The Virtual Instrument Control System

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Abstract

LabVIEW is a graphical programming language for data acquisition, data analysis and data presentation. It offers an easy and fast way to develop control systems and program instrumentation systems. We have developed a virtual instrumentation system that will be used in the control system of BEPC or SSRF on the basis of LabVIEW. The main purpose of this virtual instrumentation system is to meet special needs for the control system of BEPC and SSRF. The virtual instrumentation system integrates many instruments and devices such as CAMAC, PLC, DAQ and other devices with GPIB interface. Many applications have been designed and developed by using LabVIEW as interface. The PC is used as a server that acquires data from CAMAC, PLC, DAQ, GPIB devices and other data sources via the network. In addition, a command library to be used with PLCs has been implemented and stored in the userlib of LabVIEW. Users can build PLC monitor and control systems easily by using the programs in this library. In this paper, we will discuss the virtual instrumentation system in detail.

1 Introduction

There are many instruments and control devices in the control system and beam diagnostic system of BEPC. Most instruments can only provide special functions, at the same time some instruments can not be accessed directly from control and beam diagnostic systems. In order to solve these problems, we chose LabVIEW as the solution. The reason is following:

First, most instruments and devices used in the control and beam diagnostic system provide standard interfaces such as GPIB R S232, etc.

Second, LabVIEW includes many drivers for communication to other instruments, such as PLC, VXI, serial ports, etc.

Third, LabVIEW is a graphical programming software which provides a friendly man-machine interface, it is very easy to learn and efficient when used by developers. Up to now, we have developed a virtual instrumentation system in our laboratory by combining LabVIEW with standard data acquisition and instrument control devices. This virtual instrumentation system includes applications which communicate from LabVIEW to the instruments and devices. We also developed a command library for the use with PLCs including almost all the commands of PLC devices by using LabVIEW as interface. This PLC command library contains many ICONS that have been put in the user library of LabVIEW. By using these ICONs users can build the PLC monitor and control system easily.

2 System structure

The virtual instrumentation system is divided into two levels.(see Fig. 1):

2.1 First level: the interface level

In this level, the server PC plays the key role. The server PC is the man-machine interface to the operator. All application programs run in the server PC. Three adapter cards are installed in the server PC. They are: GPIB adapter, DAQ adapter and CAMAC adapter. All data acquired through these adapters are transferred to the server PC. Different application programs run in the server PC for CAMAC, PLC, DAQ and instruments with standard GPIB interface. Each application program fulfills one task. For instance, the program in the PLC only communicates with a special PLC device. All these LabVIEW application programs are called VI (virtual instruments) because their appearance and operation can imitate actual instruments. Each VI includes two parts: a front panel and a block diagram. The front panel is the user interface of the VI. It is a combination of many controls and indicators. Controls simulate instrument input devices and supply data to the block diagram. Indicators simulate instrument output devices and display data acquired or generated by the block diagram. The block diagram is the graphical source code of the VI. It integrates many objects which send or receive data, perform specific functions and control the flow of execution.

The server PC also can receive and send data from and to other sources, such as EXCEL files and data via network. So far, we have developed the network communication VIs based on the TCP/IP protocol and VIs to read and write data from and to EXCEL files.

The software items installed on the server PC are the following: Windows 95, LabVIEW 4.01, Visual C/C++ 2.0. All application programs are developed by using these software tools.

2.2 Second level: the hardware level

This level includes CAMAC, PLC, DAQ and instruments with GPIB interface. The data are acquired and sent to the server PC through adapters installed on the server PC. For CAMAC, we install a CCU-2-80B CAMAC crate controller in the CAMAC crate and an adapter in the server PC. All data are sent to CAMAC modules or received from CAMAC modules through this CCU-2-80B controller. For PLCs we use the RS232 protocol to communicate with PLC devices. The data from PLC devices are transferred through a serial port to the server PC. We also send and receive data from 390ADs (a programming digitizer with standard GPIB interface) and other DAQ devices.

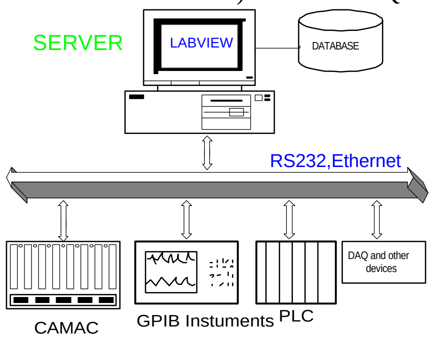

Fig. 1 Structure of virtual instrumentation system.

3 Applications

3.1 LabVIEW-CAMAC application

CAMAC devices are widely used in the control and beam diagnostic systems. It has been the standard bus in the field of high energy physics. Although LabVIEW provides some drivers for CAMAC controllers, there are many CAMAC controllers which are not yet supported by LabVIEW, among them the CCU-2-80B controller which is now widely used in the control and beam diagnostic system of BEPC.

The CCU-2-80B is a CAMAC crate controller which was designed and developed in IHEP. It supports standard CAMAC modules. Because LabVIEW has not supplied a driver for the CCU-2-80B, we have developed our own driver which provides an interface to support the communication between LabVIEW and the CCU-2-80B controller. The driver is programmed using C/C++. It supports the basic CAMAC operations including reading, writing and testing status bits.

LabVIEW provides two modes to link C/C++ programs. One mode is CIN (Code Interface Node). Through CIN, users can directly call the C/C++ program within LabVIEW by using the special format offered by CIN. The other mode is DLL (Dynamic Link Libraries). Users can call any DLL or shared library from LabVIEW.

We have developed an application program that communicates with CAMAC devices by using the above two modes.

For the DLL mode, we use Visual C/C++ to develop the C/C++ programs to support the basic CAMAC operations. Thereafter the program is changed into a DLL program which can be called by LabVIEW directly.

