Using PCs in the BEPC Beam Diagnostic Instrumentation System

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Abstract

PCs are getting more and more popular in accelerator control and beam instrumentation systems in recent years because of various reasons such as their inexpensive price, the support of a large amount of commercially available hardware and software products, etc. Some PCs are added to the BEPC beam diagnostic instrumentation system for instrument control and data acquisition. These PCs are connected with each other via TCP/IP over Ethernet and are integrated into the BEPC control system. In this paper, we will describe the implementation of PCs in the BEPC beam diagnostic instrumentation system.

1 Introduction

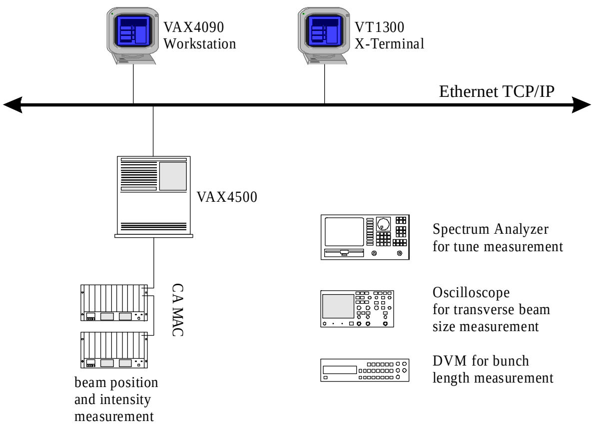
The Beijing Electron Positron Collider (BEPC) facility consists of a 202-meter linac injector, an 120-meter beam transport line and a 240-meter storage ring. The design energy of the storage ring is 2.8 GeV, but the machine has been routinely operated at an energy below 2.2 GeV since it was first put into operation at the beginning of 1989. Electrons and positrons are injected into the ring at the energy of 1.3 GeV and are then accelerated to and stored at the required energy. The collider can provide beams for over 5000 hours each year for high energy physics experiments as well as the synchrotron radiation research in parasitic and dedicated modes. Some noticeable experiments have been accomplished at BEPC, such as the measurement of the mass of the Tau lepton.[1] Beam diagnostics were very important and have been highly beneficial to the success of the BEPC operation.

As the first step, the beam diagnostic instrumentation used in BEPC was highly necessary for the initial stage of machine commissioning and operation. Most of the beam diagnostic subsystems, except for the DCCT and beam position monitoring systems, were not connected to the control computer. So, measurements with those monitoring subsystems had to be controlled manually. An upgrade work has been carried out in the last year. The main purpose of the upgrade is to realize the computerization so that the resolution and the speed of measurements can be improved. PCs were chosen to be added to the BEPC beam instrumentation system due to various reasons such as their inexpensive price, the support of a large amount of commercially available hardware and software products, etc. All these PCs are connected with each other over the Ethernet and are integrated into the BEPC control system.

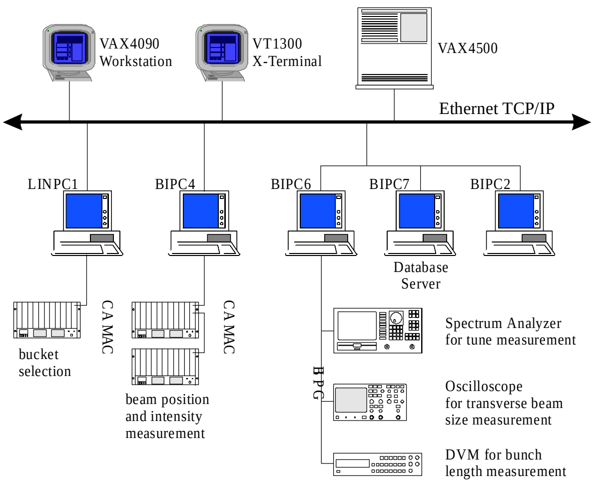
2 System hardware

2.1 Hardware architecture

Figure 1 shows a schematic block diagram of the BEPC beam diagnostic instrumentation system before and after the upgrade. The beam monitors and the front-end electronics of each subsystem are not included in the figure. The on-line control mini-computer VAX4500 with the operator′s console, the VAX4090 workstation and the VT1300 X-terminal running under VMS form a control room layer of the control system.



