5th International Particle Accelerator Conference IPAC2014, Dresden, Germany JACoW Publishing
ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-THPRO121

CONTROL ENVIRONMENT OF POWER SUPPLY FOR TPS BOOSTER SYNCHROTRON

P. C. Chiu, C. Y. Wu, J. Chen, Y. S. Cheng, D. Lee, B. S. Wang, K. B. Liu, K. H. Hu, K. T. Hsu
NSRRC, Hsinchu 30076, Taiwan

Abstract

The TPS is a latest generation of high brightness synchrotron light source and ready for commissioning. It consists of a 150 MeV electron linac, a booster synchrotron, a 3 GeV storage ring, and experimental beam lines. The booster is designed to ramp electron beams from 150 MeV to 3 GeV in 3 Hz. The TPS control environment is based on EPICS framework to support rich functionalities including power supply control, waveform management, vacuum interface, BPM, intensity monitoring support, operation supports, and so on. This report summarizes the efforts on control environment development for TPS booster synchrotron.

INTRODUCTION

The TPS [1] is a latest generation of high brightness synchrotron light source which will be commissioning in the 3rd quarter of 2014. It consists of a 150 MeV electron Linac, a 3 GeV booster synchrotron, and a 3 GeV storage ring. The EPICS (Experimental Physics and Industrial Control System) was chosen for the TPS accelerator control.

The control interfaces of TPS booster power supplies have two major categories: one is for the large main power supply which could provide current up to 1200 and 120/150 amperes and used for dipole and quadrupoles respectively; the other is small/medium power supply which supports +/- 10 amperes current output and used for sextupole, correctors and bending trim coils. Table 1 summarizes the specifications of booster ring power supplies [2][3].

Table 1: TPS Booster Ring Power Supply Summary

Magnet	Type	Max Current	Number of PS	Vendor	Control Interface
Dipole	Unipolar	1200 A	1	IE [2] Power (Eaton)	Ethernet*
Quadrupole	Unipolar	120/150 A	4	IE Power (Eaton)	Ethernet*
Sextupole	Bipolar	± 10 A	2	ITRI[3]	CPSC (Ethernet) with Waveform support in CPSC
Corrector	Bipolar	± 10 A	HC: 60 VC: 36	ITRI	CPSC

All of these power supplies should have features of waveform play with external trigger functionalities to enable electron beams ramp from 150 MeV to 3 GeV in 3 Hz. The large power supply provides Ethernet control interface and trigger input for waveform download and play. One dedicated EPICS IOC will be built to serve its control and monitor. The small power supplies have 12 special designed corrector power supply controller (CPSC with embedded EPICS IOCs allocated at power supply rack for its control. The environments of these two power supply control will be summarized in this reports.

BOOSTER POWER SUPPLY CONTROL INTERFACE

The booster main power supplies are composed of one dipole power supply with maximum current 1200 Ampere and four family quadrupole power supplies with maximum current of 120/150 Ampere. These power supplies will support external trigger and internal waveform generator for booster power supply ramping. Serial to Ethernet adapter are used to interface with the control system. Figure 1 shows the pictures of dipole and quadrupole power supply for booster synchrotron which had been installed in the site and ready for system integration test.

Figure 1: Large and medium/small power supplies for the dipole, quadrupole and correctors of TPS booster synchrotron respectively.

The small/medium power supply for booster corrector and sextupole is a sophiscated switching power supply with analogue regulator. Each power suply sub-rack accomodates up to eight power supply modules. The center slot is allocated to install a special designed EPICS IOC with waveform play features.

Figure 2 shows the overall booster ring power supplies control interface. One cPCI crate equipped with one CPU blade, one EVR fanout and ADC/DAC modules will serve to control main booster power supply and synchronous precision monitor. There are also 60 horizontal corrector and 36 vertical correctors controlled via 12 CPSCs. If corrector current ramping is necessary, the CPSC has built-in waveform generator which can fulfil this functionality.

ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-THPRO121

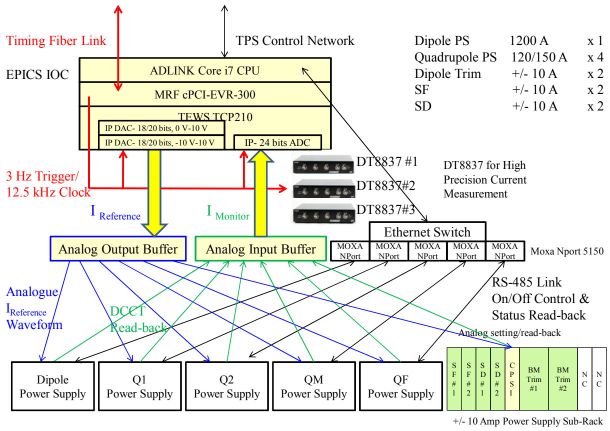

Figure 2: Control infrastructure of TPS booster ring power supplies.

