UPGRADE OF ACCELERATOR RADIATION SAFETY SYSTEM FOR SPRING-8

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Abstract

An accelerator radiation safety system (accelerator safety interlock system) that protects users from radiation hazards induced by electron beams and synchrotron radiation has been operating for over a decade at SPring-8.

The working of the accelerator safety interlock system for SPring-8 is based on the operation mode control system. The working of the latter system became complicated because the number of "operation modes" increased over time in accordance with SPring-8 upgrades. Therefore, we are planning to construct a new accelerator safety interlock system. Here, we report the status of the current safety interlock system and the conceptual design of the new one. This upgrade is scheduled for the summer of 2010.

INTRODUCTION

SPring-8 Accelerator

SPring-8 consists of five access-controlled areas—four accelerator areas and one non-accelerator area. The accelerator areas are Linac (Li), injection booster synchrotron (Sy), storage ring (SR), and NewSUBARU storage ring (NS), and the non-accelerator area is L3 beam transport (L3). These areas are connected by beam transport lines and basically divided by each electron beam shutter (no electron shutter is available between Li and Sy). The beam transportation route is determined by bending magnets. The beam is accelerated by one electron gun (GUN) and four acceleration RFs (RFs)—Li-RF, Sy-RF, SR-RF, and NS-RF. Fig.1 shows the schematic view of the accelerator components for SPring-8.

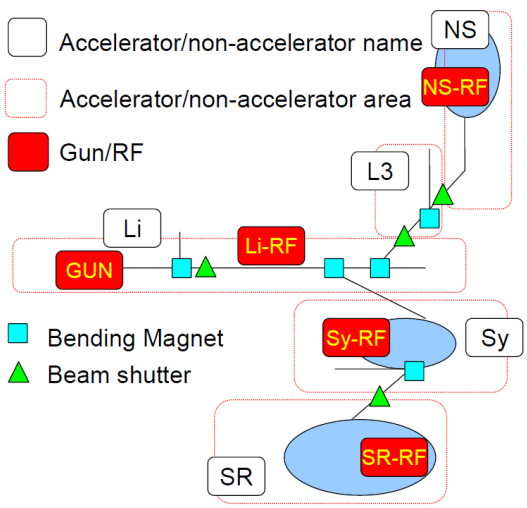

Figure 1: Accelerator components for SPring-8.

Accelerator Safety Interlock

The most important function of an accelerator safety interlock system is to manage criteria for access to radiation-controlled areas of accelerators and access permissions for fundamental acceleration devices, i.e., GUN and RF. An accelerator safety interlock system supervises the condition of access control equipment for the machine area, the radiation monitor, and other safety instruments.

For controlling the electron beam, permissions for the four RFs and one GUN are managed by the SPring-8 accelerator safety interlock system.

CURRENT ACCELERATOR SAFETY INTERLOCK SYSTEM FOR SPRING-8

Components

The accelerator safety interlock system at SPring-8 has been continuously upgraded for over a decade [1][2]. This system consists of four accelerator interlock systems and one operation mode (MODE) system. The accelerator interlock system consists of the Li-Sy system, SR system, NS system, and L3 system. Since the L3 system, which is a beam transport line, does not have any acceleration device, it is not related to any permission directly. Fig.2 shows the schematic view of the accelerator safety interlock system for SPring-8, and Table 1 shows covered areas and related permissions for each interlock system. The MODE system manages the combination of the accelerator/non-accelerator areas, which is called the "operation mode", and is connected to all accelerator interlock systems; it manages all permissions (GUN and RFs). Some operation modes include storage (str), injection (inj), and topup states. The mode transitions are governed by a fixed procedure. Fig.3 shows the operation mode and these transitions.

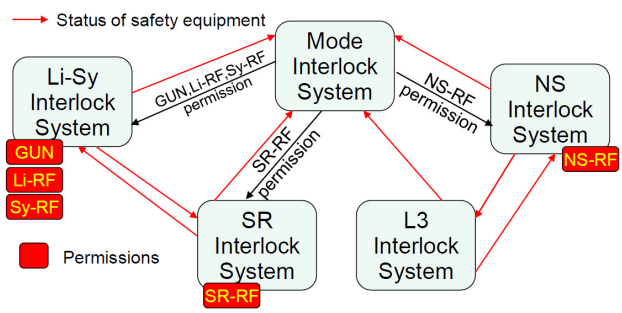

Figure 2: Schematic view of current accelerator safety interlock system. The black line shows permissions from the MODE system to each accelerator interlock system.

