THE PRESENT STATUS OF THE CONTROL SYSTEM FOR A STRETCHER-BOOSTER RING AT TOHOKU UNIVERSITY

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Abstract

A stretcher-booster ring (STB) was constructed in the autumn of 1997 and has been commissioned. The main operation modes of the STB, a stretcher-ring mode and booster-ring mode, have achieved their design performance so far. The STB control system, based on personal computers (PCs), was developed to perform a multi-mode operation and has functioned successfully. The PCs are run as a client/server system using Windows NT. The server PC plays the role of database server, and about eleven client PCs have different particular functions. All of the PCs are interconnected with a 100Base-TX/FX Ethernet. Some types of commercially available software are employed to reduce the development and maintenance loads, in particular LabVIEW, used as a graphical user interface on the operator consoles, has contributed to the construction of the software system in a short period of time. In this paper, we introduce the STB control system and report on its current status.

1 INTRODUCTION

Coincidence experiments using continuous electron beams have been commonly performed in the nuclear physics field. Several kinds of continuous beam accelerators, e.g., pulse stretchers, microtrons and recirculating linacs, have been constructed throughout the world for use in such experiments. The first pulse-stretcher rind was constructed in 1981 at Tohoku University and was subsequently used for coincidence experiments. The construction of a new ring, known as STB [1], was approved in 1995, and the STB was constructed in the autumn of 1997. The STB functions not only as the stretcher-ring for supplying the continuous beam, but also as a storage-ring for nuclear experiments and as a booster-ring, which accelerates the beam up to 1.2GeV from 300MeV in order to inject it into a proposed synchrotron-light facility. The operation of the STB is very complex due to its three operation modes, which include the stretcher-ring, the storage-ring and the booster-ring, and because the beam channel as well as the beam energy and current must be changed frequently in a multipurpose accelerator such as this. Moreover, since our accelerator is operated by people who are not acquainted with accelerator structure, the control system had to be developed which incorporated techniques for extracting beam parameters from beam monitor signals, programs for beam orbit simulation and correction, and abstractions to hide the accelerator components and configuration from the operator. In addition, it is generally necessary to provide, in a short period of time, good reproductions of operation values and of the statuses of accelerator devices. The STB control system [2] has been designed and constructed to satisfy these requirements.

The main operation modes of the STB, the stretcher-ring mode and booster-ring mode, have so far performed as they were designed to, and the STB control system has functioned successfully.

2 HARDWARE CONSTRUCTION

An outline of the STB control system is shown in Fig. 1. The control system consists of twelve PCs and eight programmable logical controllers (PLCs). The PCs play particular roles, as follows:

(1) a database server and a main control computer,
(2) an operator's console installed in an accelerator control room,
(3) a video signal digitizer for beam screen monitors,
(4) a beam signal processor for button-type position monitors and wire-scan type profile monitors,
(5) a wave form processor that observes signals from the pulsed operation devices,
(6) a ramp-up pattern generator that provides reference signals to the magnet power supplies during booster-ring mode operation,
(7) a gateway between the computer network and the PLC network,

(8) a WWW server for providing real-time information on the accelerator operation to the Internet [3].

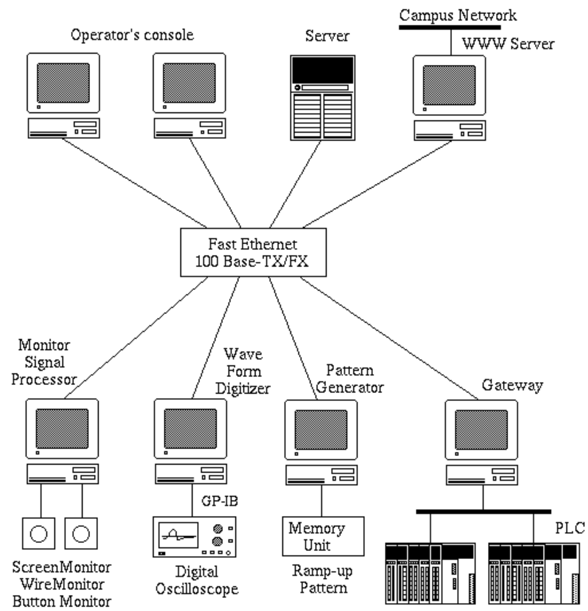

Figure 1: The control system architecture.

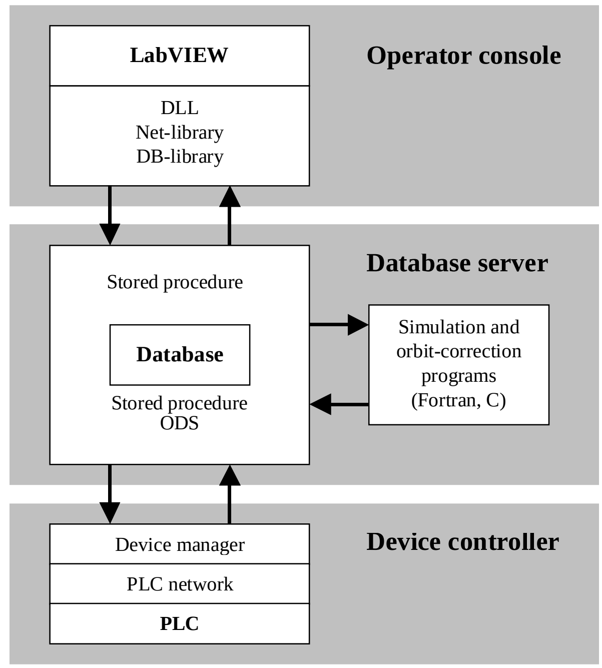

Figure 2: Software scheme of the control system.

