INTEGRATION OF NEW DIGITAL BPM IN THE TAIWAN LIGHT SOURCE

Changhor Kuo, K.H. Hu, C. J. Wang, Jenny Chen, Demi Lee, Teno Yang, Kuotung Hsu,

National Synchrotron Radiation Research Center, Hsinchu 30076, Taiwan

ABSTRACT

Integration of new generation digital beam position monitor (DBPM) was performed recently. The BPM electronics are commercial available by using direct RF sampling technology, FPGA, and embedded control environment running GNU/Linux. The implementation is emphasized on control system integration and compatible with existing system to enhance functionality and performance of the BPM system. The programmable nature of DBPM system is beneficial for multi-mode high precision beam diagnostics purposes. Sub-micron resolution is achieved for averaged beam position measurement. Medium resolution is obtain for turn-by-turn beam position measurement. Tune and other diagnostic measurements are also supported. The DBPM are seamless integrated with existed control system. System structure and preliminary test results will presented in this report.

INTRODUCTION

The newly deploy Libera series DBPM system is tested now. This digital BPM electronics are commercial products [3]. That is a four symmetrical channels structure system. It consists of analogy-to-digital converter (ADC) in the analog signal processing, digital down converter (DDC), digital filter in the digital signal processing and FPGA is for the data acquisition and control purposes. The four channels digital down converter is that convert 500 MHz beam signal into intermediately basic frequency coherently. Four signals of RF are digitized and processed by quad-digital receiver based on FPGA. The resolution of beam position measurement can be achieved around 10 μm turn-by-turn resolutions.

The ADC is based on AD9433. It is used for the analogy to digital conversion. This is a high speed, high performance, low power, and monolithic 12-bit analogy-to-digital converter. All necessary functions, including track-and-hold and reference are included on chip to provide a complete conversion solution.

The programmable DDC is composed of synchronization, input, input level detector, carrier mixer, CIC decimating filter, half-band decimating Filter, programmable FIR filter, automatic gain control, Cartesian to Polar converter. The digital data are separated to two ways for outside access after filter. One is wideband access with the circular buffer, other is narrowband access.

CONTROL SYSTEM INTERFACE FOR DBPM

To simply the complexity, the network access is separated to two ways in this implementation. One is slow access by the Ethernet; other is fast access by rocket I/O. In the fast access, the control system interface is separated to two layers. The embedded layer is planned by the VME64x crate with PowerPC module running the real time operation system of LynxOS. This interface is for fast orbit feedback and provides 10 KHz data update rate for feedback system. In the slow access, the data is acquired from console of user interface via Ethernet. The server host is a Linux server that is between user interface and DBPM. This server is a client for DBPM server. In the same time, it is also a server for user interface. It receives control parameters from user interface by Ethernet and disturbs this setting to DBPM. These parameters include that change operation mode either turn-by-turn mode or closed orbit mode, adjust gain in each channel and access length. The data of DBPM is replied to user interface after receive software trigger from Ethernet. Network connection of the digital BPM testbed is shown in figure 1. The software environment is shown in the figure 2. The DBPM is seamless integrated with the existing system. The user interface layer is located at workstation/Unix and PC/Linux control console, support commercial software Matlab and LabVIEW.

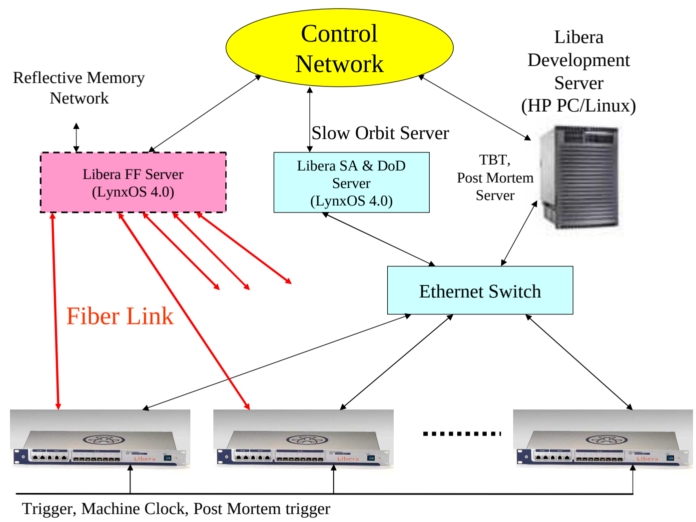

Figure 1: Network connection of the digital BPM testbed.

