PLC CONTROL SYSTEM For The PKUNIFTY*

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Abstract

A compact remote control system with the SIMATIC S7-300 PLC is being designed for Peking University Neutron Imaging FaciliTY (PKUNIFTY). PKUNIFTY consists of a 2.45GHz ECR Deuteron ion source, LEBT, a 201.5MHz RFQ cavity, HEBT and Be target. Now PLC control system for ECR ion source and LEBT has been completed and tested. This paper will present the structure of the control system, the HMI with useful data recording system, and some measures took to improve the system safety.

INTRODUCTION

Programmable Logic Controller (PLC) is a standard industrial controller with various standard signal modules, function modules and communications processors. The control system based on PLC is very stable, easy to design and maintain. PLC is used a lot as both the bottom level controller of a large accelerator control system [1] and the main controller of a small accelerator [2].

In Peking University, PKUNIFTY, a thermal neutron imaging facility, is under construction [3-4]. The facility mainly consists of a D^+ ECR ion source, a low energy beam transport (LEBT), a 201.5MHz mini-vane four-rod radio frequency quadruples (RFQ) and a high energy beam transport (HEBT). D^+ ions are accelerated to 2 MeV by the RFQ and used to produce neutrons by D-Be reaction.

The ECR ion source and LEBT will deliver 50 mA (peak current) of deuteron beam with kinetic energy of 50 keV for the RFQ. The normalized rms emittance should be less than 0.2πmm mrad and the duty cycle is 10% with maximum pulse duration of 1ms. The detailed parameters are listed in Table 1 [5-6].

PKUNIFTY will be controlled by a PLC control system based on the SIMATIC S7-300 PLC. The front part of the control system for the ECR ion source and LEBT has been completed. A lot of primary experiments have been carried out to achieve the needed control functions, such as data acquirement and record, to improve the whole control system and to verify its safety and stability.

