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SECTOR FOCUSED CYCLOTRON POWER SUPPLY CONTROL SYSTEM UPGRADE

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Abstract

The old power supply control system of SFC (Sector Focused Cyclotron) has been in operation for more than a decade. Control system architecture is centralized and equipment failure rate is getting higher and higher. The new control system uses the EPICS architecture and the hardware uses Advantech's APAX modules. The IOC runs on the APAX host and interacts with the module through API functions. The system has been running very stable for several months without failure.

INTRODUCTION

Lanzhou Heavy Ion Research Facility (HIRFL) includes Electron Cyclotron Resonance ion source (ECR), Sector Focusing Cyclotron (SFC), Separated Sector Cyclotron (SSC), Cooling Storage Ring (CSR) main ring and experimental ring, radioactive beam line, experiment terminals and other parts [1]. The power supply control system is one of the important components of the accelerator, which can realize remote debugging, data storage and historical data analysis of the power supply. The old power supply control system adopts a centralized structure. If the main control device fails, the entire control system will not be able to operate. The new control system uses the EPICS architecture, changes to a distributed control system, and realizes control of multiple power supply types (Fig. 1).

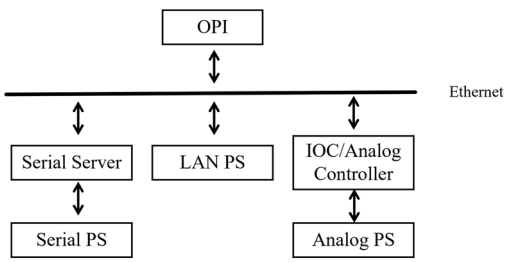

Figure 1: The structure of PS control system.

SOFTWARE

There are two types of power supply IOC control programs, one interacts with the power supply controller through the communication interface, and the other uses the analog control module to output and input analog signals. Analog power supplies also require coefficients to make the power supply output consistent with reality. The input and output coefficients are written to the analog controller through IOC. The power supply for the communication interface only needs to send and receive data instructions through the serial port or network port.

The scanning magnet power supply of SFC T1 terminal needs to first generate a triangle wave according to the period and amplitude, and then send it to the power controller according to the power supply protocol. The control flow of all power supplies is as shown in Fig. 2.

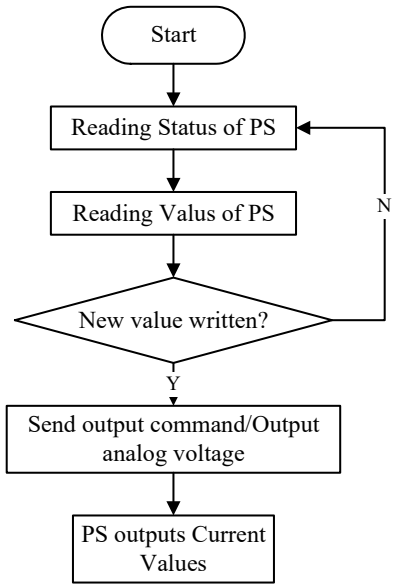

Figure 2: Control flow of all power supplies.

When the program starts running, it first reads the operating status of the digital power supply to see if there is a fault code, and then reads the output value and input value of the power supply to determine whether there are new values written. Analog power supply cannot read the status because the interface is analog signals.

HARDWARE

The main controller of the power control system uses Advantech APAX5580, the output module is APAX5028, and the input module is APAX5017. APAX5580 adopts the sixth generation Intel® Core™ i7 processor, up to 2.6 GHz, 8 GB DDR4 memory, compact fanless design, can be used for DIN rail installation in control cabinets, providing better EtherCAT performance, supports EtherCAT line, star, and ring redundant topologies [2].

APAX5017 has 12 input channels, configurable to ±150 mV, ±500 mV, ±1 V, ±5 V, ±10 V, ±20 mA, 0~20 mA, 4~20 mA. APAX5028 has 8 output channels, which can be configured as ±2.5 V, ±5 V, ±10 V, 0~2.5 V, 0~5 V, 0~10 V, 0~20 mA, 4~20 mA. The SFC analog power supply uses ±10 V control signals. All three types of power control IOCs are in the same main controller. The control hardware is shown in Fig. 3.

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Figure 3: The power supply control system hardware.

An isolator is added to the interface of the signal module, so that the anti-interference ability will be further enhanced. The control hardware is assembled with full consideration of electromagnetic compatibility and electrical safety. The electromagnetic compatibility test includes 6 test items: radiated emission test, conducted emission test, electrostatic discharge immunity test, electrical fast transient pulse group immunity test, surge immunity test, voltage drop, and interruption immunity test. Each item has passed the test, which also ensures that the hardware system can run stably in complex environments. Electrical safety can ensure that personnel will not be harmed due to normal operation during debugging. After the power system and control system were upgraded, the overall failure rate dropped by 80%. The upgraded power supply room is shown in Fig. 4.

Figure 4: SFC power supply room.

CONCLUSION

SFC power supplies are distributed in different rooms, and IOCs are distributed in each room. The power supply control system operation is stable after adopting the EPICS distributed control system. It provides a guarantee for the stable operation of the SFC accelerator and can better conduct nuclear physics-related experiments.

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