RE-ENGINEERING OF THE SPRING-8 RADIATION MONITOR DATA ACQUISITION SYSTEM

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Abstract

We have re-engineered the data acquisition system for SPring-8 radiation monitors. The previous system consisted of dedicated digital indicator/controller modules (DICMs) optically linked with radiation monitors, embedded PCs for data acquisition, and programmable logic controllers (PLCs) for 1-h integrated dose surveillance. The embedded PCs periodically collected radiation data from the DICMs through GPIB. The DICMs and the dose surveillance PLCs were interfaced with an accelerator radiation safety interlock system (ARSIS). These components were dedicated, black-boxed, and complicated for operations. The GPIB interface was legacy and not reliable enough for the critical system. Therefore, we re-engineered the previous system by adopting PLCs and FL-net. Local PLCs were deployed as substitutes for all the previous embedded PC-based components. Another PLC was installed to enable centralized management of all 81 monitors. All the new PLCs and a VME computer for data acquisition were connected via FL-net networks. In this paper, the new system and a method for upgrading this system within the short shutdown interval of the accelerator operations are described.

INTRODUCTION

SPring-8 is the electron beam accelerator complex used in experiments that require a high-brilliance synchrotron radiation beam. According to the act on prevention of radiation disease, the radiation dose from the accelerator complex must be controlled. Therefore, it is mandatory for a radiation monitoring system to always monitor the radiation dose, and when the dose exceeds the alert level, it should immediately interrupt the accelerator operation through an accelerator radiation safety interlock system (ARSIS) [1]. A total of 81 radiation monitors including the 17 monitors used for the interlock system are deployed around the SPring-8 site.

The radiation monitoring system was very complicated because of the patched update one after another. It comprised two independent systems, namely a main system for 79 radiation monitors and a subsystem for two monitoring posts. The main system consisted of radiation monitors, optical transmitters with local controllers, optical converters to electrical serial communications, 79 digital indicator/controller modules (DICMs), 11 embedded PCs with GPIB and Ethernet interfaces, 3 programmable logic controllers (PLCs) to evaluate the 1-h integrated dose for the 17 interlock radiation monitors, and 3 PLCs for the interface with ARSIS. All the DICMs were mounted on eleven 19-inch racks scattered around the site. The DICMs monitored the radiation data on the basis of the three established alert/warning thresholds (low, high, and high-high). It also checked the normal operation of the radiation monitors and communication devices.

Although the radiation data were very important for the accelerator operation, these data could not be accessed in the same manner as other data related to the accelerator, because the radiation monitoring system was developed as the completely independent system with the accelerator control system. Therefore, we built the data acquisition system three years ago for the radiation monitors by installing a server PC that communicated with all the embedded PCs. We used the data acquisition software of message and database oriented control architecture (MADOCA) [2] to accumulate all the radiation data into the common database used for the accelerator control system. Figure 1 shows the previous data acquisition system used for the SPring-8 radiation monitors.

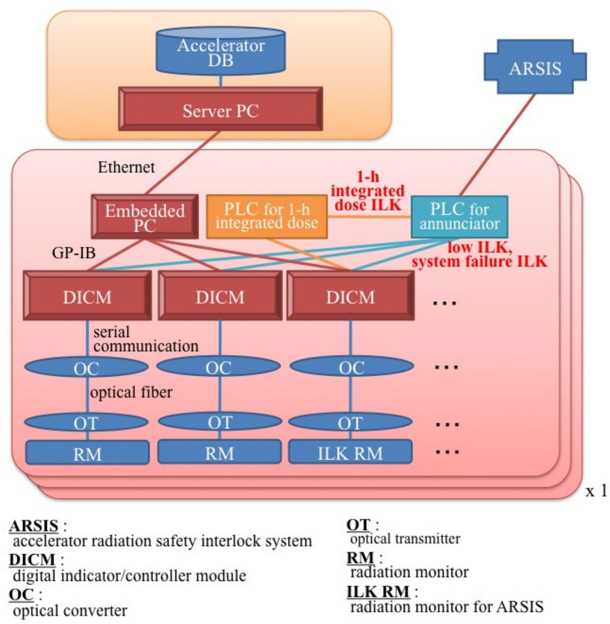

Figure 1: Previous data acquisition system for the SPring-8 radiation monitors.

PROBLEMS WITH PREVIOUS SYSTEM

Development of the previous data acquisition system enabled the accelerator operators to browse and investigate the status of the radiation monitors in the same manner as that used for the accelerators' data. The previous system, however, had the following problems.

- The GPIB interface employed in the previous system was not reliable enough for continuous use.
- The software that periodically collected data from the radiation monitors via the GPIB in the embedded

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PCs was black-boxed. It was not practical to radically modify the software. However, it was necessary to improve the software because there was no way of knowing whether or not the software was running normally.

