INTERLOCK SYSTEM FOR A FFAG COMPLEX IN KURRI

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Abstract

For basic research experiments of accelerator driven subcritical reactor (ADSR) system, an 150 MeV FFAG accelerator is now constructed in Kyoto University Research Reactor Institute (KURRI). The installed accelerator will be connected to the nuclear fuel assembly and be used for physical and chemical research using the proton beam produced by the accelerator. The highly secure and flexible interlock system is required for such a gradual developed complex. The interlock system constructed by using PC and PLC (Programmable Logic Controller) is an adequate system because of their high reliability and flexibility.

INTRODUCTION

An FFAG accelerator is installed in KURRI for basic research experiments of ADSR system [1, 2]. The accelerator has a capability of accelerating protons up to 150 MeV. The main purpose of the accelerator is neutron production by irradiating a metal target located in critical assembly facility by 150 MeV protons. The produced neutrons irradiate nuclear fuel elements in the facility for basic experiments of ADSR. Because the installed FFAG accelerator is expected to produce a stable high current proton beam, the accelerator is also a good device for many fields such as basic research of physics and chemistry, material science, and medical science including radiation therapy using a proton beam. The interlock system for the radiation protection needs gradual construction to follow the extension of purposes of the accelerator step by step. The interlock system constructed by using PC and PLC connected over the IP based network is an adequate system since such a system has a high flexibility to adapt the changes in radiation control and increase of interlock devices.

SYSTEM OUTLINE

Framework

The control system of accelerator complex is constructed by two kinds of the IP based network system. One is for the control of accelerator devices such as power supplies, vacuuming systems, and others. Another is for the interlock system connected with the radiation monitors, emergency stop switches and other devices for safe and secure operation of the facility. The outline of the interlock system is shown in Fig. 1. Operating inputs for the interlock system are as follows; radiation warning from radiation monitors, alarms from accelerator devices such as power supplies and vacuumed pumps, alarm from the entrance gate of the radiation control area, and various monitors for the irradiation target and nuclear fuel elements located in the subcritical assembly facility. These signals are inputted to PLC's (FA-M3, Yokogawa Electric Co.) adjacent to such devices. Cables from those devices are connected to the terminals of input/output PLC modules. PLC I/O modules need a CPU module on the same PLC base. However, connecting PLC basis by an optical fibre cables enables to control all modules by one CPU module. In our interlock system, PLC modules located in the same site are connected by optical cables and controlled by one CPU module, and they are connected to the IP based network. Using public parameters among this network enables to construct the interlock system. Extension of the interlock system is very easy if only IP based communication (including wireless communication) is possible.

All interlock parameters, except the radiation levels from the radiation monitors, are observed by PLC modules placed in every floor of the facility in the present system. These PLC modules have Ethernet interfaces and are connected to the IP network. Parameters, such as the status of emergency stop switches or door switches, are connected to the nearest PLC modules, then the status of these parameters are shared with the remote PC over the network. Any controlled devices for the interlock system, such as self-lock keys of the entrance door or the alarms in the rooms, are also connected and controlled by the nearest PLC modules. Accessing devices from a PC is possible through PLC over the network, and output from each device can be displayed and processed on remote PC.

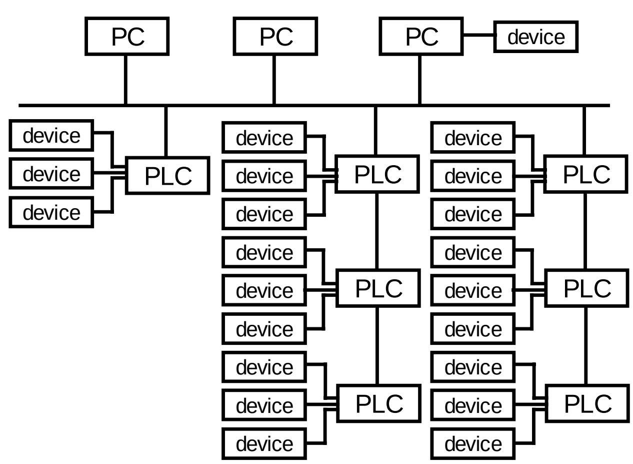

Figure 1: The outline of the interlock system for the FFAG accelerator complex in KURRI.