The software structure of server host is a multi-threads system. The user interface wake up the server host and create a multi-thread when it need to communicate with DBPM. The multi-thread is serviced to each DBPM and is closed when access is finished. In this access mechanics, it provides turn-by-turn access and slow orbit access in the same time. In the DBPM, there are two tasks in the DBPM software structure. One is CSPI access that is provided by the manufactory, other is serviced to server host. This service is supported to turn-by-turn access. All control and reading data are exchange in the share memory of DBPM.

The fast orbit information is sent to a dedicated VME host node with reflective memory (RM) network. This VME host is combined with rocket I/O and shares data to feedback node by RM. The rocket I/O access is up to 10 KHz, but it is down-sampled to 1 KHz to compatible with original feedback system. The VME host of the BPM server down sampled the closed orbit data to 10 Hz and update to dynamic database in all control consoles.

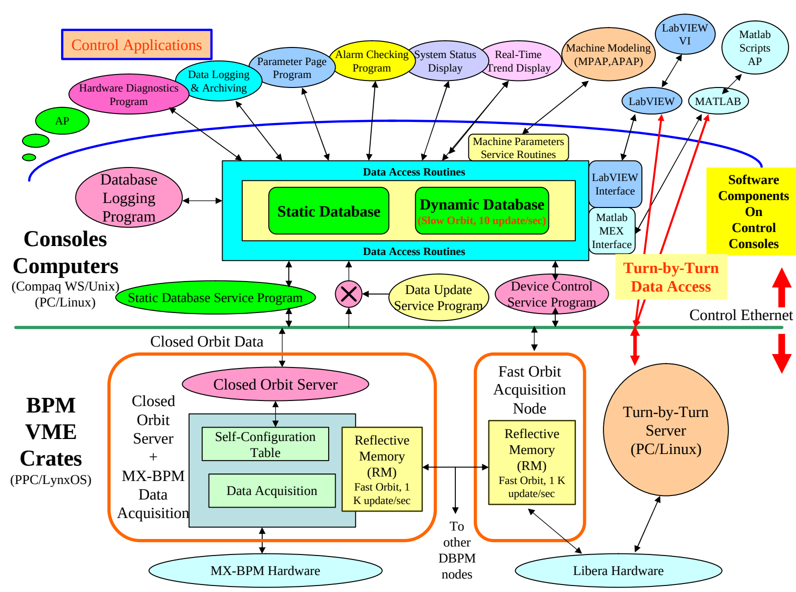

Figure 2: Software environment for BPM data access.

PRELIMINARY PERFORMANCE TEST

Preliminary beam test was done recently. The installed BPMs will join routine operation in near future. To examine the closed orbit performance, short-term and long-term test in underway. The long-term stability can be achieved ~ μm level with 10 KHz output rate that is comparative with existing orbit feedback system. The resolution can be better after optimized the parameters of digital receiver. The long-term performance of DBPM is shown in the figure 3.

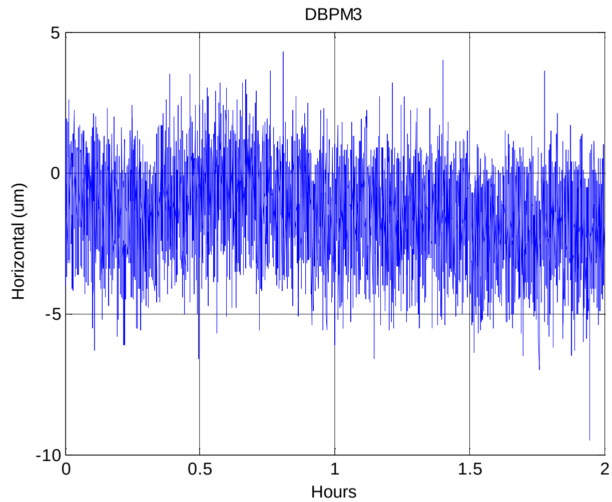

Figure 3: Long-term stability in the closed orbit mode with 10 KHz output rate.

