DEVELOPMENT OF MACHINE INTERLOCK SYSTEM HMI FOR PLS

B.R. Park, J.C. Yoon, J.W. Lee, H.S. Kang, J. Choi
Pohang Accelerator Laboratory, POSTECH, Pohang, 790-784, Korea

Abstract

The Machine Interlock System (MIS) for the Pohang Light Source (PLS) is used for the monitoring and control of machine devices and equipments for operation and maintenance, and protects machine devices and equipments by interlock chain program at fault status. The MIS consists of one central system unit and 7 remote local system units, and is implemented mainly using GE-FANUC's Programmable Logic Controller (PLC). Using information and data in the MIS, a human-machine interface (HMI) for the MIS is developed for the operator and system manager to efficiently control and monitor the MIS and also to log various event, trip, fault data automatically. Wonderware's FactorySuite is used for the HMI development software. The HMI is developed under PC environments, which communicates with the MIS through RS-485 serial link.

INTRODUCTION OF MACHINE INTERLOCK SYSTEM

The machine interlock system (MIS) monitors and protects the devices and equipments of the accelerators that form the Pohang Light Source (PLS). The HMI system monitors devices, equipments, and systems that consists of the accelerators, analyzes the collected data, and protects the machines from damages when faults occur. The system installed for data acquisition and protection of machines is Programmable Logic Controller (PLC) of 90/70 Series from GE-FANUC. It is made dual using the IC697CPX782 CPU. The software used for the system is CIMplicity Machine edition. The MIS consists of three layers: "Device and Equipment", "Local" and "Central". The device and equipment layer enable the devices and equipments to self-interlock. When faults or failures occur, the layer must be controlled by the protective signals effectuated by the local layer as well as its own function to deliver the status signals to the local layer located above it, while also protecting itself. The local layer collects the status signals effectuated by mechanical devices and equipments by function and region and send them to the central layer. The local layer also receives the signals from the central layer, which it delivers down to the device and equipment layer. The local layer consists of seven local PLC systems. The central control room has one and the storage ring has four and the linear accelerator has two. The central layer has a PLC program that monitors and analyzes the states of devices and equipments whose data have been selected by function and region. The layer activates the interlock chain program to protect the devices and equipments when faults occur. The central host PLC system consists of two PLC systems (Supervisor, Hot-Standby). This layer has other peripheral systems. The Status Display Panel, which composed of a mosaic panel (3200mm x 2200mm) that signals the states of the overall machines required for operation of the accelerators by region and group in LED lights. The panel also expresses the beam energy, beam current, and beam lifetime. The drive system is implemented with GE-FANUC 90/30 PLC series modules, which is connected to the host PLC with communication modules (CMM711, CMM311). The model selection control panel, which selects the operational modes of the accelerators among "shut down", "injection" and "operation" mode. The HMI, which enables the operators to monitor the status of accelerators, control the machines, identify the mechanic parts where faults have occurred, and protect them, and there are systems that log the data of status changes in the machines and conduct troubleshooting. The MIS is operated in one of four operation modes; "PAUSE", "SEARCH", "INJECTION" and "STORAG". These modes are selected by operator by using a "Mode Selection Control Panel" in the main control room. The pause mode is selected during machines shutdown or maintenance time. It drives pause mode interlock chain when abnormal machine conditions are detected. If the pause mode says that the machines are normal, the operator can select the search mode. It drives search mode interlock chain. If the search mode says the machines are normal, the injection mode can be selected and the beam injection can be started. If desired beam current is stored in the storage ring, the interlock system goes into storage mode. It uses storage mode interlock chain.

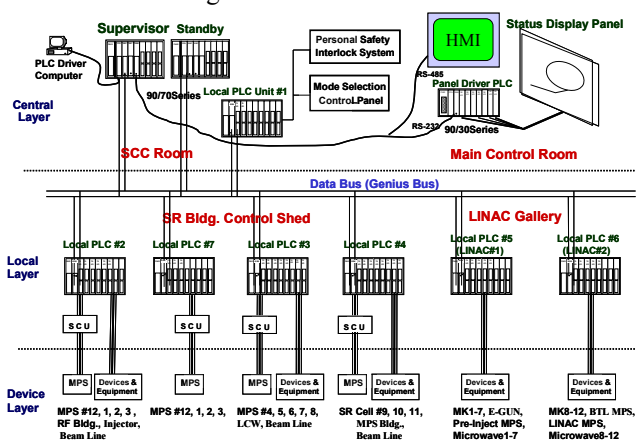

Figure 1: Configuration of MIS.

