Installation of changeover switches for dipole and quadrupole magnet on a new beam transport line

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A new beam transport line dedicated to provide high-energy beams for biological experiments was constructed in the last year[1), 2)]. Beam commissioning of the beam line was carried out from January 24th to 25th in 2015. A 160MeV/u ^{40}Ar beam was transported from a beam exiting point of IRC to the confluent point connected to the existing beam line within 30 min. After the beam commissioning succeeded, an Ar beam was transported to the E5 experimental vault and beam irradiation to seaweed samples was carried out promptly.

One-third of dipole magnets and two-thirds of quadruple magnets on the new beam transport line were operated with existing power supplies by switching or changing the polarity of the magnet. At the time of commissioning, the switching of the magnets and/or their polarity was performed manually. The switching of all magnets took several hours. Because it was assumed that the frequency in use of the beam line becomes larger by having succeeded in the beam commissioning, we decided to install power source changeover switches to switch magnets and/or their polarity automatically using buttons.

Table 1 summarizes the scheme of the switching for the dipole magnets and Table 2 shows that for the quadrupole magnets. The automatic transfer switch type SSK-C produced by KYORITSU KEIKI CO., LTD. was used to switch dipole magnets, and type SSK-E was used to switch quadrupole magnets. Both switches have the functions of instantaneous excitation and mechanical holding. In the case of quadrupole magnets, two families of circuits can be switched using one switch. In the case of resistive load, these switches were designed such that switching was possible in the state in which an electric direct current spread in, but the inductance of the magnet might damage the contacts of switches. We designed the switches such that they are not able to switch when an electric current flows. In addition, they were not able to switch when the current sensing device broke down. An electric current passing through the circuit was detected by the current sensing device using a shunt resistor. It is designed such that a switch becomes effective when the electric current is less than approximately 1.6 mA for a dipole magnet and 3 mA for a quadrupole magnet.

The interlock signals of overheat and the coolant stop of both magnets are equipped in the power supply, but the signals originating from a magnet that is not connected are unnecessary. Therefore, the interlock was designed to be masked using the auxiliary contacts of the switching device.

Table 1. Scheme of switching for dipole magnets.

Channel	Power supply	Specification	New beam line		IRC bypass beam line
1	BT_D10_4	330A-60V	DMR3	⇔	DMK9 [a)]
2	BT_D10_3	330A-85V	DMR4	⇔	DMH8 [a)]
3	BT_D8_2	330A-155V	DMR5	⇔	DMH7 [a)]

[a)] Polarity Change

Table 2. Scheme of switching for quadrupole magnets.

Channel	Power supply	New beam line		Injection beam line to SRC		IRC bypass beam line
1	BT_QB4_1 BT_QB4_2	QDR63a QDR63b	⇔	QDG21a QDG21b		
2	BT_QB4_4 BT_QB4_5	QDR64a QDR64b	⇔	QSG23 QSG24		
3	BT_QA5_1 BT_QA5_2	QTR72b QTR72c	⇔	QDG26a QDG26b		
4	BT_QA5_3 BT_QA5_4	QDR71a QDR71b	⇔	QDG41a QDG41b		
5	BT_QA5_5 BT_QA5_6	QSR73 QSR74	⇔	QDG51a QDG51b		
6	BT_QB4_6	QTR72a	⇔	QSG25		
7	BT_QB1_1 [c)] BT_QB1_2 [c)]	QDR31c QDR31b	⇔			QTH81a [a)] QTH81b [a)]
8	BT_QB1_3 [c)]	QDR31a	⇔			QTH81c [a)]
9	BT_QB5_1			QSH17 [b)]	⇔	QSH61
10	BT_QC2_2 BT_QC2_3	QDR61a QDR61b	⇔	QDG11a QDG11b	⇔	QTG92a QTG92c
11	BT_QC2_4 BT_QC2_5	QDR62a QDR62b	⇔	QDG12a QDG12b	⇔	QDG93a QDG93b
12	BT_QC1_2 BT_QC2_1	QDR01a QDR01b	⇔	QDK02a QDK02b		
13	BT_QA6_5 [c)]	QSR11	⇔			QTG92b

[a)] Polarity Change
[b)] On the injection beamline to IRC
[c)] Specification of these power supplies is 150A-40V and that of the rest of the power supplies is 150A-30V.

The switches were manufactured from June to August. In September, installation, wiring and a check of wiring and magnet polarity were carried out. The first irradiation after installing the switches was carried out from 5th to 7th October and was finished satisfactorily. The next irradiation is scheduled for 27th to 29th January, 2016.

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References

1) K. Kumagai et al., RIKEN Accel. Prog. Rep. 48, 189 (2015).
2) Y. Watanabe et al., RIKEN Accel. Prog. Rep. 48, 19 (2015).