THE INSERTION DEVICE CONTROL IN BEPC

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ABSTRACT

The insertion device in the Beijing Electron Positron Collider (BEPC) for synchrotron radiation X-ray beam lines consists of main coil and auxiliary coil that are respectively powered by two independent power supplies with high precision. The two power supplies called main power supply and auxiliary power supply are rebuilt with a new power supply interface (PSI). They are controlled by a power supply controller (PSC). This system is completed within one month after the control prototype for BEPCII magnet power supplies with PSC/PSI was finished. During commissioning, it is modified many times to meet its operational requirements. It has been running for about six months without any big problems enabling synchrotron radiation research on the two x-ray beam lines. This paper describes a new control system based on EPICS for the insertion device power supplies. The requirements to its ramp and its programming are also discussed.

INTRODUCTION

The insertion device (4W1) for synchrotron radiation X-ray beam lines is actually a single cycle electric magnet[1]. It is made up of a main coil and an auxiliary coil that are respectively powered by two independent power supplies with high precision. Its working principle is the auxiliary coil provides current compensation when the main coil provides current for the magnetic field. The auxiliary coil is working in either ramp up or ramp down with the main coil ramp up. When the magnetic field is up to the maximum value, the auxiliary power supply may be shutdown.

Since all power supplies in BEPCII will be controlled by the PSC/PSI, the two power supplies were rebuilt with new interface to the PSI before BEPC running in last half year of 2004. In the first year of 2004, the PSC/PSI had been successfully used to control a chopper type power supply prototype[2]. The performance of the PSI has been tested at SNS[3]. The PSI has one 16 bits DAC and four 16 bit ADCs with 15 bit stability. And they are commercial available manufactured by Apogee Lab. Before they are used to all power supply control, we used one PSC and two chassis PSI to implement the control and monitoring of two chopper power supplies as a prototype. The control stability of the PSI has also been tested. The result showed that the PSI reached up to the stability of 50ppm/8hours. It meets the requirement of the stability of 50ppm for high precision power supplies. The new control system for the 4W1 insertion device had been accomplished using the PSC/PSI within one month to ensure BEPC running during 2004-2005. It is first BEPCII control system put into operation with EPICS.

HARDWARE ARCHITECTURE

The control system follows a standard model[4] “three-layer” distributed architecture as shown in figure 1. It consists of a PC/Linux console computer, a PowerPC750 front-end computer, and a PSC connected to two PSIs installed inside the rack of two power supplies. EPICS base and extensions such as EDM is installed on the PC/Linux. The operator interface (OPI) for remote control and monitoring of 4W1 magnet power supplies is created using EDM. The PowerPC750 is running VxWorks and EPICS applications and PSC/PSI driver and device support downloaded from the

PC/Linux.

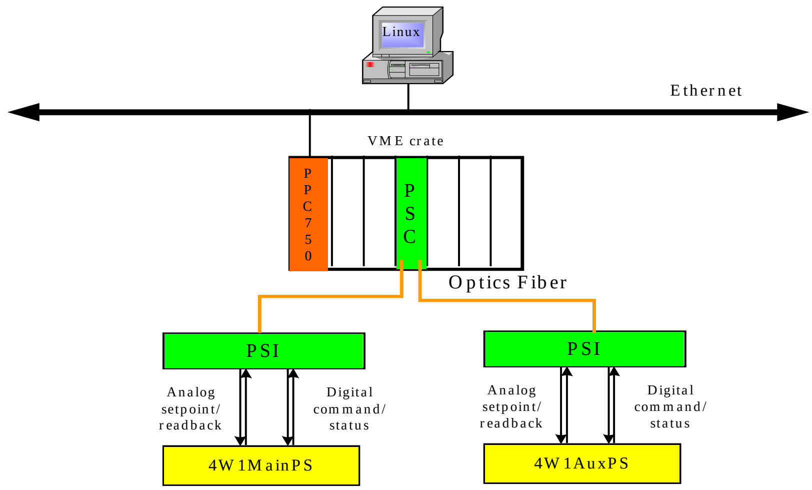

Figure1: 4W1 Control System Hardware Architecture

The PSC is a standard VME module which is installed in a standard VME crate. The PSI is a VME bus-size module that may either be placed within a VME crate or a stand-alone chassis[5]. In this system, we used two chassis PSI installed in the rack of two power supplies. The connection between the PSC and two PSI is through two pairs of optical fiber. One PSC can control up to six PSIs. The fibers provide all the isolation. There is no isolation circuit required. The connection between the PSI and the power supply is through two cables: one for the analog signals, and another for the digital signals. This makes installation and integration simple.

