BPM CONTROL, MONITOR, AND CONFIGURATION ENVIRONMENTS FOR TPS BOOSTER

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Abstract

Booster synchrotron for the Taiwan photon source project which is a 3 GeV synchrotron light source constructed at NSRRC is in commissioning. The BPM electronics Libera Brilliance+ [1] are adopted for booster and storage ring of Taiwan Photon Source (TPS). The acceptance test had been completed in 2012 [2]. The provided BPM data is useful for beam commissioning where it can be used to measure beam position, rough beam intensity along the longitudinal position and also for tune measurement. This report summarizes the efforts on BPM control, monitor and configuration environment.

INTRODUCTION

The TPS is a state-of-the-art synchrotron radiation facility featuring ultra-high photon brightness with extremely low emittance [3]. Civil constructions had been completed in early 2013. The TPS accelerator complex consists of a 150 MeV S-band linac, linac to booster transfer line (LTB), 0.15–3 GeV booster synchrotron, booster to storage ring transfer line (BTS), and 3 GeV storage ring. The booster has 6 FODO cells which include 7 BD dipoles with 1.6 m long and 2 BH dipoles with 0.8 m long in each cell. Its circumference is 496.8 meters and it is concentric with the storage ring in the same tunnel. Libera Brilliance+ electronics has been adopted for the position measurement for booster and storage ring. It has provided precise beam position measurement and useful tools during booster commissioning in progress. This report will summarize the booster BPM related environment and functionalities.

BOOSTER BPM LAYOUT AND FUNCTIONALITIES

The TPS booster ring has six cells where each cell is equipped with 10 BPMs which can be used to measure beam position and rough beam intensity along the longitudinal position. Fig. 1 shows the mechanical drawing of booster BPM which shapes 35x20 mm elliptical and button diameter 10.7 mm. The calibration factor Kx and Ky is 8.25 and 9.66 mm respectively.

The conceptual functional block diagram of the BPM electronics is shown in Fig. 2. It will provide several data type for different application. ADC and TBT data is acquired on demand by trigger; 10 Hz slow data is for DC average orbit and 10 kHz fast data could be applied for booster ramping orbit or fast orbit feedback application. It is also embedded with EPICS IOC for control, monitor and configuration. The timing AMC module would provide functionalities of synchronization, trigger, interlock and post-mortem.

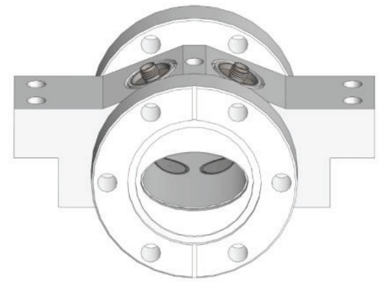

Figure 1: Button-type BPM for TPS Booster.

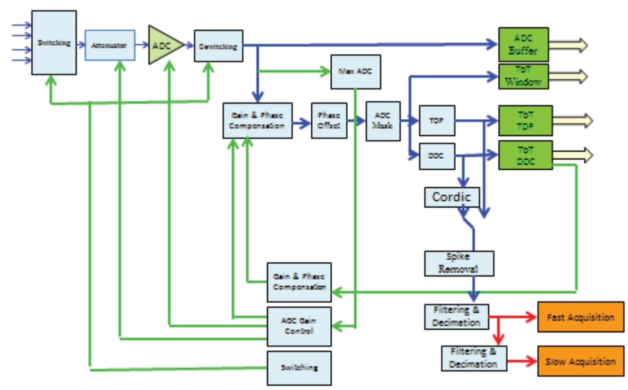

Figure 2: BPM platform functional block diagram.

FUNCTIONALITY TEST AND MANAGEMENT ENVIRONMENT

To support operation of the BPM electronics, functionalities like cold start, shutdown, housing, control system interface should meet the requirements. The delivered units also had been performed functionality and performance test to ensure compliance with this specification.

Cold Start and Shutdown

All BPM platforms and BPM electronics have been performed cold and shutdown test. Only minor problems encounter. Non-booting issue due to incorrectly shut-down procedure is reported to the vendor. Uploading the new FPGA image would fix it.

EPICS Interface

The EPICS interfaces for all BPM platforms are tested. Several defects is identified and then resolved after firmware upgrades. GUI based on EDM and Matlab is also developed for configuration and monitor.

Housekeeping

The BPM platform provides power supply status monitoring, temperature monitoring, fan status monitoring and fan control. The status looks good from the system maintenance point of view. EDM pages are

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also provided for status monitor and display as Fig. 3.

