

THE REMOTE CONTROL SYSTEM FOR LAPECR1

Wenxiong Zhou, Fuyuan Lin, Jinfu Luo, Yanyu Wang#, Jia Yin, Yanjuan Yu, Detai Zhou, IMP, CAS, Lanzhou 730000, China

Abstract

In order to support the debugging work of LAPECR1 (Lanzhou All Permanent Magnet ECR Ion Source No.1) which merely provides H⁺ beam for HIRFL (Heavy Ion Research Facility in Lanzhou), a control system was realized in November 2011. The control system is composed of some controllers, a control-software and Intranet established by a switch. All of the controllers could access to Intranet directly or through serial-switch. And the controllers of the high voltage power and motor were designed by us. An IPC (Industrial Personal Computer) could control all of the equipments through Intranet. The software of the system was designed by C++, and it could show the important data in the form of spectrum for analysis and debugging work. The control system could acquire data from the corresponding equipment and send command to it.

INTRODUCTION

In order to meet the needs of the different scientific research, the institute of modern physics developed an ion source LAPECR1, which was specially used to provide H⁺ beam for HIRFL [1]. Until 2011 there were no remote control systems for LAPECR1, because the ion source was being debugged. In order to help operators improve fixing and debugging work, we developed a set of distributed control system for LAPECR1.

The new remote control system mainly consisted of four parts: power supply system, vacuum system, gas

control system and microwave machine. In this control system, we provide an independent controller for each device according to the actual needs, and all of the controllers were coordinated by the controlling software which ran on the IPC (Industrial Personal Computer). This control software written in C++ could control and monitor all of the devices in real time and perform the interlock-protection and alarm in case of equipment breakdown or other emergency [2].

ARCHITECTURE OF THE SYSTEM

The system chose the distributed control mode and all the equipment were monitored by independent controllers. Correspondingly, the controlling software was designed to manage all of the controllers through intranet. In this way, we could take care of all the equipments. Figure 1 shows us the architecture of the remote control system.

As we can see, the controllers are divided into two kinds: one can access to the Intranet directly through a switch, the other must access to Intranet with the help of field-bus RS485 or serial port RS232. So a serial switch is used to change field-bus protocol to TCP protocol for data transmission through network.

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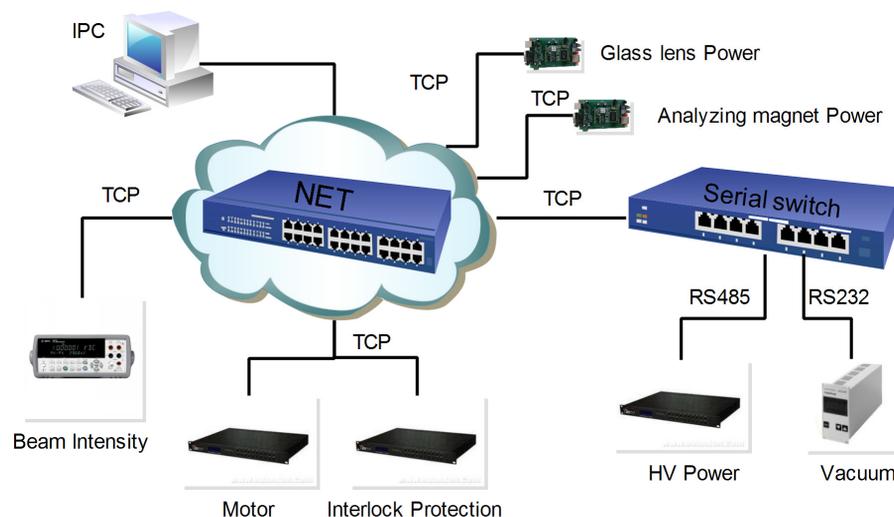


Figure 1: Architecture of the whole system

#Yanyu@impcas.ac.cn

Corresponding Author

HARDWARE DESIGN

Control of Digital Power Supply

It is the same digital power supply to provide power for the glass lens and analyzing magnet of the LAPECR1. For the sake of security and stability, the power supply must be controlled by optical fibre. So we developed a protocol-and-signal converter, as it is shown in Fig 2, to control those similar devices. The converter was designed to convert the TCP/IP protocol into RS232 protocol, and convert electrical signal into optical signal. However, as all the controlling logic was implemented by upper-layer software, this converter only needed to convert the protocols and signals.



Figure 2: Protocol-and-signal converter.

