# Magnet power supplies for GARIS-II

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The superheavy element production team at RIKEN Nishina Center is planning to produce the elements with atomic numbers z = 119 and 120. For early implementation of the project, we planned to relocate GARIS-II[1] from RILAC to the downstream of RRC. The production of new elements will be accelerated by irradiation in parallel with GARIS-III, which will be newly built in RILAC in FY2018. The GARIS-II was relocated to the E6 experimental room. The vanadium beam accelerated by RILAC2 and RRC is guided to GARIS-II after passing through the RIPS-Q6 magnet.

The magnets of GARIS-II consist of two bending magnets and three quadrupole magnets. Two quadrupole magnets and a set of steering magnets were placed upstream of GARIS-II magnets for beam transport. Since the power supplies used in RILAC have been used for GARIS-III, other power supplies had to be prepared. Table 1 summarizes the requested specifications of the power supply for the GARIS-II magnets and their current and voltage specifications. The detectors used in GARIS-II are susceptible to noise. When a power supply using thyristors as a pre-regulator was used for exciting a dipole magnet in GARIS-I, which was installed in RILAC, the noise affected the detectors in some cases. We decided to apply existing power supplies which use a saturable reactor as a pre-regulator as power supplies for five GARIS-II magnets. The four power supplies used for the RIKEN Projectile-fragment Separator (RIPS) and a power supply used in the past for the E2 dipole magnet were used. These supplies are already used not only for RIPS magnets but also for the injection/extraction magnet for the fRC cyclotron and a magnet for beam transport to the E5 experimental room. The connection between the power supply and the magnets for each beam course could be switched using the switching board placed in the E4 experimental room. Since the switching board was able to switch only to two courses (RIPS or fRC/BT), the switching sequence in the board was modified so that it could be switched to three courses (RIPS, fRC/BT and GARIS-II). Figure 1 shows the switching sequence of power supplies.

The maximum current of the power supply connected to GARIS2-D1 is nearly 2 times larger than the allowable current of the magnet. To prevent operational errors, a voltage sensor is planned to be installed in February 2018 on the load terminal to turn off the power when the voltage is higher than the allowable voltage of the magnet. It will be installed.

The power supplies that excite the double quadrupole magnets and a set of steering magnets placed upstream of GARIS-II were switched from the triplet quadrupole (QTD17) and a set of steering magnets (STH16) on the beam transport line to fRC. The switching board was relocated from the E4 experimental room, where it was used previously, to a place near the beam transport line in the D room.

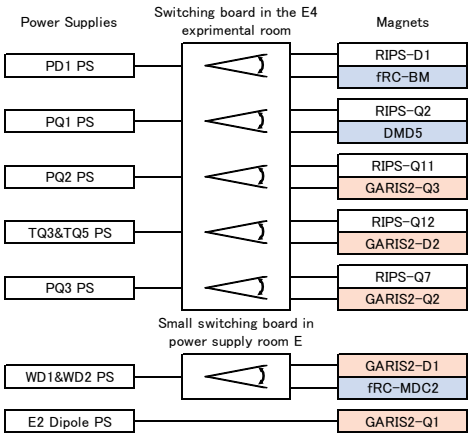


Fig. 1. Switching sequence of the connections of RIPS, fRC/BT and GARIS-II magnets.

Table 1. Specifications of power supplies for GARIS-II magnets.

| Region | GARIS-Ⅱ Magnet | Required Specification | Power supply | Max.Current & Voltage |
|---|---|---|---|---|
| Beam transport line | SH6A0 | (10A)[a)] | E-S1(E-ST7) | 5A-35V |
| | SV6A0 | (10A)[a)] | E-S1(E-ST8) | 5A-35V |
| | QD6A1a | (260A)[a)] | E-Q1P(E-Q7) | 150A-24.3V |
| | QD6A1b | (260A)[a)] | E-Q1P(E-Q8) | 150A-32.3V |
| Target | | | | |
| GARIS-Ⅱ | GARIS2-Q1 | 380A-90V | E2 Dipole | 600A-92V |
| | GARIS2-D1 | 600A-160V | WD1&WD2-PS | 1040A-270V |
| | GARIS2-Q2 | 350A-100V | PQ3-PS | 330A-95V |
| | GARIS2-Q3 | 350A-120V | PQ2-PS | 550A-150V |
| | GARIS2-D2 | 440A-55V | TQ3&TQ5-PS | 450A-80V |

[a)] Specifications when the magnets were placed in RILAC

After the wiring and the protection interlock test, the current output test for GARIS-II magnets was performed. It is necessary to adjust the power supplies so that stable current can be fed to both magnets on RIPS, fRC and GARIS-II. Most power supplies could feed stable current without matching adjustment of the feedback circuit. For the E2 dipole magnet power supply, the output current was stabilized by replacing the 3-terminal regulator that generate voltage of ±15 V DC for the error amplifier and the capacitors around it in the feedback loop circuit.

The commissioning of GARIS-II started in December 2017. The power supplies performed satisfactorily. In FY2018, DC current transformers will be installed to measure the precise current of power supplies.

Reference

1) D. Kaji, K. Morimoto, The Japan Society of Nuclear and Radiochemical Sciences **34**, 12–23 (2016).

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