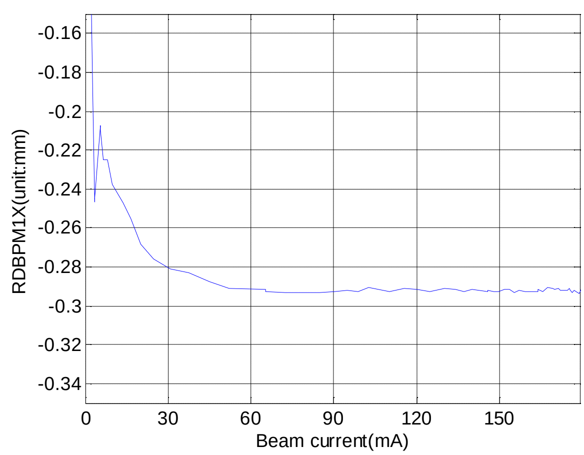

Figure 4: The dynamic range of DBPM.

The dynamic range of was done with beam. The measurement results are shown in the figure 4. The beam intensity is reduced from around 180 mA for this test by scraping of the stored beam. The beam position is still within 1 um to form 180 mA down to 60 mA with any correction.

Preliminary tests were performed on the Liberal BPM processor. Most preliminary tests were performed on the integration environment to do functionality evaluation. A Libera processor is a multi-mode device which supports turn-by-turn, sub-micron precision beam position and tune monitoring. The control system need to various software packages to support the digital BPM operation. The features of the new BPM system include analog multiplexing BPM and user-transparent digital BPM. Seamless integration of these features is the most difficult task. Fig. 5 shows the typical response of the beam position when a kicker magnet is fired (K1 @ 3 KV, ~ 1.5 mrad kick). The top diagram in Fig. 5 illustrates the damped horizontal betatron oscillation. A small regular synchrotron oscillation signal rides on the envelope of the damped oscillation, because of residue longitudinal instability probably from the vacuum component of the storage ring. Vertical signal excitation was also observed; and may be due to the imperfection of the field distribution in injection kicker or machine coupling. Fig. 6 illustrates the horizontal phase space portrait of two BPM separated about p/2 phase advanced near fourth order resonance.

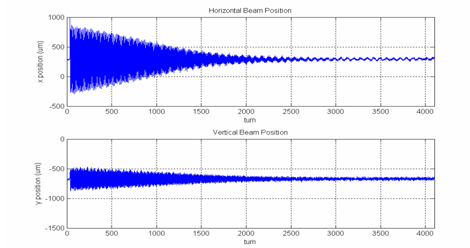

Figure 5: Turn-by-turn beam position measured by new digital BPM; upper is the horizontal beam position, and the lower figure is the vertical beam position.

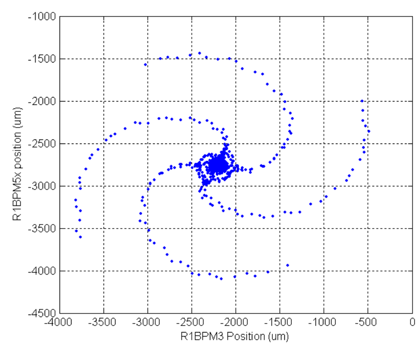

Figure 6: Horizontal phase space portrait of two BPM separated about p/2 phase advanced near 4th order resonance.

A dedicated tune monitor was implemented by using Libera. The proposed monitor is based on the Fourier analysis of the turn-by-turn data from the Liberas based on various beam excitation levels. Fig. 7 shows the system block diagram. The stored beam was excited by a narrow-band white noise or kicker. The excitation level was controlled by the software. The tune was extracted by Fourier analysis of the turn-by-turn beam position data. The very small beam sizes were magnified under adequate pink noise excitation. It may be compatible with a user not checking the beam condition.