Synchronization Stability

Synchronization is accomplished by internal PLL to lock to the revolution frequency and the stability is observed for 9 modules during 60 hours. The phase errors had never gone out of $\pm$ 1^{o} region for the PLL had always remained locked status.

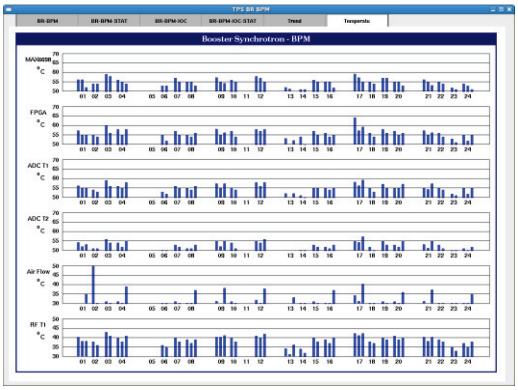


Figure 3: EDM Page for BPM housekeeping.

BOOSTER BPM MEASUREMENT

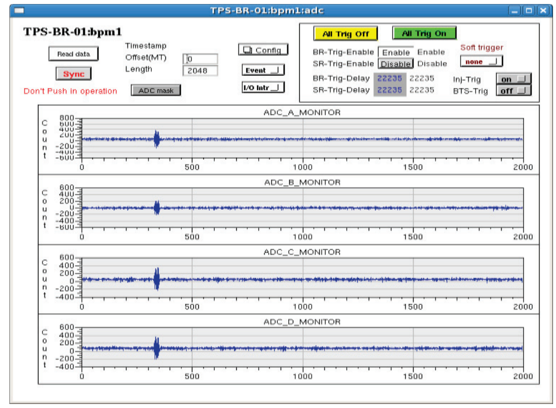
For TPS booster BPM, there are 60 sets of phase-trimmed 0.240” form polyethylene coaxial cables connected between the buttons and BPM electronics. The gain variation of BPM electronics is less than 5%. The equal length of all cable sets will contribute the same power consumptions and make possible to use the sum signal of BPM as an intensity indicator. The error would only come from position dependence of the beam. The BPM position and intensity data is useful for beam commissioning. In this section, different BPM data flow will be demonstrated for different applications.

ADC Raw Data

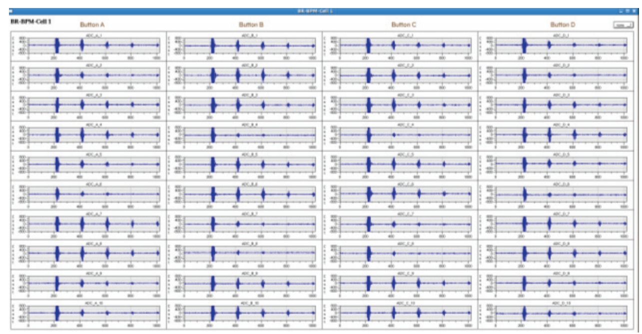
The ADC raw data is useful for checking the timing of the beam and beam property especially in the first turn. Fig. 4(a) shows that the first beam passing through the injection septum and kicker and arriving the 1st BPM of the booster ring; (b) the beam circulates complete 5 turns in the booster.

First-turn & Multi-Turn Application

BPM electronics provides single pass mode for calculating first turn trajectory from ADC data. However, vast beam losses and ADC DC offset will result in worsen signal to noise ratio and position calculation error. Therefore, a soft IOC would be applied to acquire more precise first turn trajectory from ADC raw minus DC offset. Fig. 5 shows the first turn orbit trajectory and sum along 60 BPMs. Horizontal trajectory shapes like dispersion function due to energy drift from Linac modulator. Moreover, ADC buffer with 2048 length could be applied to provide the first 9 turns data developed by Matlab as Fig. 6.



(a)



(b)

Figure 4: (a) The ADC data when beam passes through the 1st BPM of the booster synchrotron. (b) The ADC data as the beam circulates complete 5 turns in the booster.

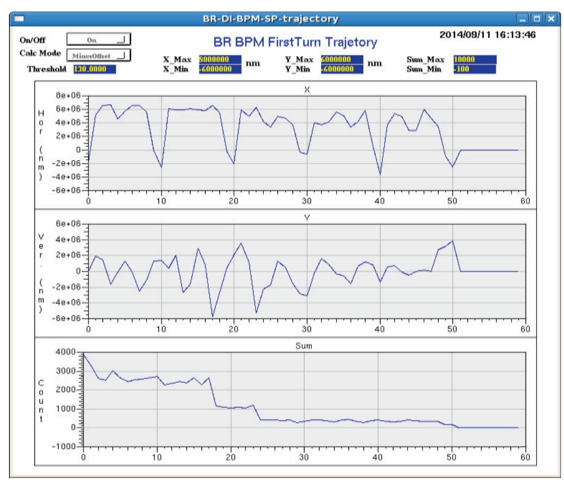


Figure 5: First turn horizontal, vertical trajectory and sum along 60 BPMs of booster.

