The Development of the Beamline Interlock System

Tomohiro MATSUSHITA[1)], Takeshi NAKATANI[1)], Yasuhide ISHIZAWA[1)], Toru OHATA[1)],
Yukito FURUKAWA[1)], Masao TAKEUCHI[1)], Miho ISHII[1)], Hiroaki KIMURA[1)], Syunji GOTO[1)],
Kunikazu TAKESHITA[1)], Tetsuya TAKAGI[1)], Tougo KUDO[1)] and Tetsuya ISHIKAWA[2)]

1) SPring-8/JASRI, 2) SPring-8/RIKEN

1. Introduction

The beam abort system has been in place since the beginning of SPring-8 construction. These demands for beam abort are collected by the beam interlock modules (BIM) which are connected to the safety interlock. The beamline interlock system controls the main beam shutter, the down stream shutter, the gate valves, the vacuum gauges and hutch components. In order to protect human and beamline components from beam damage, the beamline interlock limits the human error and notifies the operator ALARM. When the beamline devices detect a non-optimum condition, the beamline interlock notifies the corresponding ALARM and operates the beamline components to protect. The demand for beam abort is generated by some ALARMs and this signal is transmitted to the BIM.

The beamline interlock had many ALARM items, but in previous design these ALARM items were not classified. The user had to know the beamline interlock action caused by the ALARM, but there were too many to remember easily.

The beamline interlock had its own network and connected to other beamline interlock as well as to the workstation in the central control room. This network did not have enough expandability or capacity and so it was difficult to build up additional beamline interlocks and the data were insufficient for the trouble shooting.

In addition, a demand for beam abort caused by the electron beam position shifting at the insertion device (ID) was generated in the beamline interlock. The new logic for the demand for beam abort by the electron beam position shifting had been planned. This was difficult a construction in the previous frame.

Due to these reasons, BEAMLINE INTERLOCK 98 was designed in 1998. We constructed a GAPA system and developed the software for the workstations. Then we abolished the network of the beamline interlock system. The schematic view of the new interlock system is shown in Fig. 1. In addition, we constructed a BIM status collecting system and a simulator of the beamline interlock.

2. Beamline Interlock 98

In this new design of interlock, the many ALARM items are classified into seven levels. This level displays the degree of risk. Level 7 is human protection with beam abort. Level 6 is device protection with beam abort. The levels from 5 down to 1 are device protection without beam abort. Level 5 and Level 4 lock the main beam shutter and the down stream shutter respectively. Level 3 stops a new experiment. The ALARM items in the levels from 3 to 7 are recovered by a reset action by the beamline master. Level 2 is an announcement to the beamline user and its ALARM items are recovered by a reset

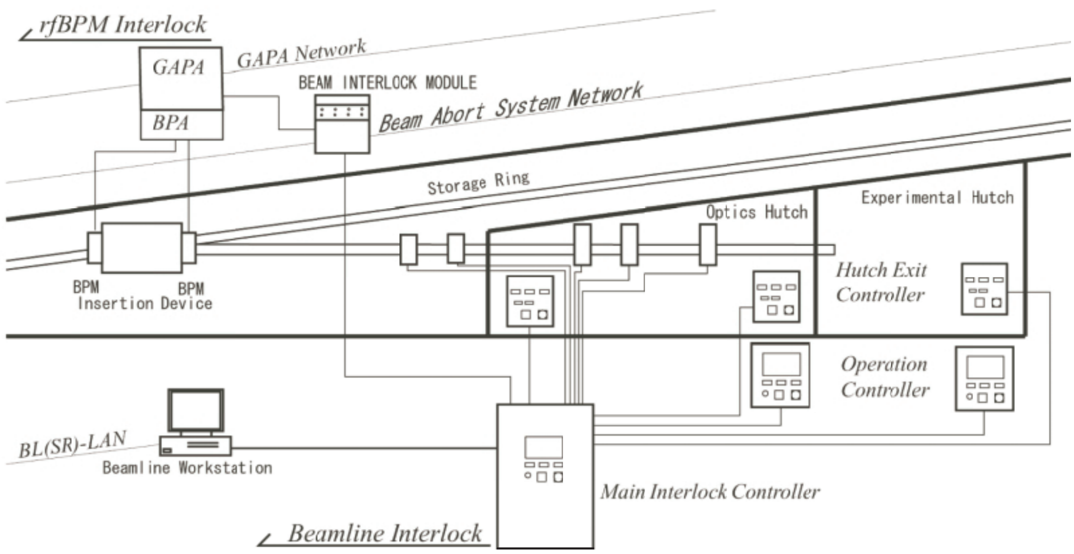

Fig. 1

action by the beamline user. Level 1 is an announcement to the beamline user and its ALARM items are recovered automatically when the status returns to optimum condition.

