TLS TRANSPORT LINE BPM UPGRADE

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Abstract

There are seven stripline type beam position monitors (BPM) installed in TLS booster to storage ring transport line. In order to provide better performance and functionalities, the latest generation BPM electronics had been adopted in TLS transport line BPM system upgrade. One unit had been tested in early 2011 and delivered the reliable and satisfactory results therefore extra six units had been purchased later. Currently, all of the new 7 units have replaced the past BPM electronics. The application had also been continuously developed. On the other hand, it is expected that the upgrade could enhance diagnostic functionalities for the transport line. In this report, the transport position and beam intensity stability had been investigated.

INTRODUCTION

TLS booster to storage transport line (BTS) has 7 orthogonal BPMs which could be used to measure beam position and intensity. No electronics accompany with these BPMs during the commissioning stage. Log-ratio BPM electronics were installed in 2002 [1]. To deliver a better functionality and provide a test bed for the 3 GeV Taiwan Photon Source (TPS) a new synchrotron light source which being construction at same site of TLS, commercial BPM electronics Libera Brilliance Single Pass [2] were installed at TLS BTS in 2012. It also supports EPICS environment and provides various data flow for multiple purposes. One unit of BPM electronics had been tested in 2011 [3] and provided the precise beam position and intensity measurement in the TLS transport line. It had been also applied for TPS Linac later for the factory delivery acceptance [4]. Taking the future maintenance and performance into considerations, all of the seven transportline BPM are determined to upgrade to the new generation instrumentation.

TLS BTS BPM SUMMARY

TLS booster to storage transportline is around 70 m long and its layout is as Fig. 1. Seven red circles present seven stripline BPM locations; there are seven horizontal and vertical bending magnets installed. The transportline chamber shape is circular with 58.5 mm diameter and BPM electrode radius is 4.5 mm. The calibration factor for Kx and Ky are both 15 mm. The BPM mechanic drawing is shown as Fig. 2(a). Figure 2(b) shows the simulation of BPM sensitivity and nonlinearity calculation.

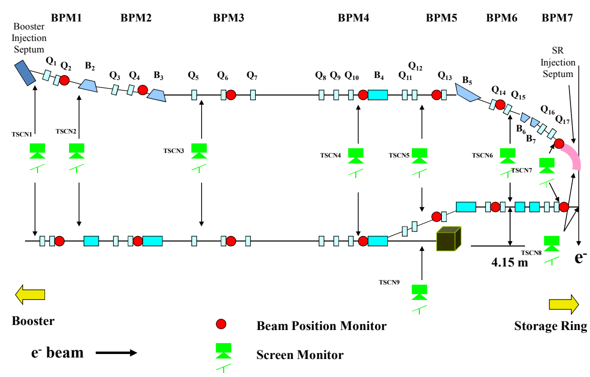
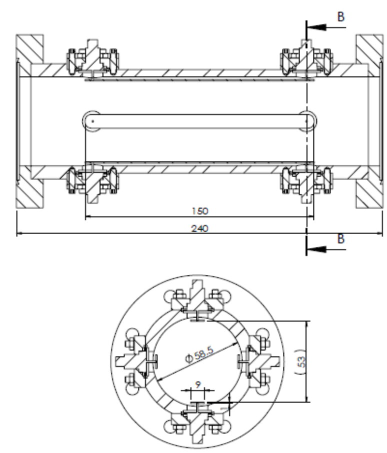
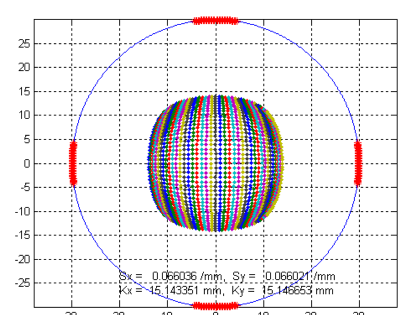


Figure 1: TLS BTS Layout Transport line layout and the BPM installation. Red circle present BPM; blue rectangles represent quadrupoles.



(a) BPM drawings.



(b) BPM sensitivity and nonlinearity calculation.

