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NUCLEAR SCIENCE AND TECHNIQUES

Nuclear Science and Techniques, Vol.18, No.6 (2007) 326–329

The control system for SSRF injection and extraction

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Abstract This paper introduces the injection and extraction control system design for SSRF, which is a distributed control system aimed at stability and reliability of the pulse power supplies, PPS (Personnel Protection System) and MPS (Machine Protection System). The hardware environment is mainly based on PLC (Programmable Logic Controller), and ARM (Advanced RISC Machine) is also applied for studying stability of the power supplies. WinCC and EPICS (Experimental Physics and Industrial Control System) have been selected as the platforms of SCADA (Supervisory Control and Data Acquisition). For unifying the interfacing to the control computer, all front-end equipments are connected via Industrial Ethernet.

Key words PPS, MPS, PLC, SCADA, ARM, EPICS

CLC numbers TP202, TP206

1 Introduction

Fig.1 describes the location of the injection and extraction systems in Shanghai Synchrotron Radiation Facility (SSRF), which is a third-generation of synchrotron radiation light source under construction in China[1]. In Fig.1, KI, KE and KIK mean Kicker; SI, SE and SEP mean Septum; BP means Bump. The SSRF's working process is as follows. Firstly electron beam emitted by the electron gun is accelerated to 150 MeV by the linear accelerator, then injected into the booster through the low energy transport line, lastly accelerated to 3.5 GeV the by booster and injected into the storage ring[2]. Here we should emphasize the importance of three phases when electron beam running, which are respectively the injection and extraction system of the booster, and the injection system of the storage ring. Therefore, the injection and extraction control system should integrate magnet power supplies, guarantee long term and continuous safety, operation stability and reliability, and machine protection systems (MPS) and personal protection systems (PPS) must work effectively.

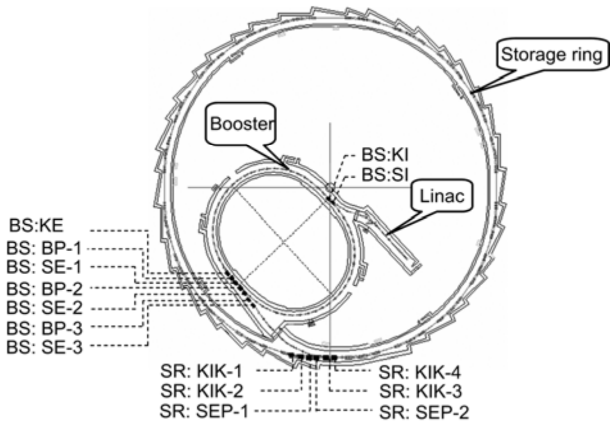

Fig.1 The location of the injection and extraction of SSRF.

2 System framework

Fig.2 is the injection and extraction control system's architecture, where nine PLCs are applied. As can be seen it is a distributed control system, with all equipments connected to WinCC based on PC (or OPI based on EPICS) via Ethernet. For the injection system of booster, one PLC is used to control one septum

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Received date: 2007-07-04

and one kicker magnet power supply. For extraction system of the booster, two PLCs are applied. One PLC is used to control the three septums, and the other to control one kicker and three bump magnet power supplies via Ethernet. For injection system of SR (Storage Ring), one PLC is used to control two septums and four PLCs respectively control four kickers.

