COMMISSIONING OF NEW BPM SYSTEM AND ITS RELATED DIAGNOSTIC SYSTEM FOR TLS

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Abstract

New digital BPM system for TLS has been delivered recently. It could support functionalities of turn-by-turn beam position data, 10 kHz fast and 10Hz slow data acquisition. 10 kHz fast data transmission between Liberas through Libera grouping mechanism also developed to acquire all BPM data for the fast orbit feedback system with low latency and jitter and succeeded to integrate into the related subsystems. Various tests are performed systematically to confirm its performance and reliability and will be discussed in this report. We also present the functionalities and infrastructure of the related diagnostic system. It could record 8 sec orbit data simultaneously via hardware and software event trigger at 10 kHz. With aids of turn-by-turn post mortem buffer inside the Liberas, post mortem data with different time resolution are provided. More integrated software tools and work will continue to develop for future operation.

INTRODUCTION

To provide better functionality of BPM system in the TLS, the BPM electronics upgrade plan was proposed and the Libera Brilliance [1], manufactured by Instrument Technologies, was employed to replace the existing BPM electronics. It is a standalone device composed of RF front end, four ADCs, a FPGA, and single board computer running GNU/LINUX and can offer multiple measurement channels with Hz, kHz and MHz bandwidth. There are now 59 Liberas for position measurement and one Libera dedicated for tune measurement installed in the storage ring of the TLS. This report will present primary tests of performance of Libera and infrastructure of BPM and related diagnostic system. Sub-micron resolution is achieved for averaged beam position measurement with high update rate. A proper offset-tune is introduced to alleviate the effects of ADC nonlinearity. Moreover, Libera grouping mechanism implemented to reduce data encapsulation overhead and improve sampling jitters for the orbit feedback system is presented. Further work of XBPM integration is also introduced.

BPM SYSTEM INFRASTRUCTURE AND STATUS

Commissioning of BPM electronics upgrade was done recently for it had taken several years from initial primary test to final online operation. Fig. 1 shows the Libera at R1, R4, R5 and R6 installed in the core area. The functional block diagram of the BPM and the related subsystems implementation is shown in Fig 2. The Libera Brilliance is grouped by multi-gigabit links [2,3] and transmits one UDP packed precision beam position data in 10 KHz rate to the data concentrator of the orbit feedback system. Different functional nodes share the 10K Hz fast orbit data via the reflective memory network including the BPM data acquisition node, diagnostic node, and feedback engine nodes. The XBPM node which acquires XBPM data and shares data via reflective memory is also under construction.

Figure 1: BPM at R1,R4, R5, R6.

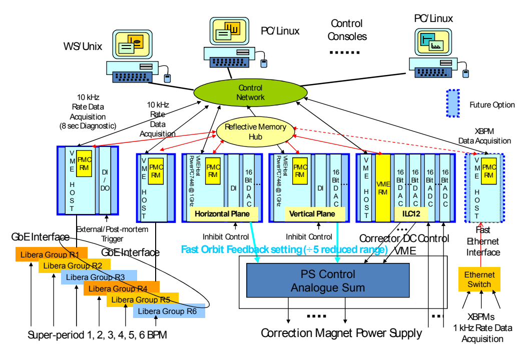


Figure 2: Infrastructure of BPM and related subsystems.

Additionally, beside data archiver of the control system with 100 msec time resolution, various tools have gradually been employed to meet various requirements in the TLS. Post-mortem buffer of the Libera Brilliance which can capture the data before and after beam trip is also included. It helps to measure beam condition, analyze beam trip event and further to improve the accelerator's reliability.

Configuration of BPM system can be operated via GUI as Fig. 3 for various machine studies. This tool is based on special designed LabVIEW EPICS channel access (LVCA) in the Linux environment (kernel 2.4 or 2.6), which includes initial configuration, EPICS setup,….etc, for Libera.

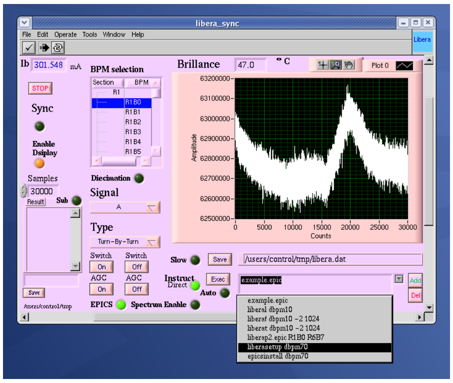
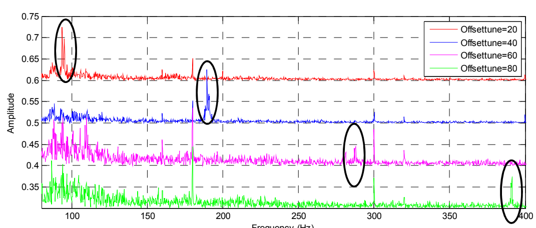


