NEW POWER SUPPLY CONTROL INTERFACE AND ENERGY RAMPING DESIGN IN SRRC

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Abstract

For the purpose of lattice optimization, eighteen individual quadrupole power supplies was installed in the SRRC storage ring in March 1997 to replace the three quadrupole family power supplies. In order to accomodate newly installed and already existed power supplies, the control interface of Taiwan Light Source (TLS) has been rejuvenated recently. The new control interface has improved drastically on control speed in comparison with the existed interface. Operation of the power supply system from device level to system level is reorganized to make control and access easier. This new control interface provides capability from complex operation such as lattice file loading, magnet degaussing, to file energy ramping scheme, etc. Performance of this power supply control interface including hardware components and software applications is presented.

1 INTRODUCTION

The new power supply control interface implemented for the storage ring quadrupole magnet in SRRC is important task within March 1997. The new power supply control interface has been integrated into SRRC control system, providing remote control function: the digital input and output for power supply status control and reading, the analog input and output for power supply current setting and reading, and other complex operation. This new power supply control interface is a VMEbus based crate containing the digital-to-analog converter, analog-to-digital converter, digital input and output modules. All these modules, together with a PowerPC VME cpu module, are running with LynxOS real time operation system.

2 SYSTEM DESCRIPTIONS

The new control interface is a part of the SRRC control system, Figure 1 shows the environment of the new power supply control interface in SRRC. Hereinafter, we will illustrate the new control interface hardware configuration and software structure with some important considerations to accommodate “new” and “old” power supplies control interface [1].

2.1 TLS power supplies control interfaces

There are three VME crates to connect all power supplies of TLS as shown in figure 1. In the VME crate #1, it is composed of digital-to-analog (DAC) output modules, analog-to-digital input (ADC) module, digital input and output boards, and a powerful new generation VMEbus processor module. The DAC provides analog output with 16 bits high resolution, it is used for power supply output current control. A high performance 16 bits ADC board is chosen to monitor power supply output current, the ADC module board provides wide dynamic range, high analog input channel density, and many other operating modes. Digital input and output board are software configured to control power supply operation and status monitor. A new and powerful cpu module is introduced to improve the control interface performance in terms of speed. We use a GPIB interface in crate #2 to control the power supply for dipole, sxtupole, and a Q4 quadrupole. About eighty correction power supply are controlled and monitored by the DAC and ADC modules in crate #3. The digital control for correction power supply operation is in crate #2.

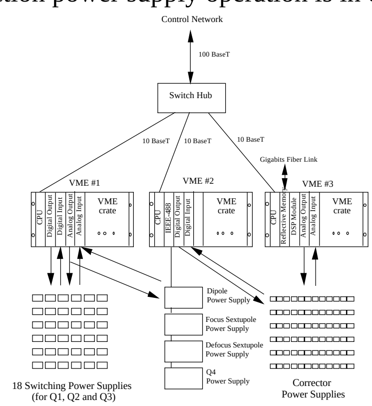

Figure: 1 TLS power supply control environment

2.2 The control software

The SRRC control environment is a two-layer network connected via Ethernet. The upper layer has several workstations and a control server, the lower layer is VME crate based intelligent local controller interfacing with various devices. Low level control functions for power supplies are built in VME crates. These functions include setting and reading tasks, interpolation, and slew rate control. There are also equipped in dipole, quadrupole, sextupole power supplies. Reading data is

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periodically updated to upper layer computers in every 100 msec. Setting is issued by the high level applications. Power supply control related high level applications are running on workstations and control server. Cold start and shutdown processes are typical examples of this application. Lattice management, energy ramping and data archiving are already in service [2].

3 PERFORMANCE

3.1 Power supply ripple

Power supply ripple tolerance for dipole, sextupole and quadrupole magnet power supplies are listed in table 1. Performance of power supplies cooperating with new control interface have been measured. Figure 2 shows the current spectrum of one of a Q2 power supply. The setting is 116 Amp, 60 Hz peak is 0.22 mA in rms. The corresponding ripple is less then 10 ppm. The other power supplies have similar performance.

Table: 1 specifications of power supply

PS-Type	Dipole	Quadrupole	Sextupole
Ripple	$< 5 \times 10^{-5}$	$< 5 \times 10^{-5}$	$< 2 \times 10^{-4}$
Long-term stability	$< 5 \times 10^{-5}$	$< 5 \times 10^{-5}$	$< 2 \times 10^{-4}$

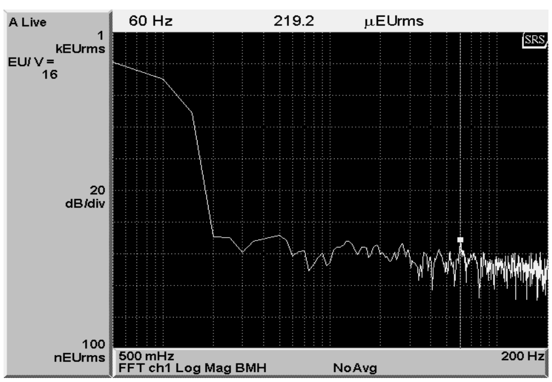

Figure: 2 Power supply output current spectrum of Q2 working at 1.5 GeV setting point. EU on the figure denote engineering unit. 1 EU corresponds to 1 Ampere.

