New operation interface for rf voltage and phase of RIBF cyclotrons using rotary encoder

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The RIBF accelerator complex can accelerate all kinds of ions up to $\beta = v/c = 0.7$ via a four-stage cascade of ring cyclotrons, i.e., the RIKEN Ring Cyclotron (RRC), fixed-frequency Ring Cyclotron (fRC), Intermediate-energy Ring Cyclotron (IRC), and Superconducting Ring Cyclotron (SRC). The rf systems for these cyclotrons are controlled by using an individual programmable logic controller (PLC) for every rf resonator. The remote control interface for the fRC, IRC, and SRC accomplished in 2006 has been actualized by an Ethernet connection to PLCs using a PC base driver and SCADA software of Wonderware InTouch 9.5. The remote control interface had some problems such as slow response and disconnection of network owing to the use of an older-generation PLC. Thus, we have constructed a new operation interface to remotely control the rf voltage and phase using rotary encoders such as that for the RRC instead of using mouse clicks in order to realize smooth and comfortable operation of the cyclotrons.

Figure 1 shows a schematic of the new remote control system. The remote control interface is directly connected to an additional PLC (OMRON CS1H) installed in the control room. The signals of rotary encoders are counted by fast counter modules of the PLC and converted to set point data for the rf voltage and phase, which are stored in the PLC memory. The data are distributed to relay PLCs installed in the vicinity of the existing RF control PLCs for the fRC, IRC, and SRC through a private data link network using Controller Link. Each relay PLC is connected to the existing RF control PLCs via an open field network, DeviceNet, because the existing PLCs were already discontinuous product but they had been incorporated in the DeviceNet master module.

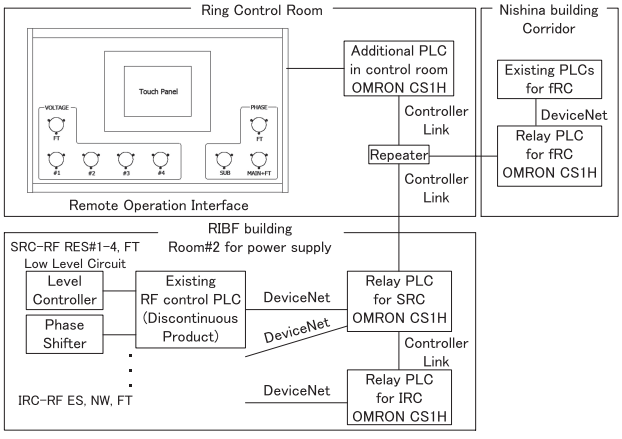

Fig. 1. Schematic of the new remote control system for RIBF cyclotrons.

As shown in Fig. 2, two hardware buttons, eight rotary encoders, and a touch panel are mounted on the interface. One of the hardware buttons is a LOCK button and the other is a SET button similar to the RRC interface. The control inhibition has to be released by the LOCK button to start the operation using encoders, and the control is automatically inhibited after 3 min. A control target cyclotron, fRC, IRC, or SRC has to be selected using the touch panel. When the lock is released, the all present set points of the rf voltage and phase on the existing RF control PLCs are imported to the memory on the PLC installed in the control room, and the operation using the conventional PC base control is invalidated, which ensures compatibility. The group of rotary encoders on the left is for rf voltage control, whereas the group on the right is for rf phase control. The voltage setting of all the rf resonators can be adjusted individually. The phase setting of the main acceleration resonators is adjusted using a rotary encoder simultaneously, and the phase setting of the flat-top resonator is adjusted independently. All the present values of voltage and phase, set points, and control step sizes are indicated on the touch panel. The control step size can be selected using the touch panel. The present set points can be saved to memory by pushing the SET button up to ten times.

The new system was successfully commissioned in March 2015 and was operated during the RIBF experiments without problems. Owing to the introduction of the new interface, smooth operation with a response ten times faster than that of previous systems and no network connection issues will lead to optimum tuning of the rf voltage and phase for the RIBF cyclotrons.

Fig. 2. Remote control interface for the new system.

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