STATUS OF THE CONTROL SYSTEM FOR THE STB AT TOHOKU UNIVERSITY

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Abstract

A stretcher-booster ring (STB) was constructed and has been commissioned. The STB control system based on personal computers (PCs) and programmable logical controllers (PLCs) has been developed. The PCs respectively function as a database server, a PLC manager, as operator consoles, signal digitizers for wave form observation, video/signal processors for beam monitors, a ramp-up pattern generator for booster-ring mode operation, and as a WWW server for providing accelerator information to the internet. The PLCs are used as an interface between the computer system and accelerator devices, and act as a device driver.

Since the STB has three operation modes, its operation is very complex. So the multi-mode STB will operate smoothly, a database system is employed in the core of the control system; database plays a very important role as a control manager rather than simply as a data storeroom. The use of the database enhances the flexibility of the control system.

When the booster-ring is used to ramp up beam energy from 300MeV to 1.2GeV, bending and quadrupole magnet currents must be boosted in one second, in accordance with the increasing beam energy. We have developed a ramping wave form generator to drive the magnet power supplies.

In this paper, we introduce the STB control system and report on its recent status.

1 INTRODUCTION

The STB[1] control system was designed with the following basic guideline in mind[2]: keeping construction and maintenance costs low, employing the latest computer technologies in the construction of the compact control system, ensuring ease of operation, and establishing a high level of flexibility and expandability. In order to achieve these goals, we agreed to use PCs and PLCs rather than a workstation and VME, which were commonly used in other accelerator control systems. We also chose to employ the database as the core of the control system, and to utilize commercially available software. Because the STB has three operation modes, which include a stretcher-ring, a booster-ring and a storage-ring, its operation is very complex. Moreover, in a multipurpose accelerator such as this in which the beam channel as well as the beam energy and current are changed frequently, it is generally necessary to provide, in a short period of time, good reproductions of operation values and of the statuses of accelerator devices. Since we have to construct a control system which can ultimately be operated by people who are not acquainted with accelerator structure, we must develop processing 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.

2 CONSTRUCTION OF THE CONTROL SYSTEM

An outline of the control system is shown in Fig. 1. The control system consists of ten PCs and seven PLCs. The PLCs work as an interface between the accelerator components and the control computer system. The PCs play particular roles, as follows: (1) a database server and a main control computer; (2) an operator's console installed in the accelerator control room; (3) a beam monitor signal processor; (4) a wave form processor that observes signals from the pulsed operation device; (5) a ramp-up pattern generator that provides reference signals to the magnet power supply during booster-ring mode operation; (6) a gateway between the computer network and the PLC network; and (7) a WWW for providing real-time information on the accelerator operation to the internet. The PCs run as a client/server system using Windows NT. All of PCs are interconnected with 100Base-TX/FX Ethernet. The number of PCs and PLCs will be increased as needed with the development of the control programs and the test operation of the STB.

2.1 Database

The use of databases has become popular recently in the accelerator control field, but in most designs the database functions primarily as a simple data storeroom. We employed the database[3] as a control manager, and it enhanced the flexibility of the control system. The database improved our ability to administer the control data, to incorporate application programs into the system,

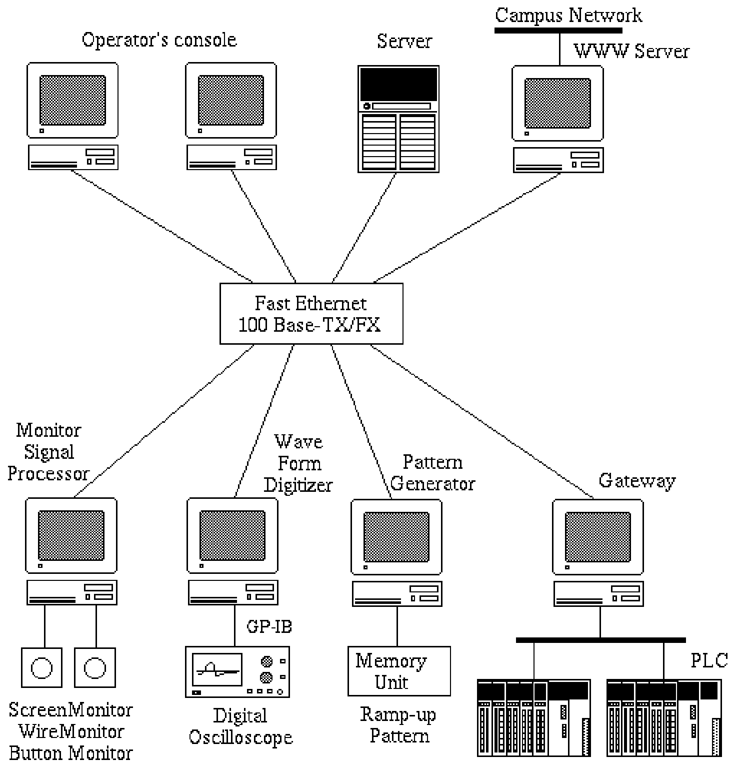

Figure 1: The control system architecture.

and to refer to operation records from the internet. The control database, MS-SQL Server, is installed in a server computer (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 by a mistake, much damage would be caused to the control system. The data is together with stored procedures, which behave like a method in object-oriented programming, and is hidden to be protected from improper access. All access to the database must be executed through the stored procedures.