(a) before the upgrade



(b) after the upgrade

Fig. 1 Schematic block diagram of the BEPC beam diagnostic instrumentation system

As we can see from figure 1-(a), only the beam position and the beam intensity measurements could be controlled by the computer before the upgrade. Devices are directly connected to the VAX4500 by serial CAMAC links. Reference [2] can be referred to for more detailed descriptions of the present BEPC ring control system.

After the upgrade, we added a PC layer between the control room layer and the device layer. These PCs are basically 486/66 MHz machines with 16-32 Mbytes of memory each. Among these PCs, LINPC1 in the linac control room controls the selection of the injection bucket, BIPC4 in the local beam diagnostic station of the ring is used for the beam position and the intensity measurements, BIPC6 in the center control room is for the tune, the transverse beam size and the bunch length measurements, BIPC7 is for the dynamic and logging database server, and BIPC2 is used for the display of the measured data. The PC layer is connected to the control room layer and the device layer by Thin-Ethernet and parallel interface buses, respectively.

2.2 Interface standard

Two control interface standards were adopted in the upgraded beam diagnostic instrumentation system: CAMAC and GPIB.

The former consists of a PC interface card and a double-width CAMAC crate controller Model CCU-2-80B[3] developed by the Electronics Division of our institute. The CCU-2-80B meets all the requirements of IEEE Standard 583 for CAMAC crate controllers. When used with the PC interface card, the CCU-2-80B forms a computer-based CAMAC system with an IBM PC or compatible processors as the host and performs a wide variety of CAMAC commands to modules in the crate. One to eight CCU-2-80Bs can be connected to a single interface card. The crate address is selected by a front-panel switch. A 50-wire flat ribbon cable is connected to the computer interface card and looped-through the crate controllers. The last CCU-2-80B terminates the bus and can be up to 12 meters from the interface card. The interface card can be installed in any available ISA expansion slot of the PC. Like most PC plug-in cards, the interface card is an ″I/O-mapped″ card, which uses the Intel processor′s 16-bit continuos I/O address space for two 8-bit controller′s control/status registers. The starting address of I/O ports is determined by the crate address setting. The CCU-2-80B/interface card system is only capable of transferring 8-bit CAMAC data word.

For the GPIB (IEEE 488) standard we used the HP82341 which is a Hewlett Packard′s high-speed 16-bit PC interface card for controlling GPIB devices with the most popular Microsoft Windows-based programming languages. The interface card fits into one ISA/EISA expansion slot in the backplane of an industry-standard compatible PC. The configuration switch on the HP82341 interface card sets the interface′s I/O port base address. The build-in buffering of the card provides I/O and system performance that is superior to direct memory access (DMA), up to 750 Kbytes/sec. GPIB cables connect the card to GPIB devices. The maximum number of devices to be connected is 15. In our case, BIPC6 serves as the GPIB system controller.

3 Software

3.1 Software platform

There are two operating systems running on PCs: Microsoft Windows NT 3.51 (BIPC2, BIPC6 and BIPC7) and Windows 95 (LINPC1 and BIPC4). Some of device drivers in the Windows NT environment are not yet available, otherwise the Windows 95 OS will be replaced by Windows NT.

Application programs were developed with the Microsoft Visual C/C++ 2.0. The high level language CAMAC libra-ry routines supplied with the CCU-2-80B crate controller and the HP Standard Instrument Control Library (SICL)[4] supplied with the HP82341 GPIB interface card were used in conjunction with the Microsoft C/C++ language. SICL is a modular instrument communications library that works with a variety of computer architectures, I/O interfaces and operating systems. Applications written in C/C++ or Visual BASIC using this library can be ported at the source code level from one system to another without, or with very few, changes. SICL has several features that distinguishes it from other I/O library, such as the centralized error handling and the formatted I/O.

3.2 Client/Server model

The software of the system is based on the client/server model which is the most commonly used paradigm in constructing distributed applications. In this scheme client applications request services from the server application. The server process remains dormant until a connection is requested by a client process. At such a time the server process ″wakes up″ and services the client′s requests.

Figure 2 shows the software structure of the PC based system. It can be divided into three layers. There are about twenty application programs, only two of which are server applications while others are client applications distributed on all PCs and VAX computers.

