SSRF BPM SYSTEM OPTIMIZATION AND UPGRADE*

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Abstract

The beam position monitor (BPM) system at SSRF was fully equipped with Libera Electrons. It have operated steadily for nearly five years. During the summer shutdown of 2012, more than 50 Libera Electrons were upgraded to Libera Brilliance, which are used mainly for fast obit feedback system. The software version of the whole system is upgraded from 1.42 to 2.07. Meanwhile, some other hardware and software optimizations were carried out. After this upgrade, the stability and performance have been significantly improved. This paper will introduce the details of the optimization and upgrade.

OVERVIEW

Shanghai Synchrotron Radiation Facility (SSRF) is a third generation light source, which located at the Zhangjiang Hi-Tech Park, Shanghai, P.R. China. Its small emittance requires a high resolution Beam Position Monitor (BPM) system, in order to achieve beam stability at the micron level. The same BPM system can also been used to measure the turn-by-turn beam position for various machine studies.

SSRF BPM system was fully equipped with Libera Electrons, which are produced by Instrumentation Technologies [1]. A total of 181 units (3 units for the LINAC, 8 units for the transfer lines, 30 units for the booster and 140 units for the storage ring) were used for BPM signal processing and orbit feedback system. It have operated steadily for nearly five years. During the summer shutdown of 2012 more than 50 Libera Electrons were upgraded to Libera Brilliances, which are used mainly for the fast obit feedback system. The software version of the whole system is also upgraded. This paper will introduce the details of the upgrade.

HARDWARE UPGRADE

The Libera Brilliance features the high precision position measurement of the electron beam in the circular accelerator. Digital signal processing inside the Libera units support programmable bandwidth and can facilitate all the required position measurements: pulsed, first turns, turn-by-turn and regular closed orbit.

The upgrade from Libera Electron to Libera Brilliance represents an economical way of getting a brand new instrument. The hardware difference between them is mainly on the analog board. Libera Brilliance uses a new analogue board with 16-bit ADCs (instead of 12-bit), as shown in Fig. 1. The beam current dependence performance (linearity) and the read-out performance are improved drastically. It's easy to achieve sub-micron resolution in the turn-by-turn data and some tens of nanometres in the FA (Fast Application) data.

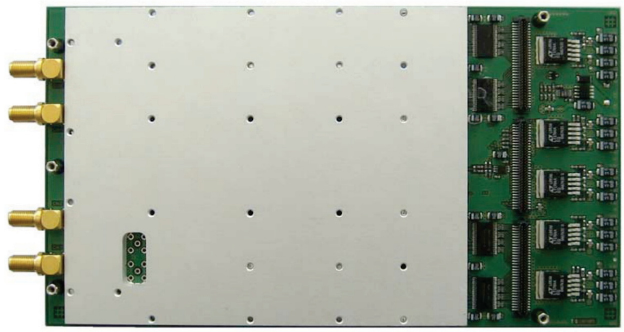

Figure 1: The analog board of Libera Brilliance.

SOFTWARE UPGRADE

The old software releases of our BPM system (Libera Electron) is 1.42. For the software upgrade, there are mainly two reasons.

- Libera Brilliance and Libera Electron share the same software releases and CSPI (Control System Program Interface), which can simplify the management and configuration.
- Some existing problems can be solved via the software upgrade, such as event overflow, phase lock failed occasionally, etc.

