Radiation Safety Interlock System for SACLA (XFEL/SPring-8)

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INTRODUCTION

SACLA (SPring-8 Angstrom Compact free electron LAser) , which comprises an 8 GeV linear accelerator and undulators, was constructed.

To protect personnel from radiation hazards, the radiation safety interlock was designed and constructed.The system controls access to an accelerator tunnel and monitors safety devices. It controls permission signals for accelerator systems in accordance with safety conditions. When a safety condition is not satisfied, the system turns off the permission signal, thereby terminating the electron beam.

The radiation safety interlock system needs to be reliable and stable.
In addition, the system requires specific functionality, as described below.

- Fast beam abort → **Beam Route Interlock**

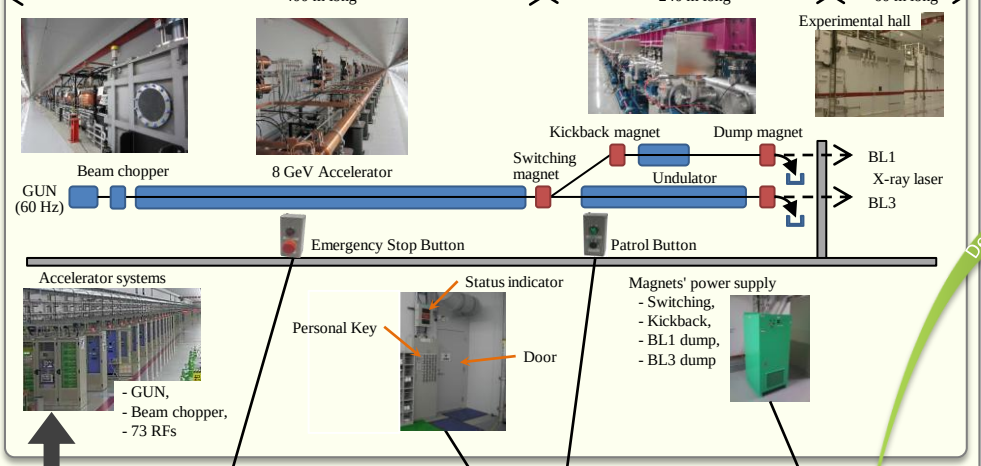
When the electron beam deviates from the beam dump, the electron beam generates unexpected radiation. Therefore, when this situation is detected, the next beam injection should be avoided, i.e., the radiation safety interlock needs to terminate the beam within 16.6 ms.

- Permission signal transmission → **Signal Transmission System**

Within the klystron gallery of approximately 400 m long, 73 RF systems are distributed and placed. Thus, the permission signal must be transmitted over a long distance to a large number of accelerator systems.

RADIATION SAFETY INTERLOCK

FACILITY



Emergency Interlock (EIS)
The EIS monitors the emergency stop buttons. When an emergency button is pushed, all permission signals are turned off.

Central Interlock (CIS)
The CIS provides the access control to the accelerator tunnel, search confirmation, and indications about the accelerator operation.

Beam Route Interlock (BIS)
The BIS evaluates the beam route based on the excitation status of four electromagnets.

Permission Permission Permission Permission

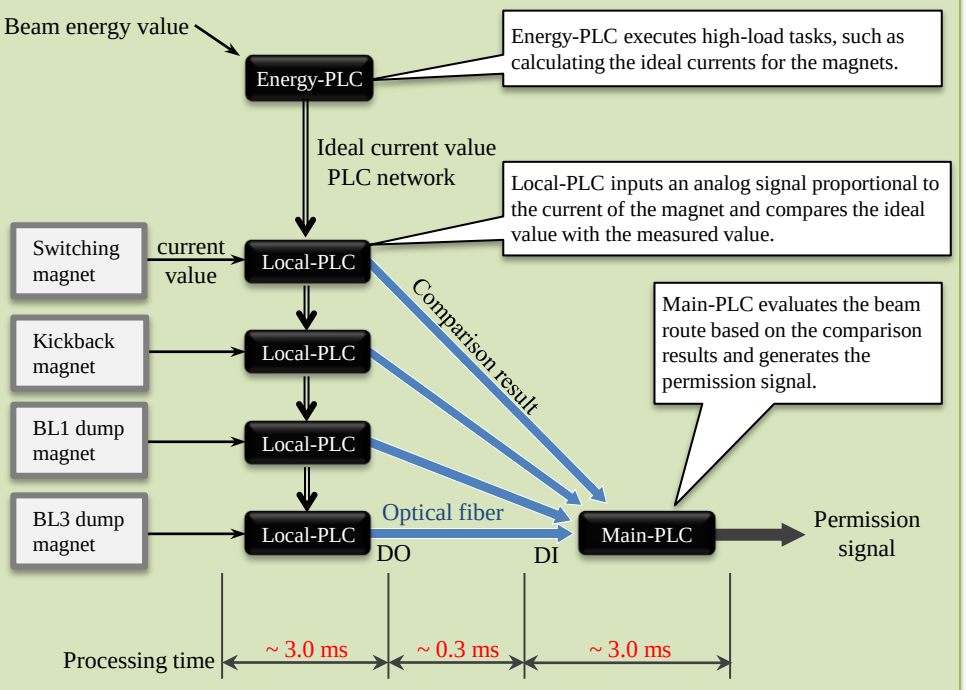
Signal Transmission System
The system transmits the permission signal to the GUN, beam chopper, and 73 RF systems distributed over 400 m.

