PROGRESS OF TLS FAST ORBIT FEEDBACK SYSTEM AND ORBIT STABILITY STUDIES

C.H. Kuo, P.C. Chiu, Jenny Chen, K. H. Hu, Demi Lee, K.T. Hsu
NSRRC, Hsinchu 30076, Taiwan

Abstract

The orbit feedback system of the TLS has been deployed for a decade and continuously upgraded as technology develops. However, due to limitation of the existing hardware, the system cannot remove orbit excursion caused by the perturbation due to fast operation of insertion devices. To improve orbit stability further, the newly proposed orbit feedback system with the upgraded digital BPM system and corrector new switching power supply system is planned to be installed and commissioned in late 2008. The preliminary calculation on the stability performance for the orbit feedback system is presented in the report. New fast orbit feedback system can be expected to achieve a submicron stability of the electron beam working at a bandwidth of at least 60 Hz.

INTRODUCTION

Several Libera Brilliance have been online operation to test the integration of slow data acquisition, fast data acquisition, post mortem and turn-by-turn beam position measurement in the TLS. The group topology of Libera Electron/Brilliance to acquire fast data at 10 kHz rate is being under testing to verify long-term reliability and stability. Both of the latency and step response measurement of Libera are also under way. On the other hand, the progress of the corrector power supply upgrade is addressed. Integration of all of the new switching power supplies will be accomplished recently. Infrastructure of the new orbit feedback system is being implemented gradually without interrupt of the routine operation of the TLS. Effects of the PID parameters on system response and noise attenuation are demonstrated both by simulations and experiments. Diagnostic functions by using 10 kHz rate will be also setup along with the new orbit feedback system. A dedicated diagnostic node which stores data at higher sampling rate and has hardware and software trigger is planned to build. All major work, constrained by available machine shutdown interval, will be completed in later 2008.

FAST ORBIT FEEDBACK SYSTEM PROJECT FOR TLS

Orbit stability is an extremely important object for a modern synchrotron light source. There are many efforts make to improve orbit stability of Taiwan Light Source (TLS) such as control of the ambient environment, removing various mechanical vibration passively, feed-forward control of insertion devices and etc. Nevertheless, the limited loop bandwidth led incapability to suppress fast excursion above 5 Hz. As a result, the fast orbit feedback system project was launched. Beam position monitoring system is undergone a major upgrade to new generation electronics with better performance and functionality. Corrector power supply is also migrated to wider bandwidth, low noise and high efficiency switching power supply. Else, infrastructure of the fast orbit feedback system is in the process of a major modification. All of these upgrades and reforms, restrained by available machine shutdown window, can have slight progress step by step. The overall fast orbit feedback system will be delivered by late 2008.

The Libera Electron/Brilliance [1] has been adopted by several light sources and shown its competent functionality. The Libera Brilliance is employed to replace the existing BPM electronics for the TLS. It integration had rise from 2007 and gradually deployed not to interfere with the routine operation. All of Libera Brilliances in the storage ring are grouped together to produce a packed GbE UDP packet to reduce the number of IP packets and improve GbE jitters. Now we have several Brilliances in online operation to verify long-term reliability. Function of grouping is also under testing. In the following section, we will show some detailed measurements and observations.

The linear type vertical corrector power supply is already replaced by MCOR 30 [2] in the January of 2007. Performance of the new MCOR3 power supply is 5 times better than the old one in noise level and large small signal bandwidth. The horizontal corrector power supply is also planned to be replaced during the shutdown in October 2008. After upgrade, bandwidth determined by a whole of power supply, corrector and the vacuum chamber can be increased from a few Hz to 100 Hz and 30 Hz in vertical and horizontal respectively.

The infrastructure of the new orbit feedback system is shown in Fig. 1. The reflective memory is employed to shares fast orbit data without consuming extra CPU resource. The Libera grouping which packs all of Liberas payload data into a single UDP packet can reduce the GbE traffic and minimize jitters. After the migration completed, higher sampling rate (10 kHz) can be achieved rather than the current 1 kHz sampling rate. Beside, since there are no dedicated fast correctors at TLS, setting of the DC closed orbit control and the fast correction signal will sum in an analogue way. It will be implemented by an in-house made interface card mounted to the leftmost slot of MCOR crate which adds the setting command and feedback correction setting to the power modules. A dedicated diagnostic node which stores data at higher sampling rate and has hardware and software trigger is also planned to be setup.

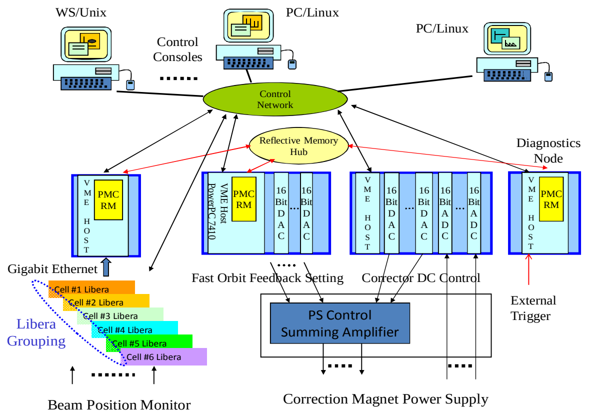

Figure 1: Infrastructure of the new fast orbit feedback system.