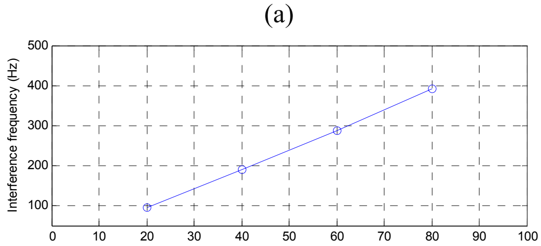
Figure 3: The Libera BPM configuration setup tool.

OFFSET-TUNE SETTING

Measurements show that the resolution of Libera gets spoiled when acquisition is precisely tuned to RF frequency [1]. Offset-tune is thus introduced for a solution. Fig. 4 shows the BPM fast data of different offset-tune tuning and reveals that the interference line shifts far away of interesting frequency of 100 Hz when offset-tune frequency increases. After evaluation, our offset-tune configure is consequently set to 100 units (around 4.2 kHz in baseband).



(a)



(b)

Figure 4: (a) BPM reading spectrum v.s. different offset-tune setting; (b) Offset-tune setting v.s. interference frequency.

LIBEAR GROUPING

Initially, each Libera provided a Gigabit Ethernet interface for fast data acquisition. It's a standard solution that enables the utilization of commercial, off-the-shelf components while in the real-time system applications like orbit feedback system, jitter problem should not be neglected. Observation [2] implies that the jitter is obvious and never vanishes as process goes on.

To overcome this drawback, we propose a grouping mechanism and cooperate with the vender. Libera Brilliance units (up to 64) are grouped together by a redundant multi-gigabit links via the LC optical links and/or copper "Molex" cables as shown in Fig. 5. This link can exchange the data among the Libera Brilliance units without the protocol overhead and send the gathered data via Gigabit Ethernet. It reduces significantly the packet number transmitted to the processor and resolve jitters effectively.

The Libera Grouping solution for global fast orbit feedback data distribution has been described and compared to the standard, single Libera Gigabit Ethernet solution. By grouping the fast acess data of several Libera units into a single UDP/IP packet, the data encapsulation overhead due to fixed UDP/IP packet header, is reduced up to a factor of 7. The global fast orbit feedback network traffic is therefore significantly reduced. The user selectable redundancy has been demonstrated on several levels and allows for flexible fast access data distribution system building, with varying degree of redundancy and reliability.

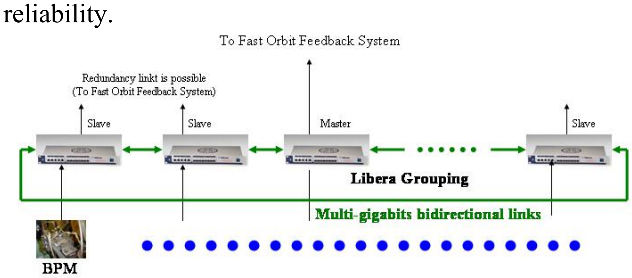


Figure 5: Structure of Libera grouping.

TYPICAL ACQUIRED DATA

Fast Data

Resolution is an important issue for fast orbit feedback system. The resolution of the TLS liberas FA data at 10 kHz is around 0.2~0.3 μm when the beam current is operated at 300 mA. Each unit slightly differs while the whole of 59 Liberas should be within 0.35μm. The Fig. 6 shows the FA data of vertical and horizontal positions.

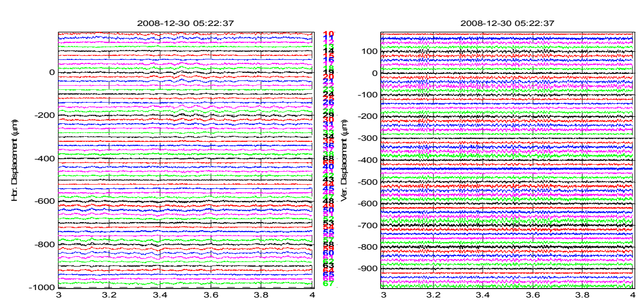


Figure 6: FA data of vertical and horizontal position. Right figure is horizontal position; left is vertical.

Turn-By-Turn Data

The turn-by-turn data can be acquired on demand or on external trigger. The Fig. 7 shows turn by turn data of all

BPM. It can be observed that the beam is excited to do betatron oscillation after kicker fire. This data allows extensive machine physics studies and can be obtained via EPICS channel access, for instance into Matlab.