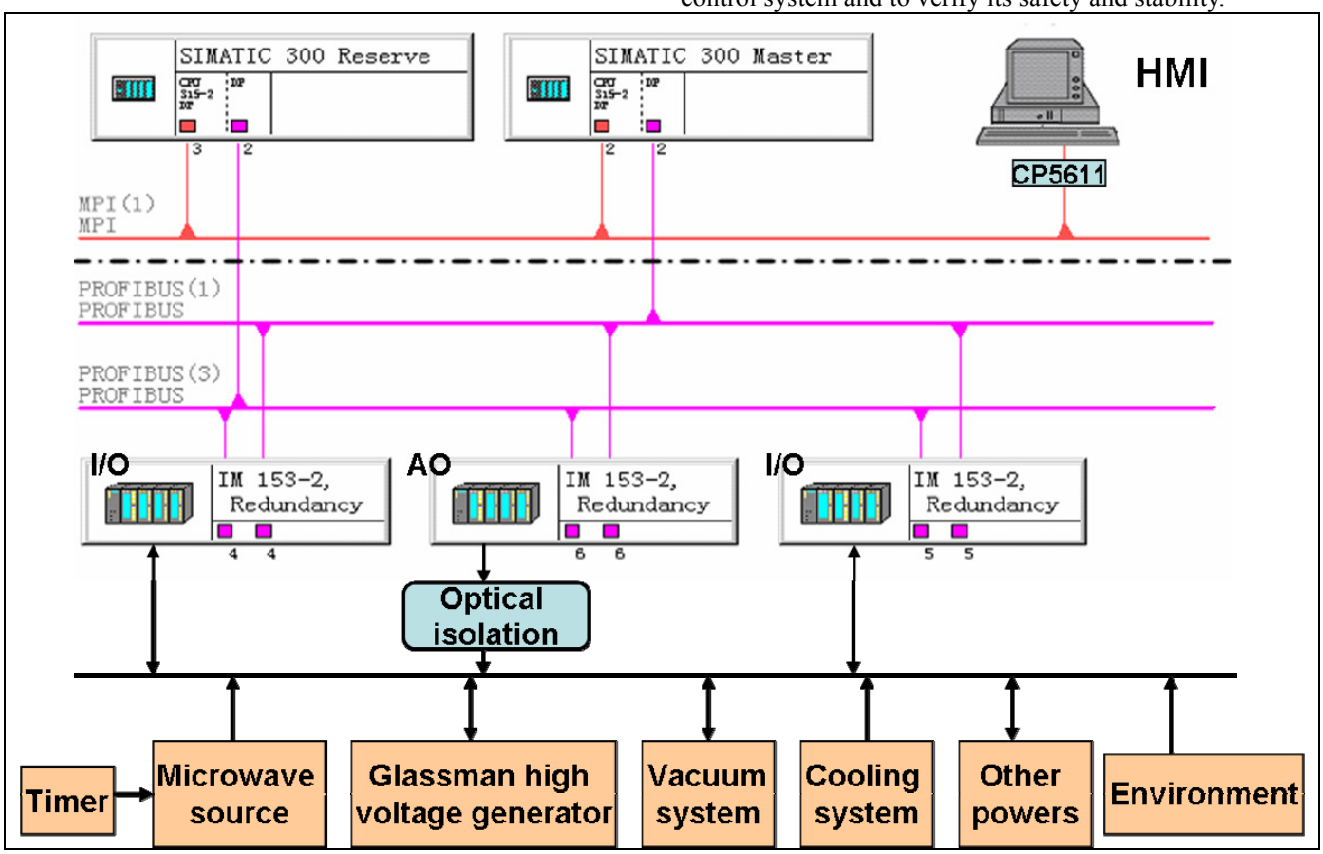

Figure 1: System components of the control system.

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Table 1: Parameters of the Deuteron Injector

Parameter Name	Value
D^+ current (Peak)	50 mA
Energy	50 keV
Duty cycle	10 %
Pulse duration	1 ms
Emittance (rms norm.)	<0.2π mm mrad
α	1.93
β	5.16 cm/rad

SYSTEM OVERVIEW

The control system includes a group of PLC, the controlled equipments, the HMI and the communication system (Fig. 1). The HMI communicates with the two 315-2DP CPUs by MPI; the CPUs communicate with the I/O modules by PROFIBUS. A software redundancy is set up with the two CPUs for fear of CPU failure. The HMI is designed with the SIMATIC WinCC V6.0, which is efficient and seamless with PLC.

We use the PLC to monitor and control the equipments as the I/O modules support a lot of standard electrical interfaces.

- Standard analogs (±10V, ±5V, etc) are directly monitored and controlled by AI and AO modules.
- The mean value of pulse signals (Faraday cup signals, ACCT signals, etc) related to ion beams are detected by integration.
- The temperature of the Cooling water and environment is detected by pt100.
- I/O digital signals (24V, 18V, etc) are detected directly by I/O digital modules or indirectly by relays.

The present I/O points and I/O modules are listed in Table 2; the final control system for the PKUNIFITY will use four DI modules, two DO modules, ten AI modules, three AO modules and a CP340/RS422.

Table 2: Statistics of the I/O Points and Modules

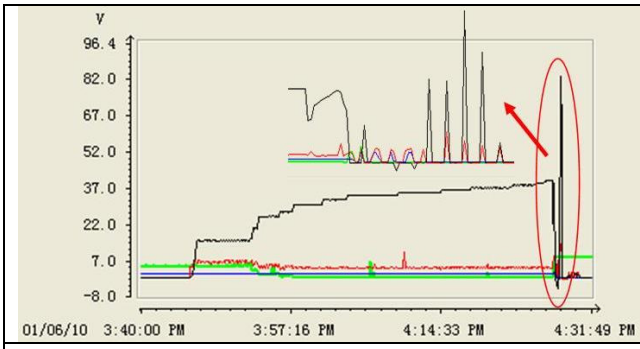
	DI	DO	AI	AO
I/O points	23	22	27	8
I/O modules	1	1	4	1

DATA RECORD

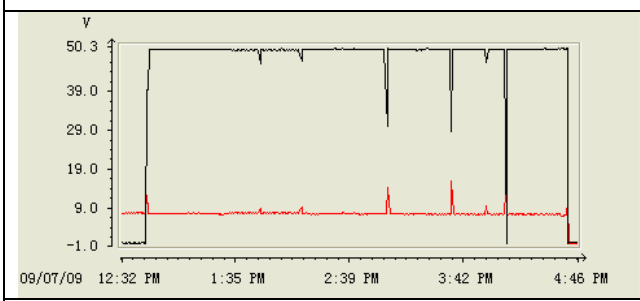
The HMI is designed with the SIMATIC WinCC V6.0, which is bound with the SQL Server 2000. The most important function of the HMI is to record and archive data. We use the WinCC alarm control to notify and review warnings, and use the WinCC online trend control to view important analogs both in real time and in history.

