FACILITY UTILITY CONTROL SYSTEM OF XFEL/SPRING-8

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Abstract

The XFEL facility under construction at SPring-8 requires highly stable RF phase and intensity control for steady X-ray lasing. The RF conditions are very sensitive to facility utilities and environmental conditions such as air temperature, power line voltage, and in particular, the cooling water temperature of accelerating structures. Therefore, these utilities need to be monitored with a required sampling rate and resolution from the viewpoint of the accelerator control. In particular, the cooling water for the accelerating structure should be controlled seamlessly from the XFEL control system to achieve steady lasing. We have designed and constructed a control system for the facility utilities as a part of the XFEL accelerator control using the MADOCA framework. In this system, all the data from the facility utilities are stored in the same database. This should help in investigating the relations between the beam stability and the environmental conditions. All the utility equipment is controlled using PLCs connected to VME systems through FL-net. We set up PLC touch panels to support the daily management independently of the accelerator control system.

INTRODUCTION

Accelerators are generally equipped with facility utilities such as electrical equipment, cooling equipment, air conditioning equipment and fire equipment. The control systems for such facility utilities are usually designed and constructed independently of the accelerator control system. The same is true at SPring-8, the world's-largest third-generation synchrotron-radiation right-source facility. The facility utility control system of SPring-8 was designed and constructed completely independently of the accelerator control system. Consequently, both systems cannot exchange either control commands or acquired data online. The facility utility control system monitors and acquires data with a required precision and sampling rate for daily monitoring carried out by facility utilities specialists. It should be noted that the facility utility control system was made based on a proprietary system of a single manufacture and locked-in to the products of the manufacture. Improvement of the control system is strongly depended on the manufacture.

We have designed facility utility control system for the X-ray free electron laser (XFEL) facility that has now been constructed at SPring-8 site based on our experience at SPring-8. This system is designed to be strongly coupled with the XFEL accelerator control system.

EXPERIENCE AT SPRING-8

As described above, the SPring-8 facility utility control system was designed and built completely independently of the SPring-8 accelerator control system. When the emittance of the the stored electron beam in the SPring-8 storage ring was decreased, an disturbance of the stored beam came from environmental conditions was a visible size. The accelerator specialists required a decrease in the thermal fluctuations of cooling water for the magnets, RF cavities, vacuum chambers etc., and in the air temperatures in the storage-ring tunnel. They also required more extensive monitoring and longer-term data-storage of the cooling water and the air temperatures of the storage-ring tunnel with higher resolution, higher sampling rate, and more sampling points as the reference data.

The reference data acquisition of the facility utilities was improved by changing the accelerator control system while the cooling water temperatures and air temperatures was stabilized in the facility utility control system. This is not necessarily efficient because in some cases, the same points are monitored by both the control systems in the different manner. In other cases, the facility utility specialists refer to the facility utility data in the database of the accelerator control system.

DESIGN OF XFEL/SPRING-8 FACILITY UTILITY CONTROL SYSTEM

The XFEL/SPring-8 facility requires highly stable RF phase and amplitude control for stable X-ray lasing. The RF conditions are very sensitive to the facility utilities and environmental conditions such as air temperatures in the machine tunnel and klystron gallery, power line voltage, and in particular, the cooling water temperatures of accelerating structures. The XFEL is equipped with precise temperature regulation systems for the accelerating structures in order to stabilize the cavity temperature within ±0.02K [1, 2].

Therefore, monitors and controls of the facility utility equipment and the environmental conditions are of great importance at XFEL. Base on our experience at SPring-8, we designed and constructed the XFEL facility utility control system considering the requirements of the accelerator experts.

Requirements of the Control System

The term "facility utility equipment" indicates electrical equipment and air-conditioning and plumbing equipment such as cooling-water and air-conditioning.

Both types of equipment are of great importance in an accelerator. Among these equipment, the so-called "machine cooling-water system", that supplies temperature-regulated (within ±1 K) cooling-water to the precise temperature-regulation system for the accelerator RF system, is of particular importance in an accelerator. Here, we ignore other facility utility equipment that are of

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lesser importance in an accelerator, such as fire detection and fire alarm system.

The control system for the facility utility equipment is required to perform the following functions;

- Monitor the facility utility equipment with the required precision and sampling rate not only for daily management but also for the accelerator operations.
- Store the monitoring data of the facility utilities in the database along with the accelerator control system to enable the accelerator specialists to be easily compared with the accelerator data.