Table 1: Covered Area and related Permission for Current Accelerator Safety Interlock System

System	Covered Area	Related Permission
Mode interlock	-	GUN, Li-RF, Sy-RF, SR-RF, NS-RF
Li-Sy interlock	Li, Sy	Li-RF, Sy-RF, SR-RF, GUN
L3 interlock	L3	GUN, NS-RF
SR interlock	SR	SR-RF, Sy-RF, GUN
NS interlock	NS	NS-RF, GUN

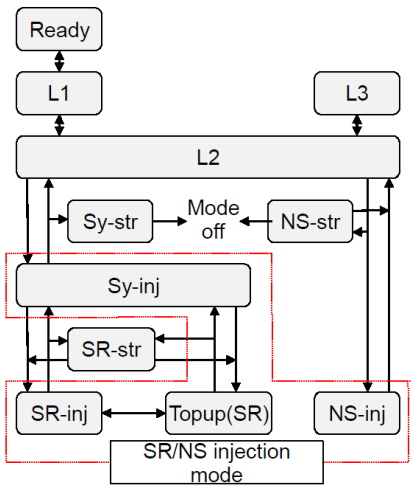

Figure 3: Schematic view of operation modes and transitions.

Complexity

Many combinations of the accelerator area (operation mode) are currently available, and the transition of each operation mode is complex (see Fig.3). The number of operation modes is around 60.

This complexity of the operation mode makes it difficult to manage an additional accelerator in the future, for example, an X-ray free-electron laser (XFEL) at SPring-8. The number of operation modes will then increase by 20–30 modes.

Such a considerable increase in the number of operation modes is not realistic for carrying out required maintenances. Any modification to the system would require a safety check for all operation modes.

Independence

The decision about all permissions for GUN and RFs is made by the operation mode system. However, the accelerator safety interlock system also decides the permission for each system. Thus, the fact that two different systems make the decision about the permission causes difficulty in troubleshooting.

Moreover, the accelerator safety interlock systems exchange their safety condition signals with each other. This implies that the working of the accelerator safety interlock system depends on the status of other accelerator safety interlock systems.

The Li-Sy system manages two acceleration areas—Linac and the booster synchrotron. To ensure independent operation, it is preferable to divide the Li-Sy system into the Li system and the Sy system.

The dependence of each acceleration safety interlock system on the others makes it difficult to carry out maintenance. Modifications made to one system can affect other systems. Therefore, if a system is modified, all other systems, including all of their operation modes, should be checked carefully.

UPGRADE OF ACCELERATOR SAFETY INTERLOCK SYSTEM FOR SPRING-8

The upgrade of the accelerator safety interlock system for SPring-8 is currently being planned. The basic concept of an accelerator safety interlock system has been reconsidered for the new system. The modification of basic components is also considered for this upgrade.

Basic Concept of New Accelerator Safety Interlock System

- Removal of operation mode system

We will construct the new system without the operation mode system. For the accelerator safety interlock system, the most important point is the safety of each accelerator area. Therefore, the new accelerator safety interlock system is based on independent accelerator interlock systems and not on the operation mode system.

The combination of accelerator areas used is determined by the key of each system (main operation key for each accelerator) and states of area separation devices (beam shutters and bending magnets). Then, it is no longer necessary to select the operation modes.

- Independent area management system

The independence of area management is very important for the new system. Current accelerator safety interlock systems are not completely independent, because some safety conditions depend on those of other systems. In the new system, safety conditions should be managed by independent accelerator interlock systems.

Construction of New Accelerator Safety Interlock System

The new accelerator safety interlock system will consist of four accelerator area interlock systems, one non-accelerator area interlock system, and one gun interlock system.

The gun interlock system will be newly constructed because the GUN permission depends on the states of all accelerator/non-accelerator area interlock systems. The gun interlock system collects the safety status related to beam injection from each area interlock system and allows the usage of GUN when all area interlock systems are safe.

Each accelerator area interlock system manages its own RF permission. Each accelerator/non-accelerator area

interlock system should be operated independently and connected only to the gun interlock system.

For separating the Li area from the Sy area, a beam shutter will be constructed between them. According to the separation of areas, the accelerator interlock system, Li-Sy, will be divided into the Li system and the Sy system and operated independently.

