PC-based Control System for Storage Ring TERAS

H. Ohgaki, H. Toyokawa, R. Suzuki, S. Sugiyama, T. Mikado, K. Yamada, T. Ohdaira, N. Sei, and M. Chiwaki, Electrotechnical Laboratory, 1-1-4 Umezono, Tsukuba, Ibaraki 305-8568, Japan

Abstract

Personal Computer-based control system has been developed for the storage ring TERAS at Electrotechnical Laboratory. The system consists of three layers: device control layer, user interface layer, and network layer. I/O cards installed in IBM-PCs are connected to the control devices. Each I/O card has a corresponding client/server-application communicating via TCP/IP protocol. A database subsystem has been developed to record the machine status and to help an operation of the ring. This inexpensive system shows a good reliability for the storage ring operation and a large flexibility for upgrading.

1 INTRODUCTION

Personal Computer (PC)-based control system is one of reasonable choices for an accelerator facility[1]. Due to the advances in the hardware technology of the PC, a PC with a moderate speed PC costs below $1000. Software development tools have also been developed in the PC world. Moreover, a recent operating system (OS) running on a PC has a built-in network service that smoothly connects with their applications working on a distributed PC environment. Therefore, a distributed control system can also be constructed with PCs over a network system inexpensively[2].

A PC-based control system is introduced to the control system for the storage ring TERAS[3] at Electrotechnical Laboratory (ETL) constructed for a multipurpose synchrotron radiation source. Electron beam is injected by a 300 MeV linac and the ring is operated ranging from 200 MeV to 800 MeV fitting for user's request. The electron orbit has also been tuned to several specific experiments. The original control system was constructed in 1979. All knobs and switches were manually controlled in the control room with hard-wired cables. Since no computer system was employed in this original system, an operator had to change the ring parameters with a good skill. Therefore, a computer control system has been greatly desired. The PC-based control system for the main magnet power supplies (PSs) has been introduced in 1990[4]. Then, the steering magnet and the RF control PC were added to the system[5]. However, these PCs were operated independently; operators still had to operate these independent subsystems simultaneously. To combine the independent subsystems and to adjust the ring parameters at any place, the system has been upgraded to use a network system since 1996[6]. A

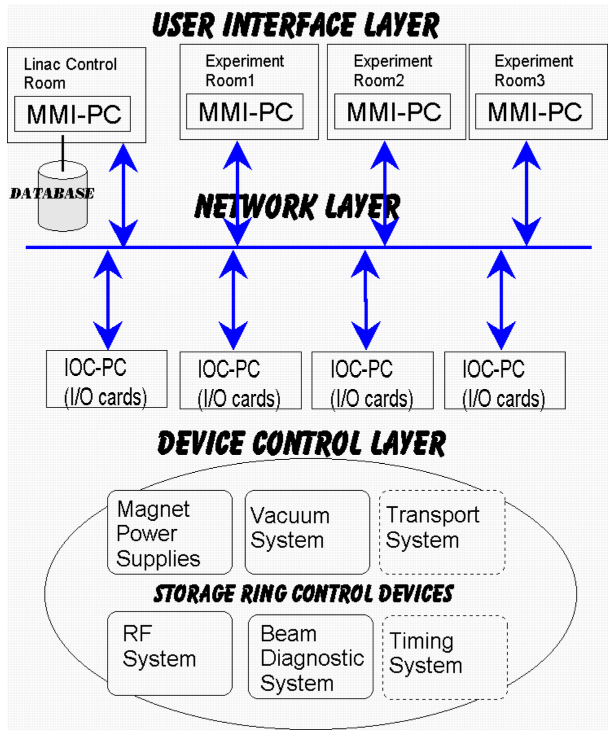

Fig.1 Schematic view of the PC-based control system. IOC-PC means I/O control PC and MMI-PC, man-machine interface PC.

vacuum monitoring system, several I/O devices, and the database subsystem have been added to the system.

The system consists of three layers: device control layer, user interface layer, and network layer. Figure 1 shows a schematic view of the system. Several subsystems, shown as dotted boxes in the figure (beam transport system, and timing system) are still isolated from the PC-control system and are wired with cables. These subsystems will be added to the system in the near future.

