

RECENT BEAMLINER INTERLOCK SYSTEM AND STARS AT THE PHOTON FACTORY

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Abstract

More than 20 beamlines are installed at the Photon Factory for synchrotron radiation research. Each beamline is equipped with an interlock system to protect users from radiation hazards and avoid vacuum-related troubles. The system is controlled by a programmable logic controller (PLC). Currently, touch panels and their corresponding communication protocols comprise the user interface. They work satisfactorily but are expensive.

We have developed a new type of beamline interlock system that has a PC user interface based on a simple transmission and retrieval system (STARS). We will describe the details of this new system as well as STARS.

BEAMLINER INTERLOCK SYSTEM

An interlock system is installed on every beamline at the Photon Factory in order to protect the users from radiation hazards, maintain a vacuum environment for the beamline, and protect the beamline components from high heat load damage.

Every beamline interlock system works with a programmable logic controller (PLC). The following three types of interlock systems run at the Photon Factory:

- Legacy system with an LED panel
- Field bus and touch panel user interface
- Newly developed field bus and PC-based user interface

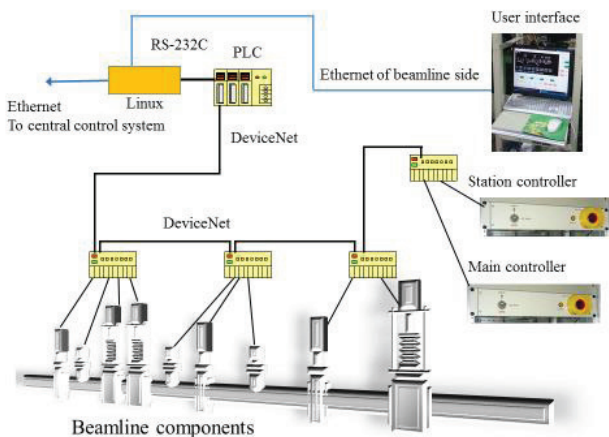


Figure 1: Beamline interlock system with field bus and PC-based user interface.

In 2015, a prototype of the beamline interlock system with PC user interface was installed onto a beamline named BL-19. We checked the reliability and effectiveness of this system and after fixing a few problems, we succeeded in the development of a new and satisfactory beamline interlock system as shown in Figure 1. The PC-

based user interface of the beamline interlock system is provided with a simple transmission and retrieval system (STARS) and it is flexible.

All the legacy systems and touch panel user interfaces will be replaced with the newly developed PC-based user interface in the future. The replacement will be done annually.

STARS

STARS [1, 2] is an extremely simple message transferring software for small-scale control systems. It is installed in various systems at the Photon Factory such as the beamline control system, room access control system, and key handling system.

STARS Server and Clients

STARS consists of a server program (STARS server) and client programs (STARS clients). The server is written in Perl and works on various operating systems (Linux, Windows, Macintosh, etc.). It is a small program that can run on low power computers such as embedded Linux. STARS provides flexible system design capabilities to a developer.

STARS clients are connected to the STARS server using a TCP/IP socket, and they communicate with other clients through the STARS server using text-based messages. STARS users can develop a control system in their preferred programming language on various operating systems if they can handle the TCP/IP socket and text. Addition a new function to the system is possible by making a new STARS client and connecting it to the STARS server. STARS clients can be connected or disconnected without stoppage of the system.

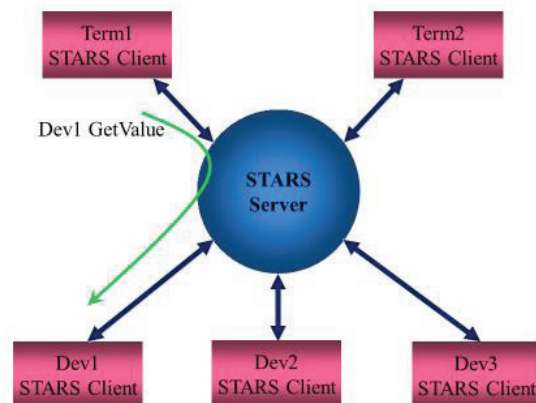


Figure 2: Example of message transferring on STARS.