In the previous design, the beamline interlock had a MANUAL mode, an AUTO mode and a TEST mode. The AUTO and MANUAL modes have been designed to be used under individual user operation and beamline master operation respectively. The TEST mode has been used to test the beamline devices without the interlock logic. These three interlock modes were not enough, because they could not open the gate valves and down stream shutter to align the beamline components. So we added an ALIGNMENT mode. Under the ALIGNMENT mode the beamline interlock ignores the vacuum gauge status in the transport channel, so that the operator can always open the gate valves. This operation is very dangerous because of possibility of the vacuum gauges and the

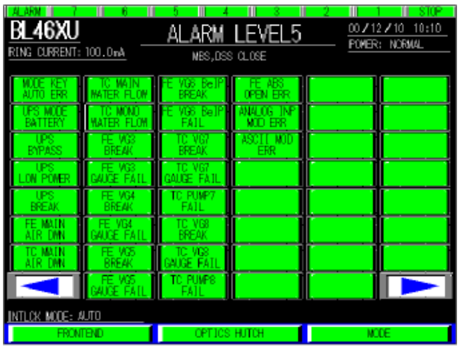

Fig. 2

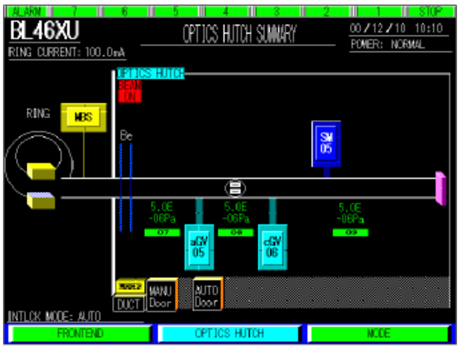

Fig. 3

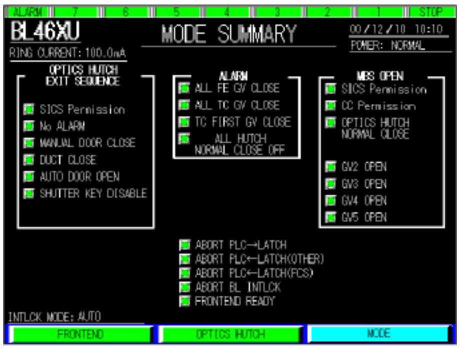

Fig. 4

gate valves breaking down. But since all front-end components are closed and locked in order to protect the front-end and storage ring, the operator can use this mode during the storage ring operation.

The beamline user controls the beamline components with the graphic panel of the beamline interlock. In order to guard against incorrect operation, the graphic panel was newly designed in BEAMLINE INTERLOCK 98. One of the ALARM panels is shown in Fig. 2. When the condition is non-optimum, the corresponding ALARM display changes to red. The top tool bar is the ALARM bar. There are seven buttons with numbers corresponding to the ALARM levels.

One of the operation panels is shown in Fig. 3. This panel displays the beamline components and the buttons to operate the components. The central double line is a symbol of the beamline pipe introducing light from the ring. The components that operate the light are displayed in the upper region of the pipe. There are gate valve buttons in the lower region of the pipe. These buttons are distinguished by using different colors in order to reduce the possibility of incorrect operation. In addition, the status of the auto door, the manual door and the cable duct are displayed. The bottom tool bar can select the operation panels and the mode panels. The mode panel is shown in Fig. 4. This panel displays the permission conditions of the exit sequence and main beam shutter.

In order to acquire the interlock status, the interlock has been connected to the beamline workstation by using RS-232C. The protocol of this communication has been newly determined in this new design. These statuses include all ALARM signals, all digital input signal, all digital output status and analog values of vacuum gauges. The number of signals is much greater than the old one. Then beamline interlock network was abolished.

All beamline interlocks in SPring-8 had been reconstructed by the summer of 1999.

3. GAPA System

An rfBPM interlock system [1] protects the beamline components. When an accumulated electron beam deviates from the center region of the ID, the generated light damages the downstream beamline devices. In this case this interlock system will abort the stored beam within 0.8msec.