The PSC may receive commands and data from VME bus. The PSI has one 16-bit analog output, four 16-bit analog inputs, fifteen digital commands, and sixteen digital readbacks. The data transmitted on the fiber optic link will be 5 Mb/s. The longest command/response time is about 20 microseconds.

SOFTWARE DEVELOPMENT

The application software is developed on a PC/Linux machine. EPICS base and extensions have been installed on this PC with a VxWorks cross-compiler. Database template is configured using VDCT. OPI is created using EDM.A special ramping application is programmed by SNL personnel. The PSC/PSI driver from BNL has been modified to match 4W1 main/auxiliary power supply interface requirements. The two chassis PSI work in unipolar mode and non-pulsed command mode.

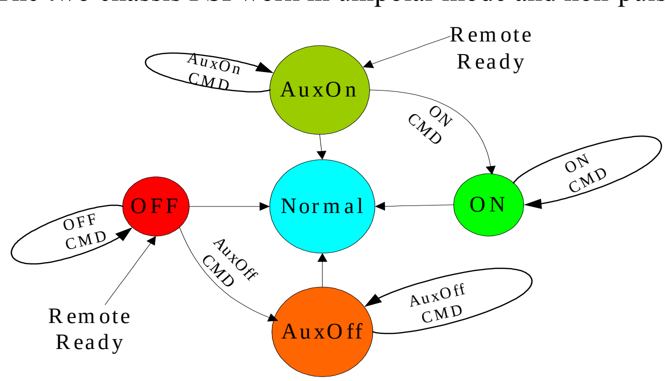

Figure2: PS Control State Diagram

The two power supplies have a initial state: Normal and four operational states: On,Off, AuxOn and

AuxOff. The power supply will change from one state to another in response to four commands: On,Off, AuxOn and AuxOff. Each command sent to the power supply is followed by a delay of 10 clock tick before changing back to the Normal state. The operational status as a result of a command is show in the State Diagram in figure 2. The four states along with alarm and remote/local state will be read back to the PSI.

Ramp principle

The auxiliary power supply will provide setpoint compensation when the main power supply provides setpoint ramping. Using the magnetic measurement data as shown in the figure 3, we used a polynomial least square and got the polynomial as shown in figure 4.

main current(A)	compensation current(A)
100	100.9
200	197.8
300	259.8
350	257.2
400	239
450	194.5
500	74
550	0
560	0

