PHOTON BPM ELECTRONICS DEVELOPMENT AT TAIWAN LIGHT SOURCE

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Abstract

Photon BPMs are very useful for photon beam position measurement and stability observation. There are several kinds of photon BPMs and electronics with different design installed at beamline front-ends at Taiwan Light Source. To provide a better integration and efficient usage of the photon BPM, a commercial BPM electronics - Libera Photon was chosen for an integral solution and has showed at least one micron performance for several months of testing. In this report, the installation process and testing results of the photon BPM are presented.

INTRODUCTION

Like most of light source facilities [1][2][3], the Taiwan Light Source also had been widely employed photon beam position monitor (pBPM) in the beamline to measure synchrotron radiation photons [4]. The blade-type pBPM was chosen for less thermal effect and non-destructive way. Additionally, 2-blade pBPM has been install to detect vertical position of bending magnet and insertion device beamline while 4-blade pBPM for both vertical and horizontal detection of undulators. The data acquisition system originally was based on respective picoaperemeters and personal computers and one signal might split into several ways into different data acquisition system. Therefore, it is expected that the system could be integrated with machine control system and have features of easy access from the beamline control system, embedded current-to-voltage converter, embedded high performance ADCs, local computation capability, and integrated control system interface. Commercial available Libera Photon [5] satisfies these requirements and could integrate photon BPMs into control system seamlessly. It is also capable to measure high-frequency motion of the photon beam up to 10 kHz.

FAST MOTION DURING INJECTION

Since the data flow of Libera Photon is somehow similar with the electrical BPM Libera Brilliance [5], it provides 10 kHz fast data through a dedicated network and enables the synchronous data acquisition between al of electrical and photon BPM. Because the electrical BPM fast data has been deployed for fast orbit feedback system and the related diagnostic purpose, to further correlated beam behaviour of electrical and photon beam, another network dedicated for photon BPM is considered to be built in the near future without interfering the existing eBPM system. Fig. 1 shows the possible layout and in the meanwhile PBPM application for orbit feedback system is also considered and studied. It is expected that these two fast links could clarify some fast transient motions of electrical and photon beam such as injection and help to improve orbit stability. Fig. 2 shows the vertical positions of R1BPM4 and PBPM10. The behaviours of both are quite similar where the field leakage causes both of electrical and photon BPM's position disturbed.

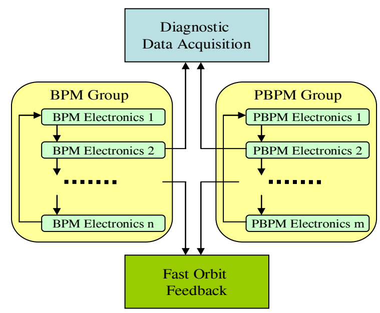
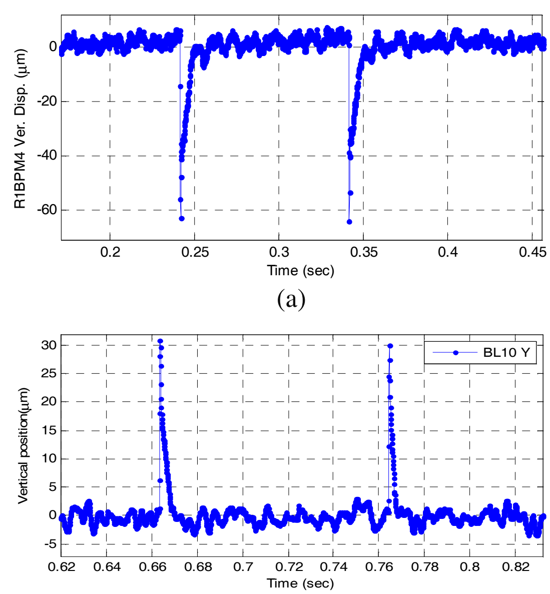


Figure 1: Fast links of electrical and photon BPM



(a)

(b)

Figure 2: (a) Storage Ring electrical R1BPM4 10kHz readings during injection (b) Beamline 10 photon BPM 10 kHz rate reading during injection.

PRIMARY TEST BY CORRECTOR KICK AND ID PHASE CHANGE

In this machine study, we made one of vertical correctors (RCVCSPS21) driven by a square wave kick and the orbit change were monitored by the pBPM and eBPM. The results were shown as Fig. 3. It can be observed that during FOFB off the corrector changes will cause orbit position over 10 um displacement while during FOFB on the displacement is almost suppressed for the same corrector change. Fig. 4 shows comparison of the photon displacement when the EPU5.6 phase was changing with/without FOFB. It can also be observed clearly that FOFB could almost suppress the displacement from several hundreds of micron less than one micron.