Common Software System

The roles of remote PC are to manage the interlock sequence and to serve the human interface for the observation of the status. The software of interlock sequences is developed by LabView in the present interlock system, and this enables us to change the logic of the interlock system easily in the prospective extensions of the system. In addition, complex conditions to trigger interlock can be constructed by analyzing output signals from monitors and devices with LabView which enables to construct advanced interlock system; the situation is analyzed not only by exceeding alarming level (ex. radiation level) but also by tendency of measured values of each monitors. Such an advanced interlock system enables to prevent accidents and troubles of devices. In the case of conventional interlock system, PC is used only for monitoring radiation and devices. We also prepared the low-level interlock sequences on PLC for the parameters which require immediate response to eliminate the delay caused by the network. It is also one of merits using this kind of system that the way to operate output signals from monitors and devices can be easily changed by the species of the signals. And the PC based software opens the possibility towards the advanced interlock system by processing complex information using advanced devices such as code reader and video camera and others.

The software on PC can display the various output signals from the monitored devices graphically and process those complex information immediately. This helps distinct understanding of the conditions of the controlled system. And logging those complex data is very easy by using the PC. One of the advantages in the development of software by LabView arises here, i.e., the up-to-date modifications of the graphical interfaces or the data logging method are easily performed. In the case of using multiple PC's for the interlock system, administration of the interlock system and data log is easily carried out by communication among those PC's. In our institute, the central control for the activities of qualified persons in all restricted areas are performed in a conventional system and our current interlock system has to share the information with this control system. Although the implementation is yet realized, the information on the activities of qualified persons in the FFAG facility will still be shared over the network by preparing a gateway PC for the central control system.

Administration of controlled area

Administration of entrance and exit of radiation controlled area is carried out using individual QR-code and the server-client software developed by Visual Basic. The QR-code reader connected to PC is located at the entrance of the controlled area. This PC is also connected to the interlock network and sends information of the entrance and exit to LabView working on the interlock system. Whenever anyone enters or exits the restricted area, the QR-code should be read by code-scanning device to open the electrically locked door. The personal identification number and valid period of the qualification in the QR-code are transferred to the remote server by the client software over the IP network. The server software on the remote server compares the received data and the database of personnel who are qualified for the work in the restricted area for the authentication. After authentication of the code in the remote server, a part of this data is sent to the PC on the interlock system. Finally, the permission of releasing the lock of entrance door is sent from the interlock software to the PLC, then the PLC releases the lock of the door. This remote server is also responsible for the observation of the number of person in the restricted area. The number of persons for each room in the restricted area is always shared by the interlock sequence software and no beam operation in the room is allowed as long as the number of person in the corresponding room is not zero.

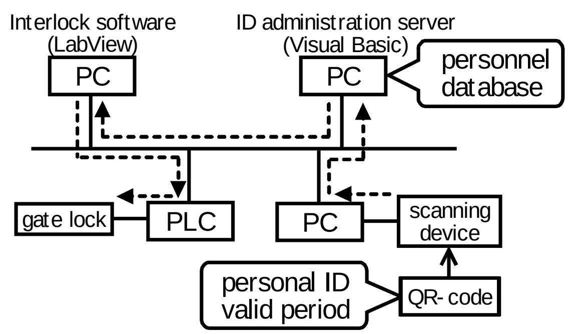

Figure 2: Administration system of the radiation controlled area. Dotted arrows show the flow of data.

Future Extension

In the future extension of the interlock system, there are some merit using the system as this work. In this interlock system, one PLC group contains one CPU module now, which means they have one common operating system. The accelerator system constructed in our institute is not so large, and the interlock system like this work is suitable. However, if large extension of the accelerator system is planned in the future, the interlock system will be easily extended to the system using advanced control system like EPICS because, if we need, FA-M3 can be worked with multiple operating system (ex. Linux) on one PLC group, and these OS's can operate EPICS (Experimental Physics and Industrial Control System) with the original FA-M3 system.

REFERENCES

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