Implement of Gas Control System

To ensure the normal operation of the ion source, we need to use two kinds of special gases which we called “supporting-gas” and “working-gas”. The amount and the rate of these two kinds of gases that were injected into LAPECR1 must be controlled strictly and monitored accurately.

As we can see the specific working mechanism from Fig 3, the amount of two kind of gas is controlled and monitored by two corresponding valves which are driven by two AC-slow motors. And the position of the valves is reflected by reading the specific numbers of the slide

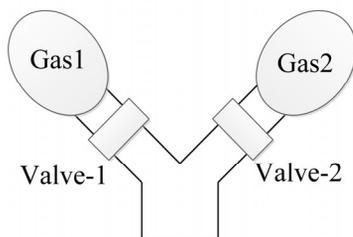
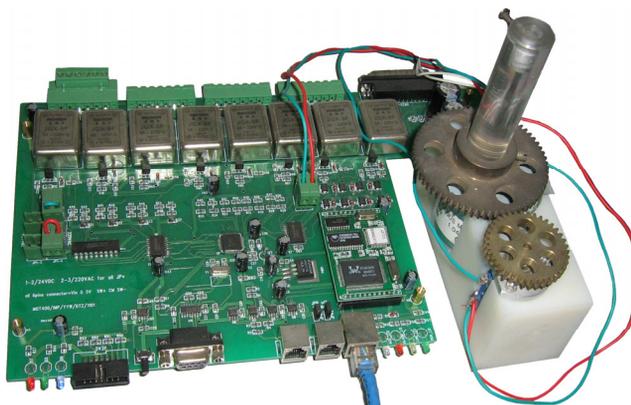


Figure 3: The working mechanism of gas control system and the Motor400 controller.



rheostat switches.

Motor400 is such a controller specially and independently developed for the gas control system. Using the MCU (Micro Controlling Units) MSP430F149 make it can supervise 4 AC-slow motors at the same time. The value of the slide rheostat switches are read by ADCs (Analog to Digital Converter) embedded in the MCU. The MCU read the value in real time, and it can execute the commands received from the control software through TCP/IP to control the AC-slow motors.

Interlock-Protection and Alarm

The function of interlock-protection and alarm plays an important role in controlling of iron source because it has to work continuously for a long time. So the repair measures must be taken in time if some devices go out of order during the operation, otherwise it is highly possible to bring about severe damage to other equipment, even lead to the interruption of beam current. For this reason, there must be some corresponding controllers to control the sound-light alarm devices and some more controllers to stop the work of other equipment in emergency.

VAC600 is such a controller independently developed by us using MSP430F149 to solve above problems [3]. It was also based on internet. VAC600 have many channels of relays which are used to close or open the power switch of the devices and the protection switch. And it also has some status-input ports. They are used to check whether the interlock-protection and alarm is successful. In the control system of LAPECR1, there are two sets of VAC600 for the alarm equipment and the corresponding devices at the same time. Even if one set of the controllers go wrong, the other can work as usual. This could improve the reliability of the whole control system, which is very important for the control of the LAPECR1 ion source.

SOFTWARE DESIGN

The Upper control software was implemented in C++. It is not only can acquire state information of different controllers and monitor all the equipments in time, but also can make the logical judgments to perform the interlock-protection and alarm or not.

In addition, when ion source is working, all of the devices and controllers are exposed to the conditions of high magnetic field, strong electromagnetic radiation and high-voltage, in which the electrical signal is likely to be interfered. So the signal may be error when it is detected by the controllers, and when there is electric surge in worst, the devices and the controllers may be destroyed. In order to filter out that interference, what we should do is more than using the isolator, protective diode and magnetic ring in the aspect of hardware. We also have to design a set of applications to decide whether it is an interfering signal. The problems and the corresponding solutions are shown in table 1. Usually, the error signal appears once a day for a few seconds. Therefore, if we receive this kind of signal, we will abandon it. Only in this way can we guarantee the accuracy of the interlock-protection and alarm.

Table 1: The Problems and the Corresponding Solutions

Problems	Solutions
Electric surge	Isolator
	Magnetic ring
	Protective diode
Error	Software

CONCLUSION

The remote control system of LAPECR1 was realized at lower cost with the simple structure, and it is also very convenient for operators to use. In this system we independently designed some controllers to solve problems of controlling multiple devices. Finally in the help of this remote control system, we successfully achieved the beam current in LAPECR1, which laid a solid foundation for later installation and operation.

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