A PROTOTYPE OF THE SSRF POWER SUPPLY CONTROL SYSTEM

J.G. Ding, H.J. Zhu, H. Zhao, L.R. Shen,
Shanghai Institute of Applied Physics, Shanghai 201800, P.R. China

Abstract

The Shanghai Synchrotron Radiation Facility (SSRF) is a third generation, 3.5GeV synchrotron light source currently being constructed at the Shanghai Institute of Applied Physics (SINAP) in Shanghai, China. There will be over 700 magnet power supplies (PS) in the Storage Ring, Booster, Linac and Transport Lines. According to the requirement of control precision, reliability and stability of the magnet power supplies, we decided to use PSI-designed digital PS control system [1][2][3] for PS control, that typical resolution reaches 1ppm and long term stability and reproducibility is better than 30ppm. Each PS has a local digital controller for a digital regulation loop and a optical point-to-point link to the VME level. The low-level EPICS [4] interface is identical for all power supplies. The VME-based front-end consists of a Single Board Computer (SBC), IP carriers and Industry Pack (IP) I/O modules. A prototype of the PS control system has been setup and tested at SINAP. Control and monitoring of the prototype has been implemented with EPICS. This paper describes the development of the prototype and the progress of the power supply control system and discusses our future plan.

OVERVIEW

The SSRF design requires a large number of magnet power supplies with a wide power range and a variety of different features. Power supplies should work with high performance of precision, stability and flexibility. The PSI (Paul Scherrer Institut, Switzerland) developed digital power supply control system was chosen as the front-end of the power supplies after investigating the control solution of the domestic and foreign labs.

The digital PS is a fully digital controlled, uniform solution for all magnet PS. It consists of two parts: a digital Power Supply Controller (PSC) and a VME 64x based system. The overall control system architecture is shown in figure 1.

One PS controller contains a pair of DSP controller card and an ADC card connected through a backplane. They executes digital regulation loop for PS. Each PS controller has two communication links to the outside. A RS232 link connects the PS controller with a Personal Computer for the local operations and system configuration. A point-to-point optical fiber link connects the PS controller with an IP module hosted on a VME carrier board for the remote control. Plastic Optic Fiber is used for the optical link. The optical communication is controlled by a FPGA on the both ends: on the DSP card and on the IP module. Each controller also has an additional optical trigger input. The trigger input is used to start a programmable current waveform.

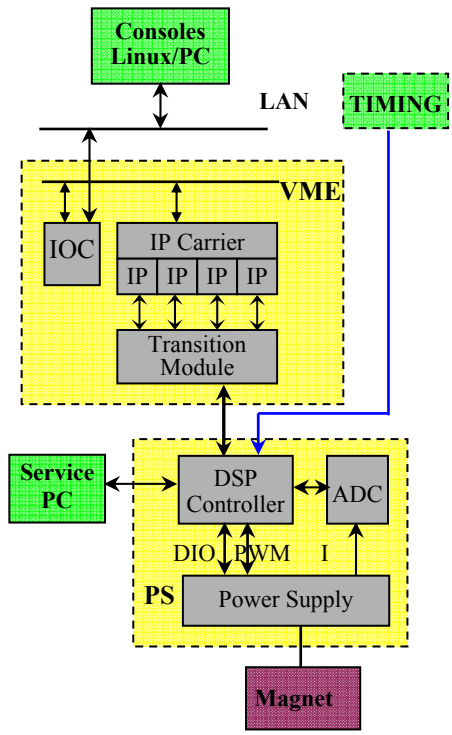

Figure 1: The PS control system architecture

The IP board is designed by PSI particularly for the solution. One IP module can serve two power supplies, each with one bidirectional 5MHz link. Four IP modules fit on an IP carrier VME card. Thus control density of eight PS per VME card can be reached. The throughput of each link reaches 10K float value frames per second.

The VME system is used as an EPICS Input/Output controller (IOC) to access the readable/writable registers of the PS controllers. IOC executes process control for power supplies by the EPICS runtime databases. The Linux/PC consoles run EPICS Channel Access (CA) clients to control/monitor the IOC execution.

SYSTEM SETUP

For SSRF project, our control platform is EPICS. The IOC for PS control is a VME 64x based system. Two kinds of SBC boards of PowerPC 74xx family have been evaluated to be used: Motorola 5500 and GE 7050. The IP carrier we use is SBS VIPC 664-ET. A Transition Module (TM) is used for the rear I/O of the carrier to connect the control system and the power supply and also executes optical/electrical signal conversion between them.