If the accelerator/non-accelerator area interlock systems are independent, modification to the area interlock system affects only the gun interlock system and not other area interlock systems.

The components of the new accelerator safety interlock system are shown in Fig.4 and Table. 2.

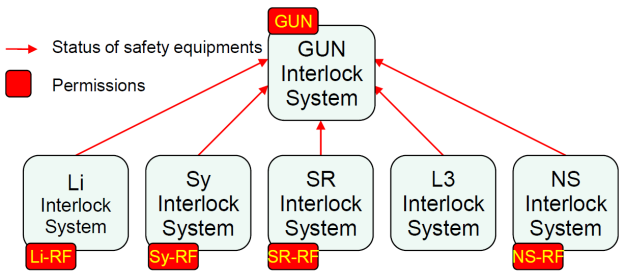

Figure 4: Schematic view of new accelerator safety interlock system.

Table 2: Covered Areas and Related Permissions for New Accelerator Safety Interlock System

System	Covered Area	Related Permission
Gun interlock	-	GUN
Li interlock	Li	Li-RF, GUN
Sy interlock	Sy	Sy-RF, GUN
L3 interlock	L3	GUN
SR interlock	SR	SR-RF, GUN
NS interlock	NS	NS-RF, GUN

SIMULATION SYSTEM

A simulation is a powerful tool for carrying out a detailed examination of the accelerator safety interlock system. Because of the recent increase in operation time at SPring-8, the time available for maintenance is limited. Many tests are performed in a local environment by using a simulation system. Further, with the use of the new accelerator safety interlock system, the modification and construction time are expected to be reduced considerably.

The mechanism of the accelerator safety interlock system is based on a programmable logic controller (PLC); the PLC manages some I/O signals by using a program called “ladder program.” Then, a simulation will be a good tool for the verification of ladder programs. Since the accelerator safety interlock system consists of some PLCs, a simulation system is required for managing some PLC systems and their combinations.

This simulation system is composed of some PLCs and one personal computer (PC). PLC ladder programs to be examined are installed in PLCs. The PC has a Windows XP operating system and includes some virtual interfaces of PLC systems. PLC-PLC communication signals are emulated among the virtual interfaces.

The simulation is mainly performed by the simulator PC. The simulator PC can set compulsory signal states via virtual interfaces on it. Signal states of all PLC systems can be controlled by command series (e.g., door control: open/close) and monitored continuously. These operations are performed simultaneously and programmatically. Therefore, the simulation system can create any situation, examine any procedures, and verify the correct safety motion for the accelerator safety interlock system.

Fig.5 shows the schematic view of the simulation system.

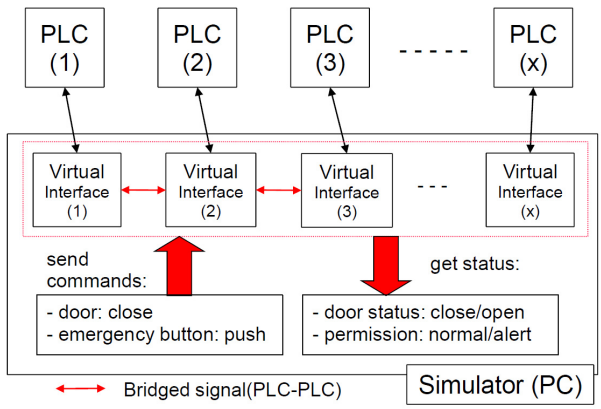

Figure 5: Simulation system for accelerator safety interlock system.

SUMMARY

The design of a new accelerator safety interlock system is presented. The new system considers that the independence of accelerator safety interlock systems is important and will aid in efficiently expanding accelerator area components.

The construction of the new accelerator safety interlock system is scheduled for August 2010 and will be ready for the user operation at the end of September 2010. The new accelerator safety interlock system will be ready to be connected to an additional accelerator area, XFEL.

REFERENCES

[1] T. Takagi, T. Asano, Radiation safety systems at SPring-8, Proceedings of the Second International Conference on Radiation Safety at Synchrotron Radiation Sources, Grenoble, France, p. 123 (2002).

[2] Y. Asano, T. Takagi, Safety considerations for top-up operation of an 8 GeV class synchrotron radiation facility, Proceedings of the 11th International Congress on Radiation Protection Association, Madrid, Spain (2004).