2 DEVICE CONTROL LAYER

The device control layer consists of several I/O control (IOC) PCs that are equipped with I/O cards inserted into the expansion slots. IBM clones are used for the control PC. Windows95/98 is used for the OS, because 1) it works with a small resource PC; 2) the I/O card is directly accessible from applications without any device drivers; 3) the built-in TCP/IP protocol is ready-to-use; 4) it is commonly used in our facility and many excellent applications and software development tools are available with reasonable costs. We use industrial ADC cards, DAC cards, and GPIB cards for interfacing to the control devices. When the density of the control device is low, I/O card system is cheaper than that with standard bus (CAMAC or VME). Each I/O card has a corresponding control application that consists of I/O card manager, data processing manager, local user interface, and Windows Socket server. Therefore any I/O card and/or IOC can be easily replaced and upgraded. Furthermore, if the number of IOC-PC increases to distribute the I/O card, the system power is enhanced within a minimum change of the application and the system itself. The data acquired by the IOCs are transported to any PCs via network, when they are required.

2.1 Magnet control

A 16-bit/32-channel ADC card is employed to monitor the output currents of the magnet PSs via isolation amplifiers. Magnet ADC-IOC is located apart from the magnet PSs and the ADC data are averaged in 500 times, because of large switching noise generated by the magnet PSs. The smoothing of the data limits the data acquisition rate below 10 Hz. This data acquisition rate is still high enough to operate the storage ring. The magnetic field of the main dipole magnet measured with a hall probe and the stored electron current measured with a DCCT are also monitored by this IOC.

Magnet DAC-IOC consists of a 16-bit/4-channel DAC card and two 12-bit/8-channel DAC cards. The 16-bit DAC card controls main magnet PSs. The 12-bit DAC cards control the beam steering magnet PSs. Each DAC card has a corresponding client/server (C/S) application, and they work independently. Because these magnets should be controlled simultaneously, the client application of the 16-bit/4channel DAC has three Windows Sockets clients and controls the two 12-bit DAC cards simultaneously. The data communication rate is 1 Hz for the 16-bit DAC card and 2 Hz for the 12-bit DAC cards. Figure 2 shows a structure of IOC-PC for the magnet control system. This figure also shows several client applications running on man-machine interface PCs (MMI-PCs).

2.2 RF control

The RF-IOC consists of 12-bit/4-channel ADC card and 12-bit/4-channel DAC card. The control PC is NEC-PC98. The ADC reads the RF parameters, i.e. the cavity temperature, the electric field strength in the RF-cavity, and RF phase. Operation energy of the storage ring that is monitored by the Magnet-ADC-IOC is referred via Windows Socket to provide an optimum RF power fed to the cavity. The 12-bit DAC controls the output power of the RF amplifier. A feedback control is required to the DAC output to stabilize the electric field of the RF-cavity

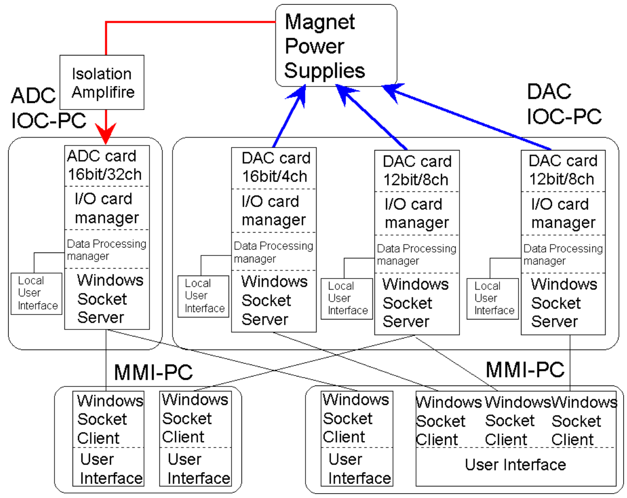

Fig.2 Structure of IOC-PC for the magnet control system.

that is monitored by the ADC. To obtain a fast feedback loop, the control applications of two I/O cards are integrated into one.

2.3 Others

Vacuum monitoring IOC controls two 12-bit ADC cards, which read the ion gauge currents and the ion pump current, respectively. This IOC also reads several RF power amplifier statuses.

Beam diagnostic IOC consists of a GPIB card reading the data from the beam position monitor.

Several important subsystems, such as beam profile monitor, tune monitor, injection subsystem are working independently. They will be integrated into the PC control system in the near future.