MAIN POWER SUPPLY OPERATION SUPPORTS

To support electron beams ramping from 150 MeV to 3 GeV, EDM (Extensible Display Manager) is used for general power supply on/off control and status display and Maltab-based GUI (graphic user interface) is developed to generate waveform and download via EPICS channel access interface. Figure 3 shows the EDM page. Power supply could be operated at DC/AC mode. Figure 4 shows the matlab GUI for ramping waveform generation and download. It could support three waveform modes: (1) DC at injection (2) on-the-fly sine-like (3) ramp to the specific energy. The injection time (Tinj), extraction time (Text), injection and extraction energy could be adjusted at different operation mode. Then according to the energy as time, current waveforms of dipole and quadupoles are mapped from the measured energy-current mapping tables.

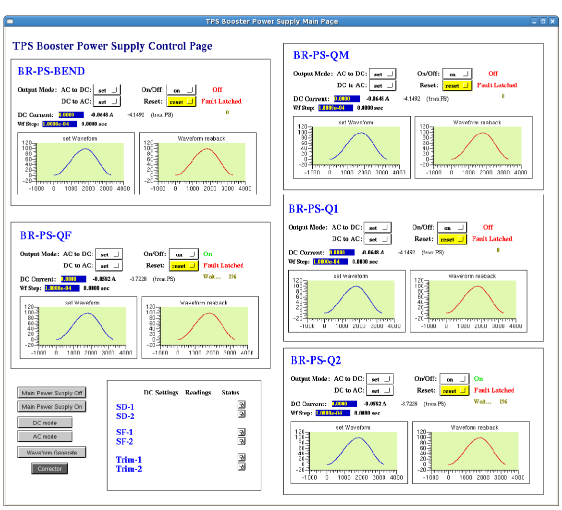

Figure 3: EDM page for booster main power supply control.

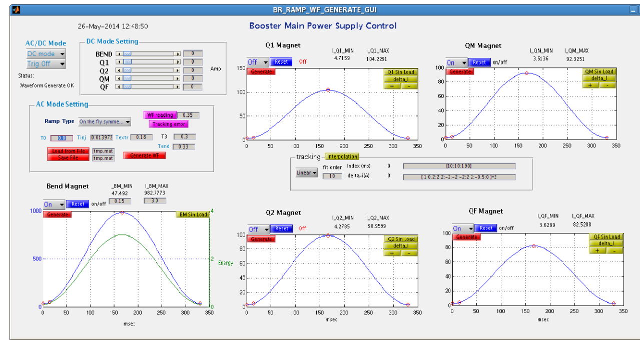

Figure 4: GUI for booster bending magnet and 4 families of quadrupoles ramping waveform generation and download.

POWER SUPPLY CHARACTERIZATION

Power supply for booster dipole and quadrupoles were contracted and delivered by Eaton. Two quadrupole power supplies were tested at laboratory with simulated loads before the installation. System test at final installation site with real magnet loads are scheduled in July 2014. Figure 5 shows the measurement of one of these first two quadrupole power supplies. It exhibits a phase delay which would result in 20% error at low current between setting/reading. Adjusting PI coefficient of power supply regulator could improve phase delay, but it's still difficult to achieve 1% error. Besides, the reproducibility of power supply itself is around 0.5% at injection. This is partly due to non-synchronize or asynchronous internal clock of power supply regulator and external trigger. The asynchronous clocks of different power supply should be also resulted in worsen relative field error between dipole and quadrupoles.

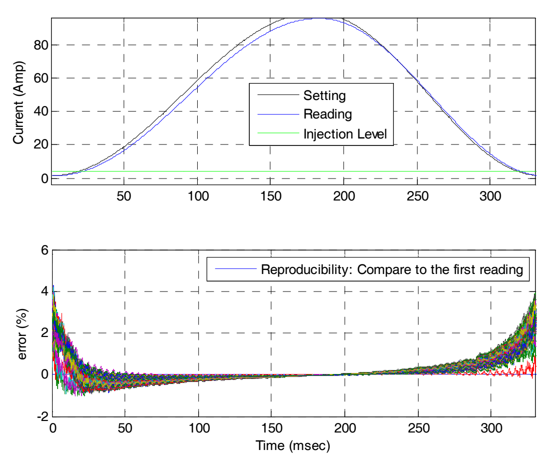

Figure 5: The upper plot shows the current delay between power supply setting/reading. The lower plot shows normalized reproducibility (stability) of power supply for different shot. The reproducibility of power supply is around 0.5% at injection point.

Therefore, the original digital regulation loop is modified to analogue and control interface is also revised so that all of power supplies could be driven by an

ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-THPRO121

synchronized current waveform reference with common clock source and trigger. Figure 6 also shows the measurement results after modification where the reproducibility is improved to achieve around 0.1%.

