# Fast beam interlock system at BigRIPS separator

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A fast beam interlock system (FBIS) with a response time less than 1 ms has been developed and installed at BigRIPS in order to cope with the recent increase of beam intensity at RIBF. If an intensive beam such as $^{238}$U and $^{48}$Ca beams with an energy of 345 MeV/nucleon and intensity of 1 particle μA was mis-steered and incident on the beam duct owing to a failure of magnet power supplies, the duct will be melted within 1- 5 ms. The fast interlock system detects the failure and cuts off the beam within 1 ms to prevent severe damage.

The FBIS at BigRIPS utilizes a compact RIO system (cRIO) of National Instrument Co. Ltd to achieve a fast response and flex configuration capability. A prototype of the system was developed in 2013 and tested.[1] Based on the successful test results,[1] the FBIS was constructed to monitor the analog and digital signals from the production target system and power supplies of the 34 magnets placed at the primary beam line and BigRIPS where a high-power primary beam is transported. The system consists of 5 cRIOs (three cRIO-9075 and two cRIO-9068) and sends the beam stop signal to the beam chopper system as well as the normal beam interlock system (BIS).[2] NI-9222 ADC modules and NI-9401 digital I/O modules are used for analog and logical signal processing respectively.

Figure 1 shows the logic diagram of the FBIS. The diagram is almost same as that for the prototype system but two enhancements were made. A digital filtering algorithm was added to analog signal processing in order to eliminate the noise in analog inputs. The moving average method was employed as the filtering algorithm. Another improvement was in the pulse rate measurement. A periodic counter was formed in the control logic and logical signal pulses were counted. The counter had a special function to produce an error signal immediately when the counting number exceeded the limit. Thus, one can set a rate limit to logical signal pulses unless waiting for the counting to end. All these control logics were stored in a field-programmable gate array (FPGA) of the cRIO-9075 and cRIO-9068 modules and executed at fast speed.

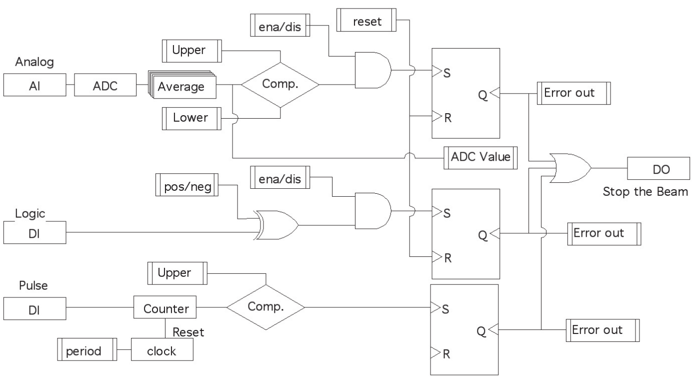


Fig. 1 Logic diagram of the fast beam interlock system.

The control conditions such as limit values of analog inputs and pulse rates, enable/disable flags, and positive/negative logic selections are dynamically set from the comprehensive control system of BigRIPS.[3] The status of faults and digitized values of the analog inputs are monitored and logged by the control system of BigRIPS.

In the operation of the FBIS, current monitor outputs and fault signals of magnet power supplies are connected to the analog and logical signal inputs, respectively. The temperature monitor and rotating speed signals of the BigRIPS rotating target system[4] are also connected to the analog input of the FBIS. Interlock windows of analog signals are set to ±0.3% for dipole magnets and ±1.5% for quadrupole magnets. Windows of ±15% are set for the rotation speeds of the rotating targets and an upper limit of 700 ℃ is set for the target temperature.

The response time of the FBIS was measured using beams at RIBF. A logical test signal was applied as the logical input of the FBIS. Signals from the beam trigger counter, which measures the secondary beam produced from the accelerated beam at the third focus (F3) of the BigRIPS separator, was monitored to determine the beam stopping timing. Measurements were performed for $^{48}$Ca and $^{238}$U primary beams, and in both cases, time differences from the test signal input to the disappearance of the beam trigger signal were about 250 μs. Thus, the response time of the FBIS is sufficiently low to prevent the severe damage of the equipment.

References

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