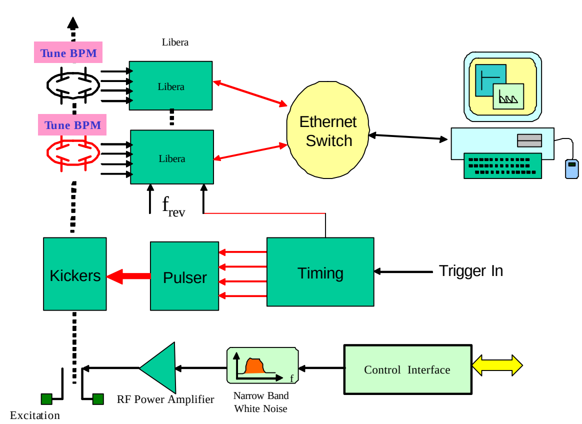

Figure 7: The block diagram of the tune monitor.

The clean tune spectrum is easy to obtain as shown in Fig. 8. The upper part of Fig. 9 displays the 128K-turn data captured by the Libera device on its large internal memory. The data show some beam instabilities in the vertical direction. An instantaneous tune extracted by the numerical analysis of fundamental frequency (NAFF) method is illustrated in the lower part of Fig. 9, shows no evidence of power line cycle tune variation. These findings demonstrate that the main storage ring have acceptable ripple values in the power supplies.

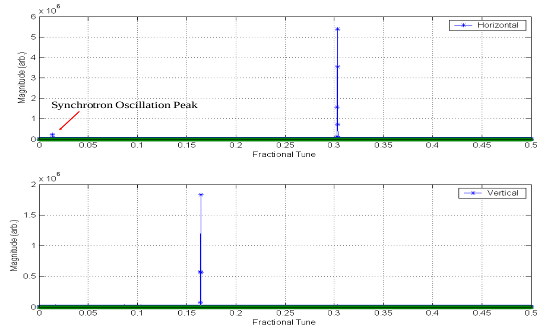

Figure 8: Tune spectrum obtained by Fourier analysis of data set in Figure 7.

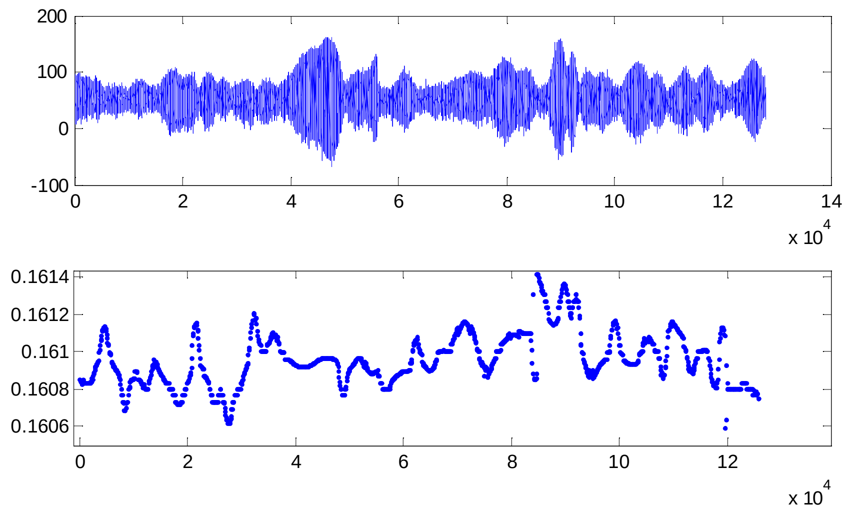

Figure 9: 50 msec turn-by-turn beam position measured data in vertical direction and its instantaneous vertical tune extracted by NAFF method.

SUMMARY

New digital BPM (Libera) testbed have been setup for various evaluation testing. The Libera is embedded a Linux environment which provides a flexible control system integration possibility. We try to integrate the Libra with NSRRC control system during last passing year. Preliminary test shows that seamless integration is possible. Current achievement includes slow orbit acquisition and turn-by-turn beam position measurement. Further integrated with existing orbit feedback system is next step. Firmware upgrade in near future will make the Libera put into routine operation.

REFERENCES

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[3] http://www.i-tech.si/