3 USER INTERFACE LAYER

The user interface layer consists of several man-machine interface (MMI) PCs distributed over the control room and the experiment rooms. Windows 95/98/NT gives both the graphical user interface (GUI) environment and the network communication environment. Because no special input device is employed for the GUI, any Windows PC connected to the Ethernet system can be a MMI PC. Two exclusive MMI-PCs located in the control room work as data logger and database server, respectively. Figure 3 shows the screen shots of these MMI-PCs. Client applications are accessible via network and no software installation procedure is required except for the database applications. Therefore IOC-PC sometimes works as MMI-PC. Tele-remote control is also available by using Windows dial-up service or ETL-PPP.

4 NETWORK LAYER

The network layer consists of 10 Mbps Ethernet LAN system installed in the whole facility. This line is multipurpose one and many items of information of Intranet and Internet also run through the line. Therefore, the TCP/IP protocol is used for the network protocol and each PCs has own IP address. In our control system the I/O cards have individual servers; the clients designate proper IP address and IP port to open the connection. The control system has never met any trouble on the network traffic and any accidental access. The network traffic of the control system is few k-bps for whole control system. The Ethernet system is protected from the invalid access outside of the facility with a Firewall. A supervisor layer should be added to limit the network access to the control system.

5 DATABASE

A database subsystem that assists the daily operation of the storage ring has been developed. The Paradox database system is used for this system, because Borland (Inprise) Delphi, which has been used for the software development tool, smoothly treats with the Paradox data. The database subsystem stores the magnet parameters, the BPM data, the RF parameters, and the vacuum condition. These values are provided via server applications running in the IOC-PCs. Data-logger applications are running on the exclusive MMI-PCs in the control room and store the data. Graphs in fig.3 show several database items. The data is logged in every 1 minute, and the record size of the database is about 12 MB per month. The database files are periodically copied to a CD-ROM.

6 CONCLUSION AND FUTURE PLAN

PC-based control system has been developed in the storage ring TERAS step by step. The system consists of IOC-PCs, MMI-PCs, and the network system. Several industrial I/O cards inserted into the expansion slots of IOC-PCs are used for interfacing to the control devices. This system has a good reliability and the large flexibility for upgrading. The beam transport system, the timing system, several beam diagnostic system, which are not included into the PC-control system, will be integrated to the system in the near future.

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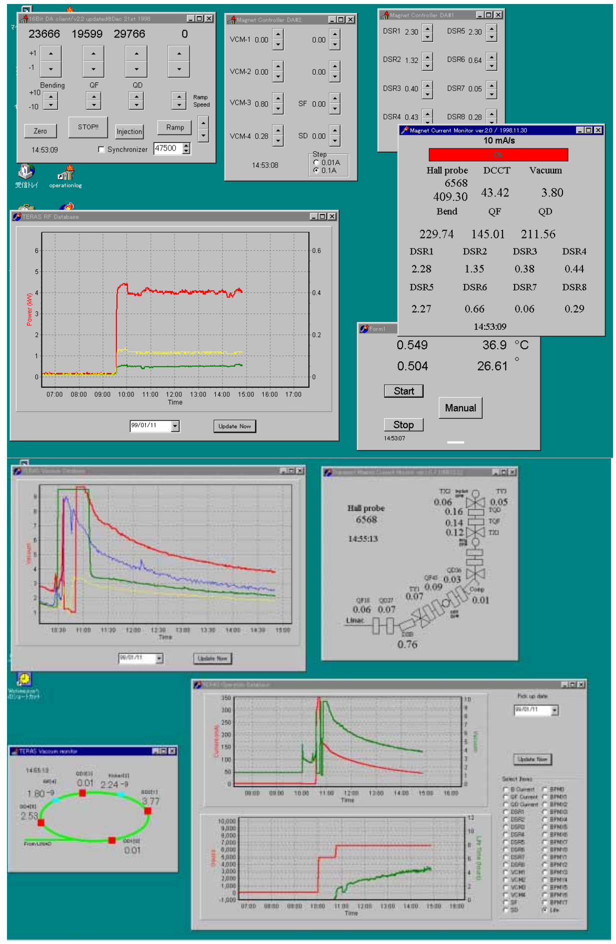

Fig.3 Screen shots of the MMI-PCs running in the control room. Several data logging applications are running on the background.

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