DESIGN AND IMPLEMENTATION OF THE REMOTE CONTROL SYSTEM OF THE DIGITAL MAGNET POWER SUPPLY OF CHINA SPALLATION NEUTRON SOURCE

Xuan Wu, ChunHong Wang, JinCan Wang, Jia Liu, YongCheng He
IHEP P. O. Box 918, 100049, Beijing, China

Abstract

The magnet power supplies of the China Spallation Neutron Source (CSNS) can be classified into three types: rapid cycling synchrotron (RCS) resonant power supplies, fast response power supplies and DC power supplies. All of the magnet power supplies are controlled by the intelligent controller called Digital Power Supply Control Module (DPSCM), which can regulate the current and voltage circuit. The DPSCM is developed by the power supply group. It has two RS-232 communication interfaces. All the command setting and reading power parameters are transmitted by Modbus protocol. Therefore, we made the communication protocol based on Modbus RTU between the remote control system and the DPSCM. This paper introduces the design of the remote control interface to the DPSCM. We developed EPICS IOC applications and real-time database on MOXA embedded serial device DA710 and OPIs using Control System Studio according to different kinds of the power supplies. We have tested the remote control system with these kinds of power supplies. The test result shows that the remote control system is stable and reliable and it can basically meet the requirements of power supply system and physicists after the continuously test for two weeks.

DPSCM INTRODUCE

The accelerator magnet power supplies of the CSNS can be classified into three types by working mode: the 25Hz AC source with DC bias (6 sets), corrector power supply (34 sets) and DC power supply (240 sets). Essentially, all of these power supplies are controlled by DPSCM which designed by power supply group. It just need to be burnt proper program into FPGA according to the kinds of power supply. As shown in Fig. 1, the core of DPSCM is Cyclone CPU, running with Nios-II system. There is a DB-25 serial port used for local control and a ST type optical signal transceiver used for remote control [1]. These two interfaces are both RS-232 serial port in fact, just addition of a photoelectric transducering module for the remote control. Both local control and remote control communicate with DPSCM adopting Modbus-RTU communication protocol. These two ports can't be used at same time.

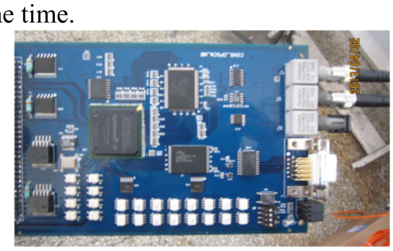

Figure 1: Picture of DPSCM.

REMOTE CONTROL SYSTEM DESIGN

Remote control system needs multi-serial devices for the large number of power supplies, 280 sets in total and the interface is all the RS-232 port. We ultimately chose high performance DA710 manufactured by MOXA company. The magnet power supply remote control system design scheme is shown in Fig. 2. Embedded Linux system and different kinds of EPICS IOC according to the kinds of power supplies run in DA710 controller. DA710 communicate with DPSCM via a serial port so that can control power supply. There is an Opti-Electronic transformation module TCF90 between them for the distance limitation of data transmission via RS-232 and it can reduce EMI via optical fiber. Four serial cards can be installed in one DA710, and there are 8 RS-232 ports in each card. So a set of DA710 can control 32 power supplies at most. The OPIs are developed based on Control System Studio (CSS) running on Linux PC. The software development work is that designing different kinds of EPICS IOC, real-time database, Modbus driver and friendly OPI coincided with the type of power supplies.

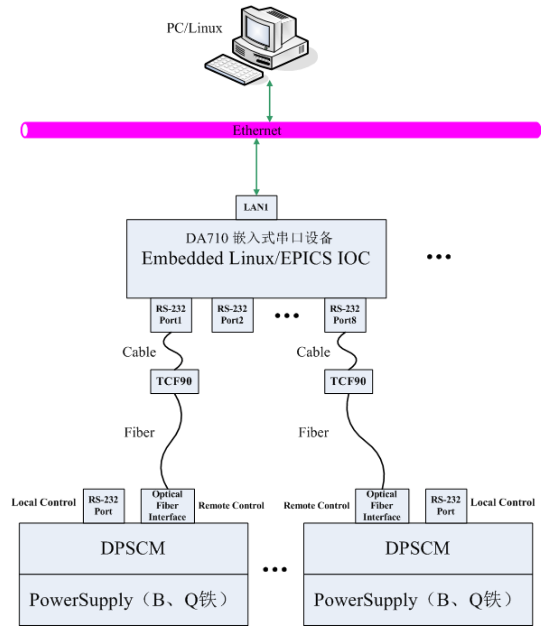

Figure 2: Remote control system sketch.