Communication between STARS Clients

Each STARS client has its own node name, which is used to indicate the destination of the message. If a STARS client sends a message with a node name to the STARS server, the message is delivered to a corresponding STARS client. Figure 2 shows an example of message transferring on STARS. In the example, a client named “Term1” sends a message “Dev1 GetValue” to the STARS server, and the message is delivered to “Dev1” by the STARS server.

NEW BEAMLINE INTERLOCK SYSTEM WITH STARS

The monitoring and logging status of the beamline interlock system is very important to keep the system stable and facilitate maintenance. Originally, STARS was used for the central control system of the beamline interlock system, and a STARS client named “PLC interface” was used for the PLC interface. We expanded the “PLC interface” to support more signal counts. Figure 3 shows the software layout around the PLC interface.

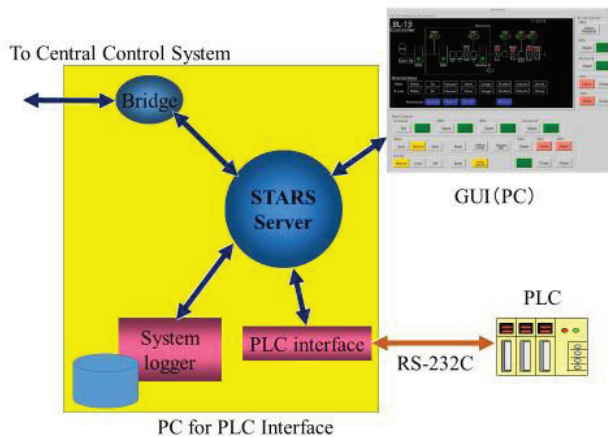


Figure 3: Software layout.

Development of the New PLC Interface

The new PLC interface is a STARS client program that can handle signals previously used by the touch panel. It communicates with the PLC through an RS-232C interface. All status signals are transported when the program is initialized and only the change of information is transmitted if the status has been changed in the PLC. This solution has enough speed using the RS-232C interface.

All interlock logic (radiation safety, etc.) is provided by the PLC, and STARS only provides the user interface.

Advantage of STARS for Beamline Interlock System

We already verified the stability and reliability of STARS with the central control system. STARS has a client certification and command suppression that works effectively to keep a secure beamline interlock system. The useful commonly provided STARS clients such as the

system logger are also effective for the development of beamline interlock system.

Client Certification

STARS has a simple certification checking procedure at connection time as follows:

- Host name checking: Is the host name or IP address of the STARS client found in the allowed list?
- Keyword checking: A STARS client must send a corresponding keyword, specified by the STARS server in the keyword list.
- Node name and host name checking (optional): Specification of the hostname for the STARS client is possible.

This simple procedure works effectively to avoid disconnection of the STARS client and helps maintain beamline interlock system reliability.

Command Suppression

The command suppression function of STARS is used to prevent commands such as “write” or “set” from unauthorized STARS clients. To protect the STARS client, “read only” is possible with this command suppression function. An example of the configuration file (command_deny.cfg) is shown below.

```
#Command deny list
hallmon-br>[AGS]
hallmon-br>System disconnect
```

A regular expression is used for configuration. The first line, which starts with “#,” is a comment. In the second line, the access from “hallmon-br” to the client, which starts without “G” or “S,” is suppressed. In the third line, the “disconnect” command of the STARS server from “hallmon-br” is suppressed.

Figure 4 shows an example of a command suppression function.



Figure 4: Command suppression.

In the example, the access to “GA1” is allowed, and the client can obtain valid data from “GA1” as follows:

```
GA1 GetValue
GA1>hallmon-br @GetValue 1.9400E-01
```

However, the access to “plcif-bl04” is suppressed as follows:

```
plcif GetValue
System>hallmon-br @GetValue Er: Command
denied.
```

System Logger

The system logger is a common STARS client that fetches all the STARS server output messages and writes to the log file. It helps in the troubleshooting the beamline interlock system. In the new interlock system, the number of signals increases because of the adoption of the STARS user interface, and the efficiency of maintenance is remarkably improved.

