function. The alarm threshold setting function and the overvoltage interlock function are designed to make the whole control system run stably and reliably.

(3) **Design of a Digital and Analog Mixed Controller Based on MSP430F149.** In order to meet the requirements of collection the various typeset electronic data which hase signals with relatively slowly speed in the site of HIRFL in IMP, a new controller which is combined with digital inputs outputs(DIOs) and analog inputs outputs(AIOs) was designed. The controller communicates with upper computer by net module or through the port of RS485 which also could place as cascade using. The controller has 4 AIO channels and 8 DIO channels, the Integral Nonlinearity (INL) error of the ADC channels could be better than 0.4% and the INL of the DAC is better than 0.2%. This controller is used as an integrated alarm for several HIRFL state monitor systems.

(4) **Design of a portable multi parameter secondary cosmic ray detector**. One small, low power consumption, portable and fully functional secondary charged particle detector is designed and developed. This detector consists of sensitive detection body, photomultiplier tube, high voltage power supply module, signal conditioning and data processing circuit. It can work at outdoor using a solar battery or vehicle power supply when monitoring the cosmic ray flux at different areas via a network for a long time, and making records of environmental parameters, such as air temperature, humidity and air pressure in these areas as large data sample. This large data sample shall be used in a further study of the correlation between cosmic rays and climate change, biodiversity and genetic variations of animals and plants.

(5) **Water conductivity detection and monitor system.** This is a newly system built which is a cooperation work with the water supply group. Up to now, we have shown 16 water conductivity monitor points of CSR in our interface. In the future, we plan to expand this system to the whole HIRFL area.

(6) **EPICS GUI reform of the water leakage detection and alarm system.** To respond the requirements of general control interface design, we paid a lot effort to reform our water leakage detection system to EPICS structure and used CSS to realize the new interface. This EPICS structure GUI is testing in our lab and will replace the older interface in the near future.

(7) **Realize of the remote switch function for the motor drivers and PLCs in SFC-ES control.** To avoid user operation error and to make user convenience, we designed a remote switch function for the motor drivers. In aids of this function, only when the beam tuning person operates the motors, the motor drives are powered on. And this work also realized the remote reset function of the PLC. This work largely reduces the chance of onsite maintenance and improve the reliably of the control system.

(8) **One Beam Emittance Measurement System for ECR Ion Source.** In order to measure beam emittance of ECR ion source more accurately and reliably, and to display data from different devices on the operation interface uniformly, the double slit motor motion control and the data acquisition of PXI board are introduced in the emittance measurement system, based on EPICS software system.

(9) **Design of a 2×4 synchronous voltage pulse amplifier.** In this work, a kind of synchronous pulse amplifier is designed, which can enlarge the input voltage pulse signal of 3.3 V to 15 V, and the rise time is less than 20 ns. This amplifier has long distance line driver capacity.

In the coming 2017, all members in our group will continue to do HIRFL operation and maintenance work, and also put the necessary studies on the pre-research of HIAF project.

6 - 31 Upgraded Control Software for Electronic Cooler of CSRm

Su Jianjun, Wang Yanyu and Zhang Jianchuan

The architecture, design, and testing of an accurate and usable electronic cooler control software for CSRm are detailed, and the results of its use is presented. The software, based on the Microsoft Foundation Class, was developed following the model-view-controller architecture pattern. On the hardware side, an I-7017R module was adopted for analog-to-digital conversion and an I-7065D module for electronic delay. The communication protocol was analyzed, discussed, and implemented, and the control software was then tested at CSRm with the $^{12}C^{3+}$ carbon beam. The fast reaction time and high-precision data processing exhibited during beam tuning verified the stability and maintainability of the proposed control software.

The control layer receives user commands and analyses them to manage the field equipment. The real-time status of the system will be sent to the data servers, which receive the experimental data acquired by the data-acquisition systems. These data are processed and stored in the experiment database. The system also provides users with data services relevant to the query commands, including data processing. The field devices execute the network commands to connect to the system. Fig. 1 is a flowchart of the system software.

