

Virtual Instrument Technology Used in the BEPC Beam Diagnostic System

K. Xue, P. Shi and L. Ma

Institute of High Energy Physics, Chinese Academy of Sciences

P.O.Box 918-10, Beijing 100039, China

xuekw@bepc3.ihep.ac.cn

Abstract

The virtual instrument technology is going to be used in the BEPC beam diagnostic system using LabVIEW[®] to take the automatic measurement, the beam parameter analysis and the dynamic display. In this paper, we will discuss the implementation of LabVIEW[®] applications based on the client/server model via TCP/IP. The hardware interface to instruments and the software interface to other programs are described. A summary of integrating virtual instrument technology with the existing BEPC beam diagnostic system is given.

1 Introduction

The Beijing Electron Positron Collider (BEPC) is a machine designed for high energy physics experiments as well as synchrotron radiation research. The beam diagnostic system was built at the same time as BEPC. The basic hardware of the most important beam parameter measurement systems are now working. During the nine consecutive years of operation, BEPC beam diagnostic system has become more and more important and has been highly beneficial to the success of the accelerator.

Since the operation and data acquisition of some sub systems were done manually, the measurement efficiency was low. In order to take the measurements more easily and more efficiently, we have done some upgrading and introduced the virtual instrument technology into our system.

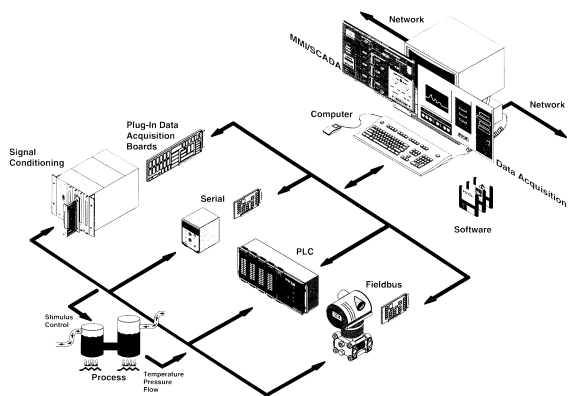


Fig. 1 The basic system of the virtual instrument technology

Figure 1 is a basic virtual instrument system given by the National Instruments Corporate^[1]. The virtual

instrument system is an open system based on computers, it can be connected conveniently to peripheral equipment, the network and other applications. In such a system, the software acts as the heart of the system while the hardware gives the input and output channels. The functions of the virtual instrument can be designed flexibly by the software, hence the term "the software is the instrument".

2 System outline

The upgrade program of the BEPC beam diagnostic system has been carried out since the beginning of 1995. In the machine operation from 1996, several computers (PCs) were added to the BEPC beam instrument system. Those PCs mainly take the device control and also the data communication^[2].

The on-line control computer VAX4500 with the operator's console VAX4090 workstation, running under VMS forms a central control room layer of the BEPC storage ring^[3]. The personal computers were added between the central control room layer and the devices. They act as the kernel of the communication between the BEPC control system and the beam diagnostic hardware. The industrial PCs are chosen to take the instrument control and another high performance PC is used as the database server. Microsoft Windows NT[™] is the network operating system (NOS). Those PCs connect upward with the control room layer via TCP/IP over the Ethernet, while they also connect downward with each device via CAMAC or GPIB interfaces. The measured results can be transmitted through the beam diagnostic system, also to the central control room layer.

3 Use of the virtual instrument technology

The virtual instrument technology is going to be delivered in the BEPC beam diagnostic system by using LabVIEW[®] at many stages. LabVIEW[®] is used in the measurement system in order to take some of the responsibilities of what the traditional instruments do and also what the operators do before.

3.1 Client/Server model and database structure

In the BEPC beam diagnostic system, there are many devices in different local stations to take different measurements and also various services, such as the device control, the data archiving and the data display. The applications should access to the services on the network transparently. So the client/server model that is

the most commonly used paradigm in constructing distributed applications is the natural choice.

There are two database servers in the system, one is the dynamic database server and the other is the historical archiving database server.

The dynamic database server is written in Microsoft Visual C/C++™ using the Windows sockets application program interface (API). That API defines and documents the use of Windows in conjunction with the Internet Protocol Suite (generally referred to as TCP/IP). Thus the dynamic database is in common use. It can respond to the requests from any client on local or remote computers. The dynamic database stores almost all the important BEPC machine parameters not only from PCs running on Microsoft Windows but also from VMS system via TCP/IP through Ethernet. The data is kept up-to-date.

The historical archiving database server is made of Microsoft SQL Server™. The Microsoft SQL Server running on Microsoft Windows NT Server™ is a relational database management system (RDBMS) based on client/server model. The historical archiving database server is running all the time. Parameters of various systems such as the beam diagnostic instrumentation, the magnet power supply, the injection, the vacuum and the accelerating RF are stored in the database. These useful machine parameters are gathered for further querying at anytime.

3.2 Using of LabVIEW®

Compared with other software development environment, LabVIEW® is the language mainly designed for scientists and engineers^[4]. In brief it has two advantages:

The first is the characteristics of graphical programming. It is easy to create and modify sophisticated data acquisition and control systems by the complete graphical programming system rather than using code-based programs in a conventional programming language.

