

Development of a system for monitoring electromagnet current fluctuations[†]

K. Kumagai,^{*1} A. Uchiyama,^{*1} and S. Fukuzawa^{*2}

The total number of electromagnet power supplies in RILAC, the old facility (RARF), and the new facility (RIBF) at the RIKEN Nishina Center is more than 850. As part of the accelerator control system, a Beam Interlock System (BIS) is used to stop the beam immediately if a problem with the accelerator components occurs, *e.g.*, with the power supply itself or its load, with the RF accelerator system, or with a change in the beam trajectory.¹⁾ For power supplies, they all have built-in relays or contact sequences that open when they fail or are turned off and send a signal to the BIS.

In 2017, the vacuum in the Superconducting Ring Cyclotron (SRC) deteriorated owing to a sudden beam loss during beam delivery. Investigations revealed that the power supply current of the steering magnet in the injection section of the SRC spontaneously changed from -24 to -97 A due to noise, causing the beam to hit the bellows at this point. We realized that we needed to develop a system that would monitor not only power supply failures but also current fluctuations and send a signal to the BIS if any anomaly occurred. The schematic of this system, called a magnet current fluctuation monitoring system (Curs-BIS), is shown in Fig. 1. The Curs-BIS consists of FA-M3V series programmable controller modules from Yokogawa Electric Corporation. The program, which monitors the current values of 48 power supplies, detects anomalies and sends out a signal to the BIS, runs on a sequence CPU. As the power supplies are controlled using the software EPICS,²⁾ the system is also equipped with a real-time CPU module running the EPICS Channel Access client. Although the power supply currents are constantly driven by the operator to control the beam, information from the real-time CPU enables the system to determine whether the current change is due to control or has occurred on its own, and it only sends a signal to the BIS in the latter case.

The current value of each power supply is measured in three main ways. (1) A “DC current transformer (DCCT) for monitoring” built into the power supply. (2) An inexpensive, simple, general purpose DC current sensor mounted externally. (3) A branch and isolated output of the “DCCT for current feedback” or of the shunt. The current values are measured simultaneously by the Curs-BIS system and a multiplexer type digital voltmeter (DVM) capable of 6.5-digit pre-

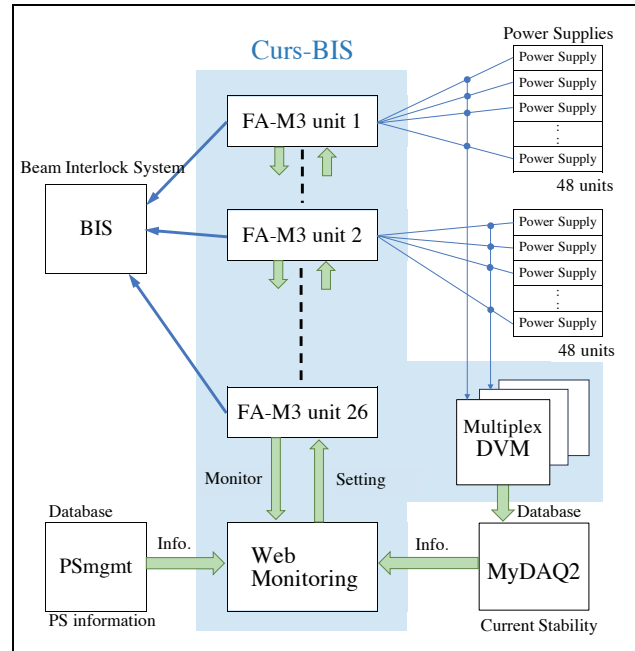


Fig. 1. Schematic view of the Curs-BIS.

cision measurements up to 60 channels, and these data are recorded in a simple data acquisition system MyDAQ2.³⁾

The Curs-BIS operates automatically by simply switching on the FA-M3 unit, and its operation can be monitored on a Web screen. A PC acting as a Web server accesses all FA-M3 units once per second, retrieves current data and interlock signal logs, and displays them on the screen. The Web screen also enables the user to change the current reference value, upper and lower limits, and BIS output masks for individual power supplies, if necessary. The Web screen is linked directly to a time series graph of the current values recorded in MyDAQ2, enabling the user to immediately check the status of the power supplies. In addition, the Web screen is linked to a database called PSmgmt (Power Supply Management),⁴⁾ which contains power supply specifications, drawings, failure histories and photographs, allowing users to quickly check power supply specifications.

Installation of the Curs-BIS system began in 2018, with several units installed, wired, connected, and tuned each year. The installation of 26 units (11 in the new facility, 11 in the old facility and 4 in RILAC), covering all 851 power supplies, was completed in 2023. The system is used in beam delivery, with software modifications and bug fixes.

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^{*1} RIKEN Nishina Center

^{*2} SHI Accelerator Service Ltd.

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