The previous logic was that the demand for beam abort is generated when gap of the ID is not opened and its own rfBPM detects a beam shift. In the new logic, the demand is generated when one rfBPM detects a beam shift and one ID is not opened in the whole storage ring. For this reason we constructed the GAPA system.

This system consists of modules of BPA and GAPA. The BPA is connected to the rfBPM and monitors any shift in beam position. The BPA is also connected to the GAPA module. A GAPA module is established at each ID and all GAPA modules are connected to each other by six optical fibers. The connection type is a "daisy chain". Three of GAPA modules are connected to three BIMs to abort the stored beam. The top GAPA module receives the signal of ring current>1mA from DCCT, and it sends to down stream GAPA modules.

The GAPA modules turn on the GFO_AND_STATUS signal when all IDs show gap full open. If a BPA module detects the electron beam position shifting, it sends this information to a corresponding GAPA module. This information, in turn, generates a beam abort signal and the first abort signal when beam shifting is on, the ring current>1mA is on and GFO_AND_STATUS is off. This abort signal is also transmitted to all other GAPA modules and BIMs.

Each GAPA module is connected to the corresponding VME of ID in order to transmit GAPA status. This VME system transmits these statuses to the database and then we can see the abort status and the first abort.

In 1999 in order to monitor the cooling water of the In-Vacuum ID, we added a flow sensor to the GAPA module. When there is an insufficient flow of cooling water flow, the abort signal is transmitted to the beam abort module irrespective of ring current or GFO signal.

4. Integration to the Central Control System of the Interlock along with the Modification to Interlock98

Before the Beamline Interlock System was introduced the Interlock98, beamline interlock network transmitted whole data to a workstation in the central control room. There was a weakness where the whole interlock system stopped when this workstation had stopped. As Interlock98 was introduced, the beamline interlock network was abolished. Then, there is no case where the whole system stops even if a workstation stops.

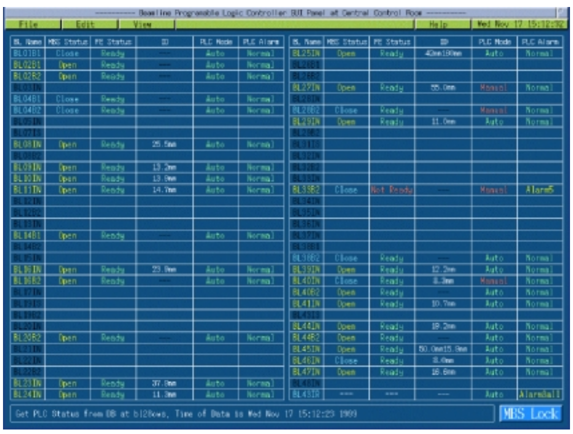

Fig. 5

There is an operating and browsing GUI that displays the interlock status of all beamlines (Fig. 5). This GUI is always running on the workstation in central control room during SPring-8 operation time. When an electron beam is injected to the storage ring, the operation of main beam shutter Lock/Unlock is carried out with this GUI. It also browses the newest important interlock status, that is, main beam shutter Open/Close, front-end Ready/Not Ready, gaps of IDs, beamline interlock mode and ALARM levels.

The workstations in the central control room also collect the data from all beamline interlocks. The collected interlock status is recorded in the database. The past interlock status of each beamline can be reproduced using these records.

5. Beam Interlock Module Status Collecting System

The BIM collects the demand for beam abort from the beamline interlock systems and the rfBPM (GAPA) interlock system. The beam abort system is composed of several BIMs connected to each other with its own network. This system determines the first arrival of a demand for beam abort. In order to acquire the signals of first arrival and beam abort, we connected the VME system to the PLC in the beam abort system by using the RS-232C. This VME system writes these signals to the SPring-8 database. Now we can see these signals all over the SPring-8 as well as in the central control room.

6. The Simulator of Beamline Interlock System

The beamline interlock system has become user friendly, but in order to use it safely, operational training is essential for the user. The simulator of the beamline interlock system constructed in 2000 is used for the beamline user’s training. This simulator has same system of real beamline interlock with no beamline devices. Nonexistent beamline devices are simulated in this system. Users can control the simulated beamline devices, for example the main beam shutter, the down stream shutter and the gate valves, by using the graphic panel. They can learn how to use the beamline components and hutch. This system is also connected to a personal computer. We are planning to provide the menus of the training program by using this computer at an early date.

References

[1] T. Kudo *et al.*, SPring-8 Annual Report 1997 (1997) 203.