- Accelerator operators were unable to access the 1 h-integrated dose data used for radiation control, because these data were integrated by PLCs using the analogue outputs of the DICMS. These PLCs were patched at a later date and were independent from the data acquisition system.

Therefore, we radically re-engineered the data acquisition system to solve these problems.

NEW SYSTEM DESIGN

The new data acquisition system was designed in the following manner.

- We deployed local PLCs instead of the DICMs, embedded PCs, and GPIB interface to enhance the system reliability and to reduce the number of black boxes as much as possible.
- We integrated the independent subsystem for two monitoring posts into the new system.
- We assigned the integration function for dose data to the newly installed local PLCs.
- All the local PLCs were equipped with touch panels to enable user-friendly operations.
- We introduced a central PLC to centrally manage all the monitors near the central control room.
- We adopted FL-net [3], which was widely used in the SPring-8 and SPring-8 angstrom compact free electron laser (SACLA) control system, to connect all the local PLCs and the central PLC.

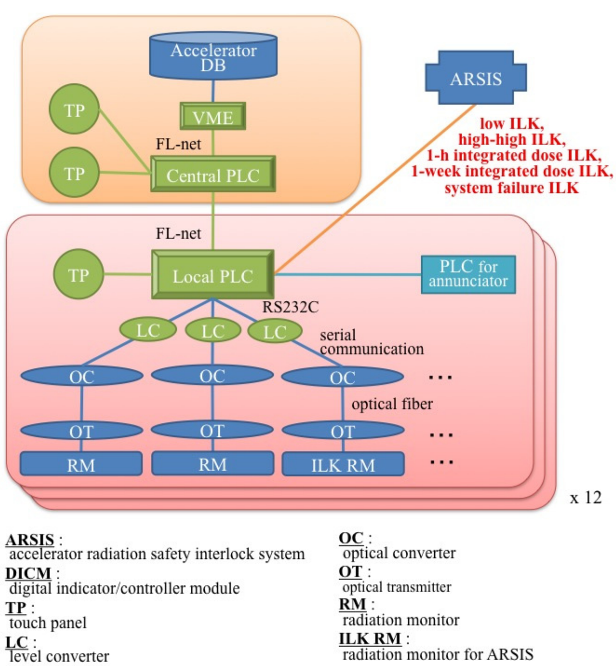

Figure 2: Schematic diagram of the new data acquisition system for the SPring-8 radiation monitors.

- The central PLC was provided with an additional FL-net module to enable connection with a VME computer that was linked to the accelerator control network. The VME computer collects all radiation data and incorporates them into the common database of the accelerator control system using the MADOCA framework.
- All the critical processes concerned with ARSIS are carried out by the local PLCs. The central PLC is not used for ARSIS.
- The interlock signals originating from the local PLC are sent directly to ARSIS. The existing PLCs are not used for interlock processing to simplify the system.

The new data acquisition system is shown in Figure 2. The new system consists of 12 local PLCs with touch panels, 1 central PLC with 2 touch panels, 2 FL-net networks, and 1 VME computer.

Local PLC Units

We simply replaced one embedded PC and its corresponding DICMs with a new local PLC because of the time and space limitations for our upgrade. We adopted a MELSEC Q-series controller [4], equipped with a 12-inch V812iS touch panel with 800 × 600 resolution as the local PLC [5]. Figure 3 shows the local PLC unit mounted on the existing 19-inch rack.

The local PLC uses an RS-232C module to interface with the optical converters that use serial communication with a different signal level than the local PLC. The local PLC is equipped with several two-channel RS-232C modules and communicates with the optical converter through a newly prepared external circuit that converts the signal level to that of the optical converter.

We give integration and evaluation roles for the 1-h integrated dose and the newly introduced 1-week integrated dose to the local PLC instead of the existing PLCs. The local PLC outputs interlock signals to ARSIS when the following conditions are satisfied.

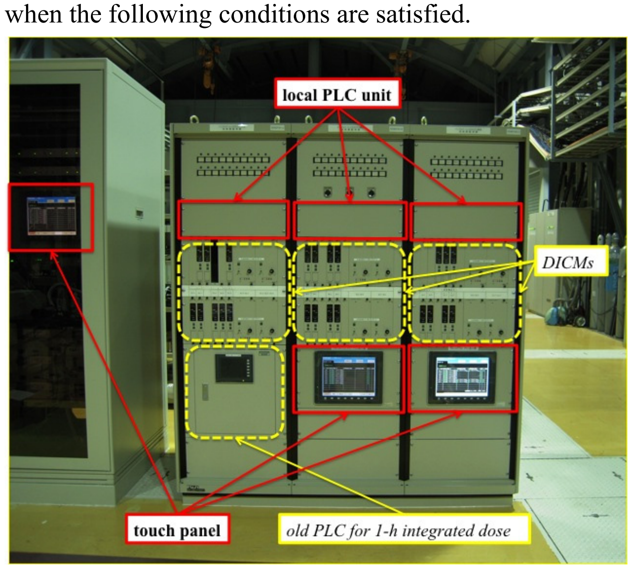

Figure 3: Photograph of the local PLC unit.