For the CIN mode, we develop the C/C++ program using the specific format drafted by LabVIEW. The following is the basic CIN format of LabVIEW:

```
/*
/* CIN source file
/*
# include “xtcode.h”
/* stubs for advanced CIN functions */
UseDefaultCINInit
UseDefaultCINDispose
UseDefaultCINAbort
UseDefaultCINLoad
UseDefaultCINUnload
UseDefaultCINSave
CIN MgErr CINRun(void var1);
CIN MgErr CINRun(void var1)
  {

/* Enter your code here */

    return noErr;
    }
```

All graphic interface programs are developed in LabVIEW, however, all I/O programs are developed in Visual C/C++. All application programs will be used in the beam diagnostic system of BEPC.

3.2 LabVIEW-PLC application

A PLC (programmable logic controller) is another important device in our control system. We developed a command library for the PLC using LabVIEW. It includes 34 VI. Each VI in the library has its own ICON and users can call this VI through its ICON which can be found in the FUNCTIONS palette of LabVIEW.

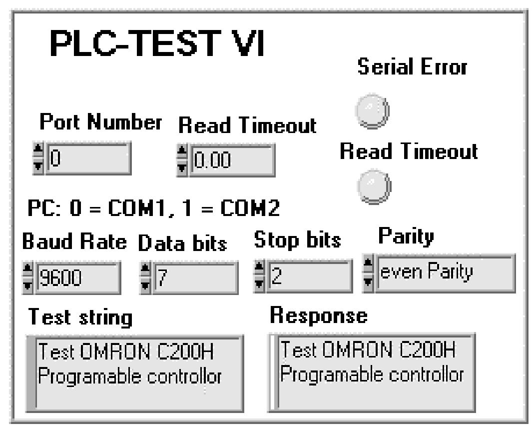

Fig. 2 LabVIEW-PLC application

Because PLC devices which we use are linked to the server PC through a serial port, every VI of the command library is developed on the basis of the serial protocol. We use the basic serial subVI of LabVIEW for this command library. The basic serial subVI are Serial Port Read VI, Serial Port Write VI, Serial Port Init VI, and Serial Port Break VI.

Although the PLC device which we use is the OMRON C200H, the command library can be used for any PLC device, which uses the serial port protocol, without any change. Nearly all PLC commands are included in our library. Therefore users can easily and efficiently construct special PLC monitor or control systems by calling VIs of this PLC command library.

The following is a sample of a VI in this library (see Fig. 2.). This VI is to execute a test command by responding to the test strings which are sent from the server to PLC devices.

3.3 LabVIEW-DAQ application

Data acquisition from DAQ adapters is another important task for which application programs had to be developed. The DAQ device which we use is the PC-DIO-96. It is a 96-bit parallel digital I/O board. It has been installed in the server PC. It contains four 24-bit programmable peripheral interfaces (PPIs). Each can be further divided into three 8-bit ports. The boards can be operated in either unidirectional or bi-directional mode. Digital signals acquired from data sources are transferred to the server PC through a 100-pin male ribbon connector. The following application is a sample of the VI which sends data through the PC-DIO-96 board.

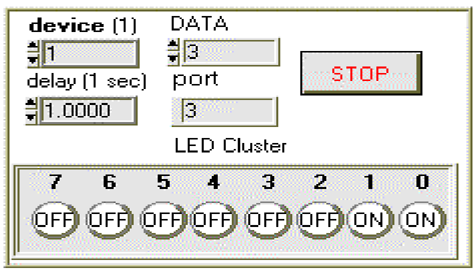

Fig. 3 LabVIEW-DAQ application

3.4 LabVIEW-GPIB application

Most instruments used in the control and beam diagnostic systems provide a standard GPIB interface. In order to meet special needs of the beam diagnostic system of BEPC, we have implemented this application by using the 390AD which is a programming digitizer with standard GPIB interface. A GPIB adapter which is produced by NI corporation is installed in the server PC. On the server PC, users can operate the digitizer just the same as the real digitizer. Our application does the following: data of channel 1 of the 390AD are acquired by the server PC through the GPIB adapter, then these data are processed using a series of mathematical algorithms in order to get the correct result needed by engineers. The calculated data are sent back to channel 2 of the 390AD and displayed on the server PC at the same time. Figure 4 is the front panel of the LabVIEW-390AD VI.

We have developed applications for other GPIB devices in a similar way.

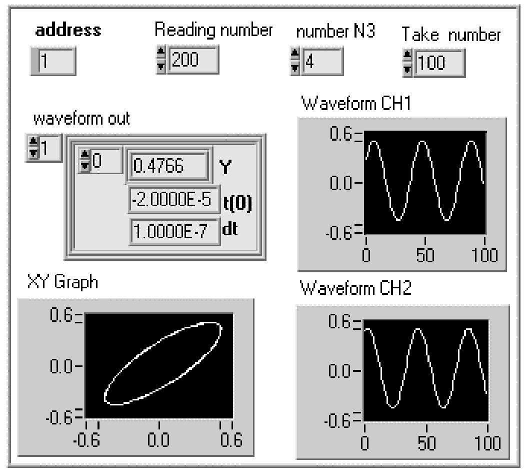

Fig. 4 Front panel of LabVIEW-390AD

4 Conclusions

A virtual instrumentation system has been developed in our laboratory and LabVIEW-CAMAC application will be used in the beam diagnostic system . Because of the limited budget and resources, we have only developed CAMAC, PLC, GPIB and DAQ applications by using LabVIEW as interface. In the near future, we will install DATABASE in the server PC and all data acquired through instruments will be stored in a database. All applications send and receive data through this database. Also, VME is our next choice to link with LabVIEW.

Acknowledgments

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