INSTALLATION OF THE NEW BEAM-LINE INTERLOCK SYSTEM

BL-4 is an X-ray beamline that used the legacy beam-line interlock system previously. We replaced it with the new beamline interlock system.

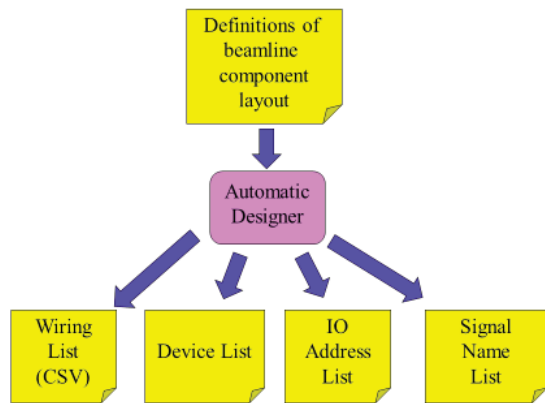


Figure 5: Automatic design.

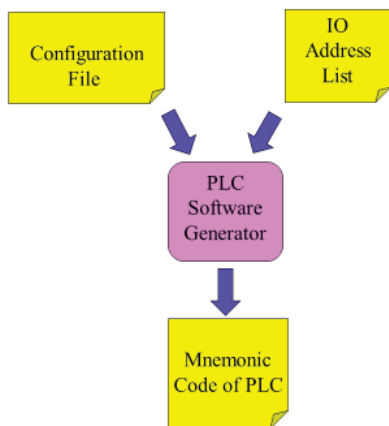


Figure 6: Generating PLC software automatically.

Automatic Designer

We are currently developing an automatic design tool for the beamline interlock system. First, we define the layout of the beamline components such as sensors, vacuum gauges, gate valves, and beam shutters. The automatic

design tool exports the wiring list, device list, IO address list, and signal list for the PLC interface with the definition (Figure 5).

PLC Software Generator

Recently, the PLC software of the beamline interlock system is generated automatically at the Photon Factory. We made a few expansions to support the PC-based user interface.

First, the PLC software generator reads the configuration file and IO address list made by the automatic designer; then, it generates the mnemonic code of the PLC (Figure 6).

Graphical User Interface

The touch panels were replaced with a graphical user interface (GUI) of STARS. Figure 7 shows the GUI panel of the new beamline interlock system.

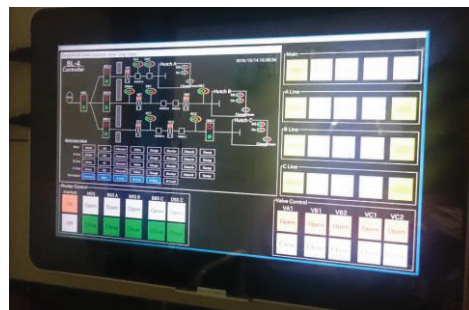


Figure 7: GUI panel of new beamline interlock system.

This GUI uses a .NET framework and the STARS.NET interface library. We are able to use the same tools and skills as those of the beamline control system. Moreover, the use of a desktop computer is more cost effective compared with the special touch panel device.

CONCLUSION

We succeeded in the development and installation of a new beamline interlock system with the STARS GUI. We then verified if the system effectively reduced required labor and cost. We are continuing the replacement of the beamline interlock systems.

At present, a new facility, tentatively termed the KEK light source (KEK-LS) [3], an extremely low-emittance 3 GeV storage ring, has been proposed and the conceptual design report preparation is in the final phase. Our new beamline interlock system is also applicable to the KEK-LS.

REFERENCES

- [1] STARS, <http://stars.kek.jp>
- [2] T. Kosuge and Y. Nagatani, "STARS: Current Development Status," in *Proc. PCaPAC'14*, Karlsruhe, Germany, Oct. 2014, paper WPO019.
- [3] T. Honda *et al.*, "Present Status of KEK Photon Factory and Future Project," in *Proc. IPAC'16*, Busan, Korea, May 2016, paper WEPOW020.