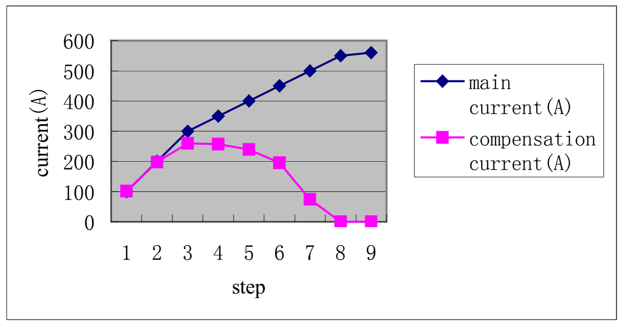

Figure 3: Magnetic Measurement Data

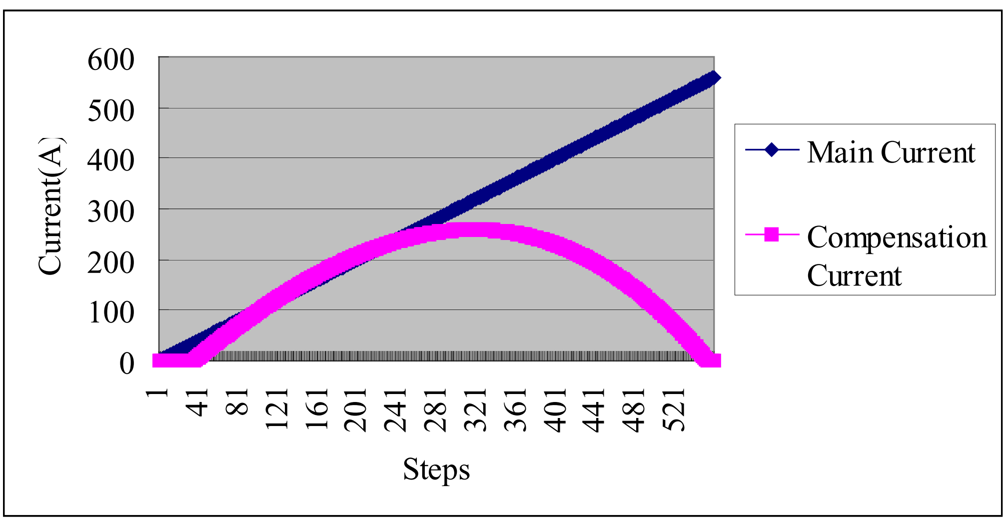

Figure 4: Polynomial Least Square Fit Data

Ramp Program

The ramp program running on IOC is created using SNL[6],. It is responsible for monitoring the ramp trigger record. When the Ramp button is pushed, it will calculate the maximum step rate from the current setpoint to the desired value for the main power supply. Then the program will send out setpoint step by step under the maximum step for the two power supplies. During ramping, this program can be aborted by the Abort button. It has four state settings: RampUp, RampDown, Standardize and Abort. RampUp is to make the two power supplies go to their own desired value at the same time. RampDown is to make them go to zero at the same time. Standardize is to make them first go to their own maximum values, then to zero at the same time. Abort is to make program stop any action. The OPI screen created with EDM is shown in figure 5. From the main OPI , the operator can enter each sub OPI for each power supply. The real time history curve of the two power supplies ramping synchronously as shown in figure 6 is created with StripTool. The curves recorded setpoint and setpoint readback step by step from the two power supplies. They reflect the relationship between the main coil magnetic field and the auxiliary coil magnetic field. They are identical with the polynomial least square fit data.

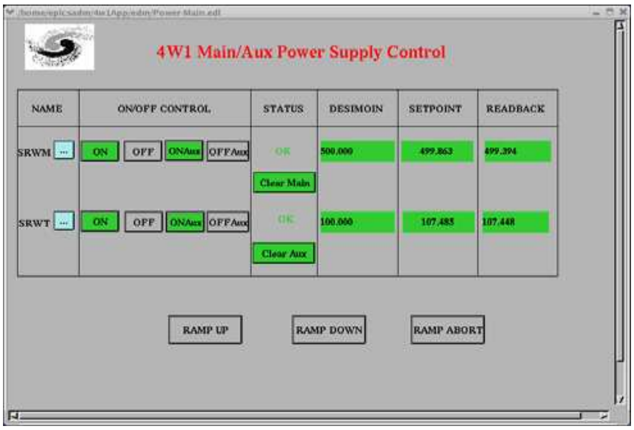

Figure 5: Main OPI

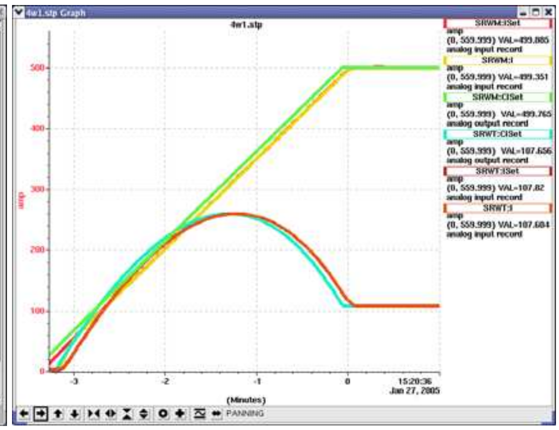

Figure6: Real Time Historic Data

CONCLUSION

The new control system for the insertion device 4W1 power supplies has been running well since it was put into operation during 2004-2005. The obvious improvement is that the polynomial least square fit data are continuous and smoothly cubic curves. There is no sudden setpoint change during ramping. This makes beam spot more stable than before. The successful running of the new control system with PSC/PSI proved it's appropriate to use PSC/PSI for high precision power supply control. It laid a foundation for BEPCII power supply control system construction.

ACKNOWLEDGEMENT

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