

Design of Instrument Control System Based on LabVIEW

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Abstract

In order to solve the problems such as poor expansion, long development cycle of instrument control system developed by traditional programming language, using VISA module based on LabVIEW platform was introduced. This paper presented a simplicity, intuitive instrument control system of pneumatic measuring instrument, which was accomplished with graphical language LabVIEW. The system could also complete the text data output. It was improved that the system based on LabVIEW achieved instrument control efficiently, openly, with operating conveniently and good human-machine interface.

Keywords: LabVIEW/VISA, serial communication, instrument control system

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1. Introduction

Instrument control technology plays a more and more important role in the field of auto measurement, with the development of computer technology and requirements of the electronics industry. Instrument control is the process that instruments are controlled by computer directly through the exchange of commands and data between them. This process is achieved frequently by textual programming languages in traditional way. But graphical language LabVIEW bases on dataflow programming. Compared with traditional way, system developed by LabVIEW more emphasises data processing procedure, and it makes it easier to write the program, shortens development time, and reduces the difficulty of program design [1]. With a digital sampling and processing system designed with LabVIEW, in this paper, the basal platform is constituted, and pneumatic measuring instrument is controlled by computer.

2. Methods in Instrument Control based on LabVIEW

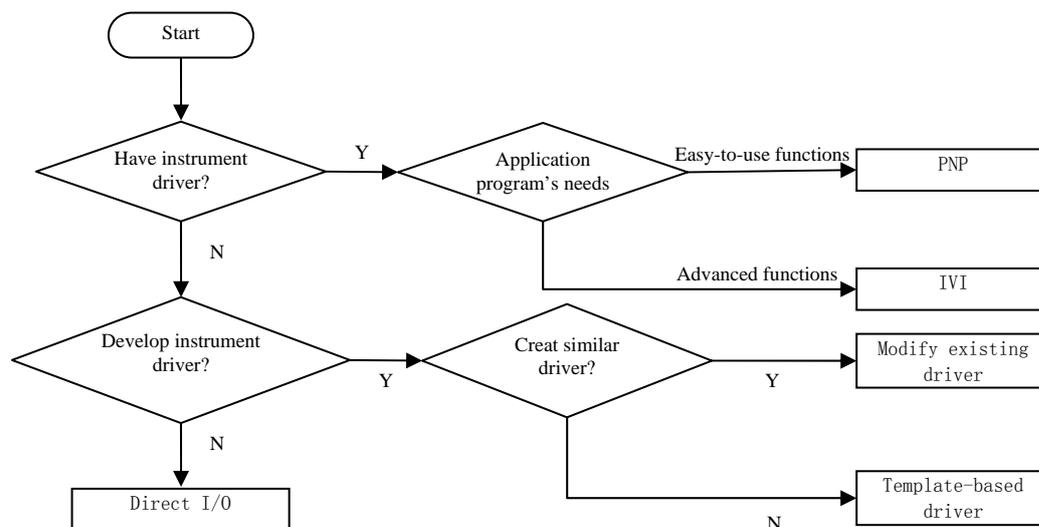


Figure 1. Process of Selecting Different Methods based on LabVIEW

Instrument driver is used to control the system hardwares, and then computer communicates with them. The crucial part of choosing the right method is to see whether the driver is given. Pneumatic measuring instrument described in this paper does not support any API (application programming interface) and manufacturer identification code, so VISA is called by LabVIEW. VISA, the acronym of virtual instrument software architecture, is the standard I/O API of programmable instrument, and it can control GPIB, PXI, VXI, USB, RS232 and RS485 instruments. Compared with other I/O APIs, VISA is not limited by platform bus or development environment, and in the system whether developed on Windows based on LabVIEW or written on Mac with C programming languages, we could use the same VI (virtual instrument) [2, 3]; VISA can also call corresponding driver on the basis of instrument automatically, so the users do not have to learn various of communication protocols, and then the process programming efficiency is improved. The method has reference value for design of instrument control system.

3. Pneumatic Measuring Instrument

Pneumatic measuring instrument is the instrument that changes flow and pressure of air to measure workplace size. The communication protocol of pneumatic measuring instrument is the basis of developing control system. It is provided by instrument manufacturer and rules data format in transferring.

