Reconstruction of RF system controller for RIKEN Ring Cyclotron

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The RIKEN Ring Cyclotron (RRC) has been supplying beams for various experiments as the key accelerator of RIKEN Nishina Center for over 30 years. The RRC has two sets of acceleration cavities and RF power amplifiers,[1] and each set is controlled by an independent controller system. Most controllers of the RRC's RF system consist of hardware logic using relays and analog transmission to/from low-level circuits and analog meter. Equipment for RF voltage setting, RF phase setting, drivers of frequency tuners and RF power coupler, and drivers of RF matching circuits for amplifier were controlled by independent control boxes for each device. A programmable logic controller (PLC) was used for the indicator control and remote operation interface, and it was replaced in 2004 without changing the system configuration. By updating the low-level circuits in 2007, the analog voltage outputs from the RF voltage and phase setting boxes were converted to digital signals by additional converters and connected to the new low-level circuits. The data logging system did not work because it was old and outdated. The previous hardware type control system could not freely set operation parameters like the frequency tuning system, which caused significant interruption in the machine time. To solve such inconveniences, we decided to update the system that can be integrated and controlled by a PLC.

The new system is controlled by the Mitsubishi Electric MELSEC-Q series PLC and a touch panel for human-machine interface. Figure 1 shows images of the main part of the original control rack and updated control rack. The low-level circuits were transferred from the RRC room to the underground passage and integrated into the PLC control rack, as shown in the right panel of Fig. 1, and controlled directly by the PLC. Power supplies for the tetrodes in the RF amplifier were also controlled directly by the PLC. We replaced the all old signal transducers of the filament and plate power supplies as well as the power supplies for grid electrodes. The old two-phase stepping motors for the two movable boxes, trimmer, and RF power coupler were replaced with a new five-phase stepping motor, SANYO DENKI FSF893S, which can set parameters such as the driving speed. The remote operation of the system was integrated into the operation terminal of RILAC2[2] through Ethernet using the SCADA software of Wanderware InTouch. The operations of RF voltage and phase were also integrated into the operational interface[3] using rotary encoders through the CC-Link slave interface, Anywire AFCS02.

The control system for RRC's RF was successfully updated in March 2016. Owing to these modifications, several improvements were obtained. The time of RF re-excitation when discharged was curtailed from 30 min to a few minutes. The RF voltage was enhanced by more than 10% by the assured automatic re-excitation function. The amplifier damage at the RF voltage trip was significantly reduced by the voltage rump-up function. The resolutions of RF voltage and phase set points were improved from 1/10000 to 1/30000 and 1/36000, respectively. The control system upgrade contributed to the stabilization of beam operation during the RIBF experiment and further performance improvement is expected in combination with the cavity upgrade of RRC reported in Ref. 4).

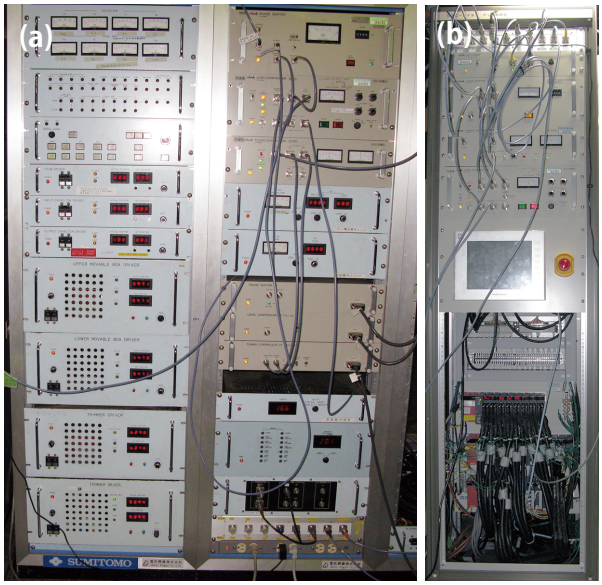

Fig. 1. Main part of control system before (left panel) and after (right panel) the upgrade.

References

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