THE REQUIREMENT OF REMOTE CONTROL SYSTEM OF POWER SUPPLY

The accelerator magnet power supplies mostly are DC source, such as the power supplies on the Low Energy Beam Transport line (LEBT), Drift Tube Linac (DTL)

ISBN 978-3-95450-122-9

and so on. It's required that operator can power it on/off, set current and the OPI can show the status of power supplies in the central control room, the data refresh rate is 1 Hz. In addition, OPIs need to be had interlocking protection, such as can power it on/off under what condition, can't exceed the rated current when setting current, can rise an alarm when communication faults taking place and so on.

There are 6 sets of resonant power supplies in the RCS ring which are 25 Hz AC source with DC bias. So it is required that operator can set the amplitude of DC, the amplitude and phase of 25 Hz AC and harmonics (50 Hz, 75 Hz, 100 Hz, 125 Hz, 150 Hz, 175 Hz and 200 Hz) [3]. It needs some special constrains to protect and control these power supplies. For example, the operator must set DC amplitude first until it's steady, and then can set AC amplitude and phase when rising current. It's required a function that can set all the values by pressing one button.

The third type of power supplies are 34 sets of corrector power supplies in the RCS ring. They can output arbitrary waveform. The data of the waveform is downloaded into one of 16 sectors of flash on the DPSCM by reading the binary file storing waveform data using CSS OPI. Each sector of flash can store one waveform, so that can switch modes flexible. The key to remote control for these power supplies is can download waveform data and upload waveform data (This is used to verify the accuracy of the downloaded data) in the central control room.

THE DEVELOPMENT OF EPICS IOC AND OPI

The essence of the implement of the requirement described above is using DA710 accesses the relevant registers in the DPSCM by standard Modbus protocol. The function codes we used are 03H (read registers) and 10H (write registers). The configuration of RS-232 port is that 115200 baud speed, no parity, 8 data bits, 1 start bit and 1 stop bit. The EPICS IOC is developed base on Asyn driver and Modbus driver. The drivers calling relationship is shown in Fig. 3. The difficulty of developing EPICS IOC is that the application is to read or write 32 bits registers, but the Modbus driver can only access 16 bits registers directly [4]. So, data processing is needed each time when accessing registers to adjust to the frame format of Modbus RTU protocol. It is needed to align the register addresses in DPSCM continuously when reading multiple registers periodically for that it can improve the performance of reading speed and reduce the usage of CPU.

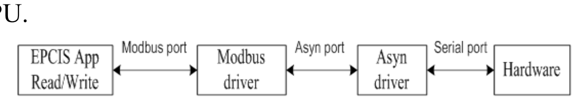

Figure 3: Drivers calling sketch.

The development of OPIs is adopted CSS which jointly developed by DESY, SNS and so on. By now, Many libraries in the word begin to use CSS and customize CSS to match their own requirements in order to replace the traditional tools like EDM, Strip Tool, Channel Archive and so on. The OPIs developed by CSS are more beautiful and flexible and can be used for complex control owe to rich tools and plugins are integrated in CSS.

As shown in Fig. 4, operator can power it on or power it off, and it can display the power status (remote control mode or local control mode, power working state), can set point and read back current, and can dynamically load arbitrary power supplies' widgets by configuring the XML file using the prototype of remote control OPI of DC power supplies.

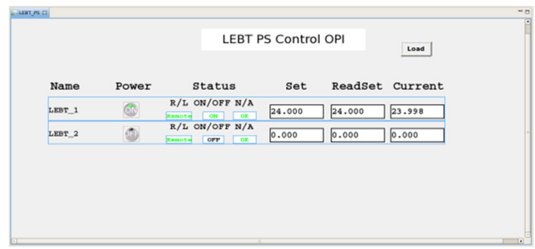

Figure 4: The DC power supplies remote control OPI.

The prototype of remote control OPI of RCS resonant power supplies as is shown in Fig. 5. It can set and read back amplitude and phase, and it can monitor the status of these power supplies. All of the values can be set automatically by pressing one button "Ramp Up", and then a new window will be coming out as shown in Fig. 6. The values are stored also in a XML file, this can reduce the operator's workload and reduce the possibility of typographical mistakes.

