Upgrading electromagnet power supply for superheavy element research in RIKEN heavy ion linear accelerator

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The RIKEN Heavy Ion Linear Accelerator (RILAC) stands as the accelerator that paved the way for the discovery of the 113th element, nihonium.[1] To further enhance beam energy for superheavy element research capabilities, downstream from the RILAC, a Superconducting RIKEN Linear Accelerator (SRILAC) was introduced. Since the beam commissioning in 2020,[2] we have actively provided a beam for the experiment of synthesis of a new superheavy element 119. To facilitate experiments related to the exploration of the element 119, a stable high-intensity vanadium ion beam must be reliably supplied to a gas-filled recoil ion separator (GARIS-III). As part of the SRILAC project, a 28-GHz superconducting electron cyclotron resonance ion source (R28G-K)[3] was installed at the most upstream position of the beam course for GARIS-III. It is essential to achieve high stability in the power supply for the main coil of the gyrotron used in the R28G-K for maintaining a highly stable beam intensity from the ion source.

In addition to the gyrotron main coil, dropper-type old power supplies have been utilized for more than 35 years for the solenoid electromagnet downstream of the R28G-K, in addition to the power supplies for the bending electromagnets and quadrupole electromagnets in the beam injection line. As part of the effort to address aging issues and promote energy-efficient operation, an upgrade to the widely adopted switching-type power supply used at the RIKEN Radioactive Isotope Beam Factory (RIBF) has been initiated. The progress of the power supply upgrade is depicted in Fig. 1. The upgraded power supplies are controlled by a VME-based remote control system utilizing NIO, a standard controller of the RIBF electromagnet remote control system.[4]

The upgraded power supplies nine in all include one main coil power supply for the gyrotron, two for solenoid electromagnets, two for bending electromagnets, and four for quadrupole electromagnets. The electromagnet power supply for RILAC does not require the same level of performance as the power supply for the main coil of the RIKEN Ring cyclotron, which requires the maximum stability. However, the operational testing of the gyrotron's main coil power supply demonstrated stability, meeting the stringent requirement of $\pm 3 \times 10^{-5}/8$ hours as output current value with the same performance as the standard stability power supply in RIBF. Furthermore, the test was conducted by setting the current values of the power supplies as operational parameters relevant to actual superheavy element experiments and comparing the performance of seven out of the nine newly installed power supplies with conventional dropper-type power supplies. The results indicated a remarkable reduction in power consumption by approximately 64%, that is, significant energy savings were achiebed.

Fig. 1. Photograph of two power supply enclosures installed in the RILAC accelerator room, with four power supplies installed per enclosure.

Although nine power supplies have been replaced this time, RILAC still has old power supplies that have been in use for over 35 years, so we would like to update these in stages.

References
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