2.2 Operation 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. An operator can control the accelerator devices using the mice provided for the console PCs, and using four knobs which can be handled simultaneously. The displays on the consoles were produced using LabVIEW. Because LabVIEW has excellent and various GUI functions, the software development load can be reduced. We can execute the console programs and control the accelerator components from other PCs which are connected to the control network from out side of the control room. This configuration is very convenient for developing the control program and maintaining the accelerator.

2.3 PLC

The PLCs are from the OMRON CV1000 series. The typical performance of the CPU involves an execution time for basic commands of 0.125 ~ 0.375μs, and 1024 available input/output control points. The PLC modules used in this control and in these interfaces for the accelerator devices are shown in Table 1. A gateway converts messages both on the control computer network and the PLC network (Token bus, 2MHz) in order to communicate between the database and the PLCs. We developed a PLC driver library[4] running in Windows NT. The gateway polls every PLC at 400ms intervals, and transfers the collected operation data of the accelerator devices to the database.

2.4 Wave form digitizer

The current or voltage wave form of the power supplies under pulsed operation is selected by a coaxial switch, and digitized by oscilloscopes. This data is then collected and entered into the PC using GPIB and transmitted to the database and the operator's consoles as well. On the operation consoles, the wave-form is displayed on a window designed to look much like the front view of an oscilloscope, making it possible to

Table 1 : PLC modules.

Module type	/module	Number of modules	Controlled devices
Digital input	64bit	10	Power supply status, Interlock, Vacuum valve
Digital output	64bit	9	High current power supply(16bit), Beam screen monitor
ADC	12bit, 8channel	8	Pulse septum, Kicker magnet, RF power source
DAC	12bit, 8channel	3	Pulse septum, Kicker magnet, RF power source
GPIB	1port	9	Low current power supply, Voltmeter, Frequency counter, Frequency generator
RS422/RS232C	2port	2	Ion pump, Vacuum gauge

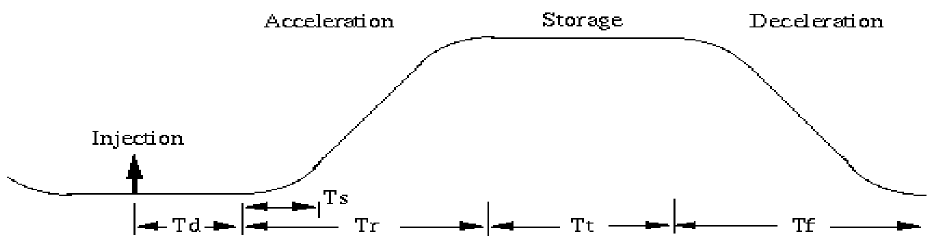

Figure 2: Reference pattern for bending and Q magnets during booster mode operation. Td : Damping time, Ts : Smoothing time, Tr : Rise time (0 ~ 6.5sec), Tt : Storage time (0 ~ 18hr), Tf : Fall time (0 ~ 6.5sec)

observe the signals from anywhere over a computer network. The transmission time of the four channel data (8bits/dot, 500dots/channel) from the oscilloscope to the operation console is about 500ms.

2.5 Ramp- up pattern generator

A ramp-up pattern generator supplies the reference patterns shown in Fig. 2 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 and a memory controller, all of which are constructed as CAMAC modules. The pattern data, which is saved in advance into the 128Kbyte memory of the memory module, is read out sequentially at 100µs intervals in synchronization with the memory address signal driven by the memory controller. This pattern data is supplied, along with 16-bit digital data, to the magnet power supplies. The PC calculates the individual pattern form from the basic parameters sent from the database, which include the following: magnet currents for beam injection and storage, acceleration and deceleration time, duration of beam storage, peculiar delay times that depend on the characteristics of each magnet, and smoothing time needed to avoid a hasty change of pattern form. The CAMAC crate controller and an interface card are used in Kinetic 3922 and 2927, and the driver library in Windows NT was developed in our laboratory using the DDK development library (WinDK) supplied by Blue Water Systems.

2.6 WWW server

The database for off-line processing and for providing real-time information[5] to the internet is separated from the control database and installed on the WWW server. This is done to protect the control database from illegal access from the internet. Moreover, separating these databases helps reduce the CPU load in the server computer used for the accelerator control. The transmission of the data from the control database to the WWW database is achieved using a replication function provided by the MS-SQL. The control database is defined as a publication-server, and the WWW database is defined as a subscription-server. Vacuum pressures in the STB are currently displayed on our laboratory's home page[6] using Java-applet, and we will provide other operation statuses soon.

3 CONCLUSION

The cost of the STB control system and manpower for constructing it were low because we used PCs and PLCs as our hardware, and the database and commercially available programs as our software. Since transmission on the PLC network and the GPIB for the magnet power supplies are not extremely fast in this system, we are preparing to install more gateway computers to enhance the PLC network and more GPIB ports to reduce the number of power supplies connected to each port. The test operation for the booster-mode of the STB has only recently begun, but all test operations will be finished in a few months. The control programs must be completed according to that schedule.

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4 REFERENCE

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