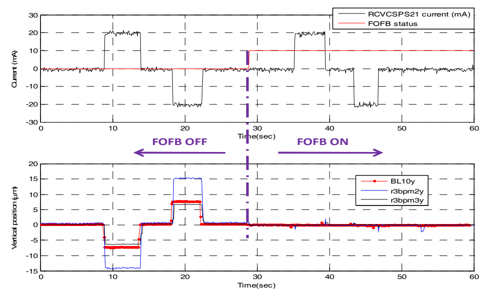


Figure 3: Beamline 10 photon BPM 10Hz reading signal related to the ring BPM.

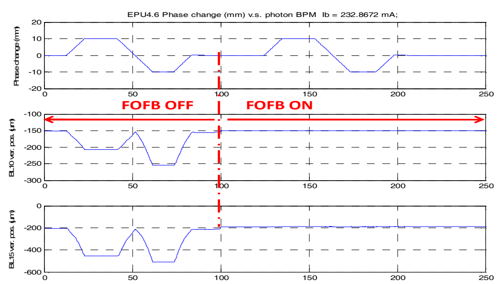
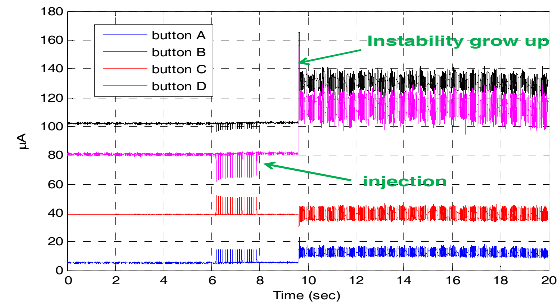


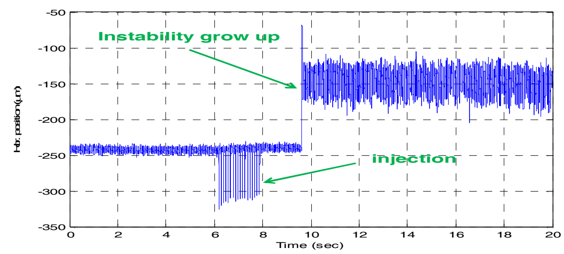
Figure 4: Beamline 10 & 11 photon BPM vertical position change v.s. EPU 4.6 phase change with/without FOFB.

TRANSVERSE INSTABILITY EFFECT ON PHOTON BEAM POSITION

In the past post-mortem analysis, the data had often been revealed that the photon beam position changed before the beam trip while we compared it with the electronic orbit which was not presented such the similar drift behavior. On the other hand, it seemed to happen accompanying with transverse bunch-by-bunch instability. To clarify the phenomenon, the experiment of transverse instability effect on photon beam position was done. Fig. 5 shows the four blades input and the corresponding horizontal position change before and after transverse bunch-by-bunch feedback on/off. It could be clearly observed that the photon currents of the four blades became quite much noisy when instability grew up and blade B and D increased around 30% but blade A and C remained. It thus resulted in the horizontal photon position changed 90 um as Fig 5(b) and the vertical change was 25 um. However, the instability actually did not affect the electrical beam orbit. It could be caused by the geometry of pBPM and were differed from one by one. In additional, the similar longitudinal instability experiment was also done while it showed that the longitudinal instability affect neither blades readings nor position calculation.



(a)

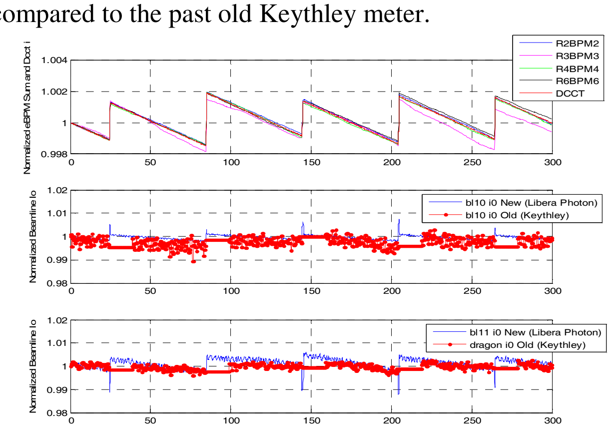


(b)