BPM STATUS AND TESTING

There are several Libera Brilliance integrated into the TLS control system to support slow data acquisition, tune measurement and post mortem [3]. Grouping 16 Libera units is also tested to check its reliability and stability. Figure 2 shows the photo of Libera grouping in the TLS. We will then increase the grouping number from 16 to 64 by to save necessary peripheral devices and improve communication jitter when the VME CPU module receives the GbE UDP package further by reducing more UDP packets that is subject to a large data capsulation overhead. Figure 3 shows the perturbed beam position due to field leakage of the injection septum. How to eliminate the unwanted perturbation is in study.

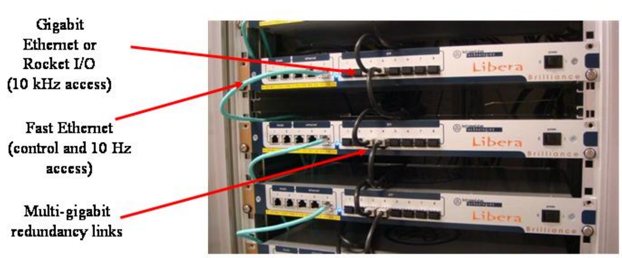

Figure 2: Photograph of Libera in the TLS

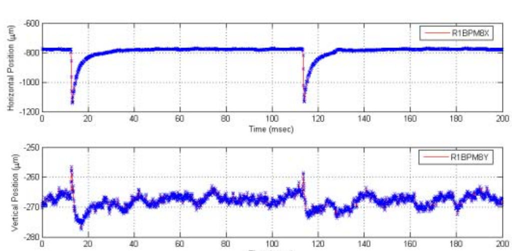

Figure 3: Perturbed beam position due to field leakage of the injection septum.

Beam motion with strong line frequency components are also observed by the fast orbit data as Figure 4. These are expected to be removed after new fast orbit feedback system deployed in 2008.

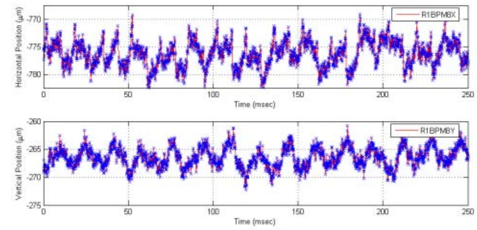

Figure 4: Strong line frequency components appear at the measured beam position.

CORRECTOR STATUS AND MEASUREMENTS

The vertical corrector power supply is already replaced by MCOR 30 in the January of 2007. Standard deviation of the vertical power supplies (vertical corrector) and horizontal power supplies (horizontal corrector) in 100 sec readings are shown in Fig. 5. The new power supply current readings of the vertical corrector power supply have the around 0.5 mA standard deviation since it is limited by the 16 bit ADC module. Figure 6 presents MCOR30 spectrum at 40 kHz sampling rate. It shows noise rms level for all frequency components almost less than 0.1 mA.

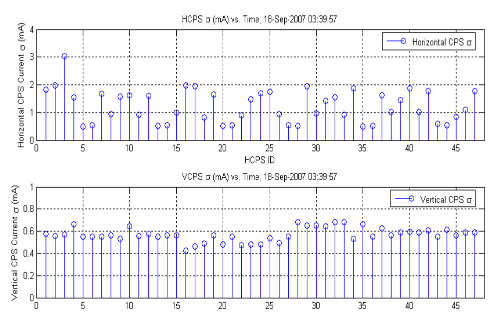

Figure 5: Power supply performance of the old power supply and the MCOR 30 power supply.

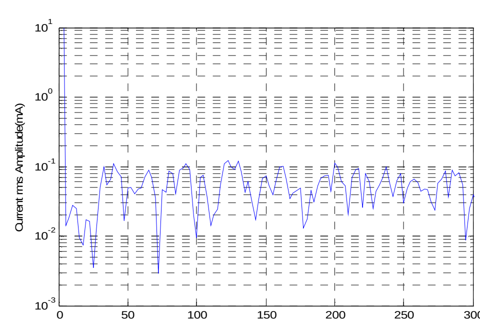

Figure 6: Spectrum of MCOR30 power supply

SYSTEM PERFORMANCE ANALYSIS

To check the performance of the selected BPM, corrector site and the conditional numbers, static simulation based upon accelerator model is done by the aids of Accelerator Toolbox. It was assumed that the vertical rms orbit perturbation was induced from 1 µm rms quadrupoles random motion, 10 nrad rms corrector noise, and 0.25 µm rms BPM noise. The vertical orbit position variation can be reduced from around 30 µm rms to less than 1 µm rms after feedback applied as in Fig. 7.