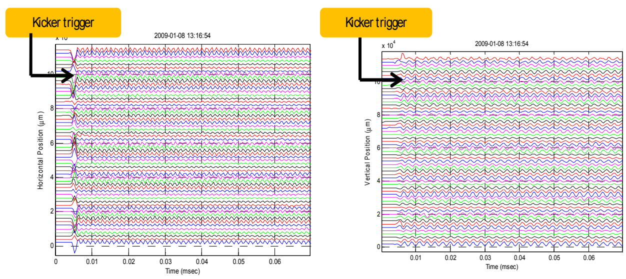


Figure 7: Turn by turn data of vertical and horizontal position. Right figure is horizontal position; left is vertical.

Slow Data

Vertical orbit data is shown as Fig. 8. The standard deviation is around 0.1~0.5 corresponding to respective location.

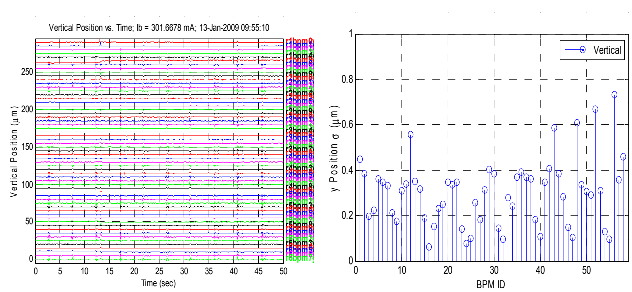


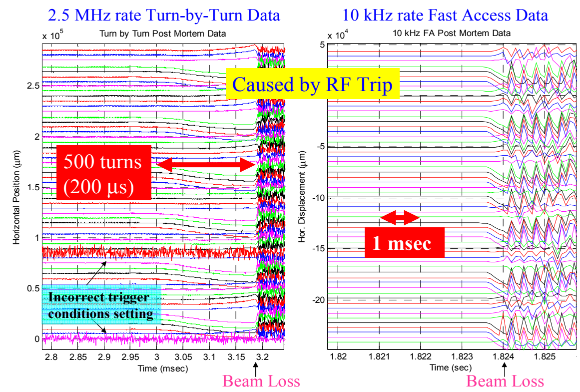
Figure 8: Slow data of vertical position and its rms value.

Post Mortem Data

Libera Brilliance equipped with up to 256K post-mortem buffer for the turn-by-turn beam position data can be triggered by beam trip due to various reasons, e.g. kicker misfired, SRF trip, and superconducting insertion devices quench, …etc.

A diagnostic node mentioned above which can record 10 kHz rate FA data up to 8 sec helps to capture interesting events with longer period by the same trip signal.

In Fig. 9, turn-by-turn data of (a) and 10 kHz FA data of (b) record the same beam trip event. It reveals the orbit shrinks after RF fault happens in Fig. 9 (a). The stored beam survives several hundreds of turns before its hit the vacuum chamber and loss completely. In Fig. 9 (b), there are only several data points when the event happened before beam loss due to the SRF system trip.



(a)Turn-by-turn data. (b) 10 kHz rate data.

Figure 9: Orbit post-mortem data for the RF system trip.

FUTURE WORK

Near eight months operation, reliability of Libera's seems satisfactory. Only few Liberas cannot work properly in early operation stage which might be due to analogue board upgrade; the others should have flaws before usage. Long term stability will be continuouly tracked in the TLS. The Libera is also the baseline design of electronics BPM for Taiwan Photon Source (TPS) .

Currently, XBPM data synchronized with BPM can be acquired. It enables to correlate the motions between electron and photon beam. Further tools will be developed to fulfill functionalities. 200 Hz data acquisition node is also planned to build up to capture BPM data which is decimated from FA for minutes with enough bandwidth.

SUMMARY

This report summarizes the progress of the implementation for TLS new digital BPM system. All past BPM electronics are replaced by the latest generation products gradually since 2007 and the upgrade finish in late 2008. The infrastructure of the BPM system to support the fast orbit feedback and diagnostic system is also presented.

ACKNOWLEDGEMENT

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REFERENCES

[1] I-Tech website: http://www.i-tech.si.

[2] C. H. Kuo, et al., "Fast Orbit Feedback System Upgrade with New Digital BPM and Power Supply in the TLS", DIPAC'07.

[3] A. Bardorfer, et al., "Libera Grouping: Reducing the Data Encapsulation Overhead", Proceedings of EPAC08, Genoa, Italy, 1041 (2008).