PS controllers, IP and TM boards are purchased from Diamond Light Source Ltd. Prototype power supplies together with backplanes are made by domestic factories. Control parameters of the PS controllers, such as PID algorithm parameters, maximum/minimum current limits, and digital input/output masks, etc., are configured by the SSRF Power Supply Group.

The VME based control system has been setup. Figure 2 is configuration of our VME based system. It is comprised of a 21-slot VME 64x crate with a Motorola 5500 SBC, seven IP carrier cards and seven TM modules. The first six IP carriers each has four IP boards installed, and the seventh has only one. Therefore our setup can control 50 sets of power supplies.

Figure 2: The prototype system configuration

A laptop computer is used for vxWorks/EPICS development. The laptop running Windows XP with Tornado 2.2.1 and vxWorks 5.5.1 installation performs functions to build vxWorks boot ROM and loadable image, compile EPICS base and EPICS applications for the PPC 5500 BSP target. The IOC runs vxWorks kernel, EPICS iocCore and applications these are download from the laptop when IOC is booted or reset. A desktop PC is used as a console running Linux with EPICS base and extensions installation.

SOFTWARE

The software functionality is organized in layers as shown in figure 3.

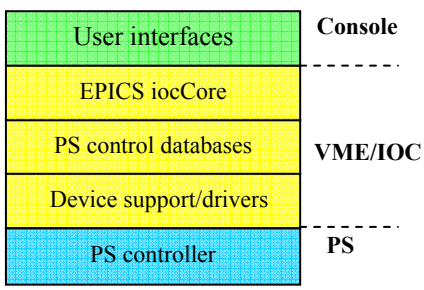

Figure 3: The PS control software scheme

PS Controller Software

The regulation loop and control of fast current waveform is handled by the PS controller. Software has already been written in the Flash EEPROM before PS controllers are shipped. Software is identical for all PS controllers and only differs by control parameters.

VME/IOC Software

For the IOC software, EPICS base 3.14.8.2 is used. The PS control EPICS device support/driver was transferred from Swiss Light Source that is also identical for all PS. The original version of device driver was run on EPICS base 3.13.x. To run the driver on the EPICS core of 3.14.8.2, some modifications have been made.

For the EPICS runtime database, we have developed two database templates for PS control: a standard template for PS basic control functions and a waveform template for current waveform download/upload. The standard template is used for all Linac, Booster, Transfer Lines and Storage Ring power supplies. The waveform template is only for the energy ramping power supplies of the Booster. The two templates have a total of more than 100 records. Some of the records are directly connected to the communication registers of the PS controller. The others are soft records for extra features, like initialization after IOC is booted or rebooted and hysteresis handling. Besides of the parameters like the switch, set and read-back the current, and the status of the power supply, there are parameters for PS fault diagnostic. Further more, there are some channels for diagnostics of the optical link. The database for each individual power supply is generated from the templates when IOC is booted by its PS name and other macro substitutions.

Console Software

The operator interface for magnet control is implemented with EDM. EDM is an EPICS GUI "display manager" tool to edit and execute controls to access process variable in IOCs. EDM screens are developed on Linux/PC platforms. Some application programs like routines for waveform download and upload from PS controller have been developed and already available. These applications are embedded in the EDM screens using the Shell control.

TEST RESULTS

The system described above has been tested with the prototype power supplies at SSRF. With up to 50 PS databases, more than 5,000 records loaded, VME/IOC works fine. For long time test over 50 hours, there was no any error noted. EDM screens, waveform download/ upload programs have been tested with the prototype control system. Features of IOC initialization and automatic/manually hysteresis handling also have been tested.

SUMMARY

There will be 608 power supplies used in SSRF project with fast corrector power supplies excluded. These power supplies will be controlled by 27 IOCs. It is estimated there are nearly 60K channels to be controlled in the power supply control system.

Besides, there are 40 common DC converters distributed in 20 PS stations along the storage ring. They are locally controlled by OMRON PLCs and connected to Local Area Network. We will use a soft IOC to control them via Ethernet communication.

The prototype power supply control system has demonstrated good performance of the digital PS solution. More tests will be done for runtime databases. Presently screens to meet physics requirements and screens of engineer levels have started to design. They will be in tree-layered structure, expanded from primary templates with macro-substitutions at runtime.

In addition, compared performance of Motorola 5500 to GE 7050, both are compatible in application layer, but the latter have shown higher performance and cost-efficiency. So GE 7050 will be used as IOCs for power supply control of the storage ring.

SSRF will begin beam commissioning at April, 2007. So the control system will be available before then.

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