PXI, VXI and PC, and Vxworks for VME. EPICS has been proved quite reliable and efficient for these various configuration.

The most of device drivers has been available from EPICS distribution but a few PC card drivers were written by C language, and therefore, the most effort has been delivered to make control logic and OPI (OPerator Interface). The control logics made of EPICS records have been written by using graphical tool like VDCT (Visual Database Configuration Tool) or Sequencer language, which is consisted of quite convenient and efficient language, included in the EPICS module.

Visual OPIs are made of EDM (Extended Display Manager) or MEDM (Motif Editor and Display Manager), that consist of a collection of graphical objects that display and/or change the values of EPICS process variables. By using these supports, operators could configure the interface by their own tastes. Alarm Handler is another OPI that is designed to provide an effective overview of any outstanding alarm conditions reported by the control system and also give the ability to manage the alarms in detail.

One of major tool is for archiving experimental data on the hard disk of data server and retrieving/ manipulating these data for post-analysis. For this purpose, EPICS Channel Archiver, that archive any value that available via EPICS system, is used with a combination of Archive Viewer. Once the data is stored on the server, it can be retrieved with timestamp by Archive Viewer, and then can be modified or saved for further processing.

2. Hardware components

Control system for transmitter is the most complicated among the other subsystems in ICRF test facility. There are four bias power supplies for each three driving stages and they should have correct turn on/off sequence. For these automated sequential operation, EPICS Sequencer module is used. The interlock system monitors water/air coolant and power supply status, and when the flow rate does not meet the criterion or unusual behavior of power supply is found, bias power supplies is turned off sequentially. Detection of over loading due to the high reflection power triggers synthesizer to block source rf within 100 msec to protect tetrode.

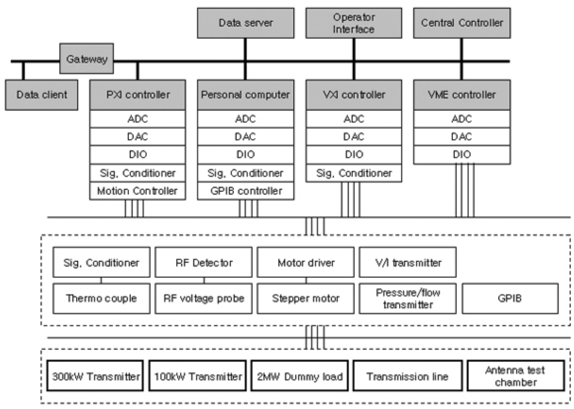

Figure 1. Configuration of instrumentation and control system of ICRF test facility.

The temperature of soda water flowing through dummy load should be maintained constant within pre-defined range of temperature because the impedance of dummy load depends on the temperature of soda water. For this purpose, PID algorithm included in the EPICS receives temperature of soda water and then control pneumatic valve inserted in the secondary cooling loop of dummy load. For example of OPI, screen shot of control display of dummy load is shown in Figure 2, and typical low power experimental data is shown in Figure 3. Because input power is far smaller than designed power of 2 MW, oscillating water temperature is quite visible.

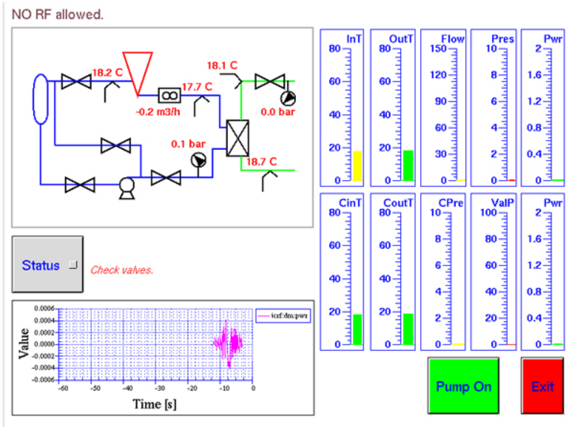

Figure 3. Screen shot of OPI of 2 MW soda water dummy load controller.

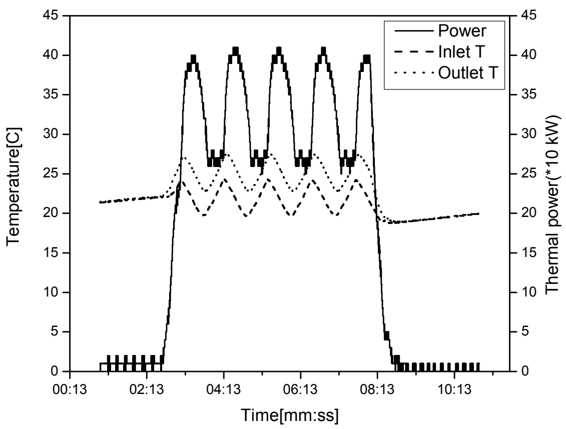

Figure 3. PID controlled water temperature with low applied power.

Because developing ICRF components is aiming to steady state operation for which controlling temperature increment is one of key factor, lots of thermocouples are attached on the transmission lines and antenna test chamber.[3] These signals should be conditioned before connected to the ADC. For rf voltage/current measurement, linear rf peak detector was developed and connected between rf probe and ADC.

3. Conclusion

For the integration of the instrumentation and control system for ICRF test facility in KAERI, EPICS was chosen and applied to various rf subsystems which were interconnected by rf transmission lines and signal lines. The integrated EPICS system has shown reliable and efficient performance with operator satisfaction. Because most software components have been pre-configured at the distribution stage, developing workload has not been high. Independent expansion of controller for new control target is relatively easy due to the modular design of software core and the inter-connectivity by the network.

REFERENCES

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[3] Y. D. Bae, J. G. Kwak, S. K. Kim, J. S. Yoon, B. G. Hong, C. K. Hwang, S. J. Wang, S. U. Jeong, Nucl. Fusion, **43**, pp. 805, 2003