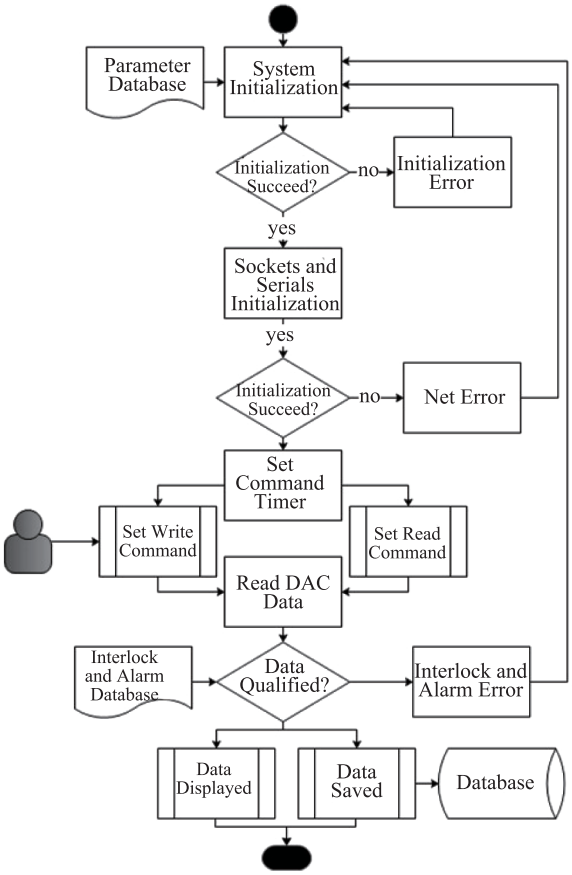

Fig. 1 Flowchart of the control software.

As the control software was designed with independent modules, new devices can be easily added. If a new device is added, it is only necessary to instantiate a class and call the function of the class. Most functions are called by these classes. Fig. 2 shows the remote-control software interface. The system was completed and operated in 2016, and it can acquire data at a minimal rate of 3 times/s and complete the entire interlock protection and alarm processes in 50 ms.

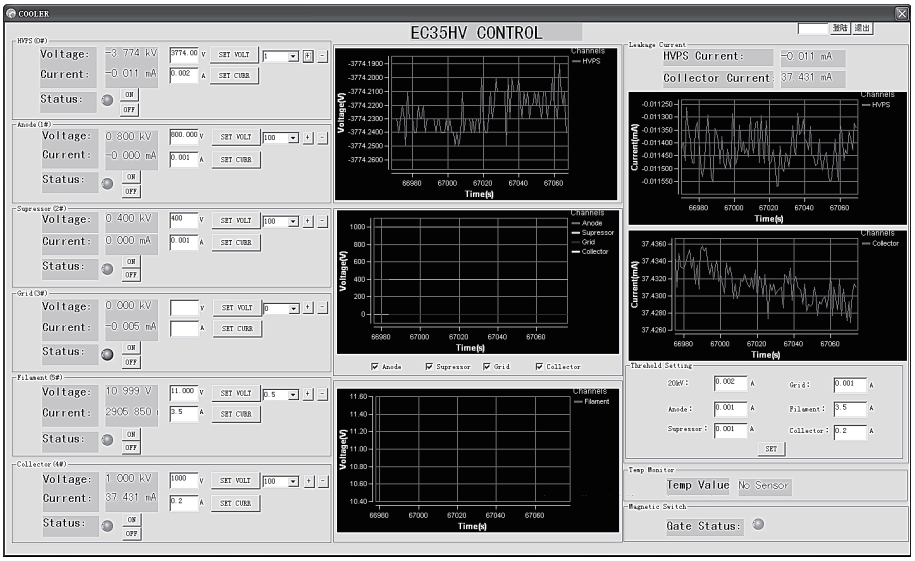

Fig. 2 Remote-control software interface.

