Study on remote PLC experiment system based on web

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***Abstract*—According to requirements, a solution of remote PLC experiment system has been introduced, including total architecture, hardware and software design. We made a remote experiment in order to control simple mechanical equipment with S7-200 PLC. Then through CP243-1IT, mechanism, PLC, server and clients from internet are mutually connected. By visiting lab web and operating panel of console interface, students can finish required tests at any time. Exams indicate that the scheme of system is feasible.**

Keywords- PLC; remote experiment; console interface

I. INTRODUCTION

PLC with high reliability and stability can work in harsh environments. With the development of network and modularization technology of PLC, it can be used to the solution of web-based remote laboratory. So students can simulate various experiments through network, which is essential for students to develop practical skills and skills of solving problem. This experiment can free students from the constraints of time and place. You can make experiments at any time, anywhere, via network. It is beneficial to open a laboratory for students. It also can take advantage of laboratory resources and reduce the purchase of equipment. Laboratory maintenance costs and workload will be greatly reduced.

Distance experimental teaching requires non-traditional instruments and apparatus. At the same time, students need to participate in experiments actively. A two-way information transmission and a special experimental device are needed, and its implementation is far more difficult than a remote classroom teaching. In this paper, a remote PLC experiment has been designed. Simple mechanical equipment is dominated by PLC. Through CP243 IT module, PLC, server and apparatus can be connected into a network. Through the study of PLC remote experiment, web-based experimental method is investigated, including a local experiment, a remote experiment and homepage guide.

II. OVERALL SYSTEM PLAN

Distance experimental teaching is an important part in distance education. Experiment is an essential process in many area studies. Particularly for some practical subjects, most of practical ability of students is obtained through experiments. In this paper, a pneumatic manipulator used in common actual production is made as control object. An experimental system is developed based on remote laboratory. The system comprises a S7-224 PLC, a CP243-1 IT module, a server with Windows2000 operating system and STEP7-Micro/WIN32 software, a network hub, a network camera, a pneumatic manipulator, Internet network, remote computers and other accessories. The schematic picture is listed as follows:

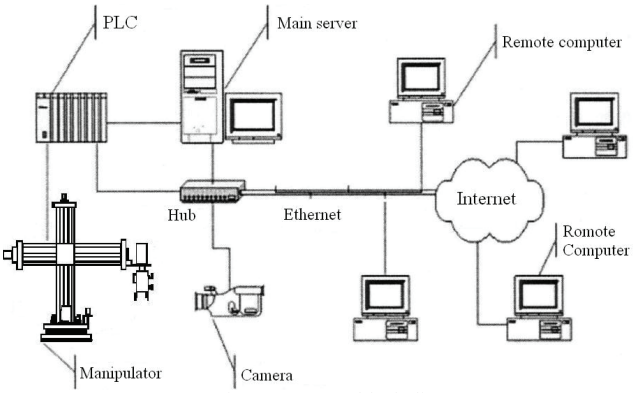

Figure1. System block diagram

As shown above, system network includes LAN (Local area network) and WAN (Wide area network) control network. Remote computers of LAN and WAN are used to access CP243-1 IT module through web page and control manipulator. At the same time, you can watch running condition of manipulator by accessing the network camera. Of course, all related information on manipulator is also feed backed to web page dynamically.

III. LAN CONTROL OF EXPERIMENT

CP243-1IT module is compatible with CP243-1 module. Through LAN technology and CP243-1IT, program of remote computer is downloaded to S7-224 PLC via network cable and router, and operation of manipulator is monitored simultaneously. It has proved that the speed of download via LAN, monitoring and other operations to manipulator is much larger than the local speed. Another way is to access the server with Windows2000 directly, including programming and monitoring. Here we introduce IT module communication method in detail.

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A. *Hardware connection*

The whole system is formed as follows. S7-224 PLC and CP243-1 IT are connected through flat cable, and the two input power supply are all 24VDC with minus polarity linked to earth. Pneumatic manipulator is connected with PLC, and the output of PLC is to control manipulator. PLC and server are joined through PPI cable. CP243-1IT, server and the remote computer are linked to the same LAN. If necessary the server can be installed with camera.

