BEAM POSITION MONITORING SYSTEM UPGRADE FOR THE TLS

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Abstract

Taiwan light source (TLS) is equipped with 59 beam position monitors (BPM). The existing Bergos's multiplexing BPM electronics are working well during the last decade. To improve the functionality of the BPM system, Libera Electron will be employed to replace some existing multiplexing BPM electronics to enhance system functionalities. Reflective memory is also applied to seamlessly integrate two kinds of electronics in the meanwhile. The high precision closed orbits were measured by multiplexing BPM via multi-channel PMC form factor 16-bits ADC modules and gigabit Ethernet fast access channels of Libera Electron. Turn-by-turn beam position measurement is also supported by new BPM electronics. Tune measurement is also possible by spectra analysis of the turn-by-turn beam position data. The preliminary version of the orbit data was sampled every millisecond. Fast orbit data were shared by reflective memory network for fast orbit feedback application. Averaged data were updated to control database at a rate of 10 Hz. The system structure, software environment and preliminary beam test of the BPM system are summarized in this report.

INTRODUCTION

The storage ring of NSRRC is a 1.5 GeV synchrotron light source. To improve performance and satisfy users' stringent demand, both of the orbit and the multi-bunch stability are required to achieve a decent specification. The Multi-bunch instability is eliminated using the SRF cavity and multibunch feedback systems. In the same time, the orbit stability is improved by magnet correctors and orbit feedback system to suppress various disturbances. Both of the above two feedback system will need to calculate the error signal between the measurement beam position and the desired ones as a control signal to apply to the target objectives. Furthermore, the efficient diagnostic system which is indispensable for accelerator physics and machine dynamics is also contributed by accurate beam position measurement. All of them depend critically on a precise and fast beam position monitoring system for which observes and controls an orbit. Therefore, we employ the latest digital BPMs to upgrade the orbit monitoring system and expect to acquire more precise and faster orbit position. The thirty Libera Electrons, manufactured by Instrument Technologies, have been planned to be integrated into the existing system via up to six VME or compactPCI nodes and more Liberas will also gradually

replace the old analogue BPMs in the future. It was expected that the functionality of multi-bunch feedback, orbit feedback and diagnostic systems will be efficiently enhanced after the BPM upgrade.

BPM UPGRADE PLAN

A total of 59 button-type BPMs were installed in the storage ring of TLS. The orbit signal was processed using Bergoz's MX-BPM [1]. The measured performance was around one micron. All MX-BPMs were synchronized externally using a common clock source to easy fine tune of the multiplexing frequency of the buttons to prevent the alias effects resulting from synchrotron sideband. The beam position is acquired by 16 bit ADC modules with simultaneous sampling. The ambient environment of the BPM electronics was also monitored to confirm the performance of BPM. The BPM server node is based on VME crate that acquires the orbit data every 1 msec for fast orbit feedback control. These fast orbit data were shared to an orbit feedback VME crate and a corrector control VME crate via a dedicated reflective memory network. The precision slow orbit was updated to the control database every 100 msec independently of orbit feedback system. The beam position can be maintained at the micron level using an orbit feedback system, even when the undulator parameters are changed.

However, due to the current hardware limitation, speed of gap and phase change of the conventional insertion devices is restricted to a relatively slow motion. To achieve relatively stringent requirements of orbit stability, we have planned to upgrade a half of BPM of the storage ring and expect to suppress vibration down to sub-micro level and up to 50 Hz. Libera Electron [2], which has been adopted by several light sources and shown its competent functionality [3-5], is chosen to replace the analogue type BPMs. The upgrade will be carried out stage by stage and the BPM system will be a mixed type at this moment due to resource limit.

Since precision orbit data from Libera Elecein is in 32 bit format with unit of nano-meter, it is not compatible with the existing system which uses 16 bits ADC to convert measured analog output of Bergoz's BPM. Truncation of 32 bit data into 16 bit format is a provisional solution to compatible with the existing system. It is possible to use the 32 bit data after all of BPMs replaced by Libera Electron in the future.

Up to six VME or compactPCI CPU modules equipped with gigabit Ethernet port which is used to acquire fast orbit data from thirty Libera Electrons will be employed for integration of the existing control system. The mixed systems of VME and compact PCI interface as well as digital and analogue BPMs are adopted due to

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cost and maintenance concerns. Reflective memory is utilized to share the position data and seamlessly integrate the hybrid distributed systems. Another diagnostic node which is built on an independent VME or compactPCI crate will also access the data via reflective memory. There is another gateway server which gathers slow orbit data information from private network and updates at 10 Hz for control network directly. The upgrade is scheduled to be completed no later than middle of 2008.

The digital BPM electronics are commercial available by using direct RF sampling technology, FPGA, and embedded control environment running GNU/Linux. The programmable nature of new system is beneficial for multi-mode high precision beam diagnostics purposes. Sub-micron resolution is achieved for averaged beam position measurement with high update rate.