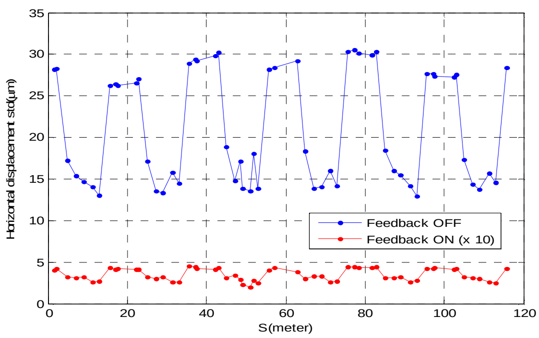

Figure 7: Vertical rms orbit can be reduced from around 30 µm rms (blue curve) to less than 1 µm rms (red curve) after feedback turn on.

On the other hand, to study how the various subsystems' bandwidth effect on the performance of the feedback system, Matlab simulation scripts were developed to simulate the operation of fast orbit feedback loop. Response function of various components in FOFB system is included in the model for simulation. Functional block diagram of the simulation scripts is shown in Fig. 8. Factors which make impacts on FOFB such as various components dynamics, system and latency are studied. Major factors which will limit the loop bandwidth are from vacuum chamber and the corrector magnet. The loop bandwidth in the vertical plane is around 100 Hz while the bandwidth in the horizontal plane is around 30Hz. Several different kinds of corrector magnets were adopted in the TLS and their distinct responses will be included in the simulation for further study. The estimated frequency response of the feedback loop in the vertical plane is shown in Fig. 9. It is shown that the perturbation can be reduced by factor of 100 at low frequency side, and factor of 4 at 60 Hz in the vertical plane. It also shows that the latency could amplify noise with frequency between 200~400 Hz and may degrade the system's performance. On the other hand, noise attenuation at -3 dB can only up to 30~40 Hz due to the limited bandwidth in the horizontal plane.

Removing small singular value is adopted to avoid an unnecessary large corrector setting. The PID coefficients settings are therefore according to different eigenvectors. The optimum control parameters (PID gain) are also studied. Correct modes with small singular value would have less weighting and not be corrected as more as other modes.

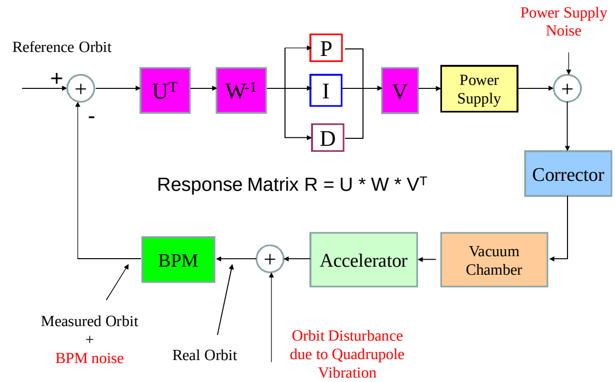

Figure 8: Function block diagram for the fast orbit feedback simulation.

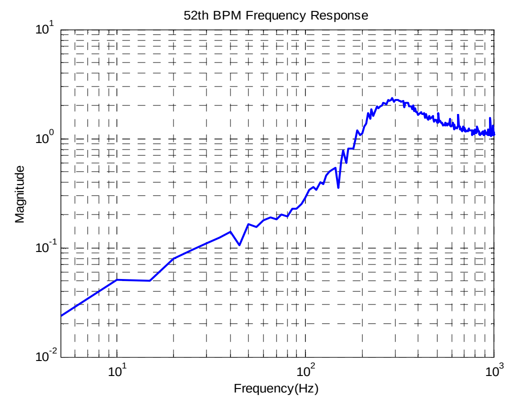

Figure 9: Simulated sensitivity function of the fast orbit feedback loop in vertical plane. It is shown that the attenuation up to 40 dB at low frequency side and the 3 dB bandwidth is about 100 Hz.

SUMMARY

Design and status of the new fast orbit feedback system of the TLS at the NSRRC are summarized in this report. Migrate to new BPM electronics and new corrector power supply is continuously proceed and planned to be completed in late 2008. In the meanwhile, infrastructure is under modified and emerged. Simulation confirms that the fast orbit feedback system can suppress various beam motions up to 100 Hz in the vertical plane and 50 Hz in the horizontal plane. Better performance is expected to cope with fast source and make fast operation of insertion devices possible.

REFERENCES

[1] http://www.i-tech.si/.
[2] http://www.bira.com/.
[3] C.H. Kuo, et al., "Fast Orbit Feedback System Upgrade in the TLS", Proceedings of ICALEPCS 2007.