Actually, there are several releases from 1.42 to 2.07. During the process, the existing bugs were fixed, the platform was updated, and a lot of new functionalities were added. Some major changes are list below:

- Updated health daemon keeps the fan rotation speed above 4100 rpms. This was done to avoid transistor overload at lower rpms.
- OS was upgraded to armel platform (EABI). Notable improvements to the Linux platform (from Debian arm to Debian armel).
- Post-mortem can be triggered from three different sources: external trigger, interlock or post-mortem specific settings (X, Y positions, ADC overflow).
- The average of the sum signal between two triggers was calculated on sum data @ FA data rate.
- Spike removal was implemented in the FPGA (for FA/SA data) and in the SBC (turn-by-turn data) to eliminate glitches due to the switching. This functionality is configured with several parameters (average window length, apply window length, offsets).
- Table of BCD correction offsets was introduced in order to improve Beam Current Dependence (BCD) performance. Depending on the level of the current, the position is offset by applying X and Y offset from a lookup table .
- PLL daemon was completely rewritten. Instead of two separate daemons (one for machine time and the

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other for system time) only one takes care for complete synchronization.

These are very important for system stability and the new functionalities are useful for the daily operation and machine studies.

Beside the existing modules, some new functionalities are added according to our specific needs, such as AGC (Automatic Gain Control) module, beam lifetime calculation module and 24-hour buffers for closed orbits data). The logic of our AGC module is different from the original. Figure 2 shows the flowchart of the gain control.

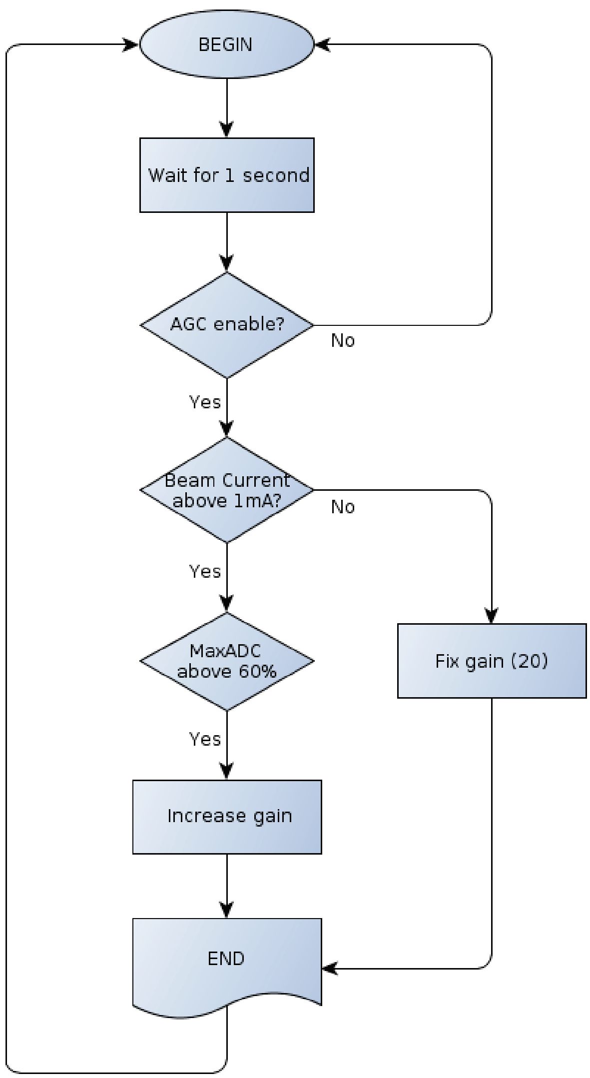

Figure 2: The flowchart of the automatic gain control.

PERFORMANCE AND APPLICATION

As the storage ring started up just few days ago, the comprehensive evaluation of the whole BPM system has not been carried out. Some data and preliminary analysis are given below.

Turn-by-Turn Data

During the beam injection, the turn-by-turn data of horizontal direction from a Libera Brilliance is shown as Fig. 3.

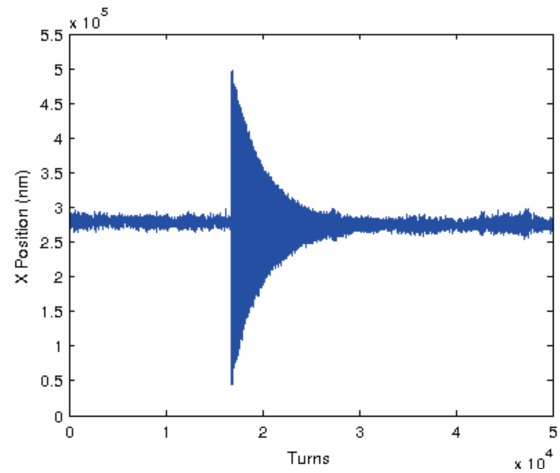

Figure 3: The turn-by-turn data during beam injection.

