PC-based Control System in Storage Ring TERAS

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Abstract

Personal Computer (PC) based control system has been developed for the storage ring TERAS at Electrotechnical Laboratory (ETL). The system consists of device control PCs with several I/O boards, man-machine interface PCs and a network system. Intel-based PCs, running on the Microsoft Windows95 and the WindowsNT, are used with the built-in TCP/IP protocol. Each I/O board has a client/server-type application written with Borland Delphi. A database sub-system has been developed for watching the status of the ring and for helping the daily operation.

1 Introduction

Recently high-speed and low-cost Personal Computers (PCs) allow constructing a control system for a small- and a medium-scale accelerator facility[1]. A PC-control system is suitable to construct a distributed control system with a restricted budget because of its cheap price. Moreover, a recent operational system (OS) running on a PC has a built-in network service that smoothly works with their applications. Therefore, an inexpensive (but high performance) control system can be constructed with PCs with a network system that is commonly adjusted in most of facilities. A PC-based control system has also been developed for the storage ring TERAS at Electrotechnical Laboratory (ETL). The system consists of device control PCs (DCPCs), which are equipped with several I/O boards that are commercially available, of man-machine interface PCs (MMPCs) and of a network system. The Microsoft Windows95 is used for the OS running on the DCPCs, because direct accessing to an I/O port can be available without any special device drivers. Both the Windows95 and WindowsNT are used for the MMPCs. The development of the new system has been started in 1990. In this paper, we would like to describe a brief history of our control system and a short review of the new PC-based system.

2 Historical perspective

The storage ring TERAS was constructed for a multi-purpose synchrotron radiation source in 1979. The ring has been injected with a linac at the injection energy of 300 MeV. After the ramping up/down, the ring has been operated with various modes in the stored current, in the operation energy (from 200 MeV to 800 MeV) and in the electron orbit. These ring parameters have been fitted to several specific experiments. The original control system was also constructed in 1979. All knobs and switches were manually controlled from the control room with hard-wired cables. Since no computer system was employed in the original system, an operator with a good skill(typically user himself) was needed to change the ring parameters. Therefore, a computer control system has been greatly desired. The PC-based control system for the main magnet was started in 1990[2]. Then, the steering magnets and the RF-control PC[3] were added to the system. However, these PCs were operated independently; operators still needed to operate these independent sub-systems simultaneously. In 1996, the system has been developed to use the network system to unify several independent sub-systems and to satisfy the requirement from users who need to control the ring parameters from their experimental stations.

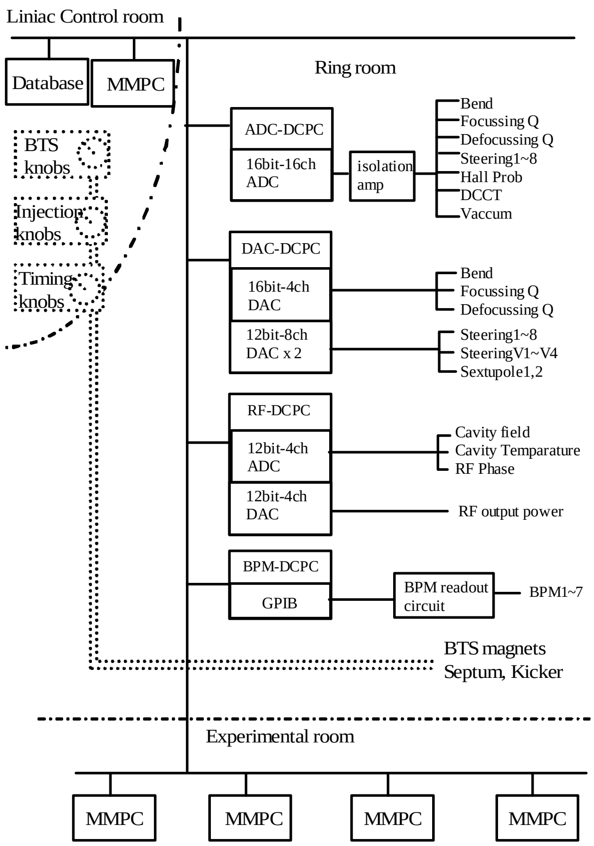

Fig.1 Schematic view of the PC-based control system. Dotted line indicates the hard-wired line and dotted boxes indicate knobs inherited from the original system.