The measurement data is XXH-XXH-XXH-0FF (low byte-middle byte-high byte-0FF), a 4-byte hexadecimal string (Table1) [4], which is ended up with 0FF. If we want to receive the number with decimal display from the hexadecimal string, we should parse data based on frame format first, and then convert it into decimal number. The final value N can be described like this:

$$N=[(\text{low byte} \rightarrow \text{decimal number}) \times 16^0 + (\text{middle byte} \rightarrow \text{decimal number}) \times 16^2 + (\text{high byte} \rightarrow \text{decimal number}) \times 16^4] \times 0.0001$$

Table 1. Communication Protocol of Pneumatic Measuring Instrument

一、basic protocol			
Baud=9600 Parity=N Data=8 Stop=1			
二、communication protocol			
55H/FXH	Receive-address	0FFH	Transmit-confirm
0AAH	Transmit-confirm address	0EH	Receive-minimum tolerance
08H	Receive-measured value	00H/01H	Receive-channel number
00H/01H	Receive-channel number	XXH	Transmit-low byte
XXH	Transmit-low byte	XXH	Transmit-middle byte
XXH	Transmit-middle byte	XXH	Transmit-high byte
XXH	Transmit-high byte	0FFH	Transmit-confirm

4. Software Design

4.1. Physical Connection between Computer and Instrument

There are two main ways to connect instrument with computer: parallel communication and serial communication. Serial communication has many common ways (RS232, IEEE1394, etc.). In industrial production, we just need a few signal lines of RS232 to realize duplex communication between instrument and computer. Considering the data size and the distance of control, we choose RS232 as our physical connection [5, 6].

RS232, the signal voltage of which referenced to a system ground, operates in full-duplex mode, and it can transmit and receive data at the same time. In this paper, pin2 (RXD), pin3 (TXD) and pin5 (GND) are used (Table 2). The pin2, 3 of instrument are cross-linked to the pin3, 2 of computer, and the pin5 of both are linked directly. With this connection mode, the two communication sides can be regarded as data terminal equipments, and then both of them can transmit and receive data.

Table 2. The Definition of RS232 Interface (DB9)

Pin	Name	Direction	Description
Pin1	CD	←	Receive lin signal detector
Pin2	RXD	←	Receive data
Pin3	TXD	→	Transmit data
Pin4	DTR	→	Data Terminal Ready
Pin5	GND	—	Ground
Pin6	DSR	←	Data Set Ready
Pin7	RTS	→	Request To Send
Pin8	CTS	←	Clear to Send
Pin9	RI	←	Ring Indicator

4.2. Software Design based on LabVIEW

4.2.1. The Process of Programming

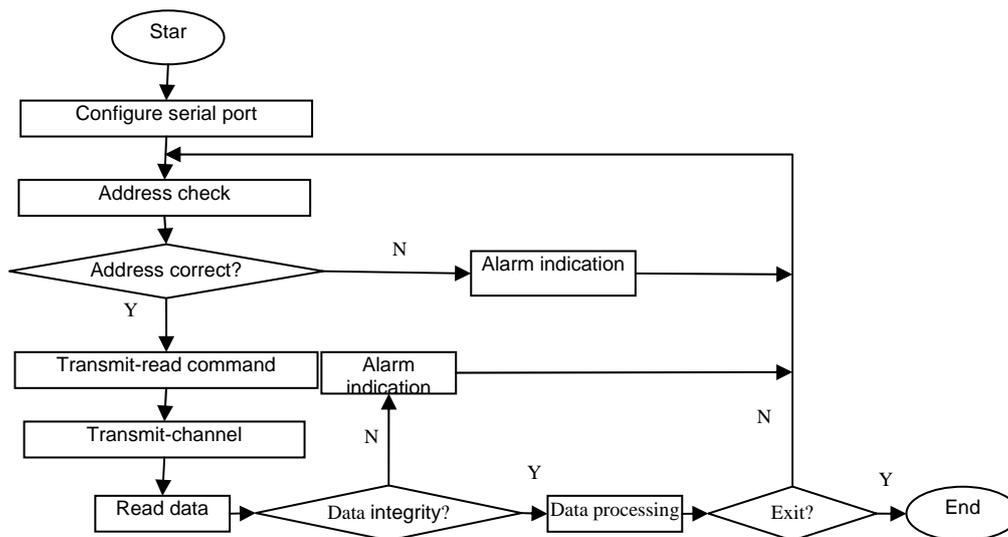


Figure 2. Process of Instrument Control System with LabVIEW

4.2.2. Platform Design

If we want to control a instrument through serial port, we must configure it first. the process of configuring the serial port contains parameter setting and resource name selecting. Four parameters-baud rate, data bits, parity bit and stop bit- must be determined between the process of parameter setting. Resource name, the only VI refnum of instrument I/O, is generally found in the ring of initialization VI. If there is not, we should write it by ourselves according to the following format:

```
Interface Type [board index] :: Address :: INSTR.
```

The finish of configuring the serial port just proves the establishment of the channel, but the conduction of the channel bases on whether the address is confirmed successfully or not. The main part of the program is illustrated in Figure 3.