Figure 2: The BTS stripline BPM.

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BTS BPM CONTROL INTERFACE

The upgraded BPM had been integrated into TLS home-made control system including archive with 10 Hz update rate. The installation is shown as Fig. 3. Since the electronics also provide EPICS server, GUI for display and configuration by EPICS EDM toolkits are also implemented as Fig. 4. Otherwise, TPS would adopt EPICS, these will be also applied for the related single pass BPM in TPS project.

Figure 3: Seven Libera Single Pass installed.

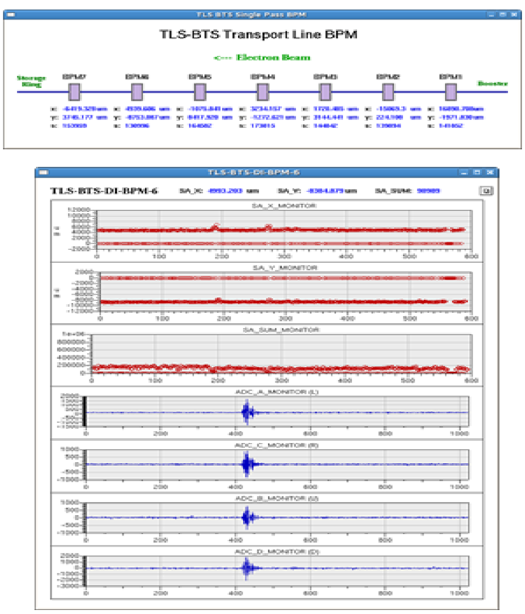


Figure 4: BTS BPM GUI for display and configuration.

BPM ELECTRONICS PERFORMACE MEASUREMENT

The beam extracted from the booster synchrotron is around 200 pC changes distributed in 50 nsec bunch train (~ 25 bunches) while it remains a half (~ 100 pC) when it enters into the transportline [5][6]. We measured the resolution by the real beam where the experiment's setup is as Fig. 5. It should be a worsen case but the resolution should actually be better measured by the signal generator. Nevertheless, the 2.2 um RMS resolution seemed better than expected and it was inferred possibly due to multi-bunch beam pattern where the multi-bunch with strong 500 MHz components also had stronger response than single bunch with the same electron quantity after passed by band-pass filter. Since TLS could not operate in single bunch mode, it would be verified later. Fig. 6 shows the results of horizontal and vertical position histogram with 14 dB attenuator plus cable loss and 6 dB splitter loss.

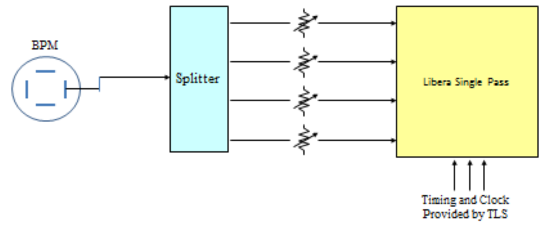


Figure 5: Setup for resolution measured by beam.

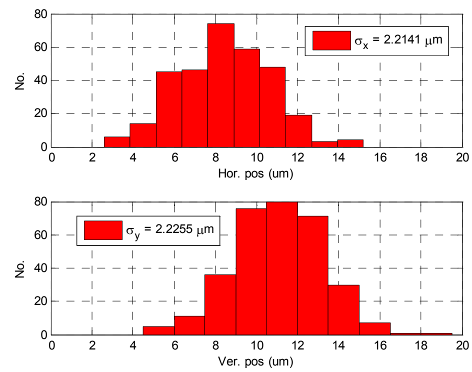


Figure 6: Histogram of horizontal and vertical position.

The position dependency and its effect on resolution are also evaluated by adjusting the inner attenuator inside the BPM electronics by real beam. Figure 7 shows the RMS resolution could achieve 2 um with the proper attenuator while it should be noticed to avoid ADC saturation. In our condition, the attenuator lower than 10 dB could cause saturation occasionally if booster current increased.