B. *CP243-1IT configuration*

Open interface of STEP7-Micro/WIN32 of master server, after PPI cable communication successful, go to "Tools" and "Internet Wizard ", click "Next", then enter the interface to configure an IP address for communication module. Click "Next", select a connection, click "Next", select "This is the server connection", the remaining steps is ok by default. And this configuration is downloaded to PLC [1]. Completing the above steps, it is equivalent to get an assigned IP address of PLC for remote network connection. Any computers from the same LAN by utilizing software of STEP7-Micro/WIN32 are available to make programs and monitor the operating condition of program through the following IP address.

C. *LAN download configuration*

PG / PC interface is set up step by step. Firstly, RTL8139/810x is chosen as your own network card of TCP / IP protocol and then double-click to refresh the button of "communication " and find PLC-224 of LAN. After completion, you can carry out remote operation just as local, such as debugging, programming, downloading, and monitoring program. And the speed of LAN is around 100Mbps, which is much larger than the download speed of PPI cable method.

IV. WAN CONTROL OF EXPERIMENT

Remote manipulator control is implemented with CP243-1 IT module on the basis of local area network. CP243-1 IT has function of HTTP and FTP server. After IP address configuration of CP243-1IT, you can visit web page to access the register variables of PLC connected to module. By reading and writing these variables, the operation of manipulator is achieved. Here the basic operation of manipulator is realized by programming, including up, down, forward, back, rotate, capture, relaxation and other activities. During the debugging, movements can be observed through network camera. Program is downloaded to PLC through a remote connection to IT communication module. And through the FTP server, web pages and Java control will be uploaded to the file system of CP243-1IT. In addition, we also have to make out port mapping on the entrance of campus network. So the main server and the CP243-1 IT module are mapped to external network. For realization of remote control, the following requirements must be met on the basis of LAN.

A. *The virtual control interface*

1) *Main interface:*

To create a control interface, software of Dreamweaver and computer language of Java is needed. Dreamweaver is a kind of web page editor for web page creation and site management. It is a type of visual web development tool designed for professional web designer. The figure of main interface developed with Dreamweaver is showed as follow:

Figure2. Main interface

2) *Monitoring Interface:*

Java is an object-oriented programming language introduced by company Sun. It is a language which runs through the way of interpretation. The grammar rules are similar to C++. At the same time, Java is a cross-platform programming language. Program written with Java language called "Applet" (small applications) [2]. The program will be compiled into class files by compiler and put in WWW (World Wide Web) pages. Moreover marks are made on HTML file. So client only need to install client of Java in your computer. "Applet" programmed can be run directly on the Internet [3].

Figure3. Monitoring interface of register variables

In this paper, web page embedded Java controls is compiled by Dreamweaver. The wed pages done are uploaded by Dreamweaver or CP243-1IT Module to file system of Module. So you can access the wed page of file system of CP243-1IT from a remote place. Simultaneously the status of relevant auxiliary relay of PLC can be changed to achieve the purpose of remote monitoring and control [4].

The figure of control interface of register variable of PLC is showed as Fig.3:

During the picture above, Type comprises output (Q) registers, input (I) registers, special (SM) registers, variable (V) registers, auxiliary (M) registers. Data Type of access method of register includes four ways, such as bit, byte, word and double words. Offset and bit can be selected for register address. For example, I register of first value is selected as a byte type with total of 8 bits. Status Value displayed from I0.1 to I0.7 is 01,011,001. In this way we can monitor the status of each variable.

3) Virtual control interface:

Because of the characteristics of remote experiment, the experimenter can not manipulate the input and output of real devices directly. Therefore, virtual console of Java Applet and JavaScript has been designed. It has the following functions:

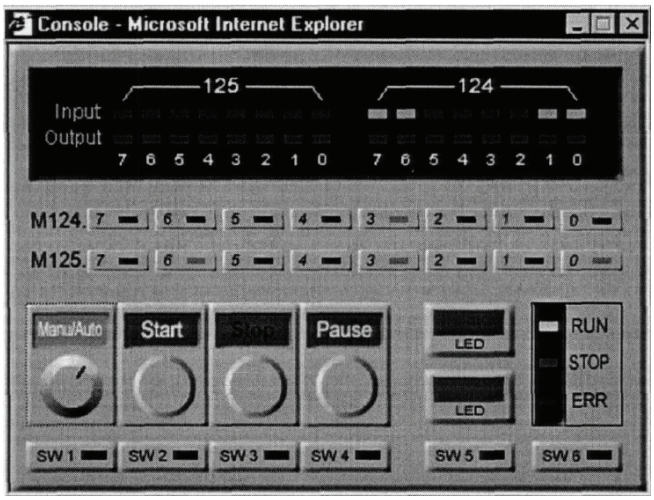

Figure4. Virtual console of remote experiment

Firstly, the input of PLC can not be modified from a remote computer. The status of input is stored in the memory units of virtual console.