3.2 Linearity of control channel

Linearity is important for power supplies control in a storage ring with variable energy. The linearity of the power supply control channel is measured with high precision, high linearity DCCT. Different linearity were observed on various power supply control. Figure 3 is a monitoring data for R56QPS1 power supply linearity. It shows the difference of the output of power supply DCCT and the Output of DAC. Both are directly and individually connected to ADC. DAC linearity is less than 1 least significant bit. The measured result shows that the phenomena observed in figure 3 is contributed by the power supply.

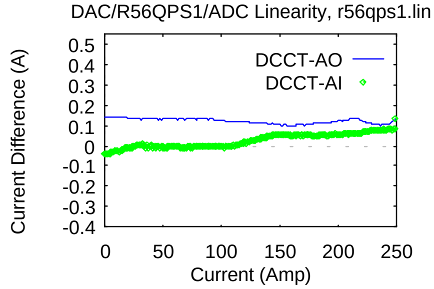

Figure: 3 Linearity of the control channel

3.3 Long-term stability

Long term stability test at full power to their final loads has been intensively tested. In cold start procedure, these swithching power supply (SPS) have a better performance in long-term stability then the “old” power supply, SPS only needs half hour to get into steady state compared with a couple of hours of the old quadrupole power supplies. During five hours operation of R61QPS2 power supply in normal operation shift, it shows that the long-term stability is well within the specification.

3.4 Calibration for power supply control

In order to control the output current of power supply precisely, a high precision, stability, and linearity DC current transform (DCCT) was taken as a reference current reading to find the correlation between the power supply output current and the digital setting. this will provide system conversion between the actual output current and the requested current. The offset measurement is also an important factor in the whole calibration procedure. All the calibration scheme is based on the specification of the power supply linearity.

3.5 Control performance of the correctors system

The corrector system in SRRC storage ring has about eighty correction power supplies, we use the new power supply control interface to improve the control performance in speed, precision and stability. In order to support a high level stability output, the new control interface is needed. The control resolution is better then 1mA which corresponds to sub-µrad kick setting .

4 HIGH LEVEL APPLICATION

There are several high level applications which support the operation of the power supply system [3].

4.1 Lattice file related applications

The main purpose of the lattice file, when it is loaded, is to make the power supplies operation easy. The functions of the loading lattice include setting current to zero, to maximum, and power supplies slew rate control. Slew rate control mechanism is built in VME crate to support smooth change between different operating lattices.

4.2 Energy ramping scheme design

File ramping scheme is used for varying energy of TLS because of its high flexibility. Energy range had been tested from 650 MeV to 1.5 GeV successfully. Ramping application at workstation is able to set output current of the power supplies 10 times per second. The VME crate performs linear interpolation in every 10 μs step to ensure the setting of power supplies is smooth enough. All power supplies are set within 20μs so as to guarantee good tracking among various power supplies. Setting of correctors can be scaled proportional to the beam energy during ramping. Ramping from 1.3 GeV to 1.5 GeV has been achieved within 5 seconds. Ramping time is basically limited by the magnet inductance and the characteristic of power supplies. Presently, the ramping duration is set to be 30 seconds [4].

4.3 Tune correction

In order to keep constant tune during energy ramping, open loop tune correction scheme has been tested. Figure 4 shows typical tune drift for energy ramping from 1.3 GeV to 1.5 GeV and then backs to 1.3 GeV without tune correction. The tune variation is mainly caused by magnetic hysteresis in dipole magnet [5].

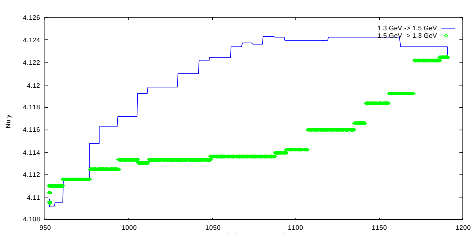

Figure: 4 Vertical betatron tune evolution during ramping - before correction.

Before SPS was installed, the relationship between tune change and Q1, Q2 current is displayed as the following relation [6]:

$$\begin{bmatrix} \Delta\nu_x \\ \Delta\nu_y \end{bmatrix} = \begin{bmatrix} -0.056 & 0.080 \\ 0.028 & -0.019 \end{bmatrix} \begin{bmatrix} \Delta I_{Q1} \\ \Delta I_{Q2} \end{bmatrix}$$

A mdified the ramping file, based on the above information, is used in order to keep ∇n_x and ∇n_y small. The correction is then applied to ramping the beam energy from 1.3 to 1.5 Gev and the result is shown in figure 5. It shows that ∇n_y can be kept within 0.002 peak-to-peak.

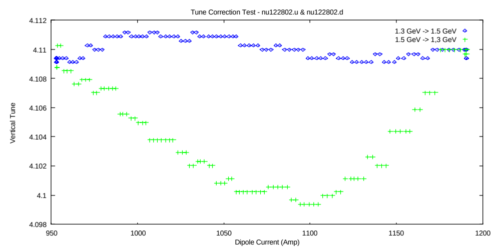

Figure: 5 Vertical betatron tune evolution during ramping - after correction

5 CLOSING REMARKS

Power supply control plays a crucial role in the operation of the accelerator system. The new power supply control interface has been commissioned successfully. Accomplished performance of the power supply system and related support control applications were satisfactory. A lot of works which are related power supplies operation will be finished in the future, a tune feedback system is under development for further improvement.

6 ACKNOWLEDGMENTS

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