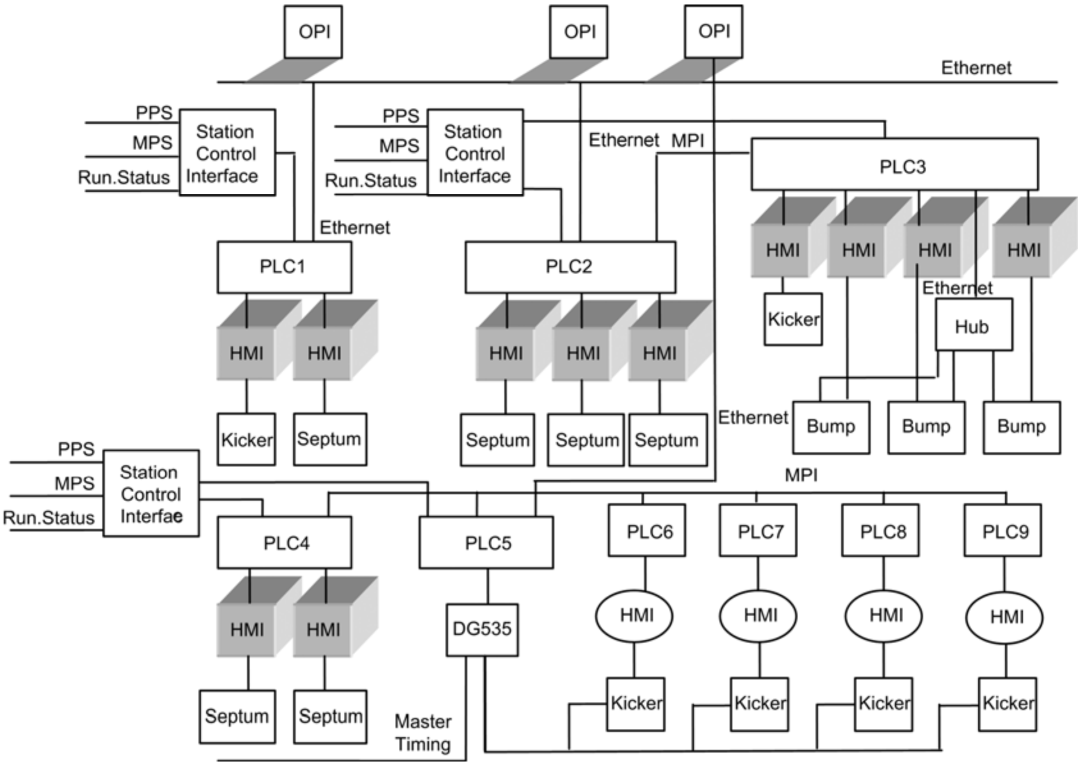

Fig.2 Architecture of the injection and extraction control system.

3 Design philosophy

3.1 Basic design issues

The controller is a key factor in designing the control system. Models of controllers are available, ranging from MCU, MPU and SoC to VXI and PXI. According to the requirements on the system's stability and reliability, Siemens SIMATIC S7-300 series of PLC was chosen as the controller. In view of the designed working environment of constant temperature, the PLCs have not adopted redundant hardware configuration. We used about 400 points in all PLC configuration modules including a certain number of AI, DI, Relay, AO, DO and net modules. A main goal of the control system is to control and monitor the power supplies, and offer as much working status as possible, e.g. status of the CPS and thyratron filament, and signals for interlocks, providing convenience to equipment maintenance accordingly. Although a PLC guarantees reliability of interlock protection, we adopt hardware circuit to ensure its reliability through logical judgment to inhibit trig signal and high voltage transferring[3]. The control of a septum is similar to the control of a kicker. In controlling a bump, however, the PLC sends SCPI (Standard Commands for Programmable Instruments) to the bump power supply to produce half-sine signal of certain width and frequency. Because SCPI is in character format, the PLC sends strings to the power supply in accordance with SCPI format demand, which requests an enter key and a new line to every command. Fig.3 is an example of database of command in the PLC program.

+0.0	STEP0	STRING[16]	'PROG:NAME "SEQ4"'
+18.0	enter0	BYTE	B#16#D
+19.0	huan0	BYTE	B#16#A

Fig.3 An example of command format in the PLC's program.

3.2 ARM controller

Amplitude stability of a kicker power supply is one of important crucial parameters. A close-loop control was adopted to improve the long term amplitude stability. We introduced ARM controller S3C2440A with peripheral A/D (high sampling rate and high resolution) and D/A (high stability) on the loop. Fig.4 is the schematic diagram of the close-loop control.

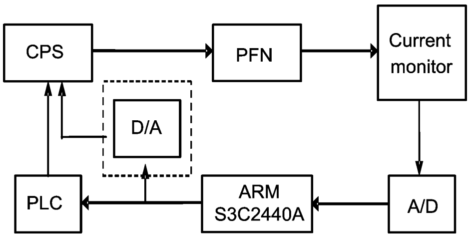

Fig.4 Schematic diagram of the close-loop control.

3.3 SCANDA

For a control system, a friendly HMI (Human Machine Interface) or OPI (Operator Interface) is also imperative. In local working mode, HMI is used to operate the power supply. In remote working mode, WinCC based on WinXP or EPICS based on Linux is used to operate the power supply. Main functions of the SSRF SCADA software are as follows:

• Monitoring (visualization of the process state and history);

• Operator control (set parameters, switch on and off subsystems or operations, acknowledge alarms);

• Archiving of process variables and alarms;

• Communication with the process periphery and supervisory computers.

3.3.1 WinCC

Apparently, the traditional development from the scratch (e.g. using VC or VB) is not a good idea for SCANDA application. “Lab automation” tools like LabVIEW look like a good choice, but it is not ideal to exchange varieties of messages between PLC and LabVIEW. Consequently, we intended to acquire an industrial Windows-based package, like e.g. GE’s ifix and Wonderware’s InTouch. Finally, WinCC of Siemens was chosen owing to long term availability, natural integration of proprietary protocols[4] (e.g. Ethernet, MPI) and the technique support.

3.3.2 EPICS

The GUI development toolkits EPICS, which was initially developed at Los Alamos and Argonne National Laboratories, has been used by worldwide scientific institutions, especially in the accelerator physics community[5]. Applying EPICS to Siemens PLC controller requests a PLC driver. We use the s7plc EPICS driver available at present, which was written to connect a Siemens S7 PLC via TCP/IP to an EPICS IOC. In the IOC startup script, the s7plc driver should be configured as s7plcConfigure (name, IPaddr, port, inSize, outSize, bigEndian, recvTimeout, sendIntervall).