- Ensure that the stored data of the facility utilities can be referenced and accessed by the facility utility specialists as well as from the accelerator control system.
- The daily management of the facility utility equipment can be performed independently of the accelerator operation. It can be continued even when the accelerator control system is stopped for the maintenance.
- The machine cooling-water equipment can be directly controlled as a part of the accelerator control system directly.
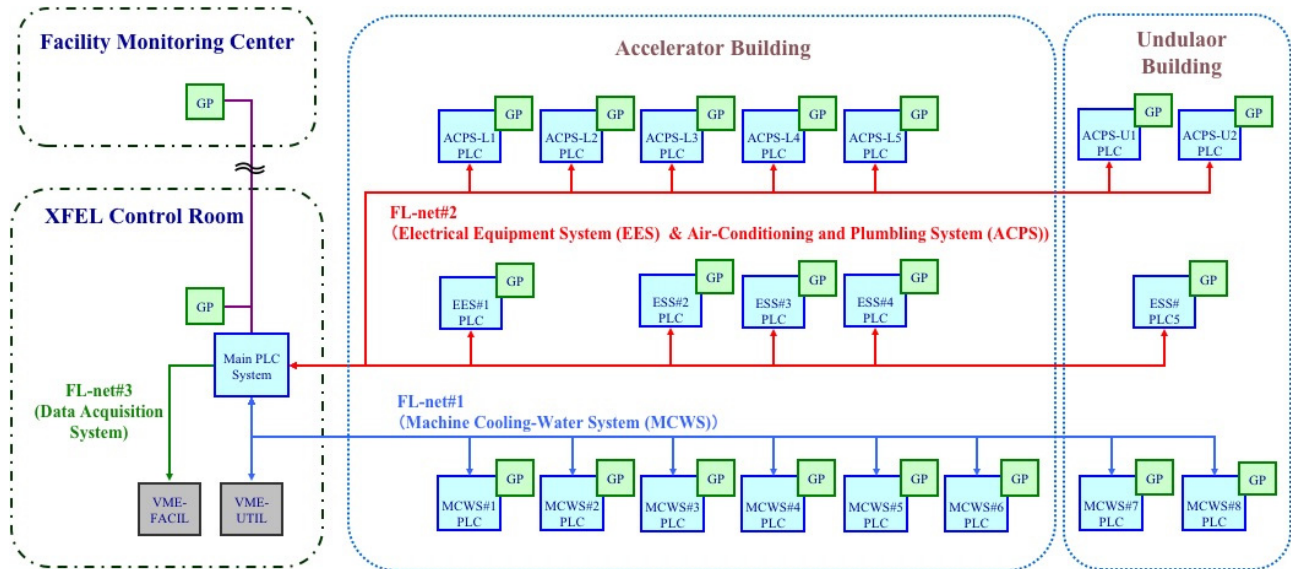

Figure 1: Schematic diagram of the XFEL facility utility control system.

Design of the Control System

In order to satisfy the above requirements, we designed the facility utility control system as shown in Fig. 1. The features of the system design are summarized bellow.

- Programmable logic controllers (PLCs) with graphic panels are deployed near the facility utility devices for a local control.
- A main PLC system is designed in order to communicate with all the deployed PLCs through FL-net, an Ethernet-based factory floor network system [3].
- The main PLC system is equipped with two graphic panels for daily management work by the facility utility specialists. One is deployed at the SPring-8 facility monitoring center for the integrated management with SPring-8, and the other is deployed in the XFEL control room.
- The facility utility control system consists of three FL-net segments. The first segment is used for the machine cooling-water system, and it enables the direct control and monitoring of the machine cooling-water system from a VME computer in the accelerator control system. The second segment is used for the other facility utility equipment, which

enables monitors and controls from the main PLC system. The third segment is used for the interface with the accelerator control system to enable data acquisition into the accelerator database.

We decided to introduce the FL-net based on its successful use in the SCSS test accelerator control system [4] and the compliance of many manufacturing vendors. The FL-net facilitates the interfaces between the PLCs and the VME systems because it can combine the interfaces on the memory mapping in the FL-net common region. Therefore, we considered that the introduction of the FL-net networks was effective in the designed facility utility control system by several manufacturers.

CONSTRUCTION

Hardware

Several manufacturers joined to construct the facility control system hardware. First, we collected the requirements for the precision and the sampling rates of the monitoring points from the accelerator specialists, and then we conveyed these to the manufacturers. Next, we collected information about the number of signals, the types of signals, direction of signals etc. in order to map

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the common memory area on the FL-net networks. Each manufacturer proceeded with the construction of each local control system on the proposed FL-net map independently. Finally, we connected and integrated all the PLCs and VME systems and performed a control test in April 2009.

The integration was quite successful and was performed within a very short amount of time considering the fact that the system was constructed independently by the several manufacturers and had a large number of signals. The FL-net successfully dealt with the differences between the different PLCs. The machine cooling-water system and the main PLC systems used FA-M3 PLCs manufactured by the Yokogawa Electric Corporation [5]. The other control systems were controlled using SYSMAC CS1G PLCs manufactured by the Omron Corporation [6]. We did not face any problems with these systems.

In May 2009, daily management was started by using the graphic panel (Fig. 2) deployed at the SPring-8 facility monitoring center along with the SPring-8 facility management.

Figure 2: Graphic panel of the XFEL facility control system deployed at the SPring-8 facility monitoring center.

Software

We deployed the data-acquisition software for the XFEL facility utility control system on the VME computers (VME-FACIL in the Fig.1) interconnected with the main PLC system. The software was developed using the MADOCA framework [7] in the same manner as the accelerator control system. In addition, we developed the data acquisition and the control software running on another VME (VME-UTIL in the Fig.1) system for the machine cooling-water system. These data acquisition software began storing the data in a database.

SUMMARY

We designed and constructed the XFEL facility utility control system. Although it is usually constructed independently of the accelerator control system, we designed to integrate it closely with the accelerator control system on the basis of our experience at SPring-8. The facility utility control system can acquire the required data with the required precision and sampling rate from the accelerator operations point of view. In particular, the machine cooling-water system can be directly controlled from the accelerator control system.

The system could be constructed smoothly by introducing FL-net although the several manufacturers were involved in its construction. The system was used for the daily management of the XFEL facility utility equipment. In addition, we successfully started data collection and storage into a database by developing software based on the MADOCA framework. The acquired data has been utilized not only for the monitoring work but also for the accelerator construction.

In the near future, we will extend the XFEL facility utility control system according as the additional XFEL facilities are constructed. In addition, we will improve the present control system, including the software used for the graphic panel. The extension will be facilitated by the introduction of FL-net.

ACKNOWLEDGEMENT

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