Control application of a superconducting magnet power supply based on EPICS

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Abstract The superconducting quadrupole magnets (SCQs) are powered by 16 power supplies in the interaction region of the BEPCⅡ. The control application of these power supplies must be interlocked with the quench protection system to protect the superconducting magnet and relevant devices. This paper describes the development procedures of this control application using EPICS and the operating result with the quench protection system on-site.

Key words EPICS, superconducting, power supply control, BEPCⅡ

PACS 07.05.-t, 07.07.Tw

1 Introduction

According to the design of the double rings of the BEPCⅡ, two superconducting quadrupole magnets (SCQs) at the interaction region are used to generate horizontal and vertical magnetic fields in the horizontal and vertical as quadruple magnets. One SCQ consists of 3 anti-solenoids, 1 dipole, 1 quadruple and 2 corrector coils [1]. Because the working current demand of the dipole coil is different in two operation modes, every SCQ is powered by 8 power supplies; 7 of them are for the colliding mode and 2 of them are for the synchrotron radiation mode. There are in total 16 superconducting magnet power supplies in the storage rings.

The superconductor is limited by some working critical conditions, such as temperature, ampere density and magnetic field. When any one of these factors is overloaded, the superconductivity will be lost and enormous energy released so that a superconducting magnet quench is caused. The quench protection assembly interface crate (QPAIC) is responsible for collecting all signals of SCQ power supplies and sending them to the control system. For safety, the ON/OFF and ramping operation of the SCQ power supply must be interlocked with the signal from the QPAIC.

2 Hardware architecture

The hardware architecture of the SCQ power supply control system, as shown in Fig. 1, consists of a VME crate, a MVME5100 CPU board, 3 PSC

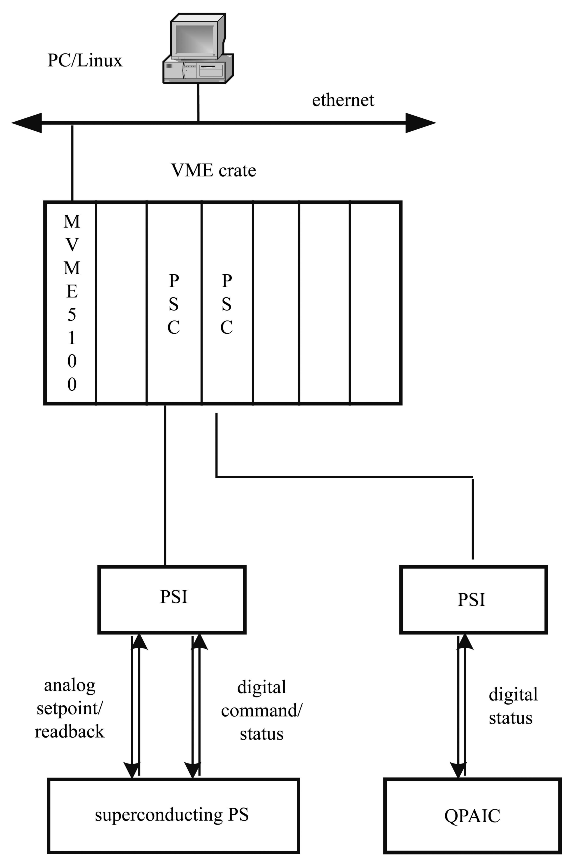

Fig. 1. The architecture of the control application.

Received 26 January 2010

modules and 17 chassis PSI modules. A PC/Linux is used for the EPICS development.

The PSC module communicates with the PSI through a pair of fibers. One PSC can control 6 PSIs. Two cables are used between the PSI and the power supply one for the digital signals, another for the analog signals [2, 3]. Except for connecting with the power supply, a special PSI communicates with the QPAIC through the 37-pin digital connector to get those signals from the QPAIC.

3 Software developments

The control application of the SCQ power supply was developed based on EPICS. The EPICS development environment was built on a PC/Linux, and the EPICS database and control application downloaded from the PC are run on the MVME5100. The control interlock and ramping program were developed using state notation language (SNL), and the operator interface was designed using EDM [4].

3.1 EPICS database

The database records of every power supply include digital output records (onAUX, on, off, offAUX), analog output records (Desomon, setpoint), digital input records (on/off status, normal/alarm) and analog input records (setpoint readback, current readback). in addition, some special records for ramping and interlock are developed, such as the power supply name option, ramping speed and RampUpAll.

3.2 Interlock program

According to the location of the SCQ in the interaction region, two SCQs are named East SCQ and West SCQ, and those power supplies of the SCQ are also divided into East SCPS and West SCPS. Every SCQ has a separate quench protection system, and it doesn't work well until the cryogenics and solenoid system work normally.

The "system ready" signal from the QPAIC interlocks with the ON/OFF and ramping operation of the power supply, and the interlock status diagram is shown in Fig. 2. It will turn from "0" to "1" after all power supplies of SCQ, QPA, SSM, cryogenics and relevant systems have no fault and all power supplies' main loops turn on.

