Deployment of a beam interlock system driven by changes in magnet current (Curs-BIS) at the RI Beam Factory

K. Kumagai[*1] and A. Uchiyama[*1]

The beam intensity has been gradually increasing at the RI Beam Factory. To prevent accidents such as melting of the vacuum chamber due to the beam orbit change, a system to detect the current change of the magnets due to unknown causes or noises during the beam operation and to stop the beam is required. The beam interlock system driven by changes in magnet current (Curs-BIS) was developed in 2019.[1)] The developed system could detect the current values of 24 magnet power supplies per unit, and now it can detect the current values of 48 power supplies. One unit of the Curs-BIS is shown in Fig. 1. Various improvements have been made to the sequence and web-based monitoring programs. The interlock signal is not erroneously when the power supply is set from 0 A, and the inactivity time of the interlock signal was adjusted according to the energizing characteristics of each power supply. It is now possible to directly link the monitoring screen to a table of power supply specifications and a graph of fluctuations in the current value of each power supply.

Three units of the system are currently installed in IRC and SRC, four units in the beam transport line of the RIBF, eight units in the RARF (the old facility) and fRC, three units in RILAC2 and AVF, three units in RILAC. The sequence program is the same for all units, and each unit can be operated independently by simply changing the parameter file for magnet power supply specifications, upper and lower limits of current values, *etc.*

Accelerators have various types and ages of magnet power supplies, and the current value of the magnet power supply is detected in three main ways. Power supplies with a very high current stability, such as cyclotron main power supplies, usually have a DCCT for monitoring in addition to the DCCT for power supply control; therefore, the monitor output is used for detection. For power supplies that do not have a high-precision DCCT for monitoring, an inexpensive external DCCT is installed to detect the current, although the output accuracy is poor at ±1% of full scale. For some power supplies, the signal from the feedback circuit is branched off and the signal through the isolation amplifier is detected. The Curs-BIS system is set to emit an interlock when the power supply current value fluctuates by more than ±1% of the rated current as the initial value, but it can be changed. For the power supply for steering magnets, the value is ±5% of the rated value.

The system is also used for the early detection of supply current oscillation in scenarios in which the feedback control of the power supply is not operating properly.

Fig. 1. Picture of a unit of the beam interlock system driven by changes in the magnet current (Curs-BIS).

A beam interlock system for detecting EIC and EDC discharges was also build using the same method as the Curs-BIS. The EIC and EDC are electric-field beam deflection channels used for beam injection and extraction of the cyclotron. The beam is deflected by applying a high voltage of approximately 100 kV to an electrode plate placed in the beam orbit. Because a high electric field is applied between the plates of ten and several millimeters, discharges often occur and the beam orbit is changed. Therefore, the beam should be stopped as soon as the discharge occurs.

Discharges were detected using only the actual voltage change with an analog type circuit. Now, a system similar to the Curs-BIS can stop the beam by detecting the change in the actual voltage and current replenishment due to the discharge. The system was installed in the cyclotrons of the SRC and IRC in parallel usage with the analog circuit. Since the RRC and fRC cyclotrons did not have a discharge detection system, this system was newly installed. With the system, the allowable value can be changed on the monitor screen, which was previously changed on site using the analog circuit. The system can also stop the beam under a sudden change in the set voltage and maintain a log of the number of discharges per hour, which can be monitored on the Web.

Most of the power supplies in the RIBF are now being monitored using Curs-BIS, but a few 10% of the power supplies on the RARF remain to be set. We are planning to increase the number of registered power supplies.

Reference

1) K. Kumagai *et al.*, RIKEN Accel. Prog. Rep. **52**, 115 (2019).

*1 RIKEN Nishina Center