* brp@postech.ac.kr

HUMAN MACHINE INTERFACE (HMI)

The human machine interface (HMI) system is installed to effectively administrate, monitor, and control the MIS and record the events and trip data. The HMI is developed under PC environments, which communicates with the host PLC system through RS-485 link. The developed tool is based on FactorySuite Version.7.1 from Wonderware corporation. The statuses of accelerator machines are graphitized in categories of buildings, equipments, and administrative groups. They are also designed to facilitate the operators and users to easily identify and control the states of the machines. The "PLS MAIN" the main page that is designed to allow the users to check the status of the machines required to operate the accelerators. It is divided into the "STORAGE", "LINAC" and "BEAMLINE" to enable different administrative groups to inspect the machines in more details. If the "STORAGE" clicks, new screen appears to view the status of the storage ring building machines. The "LINAC" supports for deeper inspection into the machines in the linear accelerator buildings. The "BEAMLINE" allows for inspecting the state of the twenty seven beamlines in operation. The small, squared windows of the main screen indicate the machines marked by group and equipments. Clicking on the activated square windows will enable the user to view the state of the machines corresponding to those groups. The "MONITOR" menu allows the user to view the data of the machines logged in real time. It is further divided into the menus of "EVENT" and "TRIP". The "EVENT" menu allows the user to log and see the changing data of the machines that do not impact the normal operation of the accelerators. The "TRIP" menu allows the user to view the changed data of machines that impact the operation of the accelerators when faults occur. The logged data are periodically stored in the hard disk. The "CONTROL" menu is categorized into the "INTERLOCK" and "G/V OPEN/CLOSE" The "INTERLOCK" menu logs the data of signals effectuated to protect the machines. The "G/V OPEN/CLOSE" menu is used to open or close the vacuum gate valves installed in the storage ring.

Main Screen (PLS MAIN)

The main screen is graphically designed with the models of the storage ring, linear accelerators, and beamlines on the frame of the PLS building structure in order to enable the user to check the status of the machines by group. The machines are grouped by region and indicated by a small window. Clicking the small, squared window, which is activated when the cursor moves about, shows a new window that indicates all the machines corresponding to it, thereby allowing the user to check the status of the machines. On the left of the page is the menu composed of "STORAGE", "BEAMLINE", "LINAC", "MONITOR" and "CONTROL".

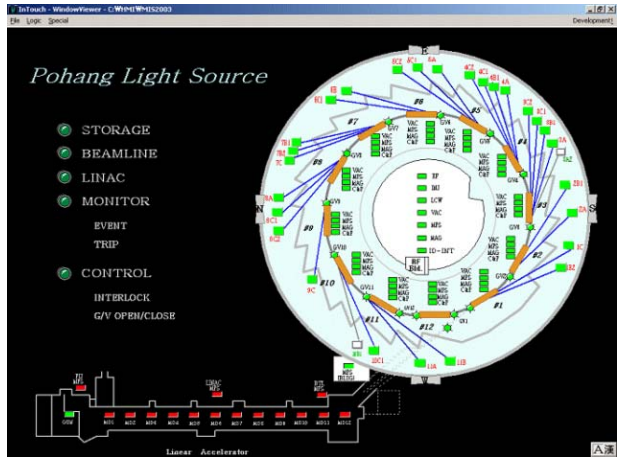

Figure 2: Main Screen of HMI.

Clicking a small square window on the main screen appears to the corresponding machine group window that allows the user to check the status of each the machines. Each the machines may be checked in the procedure as follows:

Vacuum: All vacuum statuses and twelve cells of the stor age ring are indicated by a small square window. The "V AC" window of each of the twelve cells represents the ov erall vacuum status of the corresponding region. It turns r ed when a fault has been identified. Clicking on a small w indow creates another window that indicates the vacuum s tatus of three to four penning gauges (TBG300) and one t o four Bayard Alpert gauges (GP307). The small "VAC" window in the centre of the screen indicates the overall va cuum status of the storage ring.

Magnet Power Supply: The storage ring's twelve cell M PS (210EA), MPS building MPS (6EA), the Pre-injector MPS (30EA) of the linear accelerator, the linear accelerat or line MPS (24EA), and the beam transfer line MPS (42 EA) are gathered into local groups, each of which is indic ated by a small window. Clicking on the small window of each local group will create another window that shows th e status of the all MPS's in the corresponding group. The "MPS" window in the centre of the screen indicates the st atuses of all the MPS's in the storage rings.

Chamber & Photon Stopper Temperature: Whether th e state of each of the twelve cells in the storage ring is kep t normally under the set temperature limit is indicated. Cli cking on the "C&P" window of each of the twelve cells w ill create a new window that shows the statuses of the tens of the measured points' values of the vacuum chamber an d photon stopper.