3 Current system

3.1 System outline

The system consists of device control PCs with I/O boards, man-machine interface PCs and a network system. Intel-based personal computers are used for the control PCs. Microsoft Windows95 was chosen as the OS of the DCPCs, because 1) it works with a small resource PC(486CPU with 8 MB RAM), 2) the I/O board is directly accessed from Windows95 application, 3) the built-in TCP/IP protocol is ready-to-use, and 4) it is commonly used and many excellent applications and development-tools are available with low-prices. Both Microsoft Windows NT and Windows95 are running on MMPCs. Client/server-type applications written with Borland Delphi has been developed to control the ring. Each I/O board equipped on the DCPC has an individual server application with the Winsock procedure to deliver the I/O data through the TCP/IP protocol. Client applications, which interface to operators, run on any MMPC connected to the network with the TCP/IP. Figure 1 shows a schematic view of the system. Several sub-systems, shown as dotted lines and boxes in the figure (the beam transport, the injection system and timing system) are still isolated from the network and are wired with cables. These sub-systems will be added to the network system in near future.

3.2 DCPC and MMPC

Conventional I/O boards interface to the control devices. If the system manages a small number of control devices, a system constructed with conventional I/O boards is cheaper than that with a standard bus (CAMAC or VME system). In addition, the new system has been developed one by one during the daily operation of the storage ring. Thus, a 16-channel 16-bit ADC-card was first installed in the ADC-DCPC that monitored the magnet power-supplies of the bending magnet, of the two family quadrupole magnets and of the steering magnets. A special care for the large switching noise from the power supply was paid for using the ADC board. The ADC-DCPC is placed apart from the power supply and the ADC data are smoothed by 500 times. The latter limits the data acquisition rate of a few Hz that is enough speed for our storage ring. The data acquired by the ADC-DCPC is delivered to any MMPCs when they request the data. Therefore, MMPCs simply display the ADC data taken by the ADC-DCPC and never access any I/O devices directly. After the magnet monitor sub-system has succeeded, a DAC sub-system, which controls the main magnet power supplies, was developed. The control data is sent from any MMPCs to the DAC-DCPC consisting of a 4-channel 16-bit DAC-card and of two 8-channel 12-bit DAC-cards. Then, the BPM sub-system was added to the system. A GPIB card on the BPM-DCPC also acquires the data from beam position monitor (BPM)[4]. The RF-DCPC consisting of 12-bit ADC-card and of 12-bit DAC-card has been installed in the system. The ADC reads the RF parameters, i.e. the temperature, the strength of the electric field in the RF-cavity and so on. An operational energy of the ring that is monitored by the ADC-DCPC is referred via network communication to provide an optimized RF power fed into the cavity. The 12-bit DAC controls the output power of the RF amplifier.

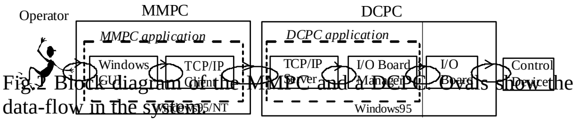

Fig.2 Block diagram of the MMPC and a DCPC. Ovals show the data-flow in the system.

Figure 2 shows a block diagram of a DCPC and a MMPC.

3.3 Applications

The DCPC application consists of an I/O board manager and of a Winsock server. The TCP/IP protocol is used for the network protocol and each server application in the same DCPC has a different IP port, because each I/O board has an individual server application. Such a tiny server application is easily developed, maintained and updated. Moreover, the system consists of several individual applications and has a great flexibility like the LEGO-block system[5]. Furthermore, if the number of DCPC is increased to disperse the I/O board, the total power of the system is increased without changing the application and the system. Of course, the network speed limits the system ability. Borland Delphi has been used to develop these applications, because it produces fast application with short programming time. Moreover, Delphi has a smart database back-end (Paradox system). An in-line assembler has been used for the I/O board manager. A GPIB routine was supplied from the board manufacture in a DLL[6], which is also easy to handle within Delphi. The Delphi add-on component, Sockv3[7], has been used for the Winsock functions. The user interface applications running on the MMPCs work as clients. These clients display DCPC data and interface to the operators via Windows GUI. Figure 3 shows the DAC-DCPC application and the corresponding MMPC application. Since several magnets are simultaneously changed at the ramping of the ring, the DAC-client application has three Winsock-connections to communicate with three Winsock servers, the 16-bit DAC and the two 12-bit DACs. This operation is called 'Synchronized mode' and the DAC-MMPC application has a check-box to switch the operational mode.

The TCP/IP communication-rate is one-Hz in the case of the DACs and two-Hz for the ADCs. The network load is small because of few k-bps data-traffic on the 10 M-bps Ethernet line. Since this Ethernet line is multi-purpose line, many items of information of Intranet and Internet also run on the same line. However, the control system has never met any trouble on the network traffic. Moreover, the Ethernet line will be upgraded to the 100 M-bps in near future. The network system is protected from the outside of the institute by using DELEGATE[8], but not from the inside. To avoid any accidental access to the control system, a password is put on the beginning of the data communication between DCPCs and MMPCs. No trouble originated from the accidental access has been reported.