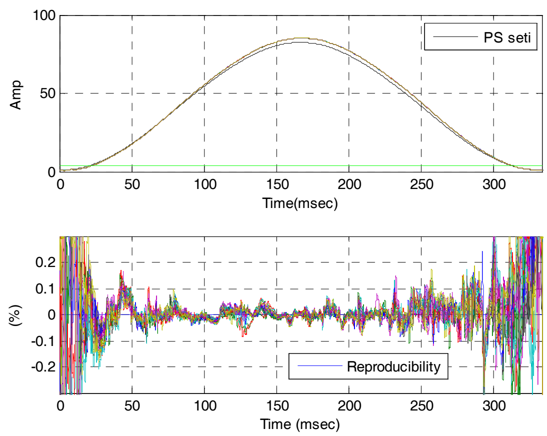

Figure 6: The current delay is improved but remained. The normalized reproducibility of power supply is around 0.1% at injection.

Different response between different power supplies, especially between dipole power supply and the other four quadrupole family power supplies will cause difficulty in tracking. Modifying waveform of quadrupoles iteratively so that output current of quadrupoles could follow the dipole output can be done if necessary. Figure 7 shows the relative error between the output and the desired reference could be decreased to 0.5% from 10% after the iterative modifications of play waveform. There are extra three current reference channel will drive two power supplies for two sextupole family and one power supply for bending magnet trimming coils.

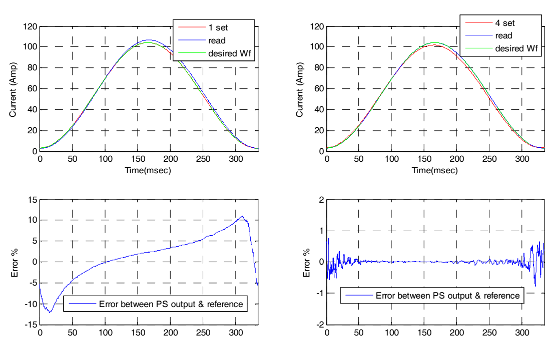

Figure 7: The left two plots shows the error between power supply output current and reference is 10% and the right plots shows the error is decreased to 0.5 % after 4 iteratively modification.

CORRECTOR POWER SUPPLY CONTROL INTERFACE

To support diverse functionalities of fast orbit feedback [4], booster ramping, compensations for insertion device and skew quadrupoles, the CPSC for TPS corrector power supply is proposed. It is embedded with Xilinx Spartan-6 FPGA and was contracted to D-TACQ [5]. This module will be installed at center slot of the power supply sub-rack to isolate ambient noise from cablings and simplify power-ground complications to achive high stability. The module embedded EPICS IOC and FPGA supports slow access for the EPICS CA clients and fast settings from orbit feedback system[6]. The functional block diagram of CPSC module is shown in Figure 8.

There are 60 horizontal and 36 vertical correctors installed on TPS booster. These correctors require 12 CPSCs to control their power supply modules. EDM control pages of each power supply had been developed and provided. It includes signal trend, waveform display, synchronization mode settings and etc.

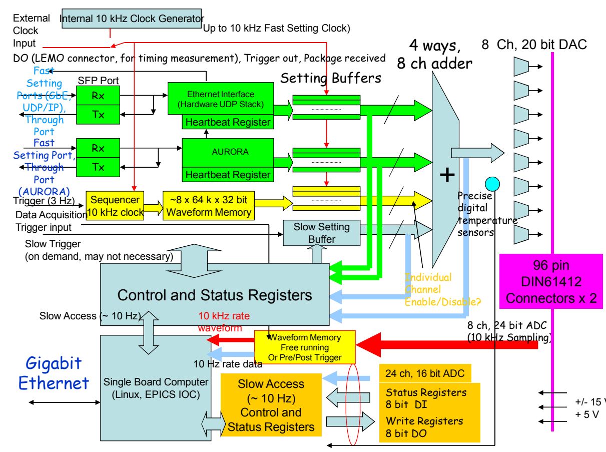

Figure 8: Functional block diagram of the corrector power supply controller (CPSC) module.

SUMMARY

Preliminary user interfaces and operation procedures of booster power supply are presented in this report. After power supplies delivered, the power supply control environment was constantly established for developing the operation applications. The operation applications including the operation interface, power on/off setting and checking, waveform download and etc. will be continuously tested.

REFERENCES

[1] http://www.nsrrc.org.tw/english/tps.aspx

[2] http://www.iepower.com

[3] http://www.itri.org.tw/eng/

[4] P. C. Chiu, et al., “Fast Orbit feedback Scheme and Implementation for Taiwan Photon Source”, IPAC2013, TUOCB202, p. 1146, Shanghai, China (2013); http://www.jacow.org

[5] http://www.d-tacq.com

[6] P. C. Chiu et al., “Control Environment of Power Supply for TPS Booster Synchrotron”, ICALEPCS 2013, THPPC062, p. 1213, San Francisco, USA (2013); http://www.jacow.org