One server application running on BIPC7 plays a role of a dynamic database server. This is the key application program in the system. The dynamic database is used as a data buffer between the data acquisition layer and the data pre-sentation layer. The size of the database is 8 Kbytes and it is easy to expand. The database stores all important mach-ine parameters of BEPC. All of the parameters have the floating-point data type with 4-byte length each. These machine parameters are updated at different rates from 1 to 60 seconds by several data acquisition client applications. The data acquisition client application requests the server application to update corresponding records of the database at the end of each measurement, while the data presentation client application receives and displays acquired data on the screen of the workstation or a PC. Some beam measurement control parameters are also stored in the database, so measurements can be controlled according to these parameters.

Another server application running on LINPC1 provides a service of changing the injection bucket number by changing settings of two CAMAC delay modules according to the operator′s request.

Both of server applications are of iterative type. The concurrent type server is under development to improve the response time of the system.

Because PC and VAX computer have different operating systems, a suitable network communication protocol has to be chosen. TCP/IP is such a protocol. The communication software relies on the TCP/IP socket library. The connection oriented transmission control protocol (TCP) is used for providing a reliable data delivery.

3.3 Logging database

For a better understanding of the machine performance, a logging system was created with the Microsoft SQL Server RDBMS running on the BIPC7 (see Figure 1) and put into operation at the end of last year.[5] All important beam parameters (such as intensity, lifetime, closed orbit position, ...) and equipment settings (such as power converter current, reference magnet field, accelerating RF cavity voltage, vacuum pressure, ...) were stored. These parameters are taken from the dynamic database mentioned in the previous section. The logging database is not used for fast recording to study short time events so the data taking rate is 1/60 Hz.

Till now, over 1 Gbyte of data of 8 months of operation were kept on-line as well as copied to off-line media. These logged data can be retrieved, correlated and analyzed with the Microsoft Office package running on any PC. These historical data will be kept for a period of at least one year.

4 Summary

The beam diagnostic instrumentation system of BEPC has been upgraded. Several PCs were added to the system. The system is simple, flexible, expandable and is integrated into the BEPC control system. This greatly improved the system performance, for example the beam position monitoring system[6] and the logging system. The software modification is still underway to further improve the system performance.

Acknowledgments

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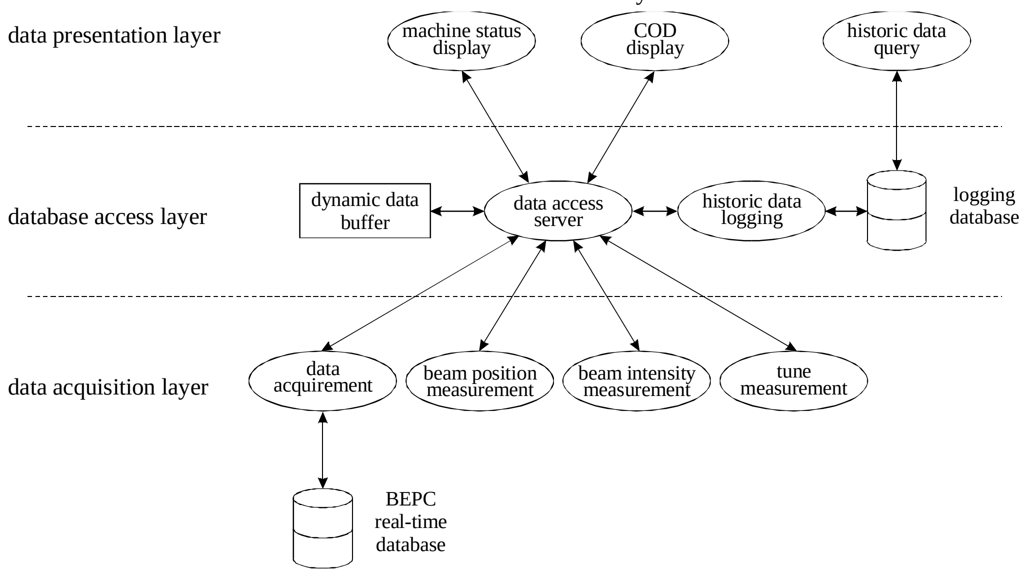

Figure 2: Software structure