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

The ICRF Control System for the KSTAR First Plasma

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1. Introduction

The first operation of ICRF discharge cleaning[1] and fast wave electron heating was performed on the KSTAR tokamak. For operation and diagnostics, ICRF local network was designed and implemented. This network provides monitoring, RF protection, remote control and RF diagnostics. All the functions of the instrumentation were realized by customized DSP board. The DSP boards were tied by local network in parallel manner. As a local control system of KSTAR machine, the ICRF instrumentation must be compatible with the central tokamak control system[2]. For this purpose, three different kinds of central networks(experiment, interlock and timing networks) were connected. Details of instrumentation and the experimental results are presented

2. Instrumentation

The functions of the ICRF control and data acquisition system are realized by using six independent digital signal processor (DSP) modules with customized peripheral boards. The number of channels(ADC-18, DAC-4, DIN-16, DOUT-8) for the board has been thought to be enough for a specific function. The C codes written in each DSP do not exceed several hundred lines so that the maintenance is relatively simplified. The DSPs are basically connected by local TCP/IP network which is disconnected to the outer world. Through this network, control and monitor signals which are not sensitive to the sampling time are transferred in near realtime. At the end of tokamak shot, the sampled arrays are collected through the same network. The governing controller of this network is made of single PC with Linux operating system equipped with EPICS input/output controller (IOC). Because the most time-demanding functions are reserved to the DSPs, CPU usage of the PC was less than 10 %.

For a few fast communications, such as internal interlock or trigger, optical fiber was connected between DIN/DOUT of DSPs. The governing PC knows only the post-event for the monitoring purpose.

The details of some functions are describes in the following sections.

2.1 Protection

Unexpected voltage rising is the most harmful or probable event for the ICRF system. The RF voltage exceeding certain limit (~35 kV for 9-3/16" transmission line) may destroy the RF components. High VSWR, which can be expressed by maximum and minimum RF voltages, also degrades the performance of transmitter. This event can be arisen by the variation of loading resistance due to the edge plasma fluctuation including abrupt plasma termination or arcing in the transmission line. To protect the system, three independent methods are provided. The first is the self protection of the transmitter. High VSWR detected at the output of the transmitter cuts the RF input of the transmitter within tens of us. The input is recovered delayed by several ms automatically. The second is over voltage protection. If one of the four voltages measured at the resonant loops are exceeding predefined value, the input of the transmitter is disconnected within us. The disconnection will not be automatically recovered and recorded as ICRF fault. The third method is activated by central PCS. When PCS detects fault, it activates no-go signal of ICRF . The three methods were operated successfully for the first campaign of KSTAR ICRF.

2.2 Diagnostics

The complex RF voltage was measured by digital I/Q detector. The detector directly samples the down converted IF without LO or Mixers so that there is no I/Q imbalance errors. The linear dynamic range of the RF amplitude exceeds 43 dB. Measured complex RF voltages are used to monitor the voltage/current distribution or the impedance of the transmission line.

3. Summary

Automated control and data acquisition system for ICRF were operated successfully during the first campaign of KSTAR. The ICRF system was reasonably protected from unintentional voltage rising during the operation. The RF voltage/current distribution and complex impedance of transmission line were measured by digital I/Q detectors.

REFERENCES

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