Figure 1 presents the concept to integrated two kinds BPM electronics. Software infrastructure of the integration is shown in Fig. 2.
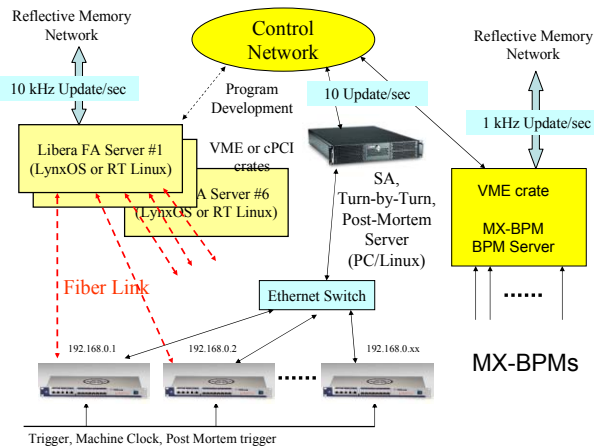

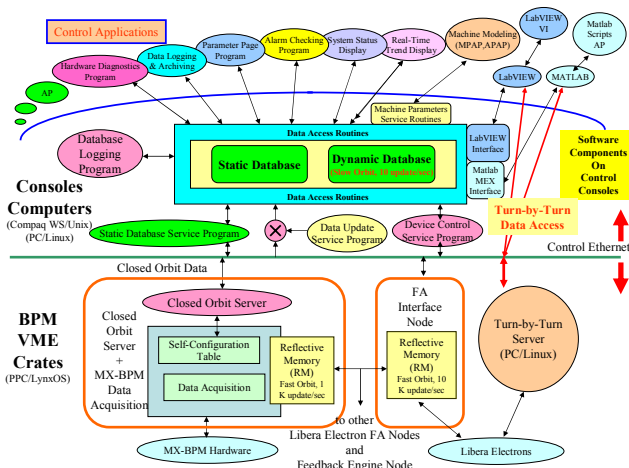Figure 1: Integration of Libera Electron with existing BPM system.

Figure 2: Software environment for Libera Electron integration..

ORBIT FEEDBACK UPGRADE PLAN

Orbit feedback system of the TLS has been deployed for a decade. The loop bandwidth was limited by existing hardware. The system cannot remove perturbation caused by fast source. Therefore, speed of gap and phase change of the conventional insertion devices is restricted to a relatively slow motion. To improve orbit feedback performance and take advantages of endless progressive technologies, we have made continuous effort on system upgrade. For examples, switching corrector power supplies with better performance had replaced some of the old linear type power supplies in this year. It has efficiently increased the bandwidth of the system loop. The planned BPM upgrade is expected to improve the performance of orbit feedback control as well.

The new infrastructure of orbit feedback system consists of several VME crates. Their functions include Bergoz's orbit server access VME crate, corrector power supply analog setting and read back VME crate, one feedback computation VME crate. There is another node running PC/Linux served as Libera BPM server for slow data access and management independently of orbit feedback. The precision fast orbit data will be acquired by gigabit Ethernet to three CPU modules equipped with gigabit Ethernet ports. The parallel processing is employed to reduce accumulating latency caused by Libera and data transmission. The number of the CPU modules is therefore adjustable according to the results of latency testing. A group of eight to ten Liberas (one super-period) will send Ethernet packets at 10 kHz rate to a gigabit network switch [2] which serialize these packets and sends them to each CPU module. Fast orbit data is shared to all nodes by reflective memory. Figure 2 shows the hardware configuration of the new orbit feedback infrastructure.

Fast orbit data from Libera Electron is updated into reflective memory in 10 kHz rate. To accompany with existing 1 kHz orbit feedback loop, the data will be re-sampling at a feedback computation engine. The corrector is updated at 1 kHz rate. After the first stage plan finished, upgrade the sampling rate of the feedback loop to higher frequency is in planning.

Figure 3 presents the control system interface of the MX-BPMs, Libera Electrons and its relationships with orbit feedback and relevant corrector control [6]. Slow data is update in 10 Hz rate. Data update for orbit feedback loop by using reflective memory network is 1 kHz for MX-BPMs and 10 KHz for Libera Electrons. Feedback loop sampling the orbit data with 1 KHz rate. After this integration completed, sampling rate of the MX-BPMs is plan increase to 2 KHz or higher. The sampling rate of the feedback loop will increase later.
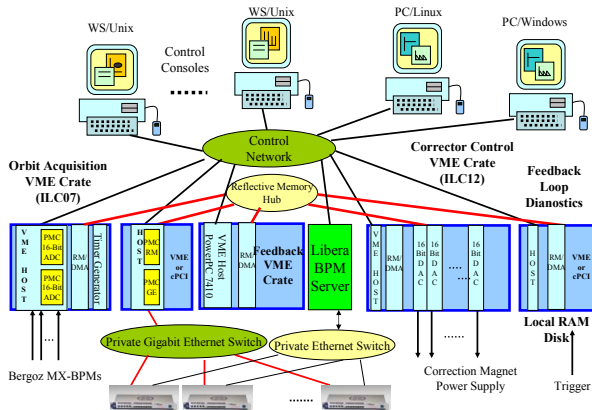

Figure 3: Infrastructure for the orbit feedback system.

To achieve a better orbit control and take advantage of latest development, upgrade of orbit feedback system for the TLS is on-going. All of vertical corrector power supplies have been replaced by switching power supplies in February 2007 and the horizontal ones are also planned to upgrade in 2008. Libera Electron will be integrated into the existing system to enhance functionality and provide precision fast orbit information for orbit feedback purpose. Infrastructure of the orbit feedback system is scheduled and will be finished within 6 months. It is expected that feedback loop by using some of the Libera Electrons can be completed no later than December 2007. It is also expected that this upgrade will provide better orbit control and satisfy users' requirement.

SUMMARY

This work summarizes the status and integration approaches to integrating the beam position monitoring system of the TLS at the NSRRC.

The short-term goals are to upgrade the performance and reliability of the existing BPM system and consequently improve the orbit feedback system and the relevant diagnostic system. New BPM electronics are being incorporated into the monitoring system with the current MXBPM system which works well in routine operations. More testing must be performed to confirm the performance and the operating environment of this hybrid BPM system. A small quantity of multi-mode BPM electronics is integrated into the current system and more ones will also be gradually planned to replace the rest of the aged BPMs in the future. The features of the updated BPM system include the analog multiplexing BPM and the user-transparent digital BPM. Seamless integration and operation are expected in the near future.

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