Vacuum Gate Valve: The storage ring has fifteen gate va lves. Clicking each "G&V" window will create a new win dow that shows statuses of the controllers, remote/local an d open/close. Once the vacuum state falls below the set va lue, the corresponding gate valve is automatically closed.

Injector: Clicking the "INJ" window in the centre of the main screen will show the statuses of the kicker MPS, sep tum MPS, septum magnet status.

LCW: The "LCW" window in the centre of the main scre

en indicates the status of the low conductivity water suppl ied from the utility building.

Insertion Device Interlock: Clicking the "ID-INT" wind ow in the centre of the main screen creates a window that enables the user to check the statuses of the insertion devi ces, including the EPU6 (2A), U10 (3A), MXW (4A), HF MS (5A), U7 (8A), and the beam position data of the Rev olver (11A).

Beamline: each of the twenty-seven beamlines in operati on is indicated. Clicking the small window of each beamli ne shows the statuses of the beamline, such as "beamline ready", "beamline vacuum status", "safety shutter status" and "beam dump request".

Data Log of Monitor

The change in the status of the input data of the machines, supplied from the seven local PLC systems in the machine interlock system, is to be recorded automatically, while the data on the status change in machines are to be periodically stored in the hard disk of the PC. The data log has two formats: One "EVENT" is for logging the changing data of the machines that do not impact operation of the accelerators. The other "TRIP" is for logging the changing data of the machines that impact operation of the accelerators. The trip data that has been logged is periodically stored in the hard disk driver. Clicking the "EVENT" and "TRIP" on the MONITOR menu on the left side of the main screen creates windows that indicate the time of status change, the signal characteristics, and the signal statuses of corresponding machines.

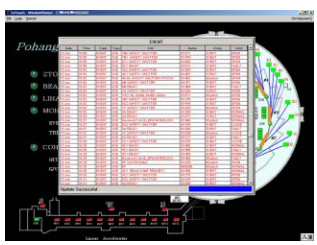

Figure 3: Data of EVENT.

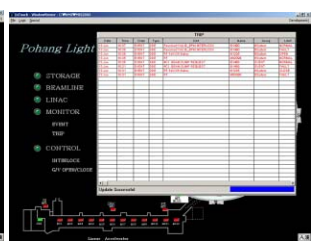

Figure 4: Data of TRIP.

Data Log of Interlock & Control

The protective output signals are effectuated by the PLC interlock chain program to protect the accelerators when faults are found in the systems or the operating environment has changed. The "INTERLOCK" logs the output signal data generated here, and the "GV OPEN/CLOSE" is in order to open and close gate valves installed in the storage ring. Clicking the "INTERLOCK" menu creates a window to view the detailed data on times of signal occurrence, types of signal, and conditions of the output signals, which are periodically stored in the hard disk drive. Clicking the "GV OPEN/CLOSE" creates the windows shown below, which are used to artificially open or close the gate valves.

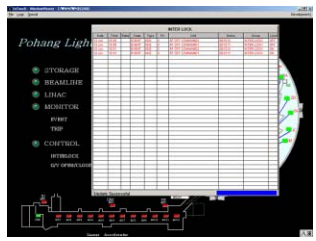

Figure 5: Data of INT.

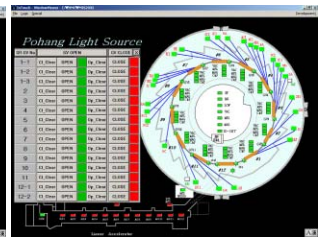

Figure 6: GV Control Screen.

CONCLUSION

All the accelerator machines that constitute the linear accelerator, storage ring, beamlines and the conditions of their surrounding environments must stay normal in order to operate the accelerators. So that, the HMI was developed in order to enable the accelerator operator to seek and check the statuses of all the machines and surrounding conditions on one screen needed to run the accelerators. When a fault or problem occurs in a machine or surrounding environment needed for operation of the accelerators, the operator can monitor the change of status and contact the person in charge of the machine to take corrective measures. The HMI was also designed in order to allow the times of occurrence, types, and current conditions of the signals generated to protect the machines to be automatically logged. Therefore, the operator working in the central control room can effectively monitor the conditions of the accelerators and make more accurate decisions. The system continues to be upgraded to be more user-friendly by adding more machines and improving problems found in the system operation. Now, the HMI system has very stable and reliable operational characteristics.

REFERENCES

[1] B.R. Park, J.W. Lee and I.S. Ko "PLS-based Machine Interlock System for PLS 2-GeV Storage" ICALEPCS97, Beijing, Chine, October 1997