The commands received and transmitted in this paper are all shown in hexadecimal directly, which is the simplest way to write in a hexadecimal string in LabVIEW [7]. There is a gap in time between the write command and the read, the length of which depends on the instrument's ability of data processing and always lies from several ten milliseconds to several seconds. As LabVIEW supports multithreaded application design and executes code in an inherently parallel rather than sequential manner, we can put the time delay (200ms) or create a sub-VI into a flat sequence structure to solve this problem (Figure 3).

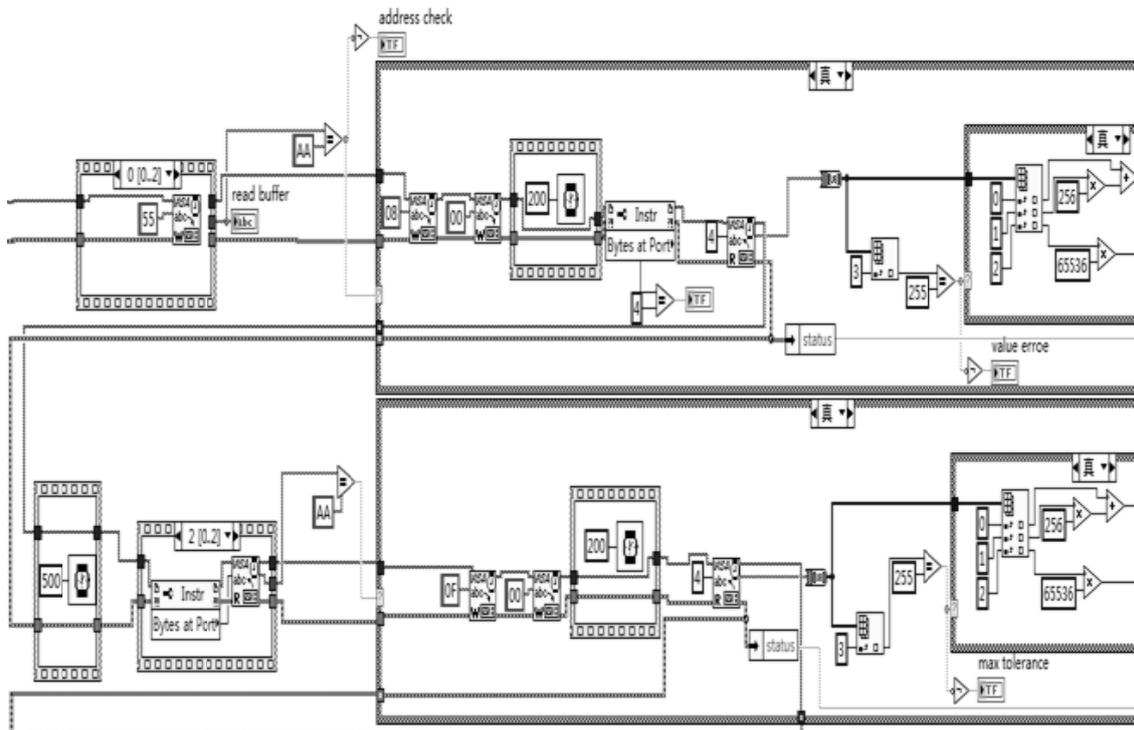


Figure 3. LabVIEW Program

Two pneumatic measuring instrument's commands, 08H (receive-measured value) and 0FH (receive-maximum tolerance), are shown in Figure 3, and the process of transmitting and receiving data is the key part of the whole program, during which exists rigorous order between the two commands, that is to say, the second read-in command must follow behind the completion of getting the returned value from buffer cache in the first command [8]. Factually, there are two main methods to realize sequential execution in LabVIEW: error cluster line and sequence structure. the precondition of method of sequencel structure is that all codes should be written in the same branch, which exists an limitation due to some more sophisticated programs, however, the method that selecting error cluster line to connect and guide data flow helps to change the order of execution sequence more simply. As to the instrument control needing address check, transmitting the second command directly without address check is not allowed, which means the verification is needed between any two commands.

The result data returned from the channel is a 4-byte hexadecimal string. We have to convert it to a byte array first, and then we separate the data by "index array.VI" [9]. In LabVIEW, a index starts with 0, rather than 1, so the indexes of 0-3, represent four decimal numerals transformed by low byte, middle byte, high byte and 0FFH from the hexadecimal string, and finally the result data is calculated through the formula which is given in the previous chapter.