The interlock program is developed using SNL and is run on the MVME5100. When the "Ready" signal changes from "0" to "1", the ramping operations of the SCQ power supplies are allowed. In contrast, when it changes from "1" to "0", all of the power supplies will be ramped down from the current value to zero.

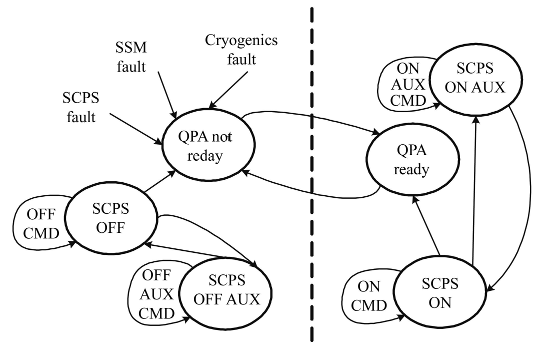

Fig. 2. The interlock state diagram.

The ramping program has six state sets: Initiation, RampUp West, RampUp East, RampUp All, Abort and END [5]. During ramping, it can be interrupted by the Abort button. In addition, in order to meet the magnetic field measurement, every power supply can be ramped alone. To avoid the quench of the SCQ, manual current setting is forbidden. The current setting must be done by the program with limited speed. Therefore, 5 selections from 0.2 A/s to 5 A/s are provided to the operator. The flow chart of ramping control is shown in Fig. 3.

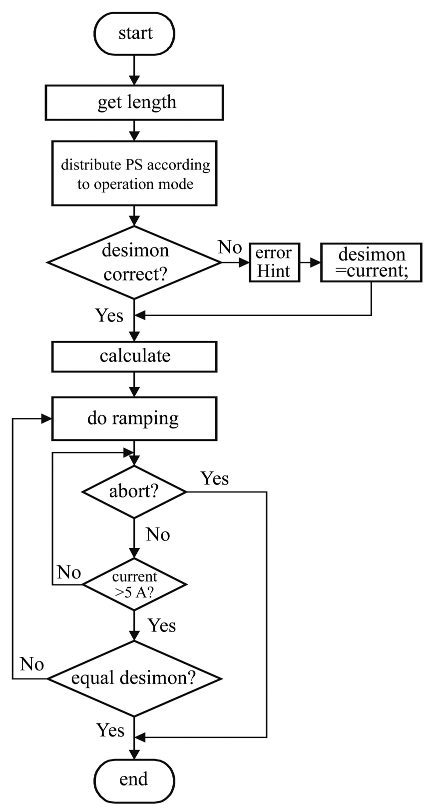

Fig. 3. The ramping flow chart.

3.3 Operator interface interlock

The operator interface includes colliding mode and synchrotron radiation mode. Their layouts are similar. The colliding mode OPI is shown in Fig. 4. Only the information about the VDC and SCB can be seen when in the synchrotron radiation mode; the information about other power supplies will be invisible.

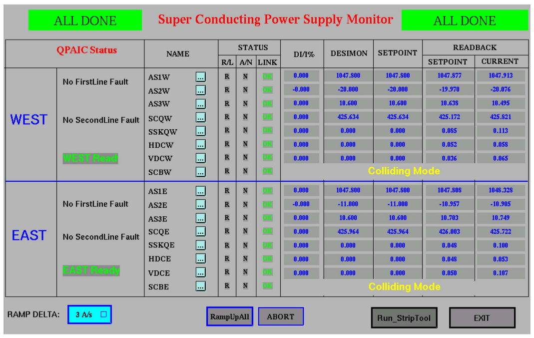

Fig. 4. The operator interface.

The current OPI displays the remote/local and alarm status, the setpoint and current value of each power supply, the ramping button, the power supply selecting button, the step length setting button and the QPAIC status. Some buttons interlocks with the QPAIC ready signal to avoid operation mistakes. When the ready signal is "1", the ramping button appears. Otherwise, the ramping button is invisible.

4 Summary

The control application of SCQ power supplies is very useful to protect key equipment of the interaction region and provide real-time information to operators, which is helpful to beam tuning. It was finished in September 2006 and tested with the SCQ and the QPAIC online. It was put into operation officially for the first time in October 2007. Now it has worked steadily and reliably on-site for about two years.

The authors would like to thank their colleagues for their help with the program development. Thanks also go to the Magnet Group and Power Supply Group for their useful discussions.

References

1 CHEN Fu-San, CHENG Jian. High Energy Physics & Nuclear Physics, 2006, **30**(4): 349–353 (in Chinese)

2 PENG Sheng, Lambiase R, Oerter B, Smith J. SNS Standard Power Supply Interface. ICALEPCS'01, California, November 2001

3 Lambiase R, Oerter B, Smith J. Power Supply Control for the Spallation Neutron Source. EPAC'00, Vienna, June 2000

4 http://www.sns.org/

5 WANG Chun-Hong et al. High Energy Physics & Nuclear Physics, 2007, **31**(1): 91–95 (in Chinese)