The second, LabVIEW® is an engineering-oriented development environment. It comes with the hardware interface to most instruments, also includes an extensive analysis library. It is suitable for data acquisition, control, data analysis, graphics, and data presentation.

Because of the advantages of LabVIEW®, some applications will be implemented in the BEPC beam diagnostic system with that software package.

3.3 Beam diagnostic VI

In the BEPC beam instrumentation system, LabVIEW® applications are called virtual instruments (VIs) and are used as clients. They will take the instruments control, the data acquisition and the data process. Then the clients will ask the server to refresh the dynamic database. From the operators' point of view, they are facing a group of virtual instruments that look like traditional ones but more intelligent, more automatic, and easy to use. Many things are done by the VIs, while all the necessary parameters

and information are available to the operators.

Since we are the beam diagnostic group of BEPC, besides providing static and numerical parameters display, we want to give more intelligent results. We not only want to show operators the beam parameters but also want to show operators the information of how to control the quality and the behaviors of the beam. We want to make our virtual instruments realize the beam diagnostic functions in a lively style.

The working of establishing the beam diagnostic VIs can be divided into several steps: The first step is the automation of instruments control and the data acquisition. The second step is the data communication between VIs and the dynamic database. The third step is the dynamic display.

Since some of the device drivers are coming with the LabVIEW® software package, it is easy to control the instrument and acquire data through the GPIB interface or the RS232 interface. The beam parameters we want to measure with virtual instruments include:

- the tunes, measured with the spectrum analyzer model HP3588A (10Hz to 150MHz);
- the transverse beam size, measured with the digital oscilloscope model HP54610B (500MHz);
- the bunch length, measured with the digital multi-meter model Fluke8520A.

The data communication through the beam control and diagnostic network is depend on the dynamic database that we have already used. The virtual instruments can send data to the dynamic database and also read data from the database. Since various beam parameters can be gathered to the virtual instruments, different kinds of data analysis can be performed with that data.

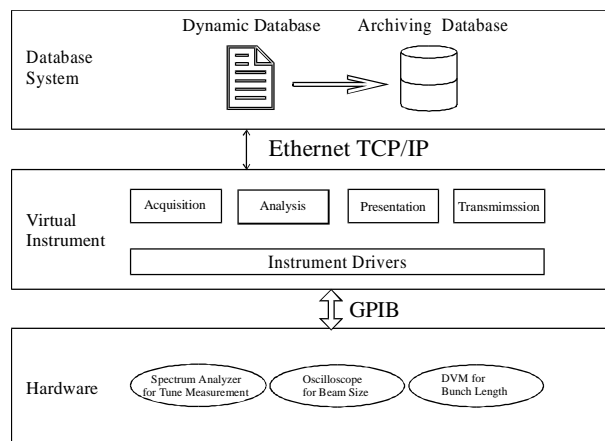


Fig. 2 The structure of VIs made for beam diagnostic system

Figure 2 is the structure of those VIs. For each virtual instrument, it obtains data from the instrument through the GPIB interface and also acquires data from the dynamic database through the Ethernet via TCP/IP. The on-line analysis can be done and the dynamic display can be

shown with that data. Another kind of data communication is transmitting the data gathered from the instruments to the dynamic database. Then the data will be stored in the archiving database for further querying.

Figure 3 gives the VI for beam size measurement. The beam size is measured by the synchrotron light with the

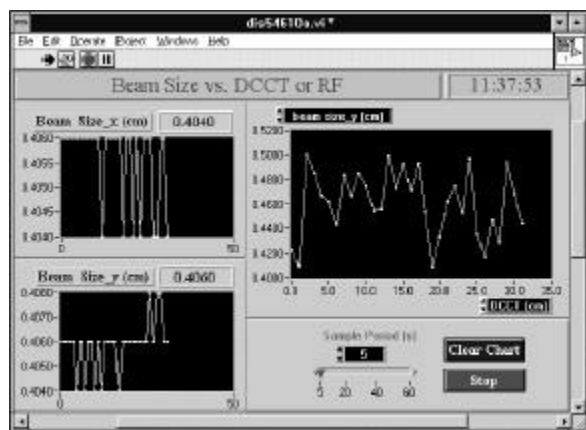


Fig. 3 Beam size measurement virtual instrument

photodiode array. The output waveform is sent to the digital oscilloscope model HP54610B. The left two waveforms are the beam size of horizontal (Beam Size_x) and vertical (Beam Size_y) directions. Some analyses are shown on the right waveform. The vertical axis of the waveform can be chosen from the Beam Size_x or Beam Size_y. The horizontal axis can be chosen from the beam current (DCCT), or the accelerating RF voltages. The function of the beam size vs. DCCT or the RF voltage can be shown on the screen. The digital control at the bottom of the VI front panel configures the sample period of HP54610B. Other configurations of HP54610B were fixed by the program. The user can not change them from the

front panel. The clear chart button can be used when the chart is confused with too many data points.

4 Summary

The primary virtual instruments for some parameter measurements have been established by LabVIEW®. These VIs will be put into operation in the next run. In these VIs, useful beam parameters can be gathered and the on-line analysis can be done. The VIs can work smoothly with the existing beam diagnostic system. In the future, the VIs we have already made will be improved step by step, and more things will be done with LabVIEW® for the BEPC beam instrumentation system.

Acknowledgments

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