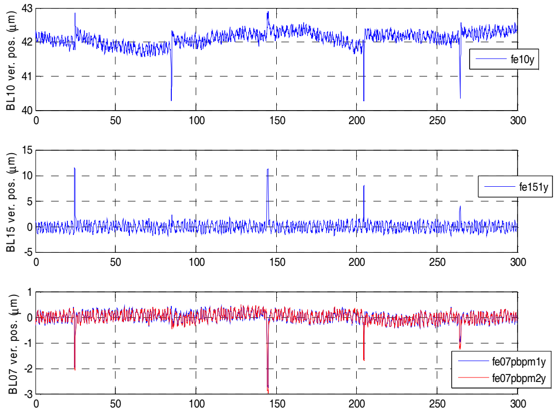
Figure 5: (a) The four blades reading for transverse bunch-by-bunch feedback on/off (b) the horizontal photon beam position change for TBF on/off

PERFORMANCE COMPARISON OF APPLICATION ON BEAMLINE INTESNSITY MEASUREMENT

Since the pBPM electronics are equipped with four port input, there would be two ports remained not occupied when it is applied 2-blades pBPM. Therefore the possible application to measure beamline photon intensity Io is considered. For example, pBPM10 is 2-blades type, only B and C channel are used to calculated vertical position, the rest channel A and D thus is connected to bl10Io and bl11Io input to monitor photon intensity change. The similar scheme is also applied to measure pBPM23, bl18Io and bl22Io. Fig. 6 shows the DCCT, electrical and photon beam intensity in top-up mode. DCCT and eBPM sum measurement seems to be apparently precise and is independent of beam position change compared pBPM. However, it still could be an enough auxiliary tool compared to the past old Keythley meter.



(a)



(b)

Figure 6: (a) DCCT, electrical and photon beam intensity in top-up mode (b) the corresponding pBPM position change.

From the above figures, the photon intensity is quite affected by position change especially during injection. If the transient spike caused by injection could be excluded, it would be much useful to measure Io. Fig. 7 shows the similar photon intensity, BPM sum value and beam current change during injection from zero to 360 mA. These 10 Hz data looks smooth due to the continuous injection and linearity with beam current looks better. Nevertheless, compared to the BPM sum, it is not so completely consistent.

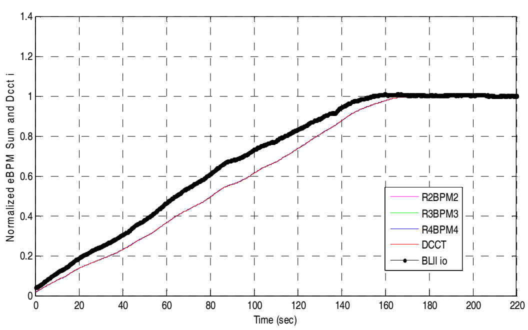


Figure 7: photon intensity, BPM sum value and beam current change during injection from zero to 360 mA.

POST-MORTEM FUNCTIONALITY OF PHOTON PBM

The photon BPM is equipped with post mortem buffer up to 16000 samples which can record 1.6 sec data changes before and after external beam trip trigger according to post-mortem buffer offset. The recorded length is allowed to observe the orbit related behaviour. High bandwidth also enables to look at some fast transient variation. It is planned to be integrated into the existing post-mortem diagnostic system [6] and provide another confirm mechanism to analyze to the causes of beam trip and further to improve machine reliability. Fig. 8 shows the post-mortem data at one beam trip event. The post-mortem buffer offset is set to 2000 so the beam trip signal arrived at time 1.4 sec. According to the data, although it can't be figured out the exact cause of this trip, it can be at least excluded the causes from orbit change neither partial beam loss.

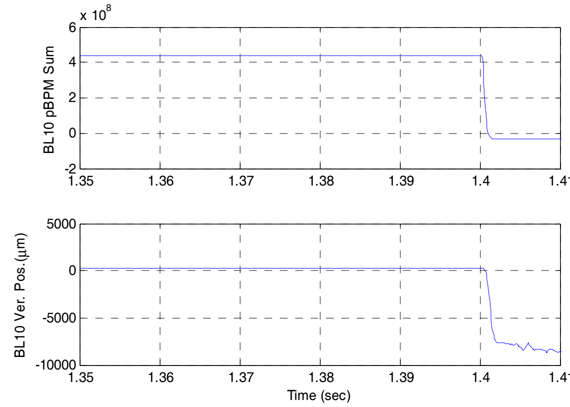


Figure 8: BL 10 Photon BPM post-mortem data. The beam trip occurred at time 1.4 sec.

SUMMARY

This report presents the several primary tests of photon BPM electronics. It displays competing sub-micron performance and provides various data flow to observe fast transient and slow averaging photon motions in real time. The EPICS compatible environment is also very beneficial to integrate with the control system of the future TPS project. Since the fast links is also compatible with the TPS orbit feedback control system, its possible application in the orbit feedback will be carefully considered.

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