Maintenance and development of the RIBF control system

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We report on the maintenance work and development of the RIBF control system, which include addressing a problem experienced with a beam interlock system (BIS),[1] upgrades for two types of control boards used for magnet power supplies and an extension of the control system to install a new beam transport line.

The RIBF control system consists of two parts according to the development of RIBF. One of them is used for the old facility, once called the RIKEN Accelerator Research Facility (RARF), which started its operation in 1986. The other is the new facility that started its operation in 2006. A BIS was developed to protect the hardware of the RIBF accelerator complex from unallowable beam losses for high-power heavy ion beams. The BIS is composed mainly of Melsec PLCs[2] that process many interlock signals, such as failure signals sent from rf systems used in our cyclotrons, magnet power supplies, and vacuum gate valves in beam transport lines, within 1ms. At the RIBF facility, there are two sets of BIS working for the old facility and the new facility as well as the control system. In 2014, we experienced for the first time a serious problem in which several interlock conditions were changed without any command inputs. After careful investigations, the cause of this malfunction, a failure of the CPU module used in the BIS, was rectified by replacing the existing CPU module with a spare one. Because the hardware used in the BIS is aging and the trigger of this malfunction is unclear, we prepared spare CPU modules in preparation for similar troubles in the future; this would be effective in reducing downtimes during RIBF operation.

The second topic is upgrades for the Network-I/O (NIO) system. The NIO is a commercially available control system manufactured by Hitachi Zosen Corporation. It is widely used to control many magnet power supplies used in the new facility and a part of the old facility. The NIO system consists of several types of controllers. The NIO-S board is directly attached to a magnet power supply and controls it according to a signal from an upper-level control system. About 500 NIO-S boards are used in RIBF. The NIO-C board works as a master board of NIO-S boards and is designed to run in VME computing machines. The NIO-C and the NIO-S are connected by an optical cable through a branch board. The existing NIO system has been working stably but production of the present NIO-S board was terminated because some parts are unavailable today. Therefore, we developed a successor of the existing NIO-S board in 2013 and this year we ran its performance tests. This successor was designed to be compatible with the existing NIO-S board but the performance tests revealed that some types of magnet power supplies cannot be controlled by the successor because the widths of some output pulses produced by the successor are slightly different from those given by the existing one. Currently, finding a solution to stably control these magnet power supplies is under consideration.

On the other hand, production of the NIO-C has also been completed for the same reason as in the case of NIO-S. Hence, we should also develop a successor board of the present NIO-C. Its R&D started in 2014. The specifications required for the new board are essentially the same as for the existing one, but we decided to design the new board to run in a control system constructed by PLC modules instead of the VME computing environment currently used, in order to achieve cost reduction and functional scalability. We started the design of its prototype in 2014, which is scheduled to be delivered in March 2015. Software developments required for the successor board are scheduled in 2015, where some new features will be added.

The third topic is extension of the control system to cover a new beam transport line now under construction, aiming at increasing the available beam energies in the existing beam irradiation port dedicated to biological experiments. The new beam line transports a beam extracted from the intermediate stage ring cyclotron (IRC) to the E5 experimental vault (hereafter, IRC-E5 BL). The control system for the IRC-E5 BL is constructed as a natural extension of the existing control system of the RIBF accelerator complex by adding the new components used in the IRC-E5 BL to the existing control system because no new types of components are installed in the IRC-E5 BL. Magnet power supplies are controlled by the NIO system and F3RP61,[3] which is a Linux-based PLC-CPU module manufactured by Yokogawa Electric Corporation, on which EPICS programs can be executed. Vacuum systems and beam diagnostic devices such as beam profile monitors are controlled using in-house controllers' Network Device Interface Module (N-DIM[4]) as well as the other beam transport lines of the RIBF accelerator complex. Regarding the beam interlock signals of the IRC-E5 BL, we incorporate them into BIS. Beam commissioning is scheduled in January 2015.

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