A database sub-system has been developed for watching the status of the ring and for helping the daily operation. The Paradox database is used for this system, because

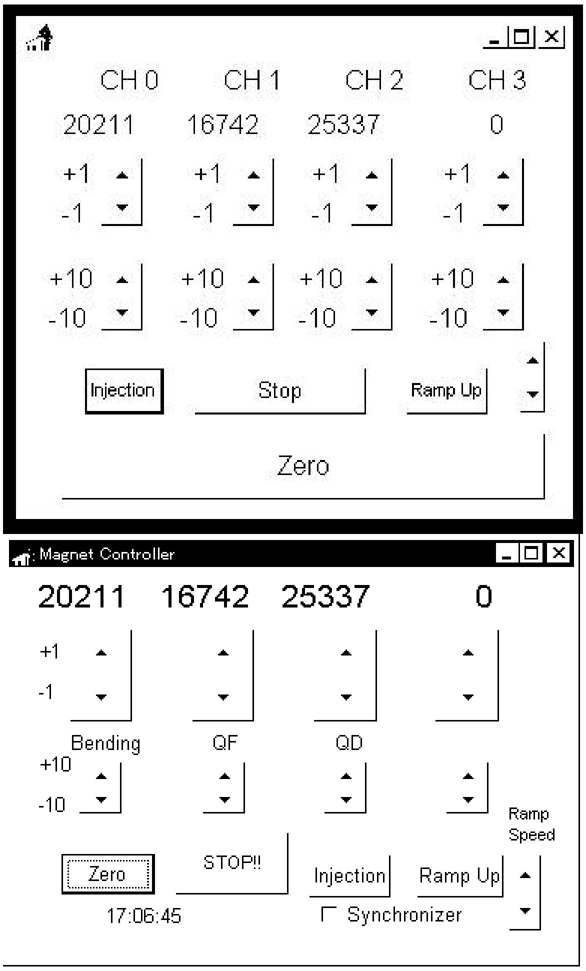

Fig. 3 Snapshots of the DAC-DCPC application (upper) and the corresponding MMPC application (bottom). The check box labeled as 'Synchronizer' is a switch for the 'Synchronized mode' operation of the ring for the ramping.

Delphi smoothly handles the Paradox data. This database stores the magnet parameters, the BPM data, the RF parameters, and the vacuum condition. These values are served by the Winsock servers in the DCPCs. Figure 4 shows an application for displaying the database items. The top graph in the application displays the vacuum of the ring and the stored current; the bottom graph displays the magnetic field of the main bending-magnet and the lifetime of the beam. The last item can be selected with the radio-buttons on the application. The database table is quickly looked up by the Borland Database Desktop utility. The data acquisition interval of this database system is 3 minutes and the record number of the database is about 14,000 records (4 MB for a file size) for a month.

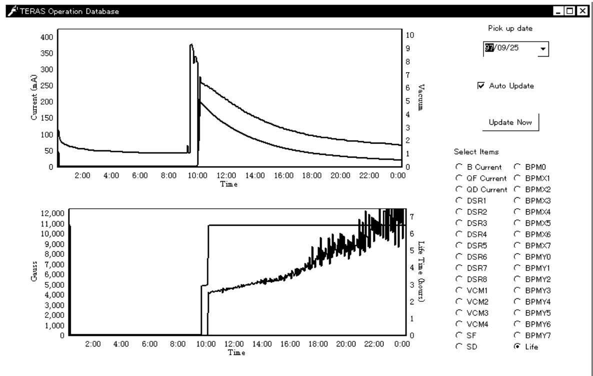

Fig. 4 A snapshot of an application for displaying the database items. The top graph in the application displays the vacuum of the ring and the stored current; the bottom graph displays the magnetic field of the main bending-magnet and the lifetime of the beam.

4 Conclusion and future plan

A PC-based control system has been developed in the storage ring TERAS. The system consists of data acquisition PCs, man-machine interface PCs, and a network system. Conventional I/O boards are used for interfacing to the control devices. The total cost of the DAC-DCPC subsystem, that is the most expensive PC in our system, was below $5,000. We will add the beam transport sub-system, the injection sub-system and timing sub-system to the system to realize a fully computer controlled ring. A Web server method is planned for the DCPC applications and the database access, because browsers that run on all kind of computers are used for the MMPC applications to reduce the development time and to provide a multi-platform system. Moreover, the web server that accesses to the database table helps the outside users to monitor the status of the ring. This work is supported by the Science and Technology Agency of Japan.

References

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[5]*LEGO*, a famous toy-manufacture.
[6]Distributed by National Instruments Corp.
[7]Free add-on component written by G.T.Desrosiers.
[8]Free fire-wall program developed by Y.Sato.