New fast-kicker system for Rare RI Ring

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We are developing a new fast-kicker system for Rare RI Ring. Figure 1 shows the block diagram of the new fast-kicker system. It primarily consists of a thyratron switch, a charger coupled with a pulse forming network (PFN), a kicker magnet, a matching resistor, and a control section of the discharge trigger. The thyratron is a deuterium-filled three-gap ceramic CX1171, which was assembled by e2v technologies. The kicker magnet is a distributed constant type magnet with a characteristic impedance of 12.5 Ω. We use a new substrate of the thyratron grid pulser on the basis of a previous feasibility study[1] to shorten the response time. In addition, we adopt a fast-charger named the hybrid charging system[2] to reduce the recharging time.

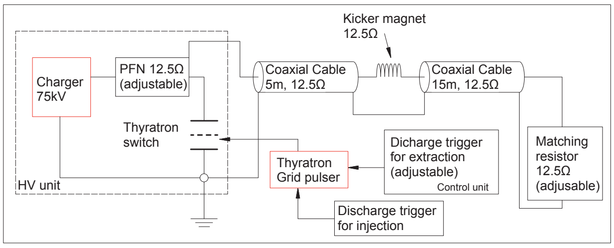

Fig. 1. Block diagram of the new fast-kicker system.

The new substrate of the thyratron grid pulser is mainly composed of four FET drivers, four MOSFETs, and four pulse transformers (PTs). Here, the response time refers to the interval between the time of input of the discharge trigger signal and the time of 10 % of the thyratron current output. The response time steadies at around 250 ns when the charging voltage becomes 25 kV or more.

The hybrid charging system, which consists of a main charging part and a sub-charging part, is indispensable for extracting a particle from the ring in 700 μs using the same kicker magnet. The main charge (90 %) is achieved in about 0.1 ms using a double forward converter composed of IGBTs and a PT. After the main charging process is completed, the sub-charging process is immediately started. The sub-charge is completed within 0.1 ms using a high-frequency (500 kHz) resonant circuit and a PT. In addition, a high-precision voltage divider, which connects to the sub-part coupled with a comparator, can be maintained at a constant charging voltage level within the range of fluctuation of less than ± 1 %. Figure 2 indicates an example of the PFN charging waveform for injection/extraction.

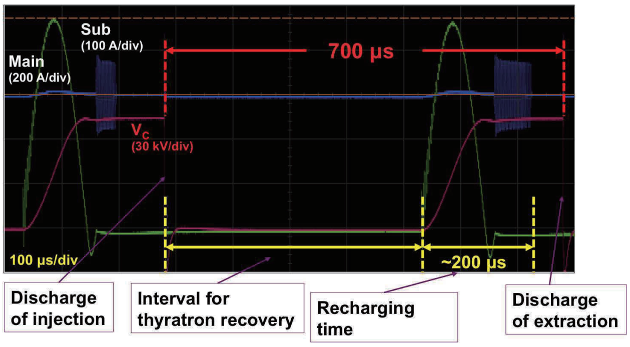

Fig. 2. PFN charging waveform for injection/extraction.

We fabricated a prototype twin kicker magnet to investigate the magnetic field by using a single-turn long search coil. Figure 3 shows the waveform of the magnetic field. Owing to the faster response time, the propagation time from a trigger signal input to the power supply until the flattop center of the kicker magnetic field is about 465 ns. On the other hand, the shape of the flat-top part and the tail-part of the waveform does not satisfy our requirements. The fluctuation of the flat-top, which is defined as ±80 ns of the flat-top center, should be maintained at less than ±3%, and we want to restrict it to less than 0 ± 1% for the region after 355 ns (for 200 MeV/u) from the flat-top center. Therefore, we are trying to reduce the disturbance of the waveform.

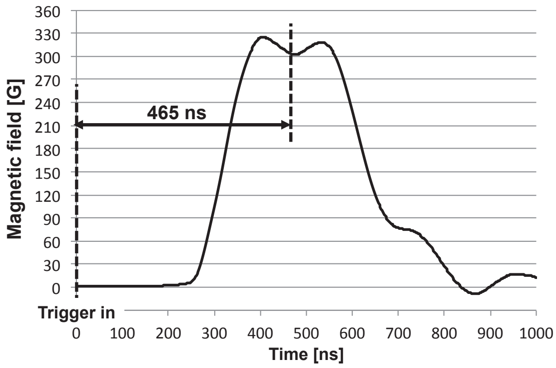

Fig. 3. Waveform of the magnetic field at the charging voltage Vc = 25 kV.

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References

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2) Y. Yamaguchi et al.: RIKEN Accel. Prog. Rep. **46**, 166 (2013).