The PCs run as a client/server system using Windows NT. All of the PCs are interconnected with 100Base-TX/FX Ethernet.

The PLCs work as an interface between the accelerator components and the control computer system. The PLCs are from the OMRON CV1000 series. A PC used as a gateway converts messages both on a control computer network and a PLC network (Token bus, 2MHz) in order to facilitate communication between the database and the PLCs. The gateway polls every PLC at 400ms intervals, and transfers the collected operation data of the accelerator devices to the database. We developed a PLC driver library [4] running in Windows NT.

A ramp-up pattern generator supplies the reference patterns to the magnets and the RF source so as to accelerate the beam energy from 300MeV to 1.2GeV in the booster-ring mode of operation. This generator is comprised of a PC and a memory unit. The memory unit consists of five memory modules having 128K word memory, and a memory controller, all of which are constructed as CAMAC modules. The PC calculates the pattern data in detail according to the outline pattern data of each magnet as entered at the operator console, and saves the data into each memory module. The pattern data is read out sequentially at 100μs intervals. The CAMAC crate controller and an interface card are used in Kinetic 3922 crate controller and 2927 interface card for PC, and the driver library in Windows NT was developed in our laboratory using the DDK development library (WinDK) supplied by Blue Water Systems.

3 SOFTWARE CONSTRUCTION

The block diagram of the control software is shown in Fig. 2. The control system consists of three layers: a human-interface layer (namely, an operator console), a control layer (namely, the database), and a device layer (namely, the device controller).

3.1 Operator console

The PCs used for the operator's console have a graphic accelerator to enhance their drawing speed, because fast drawing and quick response are required of console displays to ensure good performance as a man-machine interface. The display windows on the consoles were produced using LabVIEW. Using LabVIEW enable the software development load to be reduced because LabVIEW has various GUI components, for example, meters, switches, slide-volumes, a wave-form charts, and so on, and has excellent functions such as multi-thread correspondence, communication between distributed PCs and so on. Fig. 3 shows a typical window, that used to control magnet power supplies. An operator can adjust the parameters of accelerator devices displayed on the screens using the mice provided for the console PCs, and can also control them using the four knobs provided on the console desk so as to handle four parameters simultaneously. LabVIEW is also used to display the current or voltage waveforms of the power supplies under pulsed operation. The signals are selected by a coaxial switch, and digitized by oscilloscopes. This data is then collected by the PC located near the power supplies using

Figure 3: Typical control window.

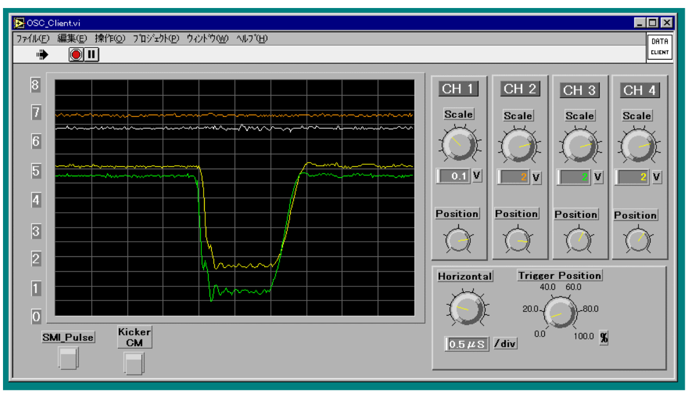

Figure 4: Example of waveform display.

GPIB and LabVIEW, and transmitted to the operator's consoles in TCP/IP. On the operation consoles, the wave-forms are displayed on a window designed to look much like the front view of an oscilloscope, as shown in Fig. 4. The four channel data (8bits/dot, 500dots/channel) are updated on the console screen about three times per second.

We can control the accelerator components and observe the signals from other PCs connected to the control network from outside the control room. This configuration is very convenient for developing the control program and maintaining the accelerator.

3.2 Database

In order to fulfill some of the requirements of multi-mode operation, we employed the database [5] as a control manager, and found that it enhanced the flexibility of the control system. The database improved our ability to administer the control data and to incorporate application programs into the system. The control database, MS-SQL Server, is installed in the Windows NT Server. Because the database is a control manager, every communication between the operation console and the PLC must be executed through it. If the control data were rewritten erroneously by a mistake, much damage would be caused to the control system. The data is maintained along with stored procedures, which behave like a method in object-oriented programming, and is hidden to protect it from improper access. All access to the database must be executed through the stored procedures.

4 CONCLUSION

We could construct the compact control system using PCs, PLCs and commercially available software. The control system has performed successfully in the STB test operation of both the stretcher-mode and booster-mode. The practical operations for the nuclear experiments begin soon, but since the control system has plenty of room for improvement if it is to be easily operated, we will continue to update the hardware and software configurations.

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