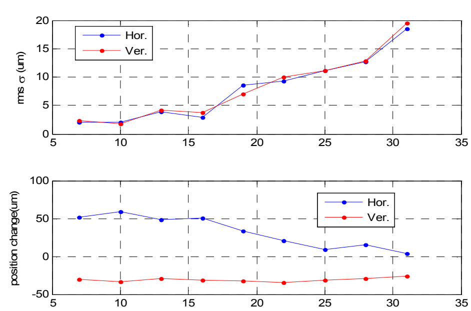
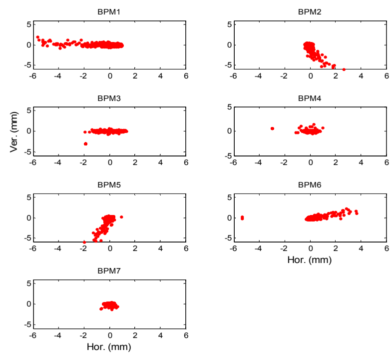


Figure 7: (a) The RMS resolution (b) The position dependency with different attenuator settings.

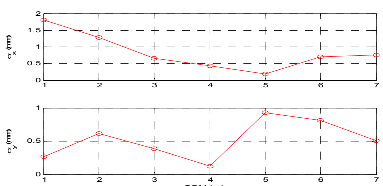
BTS BPM POSITION STABILITY OBSERVATION

Figure 8 (a) shows transport line BPM position distribution during 10 hours recording at top-up mode injection. The overall average position stability is around

490 um for horizontal and 270 um for horizontal. The position vibration is over 5 mm peak to peak at some BPMs. It could be suspiciously resulted majorly from energy drift. Figure 9 (b) shows the standard deviation where the largest σ_x located nearby BTSBPM1which just has largest dispersion η_x and the largest σ_y located nearby BTSBPM5 which has largest dispersion η_y as well as Fig. 6.



(a)



(b)

Figure 8: (a) Transport line BPM position distribution record during 10 hours at top-up mode injection. (b) Standard deviation for horizontal and vertical position.

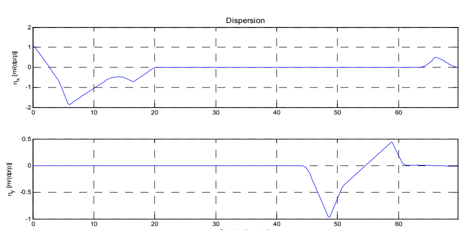


Figure 9: Dispersion for the Storage Ring transport line.

TL BEAM INTENSITY MEASURED BY BPM SUM SIGNAL

There are three ICTs (integrating current transformer) installed at the TLS transport line for beam intensity measurement while the accuracy of the first and the third ICTs would be affected by the nearby septum and kicker fields during injection. Although BPM sum signal could not present absolute current intensity, it could provide more precise relative beam loss ratio when the beam passes by each BPMs if the position stability is assured. After cable loss calibration, it does be a more economical solution for beam intensity indicators compared to the ICT and possibly used for efficiency calculation at the transport line. Figure 6 shows the 3 ICTs and 3 BPM sum signal comparison. The three BPM sum readings show more consistent and reliable than ICT’s.

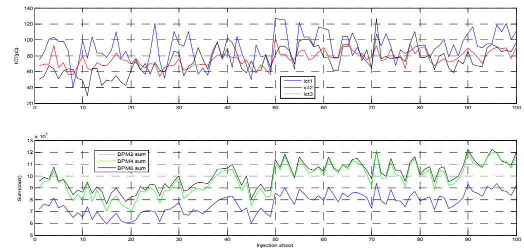


Figure 6: Three ICTs (above) and three BPM (below: 2nd , 4th and 6th) sum signal readings in the TLS transport line.

SUMMARY

The BPM electronics at TLS BTS transport line has upgraded for the latest instrumentation. It provides diverse functionalities to enhance various diagnostics for the transport line. The transport line beam stability had studied. Horizontal variation is almost twice than vertical and it is suspicious resulted for energy instability. Besides, the BPM sum signal is tried to apply for intensity measurement while it has strong position dependency but is still consistent and reliable when the position is stable.

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