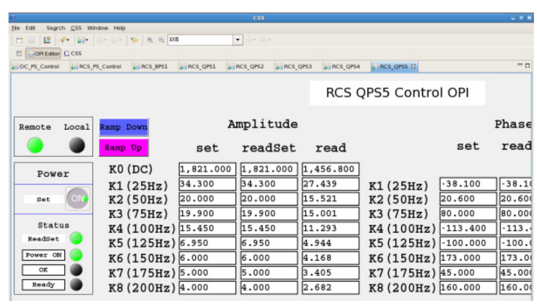

Figure 5: The RCS resonant power supplies remote control OPI.

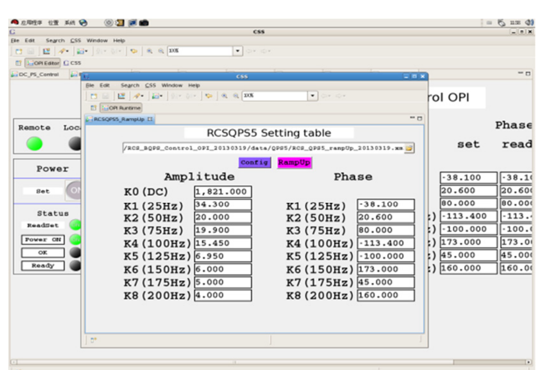

Figure 6: The setting values by one button OPI.

The prototype of remote control OPI of RCS corrector power supplies as is shown in Fig. 7. The major function is to pre-download (download data before power supply is on) waveform data into the flash of DPSCM. Firstly, choose the sector that waveform data will be stored, then press “waveform download” button, and users can see the progress bar. Waveform upload is to verify the correction of the downloaded data. This function is implemented by sequencer, because of that the data of a waveform transmission is needed 200 times of calling write request of Modbus driver.

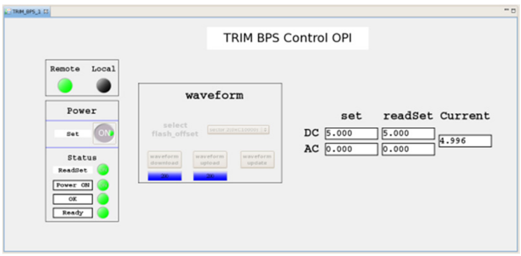

Figure 7: The RCS corrector power supplies remote control OPI.

FIELD TEST

We used remote control system to test 8 simulation circuit boxes as the DC power supplies， 6 simulation circuit boxes as the resonant power supplies and 2 simulation circuit boxes as the corrector power supplies in April 2013. This test lasted 2 weeks without failure, every basic function and soft interlock has been implemented. The remote control system is stable and reliable. It can meet the requirements of the power system and physicists. It’s the field test picture as shown in Fig. 8.

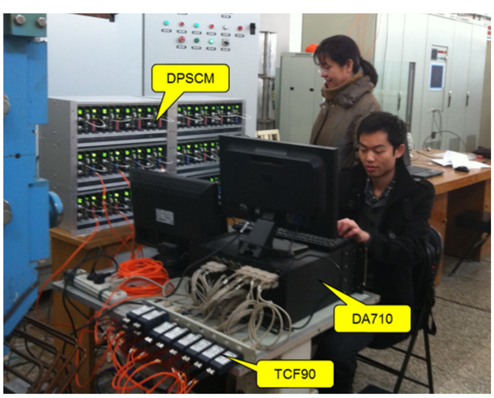

Figure 8: The remote control system field test.

ACKNOWLEDGMENT

Thanks for Professor ChunHong Wang and JinCan Wang’s concentrated guidance and the cooperation and help supplied by colleagues of the Power Supply Group when I develop the remote control system of magnet power supply of CSNS.

REFERENCES

[1] FengLi Long, “Research of Intelligent Control for High Precision Stabilized Current Power Supply,” Ph.D Thesis, Graduate School of CAS, p. 42 (2006).
[2] Sheng Wang, Nan Huang et al., “The Control System Requirement of RCS Power Supply-Preliminary Design Version 2.0,” CSNS internal documents, 2011.
[3] Sheng Wang, Nan Huang et al., “The Control System Requirement of Transport Line Power Supply-Preliminary Design Version 2.0,” CSNS internal documents, 2011.
[4] SongQiang Liu, “The Serial Port Communication Protocol of DPSCM,” CSNS internal documents, 2011.
[5] http://epics-office.desy.de/content/index_eng.html.