Detail

BEAM ROUTE INTERLOCK

If the electromagnet is not properly excited, the BIS turns off the permission signal for the GUN and beam chopper within 16.6 ms.

To achieve fast processing time → Multi-PLCs with tiny program
→ Divided communication line:
- Direct fiber optic I/O connection (fast)
- PLC network (slow)

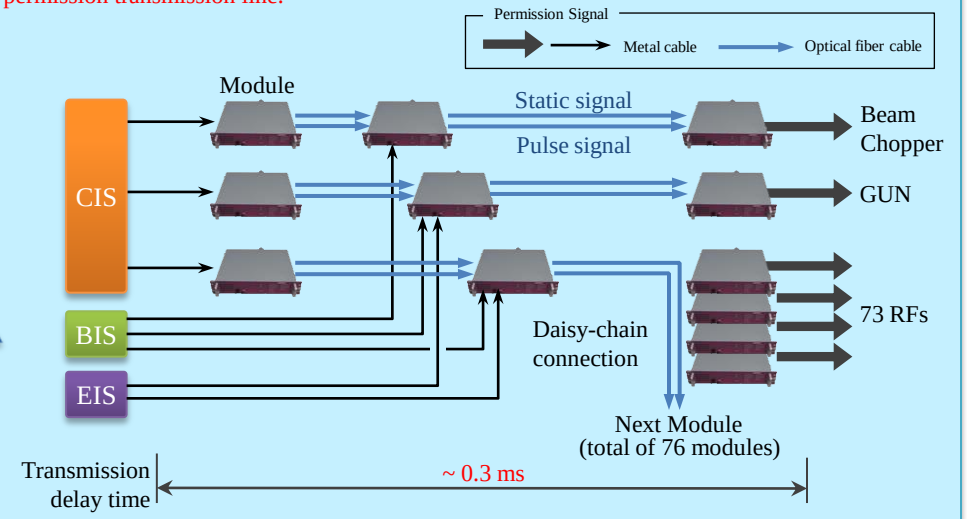


Detail

SIGNAL TRANSMISSION SYSTEM

- To achieve fast beam termination, the permission signals for the GUN and beam chopper must be stable and must have fast transmission speeds.
- The permission signal for RF systems is required to transmit over long distances and to a large number of systems.

→ We developed a new module to transmit the permission signals and used it to construct the permission transmission line.

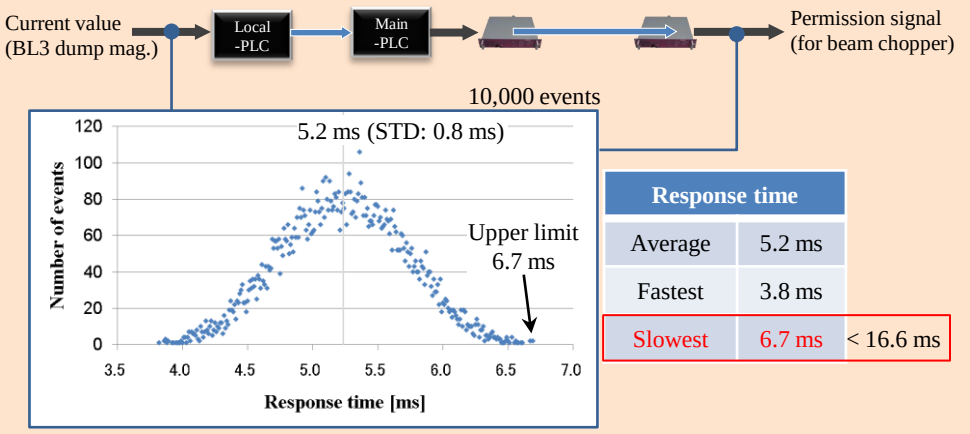


● Module Specification

Controller	CPLD
Transmission signal (Permission signal)	・Static signal ・Pulse signal (1 kHz) of the heartbeat
Connection method	Daisy-chain connection by using optical fiber (GI-50/125)
Distance between modules	~ 1 km
Immunity test	Fast transient/burst test (IEC 61000 4-4), Power line: 2kV
	Operation test in SCSS test accelerator

TOTAL RESPONSE TIME

We measured the total response time of the BIS and the permission transmission system.



Response time		
Average	5.2 ms	
Fastest	3.8 ms	
Slowest	6.7 ms	< 16.6 ms

SUMMARY

We constructed a radiation safety interlock system for SACLA. To stop the electron beam injection within 16.6 ms, an radiation safety interlock using multi-PLCs and new module were developed. The optical module was able to transmit a permission signal over a long distance to numerous accelerator systems. The radiation safety interlock achieved a response time of less than 6.7 ms. The operation of the system commenced at the end of February 2011.