The graphical interface of the control software has been running normally in the central control room since activation. The electronic cooler software was tested with the $^{12}C^{3+}$ ion beam. The $^{12}C^{3+}$ injection beam with energy of 4.282 MeV/u is successfully cooled by electrons, and the extraction beam energy is 2.401 3 keV. The ion

beam intensity is 90 μA. In practice, the proposed control software ensures safe and stable operation. Under the support of the control software, the electronic cooler has successfully cooled theion beam according to expectations. The experimental results show that the operation and control of high-voltage power supplies are also stable. The proposed electronic cooler control software meets the requirements of the control functions and makes experimental operations more automatic and visual. The software has been running successfully for several months, and the desired advantages of precision, efficiency, stability, and convenient operation have been shown in experiments.

6 - 32 Realization of Limit Position Protection Function Using PLC Program in Motion Control Area

Zhang Jianchuan, Zhou Detai and Wang Yanyu

In motion control area, safety consideration while the moving part touches the limit switch is very important. Otherwise there might be device damage if the moving parts still move toward the limit switch after it touches the switch. In the SFC extraction electrostatic spectrum motion control project[1] and the Xi'an 200 MeV proton device electrostatic spectrum motion control work, we realized the limit position protection function using Phoenix PLC and Rockwell Allen Bradley (AB) PLC. In the Phoenix PLC, a function block is designed using ST language. In the AB PLC, ladder logic programming language is used to realize the function.

Basically, two actions are executed as soon as the moving part "touches" the limit switch: the moving part stops emergently and the moving direction will be auto set to a "safe" one. The moving direction auto set function means that if the moving part touches the "left" limit, the moving direction will be set to "right" automatically. In this case, even if an error command "moving left" is send to the controller, the moving part will still move right.

Fig. 1 shows the ladder logic of the emergency stop function in RSLogix500 platform. Fig. 2 shows the function block of the moving direction auto set module in Phoenix PC WORX platform.

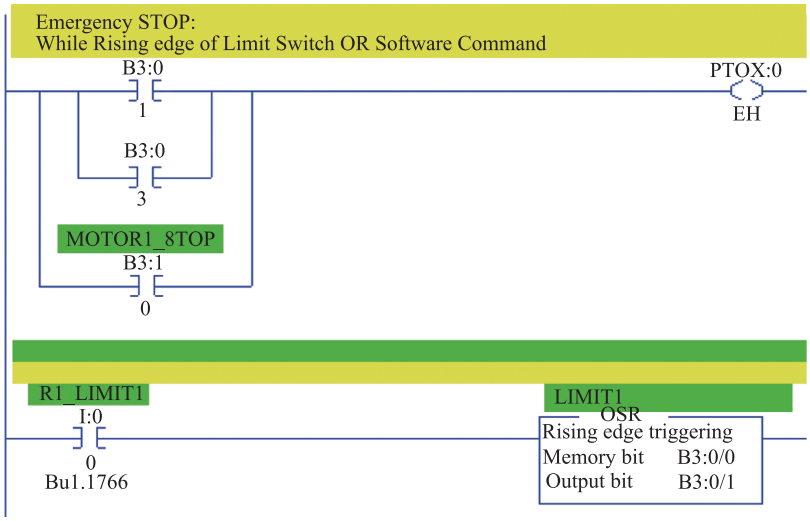

Fig. 1 (color online) Emergent stop function in RSLogix500 platform.

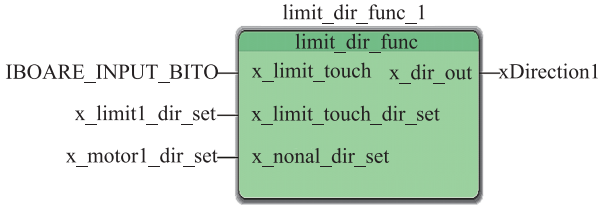

Fig. 2 (color online) Direction auto set module in PC WORX platform.

These protection functions were tested and proved to be working well. In the future, we will try to use this method in other application areas and maybe find other good ways to achieve better protection functions.

Reference

[1] Jianchuan Zhang, Xiaoying Zhang, Detai Zhou, et al., Nucl. Phys. Rev., 33(2016)41.