The Glassman high voltage generator works at 50 kV, of which the sparks tell the stability of the ECR ion source. Serious sparks would cause protection of the Glassman high voltage generator and is harmful to the other equipments. We monitor these sparks intensively on the HMI.

Continuous high voltage sparks happened when we commissioned one new ECR ion source (Fig. 2(a)). We solved the bugs of the ECR ion source before further experiment. And another ECR ion source is quite stable in most times (Fig. 2(b)); the system record only three obvious sparks during four hours.



(a): Serious sparks detected by PLC when the ECR ion source was being commissioned



(b): The ECR ion source worked stably.

Figure 2: The voltage (black line) and the current (red line) of the extraction high voltage recorded by the HMI.

SAFETY IMPROVEMENT

Automatic chain protection is designed to ensure the system safety (Fig. 3). If the cooling water temperature goes up to 35 ^{0}C, the vacuum goes worst than 1×10^{-2} Pa or any other power supplies are failed off, the PLC control system would at first make a alarm, if any failure is serious and lasts for the limit time, it will automatically shut down the Glassman high voltage generator, the microwave power generator, close the vacuum valves driven by gas pressure and turn off the other power supplies in sequence. Meanwhile it will send the failure signals to the HMI data recording system. We can turn on the manual mode when we need to debug the bench without the chain protection.

A lot of experiments have been taken to avoid the high voltage sparks and some measures are taken to protect the control system.

- All the AO signals are isolated with the other I/O signals and equipments by fixing the AO modules on one rack and adding optical isolation modules to AO points (Fig 1), as the AO modules themselves do not have electric or optical isolations.
- The PLC program is refined. If the system detects a serious spark, it will directly lower the output level of the high voltage generator down to 20 keV, and then slowly restore the voltage; if it detects more than one serious sparks in two minutes, the high voltage generator will be stopped and requires restoring the voltage manually.
- A chain lock button of the high voltage generator will be installed in the console room, which will be pressed to stop the high voltage when an unexpected situation happens.

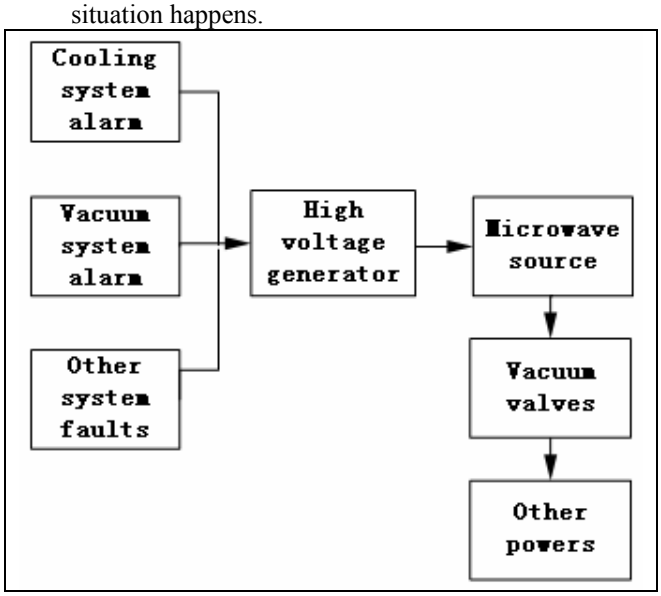


Figure 3: The chart of chain protection.

In the past several months, a lot of beam extraction experiments for full voltage on the ion source have been tested with the help of the PLC control system, and it shows that the PLC control system is very stable and helpful for the system operation.

SUMMARY

A compact PLC control system has been designed for the PKUNIFITY, and the front part for the ECR ion source and LETB has been completed. The software redundancy and some other measures enhance its safety. The powerful HMI can not only control the bench but also record important data. Months' experiments prove that the system is very reliable. We have got 50 mA D^+ beams and all the other parameters at the end of LEBT with the help of the control system. The final control system of PKUNIFTY will be expanded from the present.

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