- The radiation value is lower than the low threshold level during the 3 s when the interlock by low alert is enabled.
- The radiation value is higher than the high-high threshold level during the 3 s when the interlock by high-high alert is enabled.
- The 1-h integrated dose becomes larger than its threshold level when the interlock by 1-h integrated dose is enabled.
- The 1-week integrated dose becomes larger than its threshold level when the interlock by 1-week integrated dose is enabled.
- The radiation monitor or the communication device encounters an error when the interlock by system failure is enabled.

These thresholds can be changed using the local touch panels. Alert histories encountered on the local PLC can be viewed on the touch panel.

We have incorporated the data-logging function into the local PLC unit. An 8-GB compact flash drive installed into the local touch panel stores sampling data for 7 days. This function ensures continuous data logging even when data acquisition into the accelerator database is stopped for some reasons.

Central PLC Unit

The new central PLC unit has been deployed in the radiation monitoring room near the central control room to enable centralized management of all the radiation monitors. The central PLC unit is equipped with two FL-net interface modules. One module communicates with the twelve local PLCs, while the other module communicates with the VME computer. We have also adopted the MELSEC Q-series PLC with two touch panels.

The central PLC unit simply oversees the entire system management; that is, it does not play critical roles related with ARSIS. The central PLC unit provides the following functions.

- Browse the current radiation data and status of all the radiation monitors.
- Browse 1-h and 1-week integrated dose data for the interlock monitors.
- Browse the alert histories occurring in all the radiation monitors.
- Change the alert/warning thresholds of low/high/high-high/1-h integrated dose/1-week integrated dose of all the radiation monitors.
- Enable/disable each interlock function of high-high/1-h integrated dose/1-week integrated dose.
- Attach/detach the radiation monitors to/from the surveillance system.
- Change the system times of all the PLC units.
- Change the common password to enable privileged accesses to the all the PLC units.

To enable the VME computer to collect the data, the central PLC copies almost all the data from the local PLC on the FL-net for the VME computers.

UPGRADE

We faced several difficulties during upgrade. The biggest problem was insufficient time for upgrade. Although the work had to be completed by 18th March 2011, it started after the SPring-8 operation was stopped in the end of February. Furthermore, we were not able to start the detailed designing work with the contractor until November 2010, even though we had already finished the ground design.

The restriction that the old devices such as the DICMs had to be kept in 19-inch racks made the work troublesome. On the other hand, this restriction enabled the old system to be restored immediately even when the new system did not work well. However, there was not enough space left to install the new system in the existing 19-inch racks.

In order to overcome these difficulties, we carried out the upgrade following a well-defined process.

- We prepared a ladder program and a level conversion circuit for the communication test held in the winter shutdown period of 3 weeks that was the unique opportunity for the test before the end of the February. The preparation of the ladder program and the level conversion circuit was carried out according to the specifications.
- During the winter shutdown, we investigated the communication protocols between the DICMs and the radiation monitors, and we tested the prepared program and circuit with the actual system.
- After the winter shutdown, we prioritized the design of touch panels because they made clear the necessary functions of both local and central PLCs. We discussed the design with the safety office, the main user of the new system.
- The PLC units were designed simultaneously. The units had to be as compact as possible because of shortage of installation space in the 19-inch racks. All the level conversion circuits and terminal blocks for external signals were put together in the units.

Consequently, we successfully upgraded the system before the deadline. The remaining minor troubles were fixed during a short shutdown period from 28th April 2011 to 9th May 2011.

SUMMARY AND FUTURE PLAN

We have re-designed the data acquisition system for the SPring-8 radiation monitors. The new system is a PLC-based system and is simpler, more comprehensible, and is more reliable than to the previous system. The new system consists of 12 local PLCs and 1 central PLC. The introduction of the central PLC enables the centralized monitoring and management of all the radiation monitors. All the local and central PLCs are equipped with touch panels to facilitate ease in operation for the radiation monitors.

The new system has been employed in the practical use since the end of March 2011 and has been working well without any issues after a minor problem was fixed in May 2011.

In August 2011, we succeeded in adding the same setup functions to the radiation monitors as those employed in the DICMs. These functions are mainly used for maintenance work during long shutdown intervals. The new system was successfully applied for the practical maintenance work, in August 2011. This proved that the new system was realistic enough for maintenance work. This will enable us to eliminate DICMs from the radiation monitoring system and rearrange the 19-inch racks to enhance maintainability by eliminating the dispensable devices.

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