Display and save data in real-time is beneficial to analyse the result, and it is more convenient to be achieved with LabVIEW, compared with other textual programming languages (Fig.4). To display the data, we bundlen it from different structures by name and then send it into a waveform chart, which can turn the data into waveforms And display them without anyother operation; In the process of the data storage, we need pay attention to that we must build a 1D array before we connect it to "write to spreads file.vi"; In order to make the system operates automatically, we use a while loop [10], but the false branch of the case structure in the loop also outputs useless defaults, which we do not want to save in our final file, so we use another csae structure to display the useless defaults in the false branch, and hide the waveform chart which used to display them in front panel.

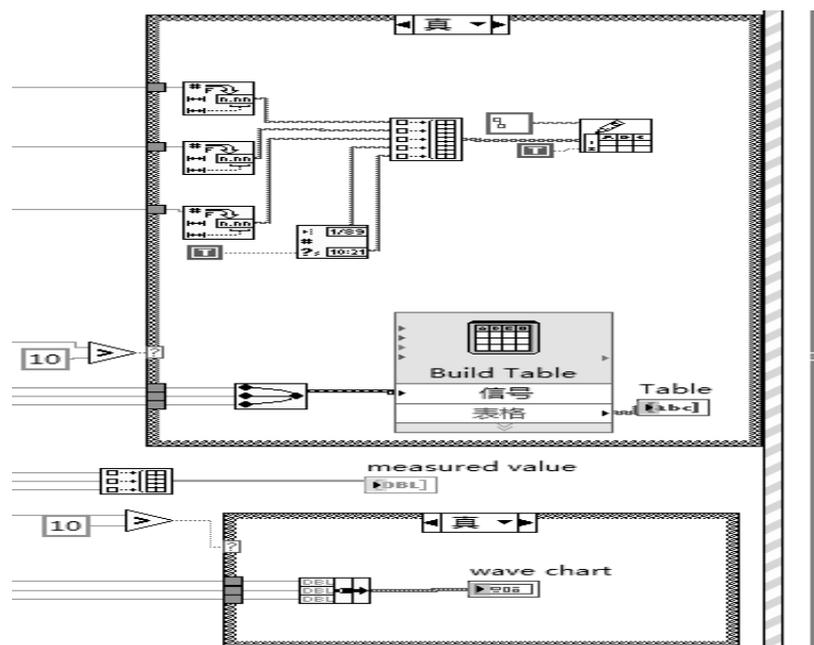


Figure 4. Data Display and Storage

The final instrument control system of pneumatic measuring instrument is designed with aforementioned method and the following pictures show the results in front panel.

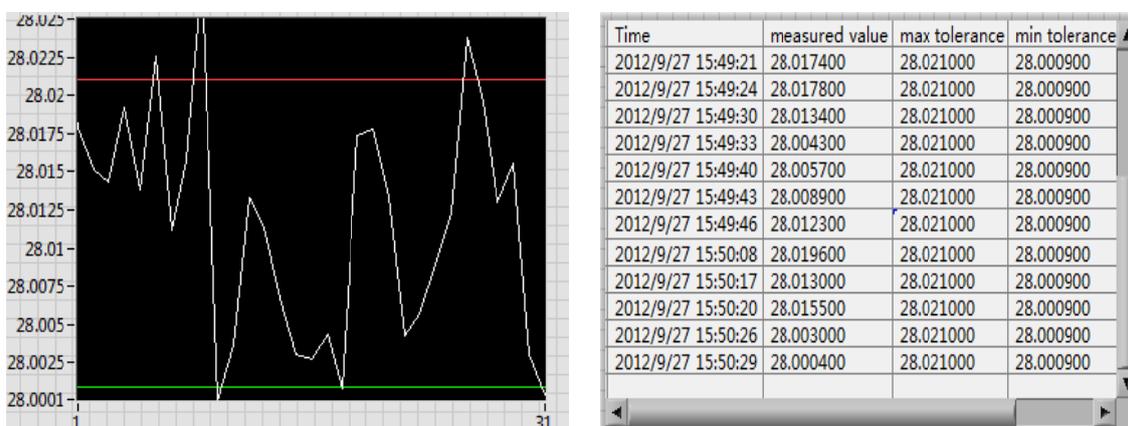


Figure 5. Real Time Display in Front Panel

In this paper, only part of the communication protocol is introduced. if we want to implement other functionality, such as geometric error measurement, audible alarm, etc., we simply change the corresponding commands on the basis of the original code. So it has some reference value in instrument control system development.

5. Conclusion

A system has been developed by graphical language, which breaks through the limitation of textual programming language, such as poor extensibility, complexity in relations, structural redundancy and management difficulty. By controlling a pneumatic measuring

instrument in reality, we can find that the instrument control system based on LabVIEW is with good scalability, and can be transplanted into other industrial control systems easily.

Acknowledgements

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