In our application, the control system based on EPICS consists of three layers, OPI, IOC (Input/ Output Controllers) and LAN (Local Area Network). OPI is a PC, running Linux, which provides a man- machine interactive interface. IOC, running Linux, directly or indirectly provides actual control for power supply. LAN is Ethernet, which provides the communication between OPI and IOC, using the Channel Access (CA) network protocol.

3.4 Timing

Timing of the injection and extraction is one part of the master timing systems of SSRF. The kicker, septum and bump magnet power supplies must operate precisely in accordance with timing schedule of accelerator physics. All timing signals of injection and extraction come from master timing systems, whose frequency is 2 Hz and delay time can be modulated in an 8 ns step. As far as injection and extraction of booster is concerned, the 8 ns step size is sufficient. But the kicker for the injection of SR needs a shorter step (e.g. 1 ns). Thus we selected DG535 from Stanford Researcher Systems, which is a very precise delay and pulse generator providing four precision delays or two independent pulses of 5 ps resolution. The trigger to output jitter is less than 50 ps. The internal working timing relation of magnet and power supply is demonstrated in Fig.5[6].

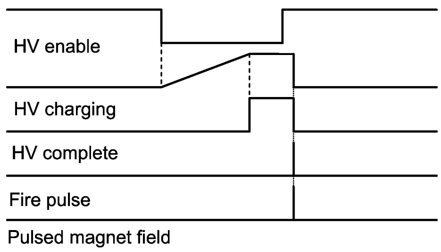

Fig.5 Pulse power supply timing.

4 Test and summary

The test and verification include hardware and software tests. The hardware test examines whether a disposal of interlock requests (MPS, PPS, internal and external request) and HMI operation is prompt and accurate. During actual equipment operation, all kinds of interlock request occur at random, and what would take place next time cannot be predicted. In addition, to make an artificial fault is not feasible and a good idea. Then, S7-Plcsim is a useful tool internally rooted in step7, with which we simulated varieties of interlock requests to verify logical tackling and right protection function of controllers. Tests on the kicker and septum have been performed. The results show that the controller is capable of running stably and reliably. The software test checks whether WinCC can precisely communicate with PLCs and display promptly the statuses. WinCC has been used to monitor and control power supply via Ethernet remotely, and the outcome is excellent. Fig.6 is the main interface of WinCC.

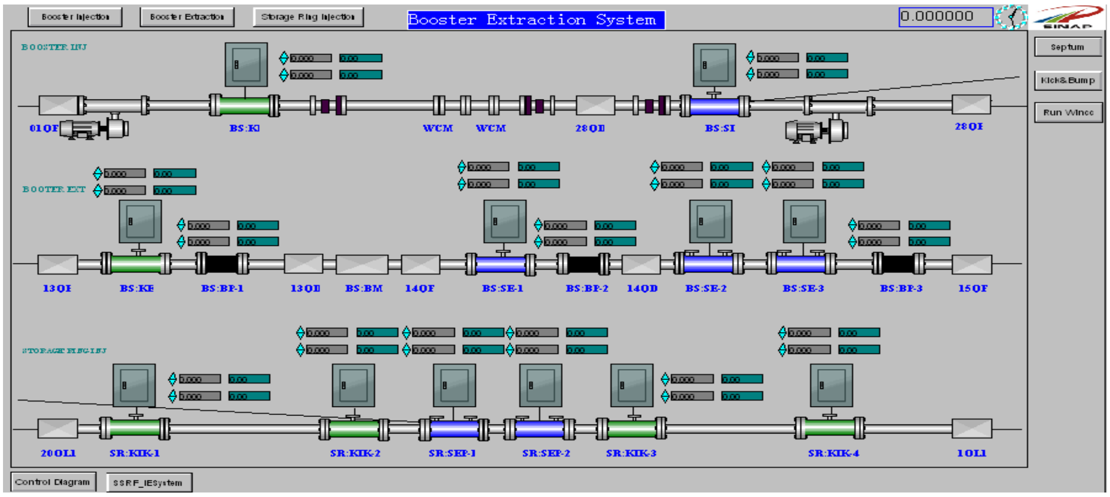

Fig.6 Main interface of WinCC.

References

1 China National Synchrotron Radiation Centre, SSRF Project Preliminary Design (in Chinese). 2001: 200-277.

2 Kang Wen. Theoretical analysis and experimental research on vortex septum and physics research of injection and extraction system of SSRF (in Chinese). 2001: 4-130.

3 Antoine A, Carlier E, Marchand A, *et al*. Proceedings of EPAC, Paris, France, 2002: 1-3

4 Kleines H, Sarkadi J, Zwoll K, *et al*. International Conference on Accelerator and Large Experimental Physics Control Systems, Trieste, Italy, 1999: 1-5.

5 http://www.aps.anl.gov/epics

6 Johnny Tang. Injection and extraction kicker control systems using epics. 2006: 4-25.