Secondly, if some error of an experimenter in the process has produced, the controlled device activity is unpredictable. In order to block the error and reset the running program of controlled equipment, a "pause" button of virtual console for blocking the running programs is set up. And "stop" button is used to enable stop mode of CPU. That is to say, Block 35 of periodically interrupt organization is open and SFC46 system function is called conditionally.

Thirdly, the start button is set for start of program. Manu / Auto Run button is set for manipulator manual / automatic control mode choice.

Finally, in order to monitor the status of input and output of PLC and CPU directly on remote computer, status indicators of virtual console for input and output of PLC and CPU are established. And implementation of input and output status, CPU status dynamically updated with JavaScript.

The picture above is the virtual console of remote experiment system. Although the interface is simple, but requirements of experiment are fully meet. And buttons can be customized to meet variety of control systems, not just this experimental control.

B. Program of manipulator control

By STEP7 software for Siemens S7-200 series PLC, program of control can be made and written to PLC. Manipulator model is designed for need of experiment. Mechanical structure comprises a ball screw, a slider, cylinder, gas and other mechanical components folder. Electric component is made up of stepper motors, stepper motor drivers, sensors, switching power supply, solenoid valve components and other electronic devices. The manipulator model can simulate the running of industrial robots. In this Experiment, the manipulator control program is written. The flow chart of PLC control of manipulator is shown as below:

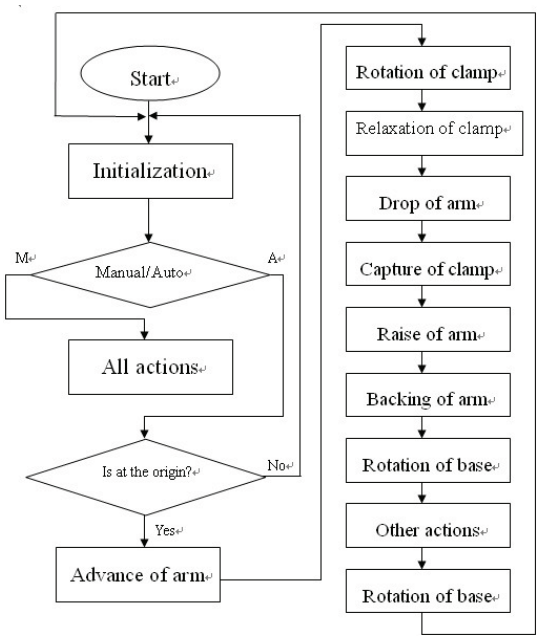

Figure5. Flow chart of manipulator control

C. Server configuration

The main server and CP234-1 IT module is located in campus network. And Internet is WAN. So we have to map IP of our main server of experimental control system and CP234-1 IT module to external network. So if no firewall blocking, Internet hosts can access the online system and control the operation of manipulator [5].

The main server is equipped with a Win2000 Server Edition operating system. The server is composed of Core Duo CPU, 2G memory, plus discrete graphics with high computer components. In order to meet the needs of remote experiment, the network camera is also equipped in system.

So students can do remote experiments and debug while observing the operational status of manipulator. A real effect of experiment is achieved. FTP server is set up to solve some problems, including experimental documents, experimental data sharing, guiding students to experiment.

V. SUMMARY

After installation, commissioning and trial operation period of time, the results of experiment we found are summarized as follows:

1) Remote laboratory based on web through CP243-1IT is feasible.

2) During remote experiment system, the virtual console can be designed with JavaScript and web. It has a strong practical value.

3) Since data transmission delay, the remote laboratory system can not be applied to real situations. The effectiveness of system needs to be improved.

4) Since the whole system is based on web, the implementation of program is independent on configuration of hardware and software. It has highly portable.

Finally, the method of remote experimental control of PLC based on web is investigated. It will bring huge promotion on remote control technology in industrial applications, scientific research and distance education. The technology can be integrated with enterprise network. Optimal allocation of resources can be achieved inside the enterprise. And it can make the best use of external conditions. So it may acquire a good position in the fierce competition of market. In the future improving effectiveness will promote the popularization and application of the experimental system.

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