Tune measurement is an important application of the turn-by-turn data. The fractional tune can been obtained through the FFT (Fast Fourier Transform). As shown in Fig 4 and 5, they are 0.2172 (horizontal direction) and 0.2953 (vertical direction).

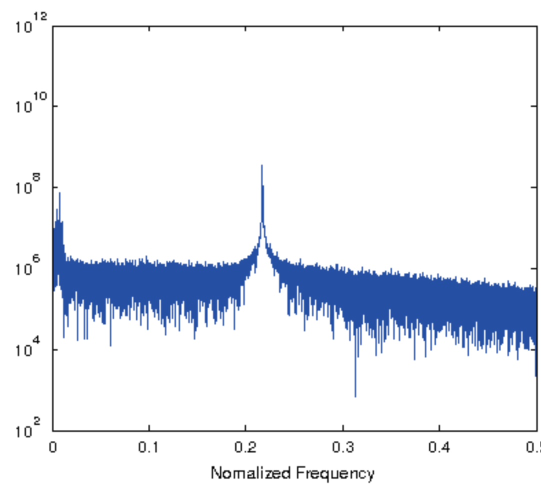

Figure 4: The spectrum of horizontal turn-by-turn data.

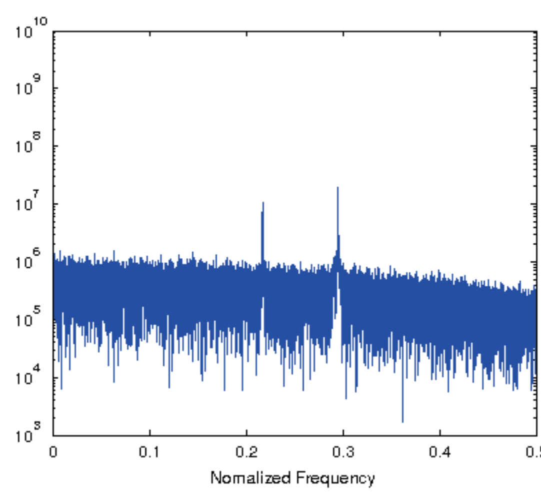

Figure 5: The spectrum of vertical turn-by-turn data.

The resolution of turn-by-turn data from all 140 BPMs of the storage ring are shown in Fig. 6.

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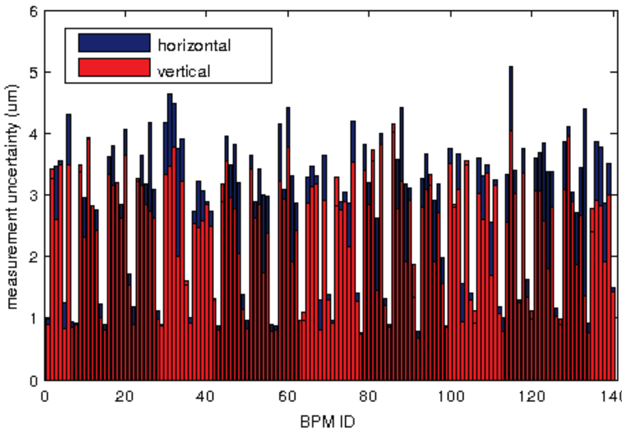

Figure 6: The measurement uncertainty of turn-by-turn data.