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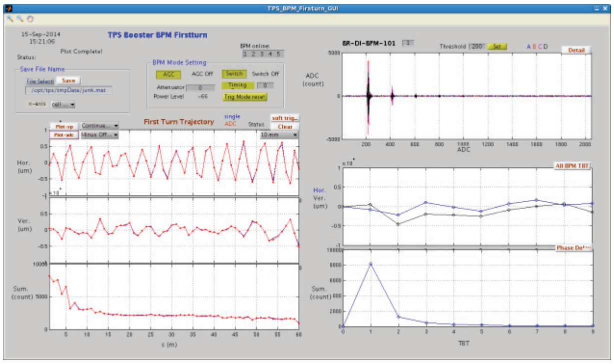

Figure 6: The first 9 turns data calculated from ADC.

Turn by Turn Application

DDC (Digital Down Converter) and TDP (Time Domain Processing) Turn-by-turn data are both provided by BPM electronics and the resolution could achieve around 150 um at 0.5 m. To use TDP properly, phase offset should be adjusted by beam and mask window also should be set correctly according bunch length. It could be observed that the beam charge loss could be well resolved. Besides, the BPM TBT data could also be applied to calculate tune value as Fig. 7.

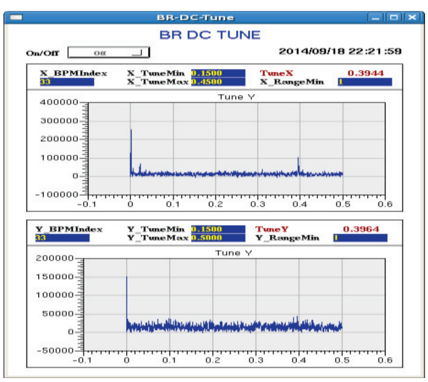

Figure 7: Tune Measurement from BPM TBT data.

Slow & Fast Position Measurement

The BPM electronics also provide 10 Hz slow and 10 kHz fast position data to measure average stored beam orbit. The related applications including GUI and acquiring scripts are developed and provided for studying and helping commissioning as Fig 8 & Fig 9.

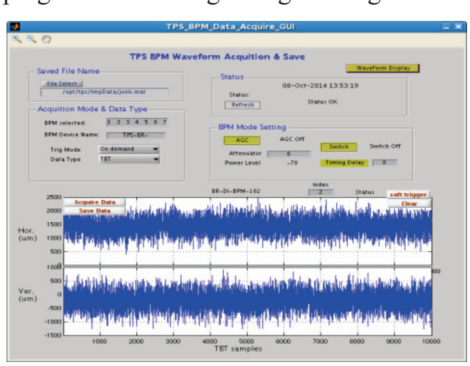

Figure 8: Acquisition tool for different data type of BPM.

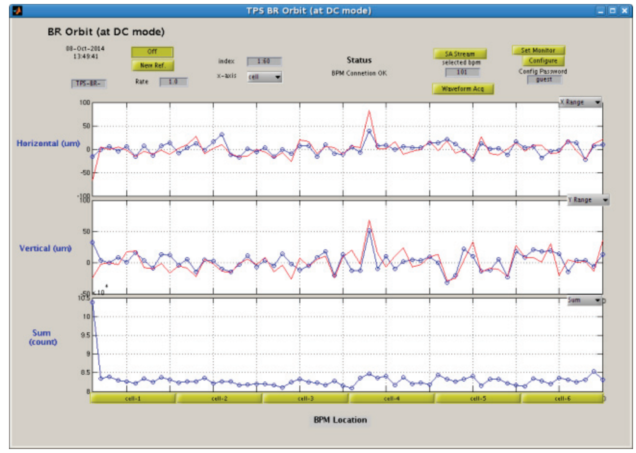

Figure 9: Booster DC orbit display page.

CURRENT STATUS

Final system integration test of booster with the installation of the storage ring and preliminary beam commissioning of the booster synchrotron is in progress at NSRRC now. Beam was circulated one turn soon after commissioning work started. To store beam and ramp the energy into 3 GeV are the recent efforts. BPM functionalities and performance for the booster synchrotron has been exercised with beam during last several weeks. Supporting tools of software have been continuously revised. Preliminary results show the BPM being a useful diagnostic tool during beam commissioning.

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