At the storage ring, a total of 55 Libera Electrons were upgraded to Libera Brilliance, which were installed at the #1, #7 and partial #5 positions of every cell (total 20 cells, 7 BPMs per cell). As shown in Fig 6, the measurement uncertainty of Libera Electron are about 3.4um (horizontal direction) and 3.0um (vertical direction). For Libera Brilliance, the measurement uncertainty are about 1.2um (horizontal direction) and 1.0um (vertical direction), which are significantly smaller than Libera Electron.

Closed Orbit Data

The closed orbit data are very important for the daily operation and orbit correction. The SA data of vertical direction from a Libera Brilliance is shown as Fig 7.

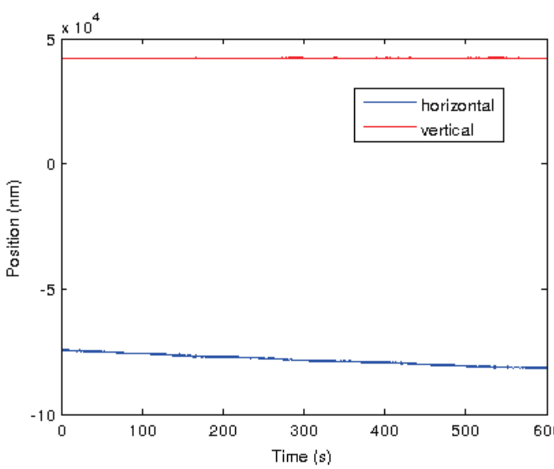

Figure 7: The closed orbit data of vertical direction.

The measurement uncertainty of vertical direction is about 89nm. The Libera Brilliances are installed at ID BPM positions, which use the independence mechanical support.

Average SUM Data

This data is the average of the sum signal between two triggers, which is updated at FA rate (about 10kHz). It can be used for monitoring the current increase during beam injection. Figure 8 shows the corresponding relation between the average sum data and the current data.

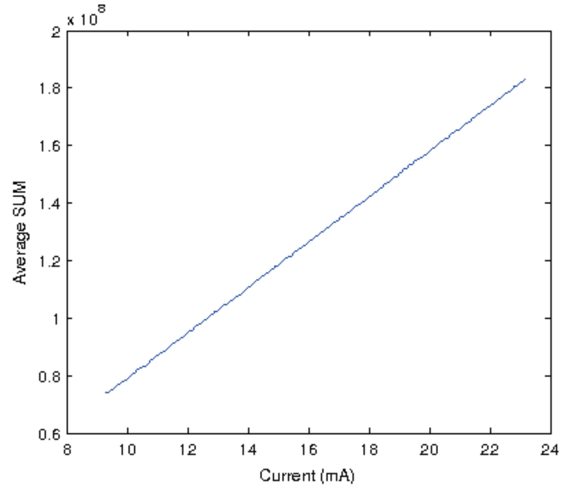

Figure 8: The average sum data vs the current data.

The histogram of the difference between two adjacent points is shown in Fig. 9, which can be used for the evaluation of the injection system.

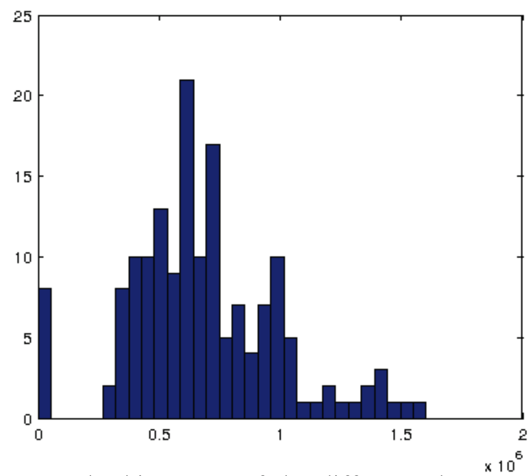

Figure 9: The histogram of the difference between two adjacent injections.

CONCLUSION

After this upgrade, the stability and the performance of the whole system have been significantly improved. More research related to the BPM system will be carried out in the future.

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REFERENCES

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

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