Injection Efficiency Diagnostic at Taiwan Light Source Storage Ring

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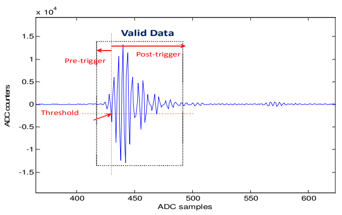
Abstract

TLS is now running at 360 mA top-up mode. In the normal situation, it takes few minutes for injection from zero current to 360 mA. When the machine condition is drifted or parameter settings are reset improperly, however, injection efficiency sometimes become worsen and it is necessary to adjust some machine parameters such as quadrupole strength, transport line correctors or booster dipole to improve efficiency. In the present, the injection efficiency is roughly based on the charge loss from the booster to storage ring. To determine the more precise efficiency from different transmission paths, some diagnostic tools are developed. A single pass BPM was tested and installed in the first BPM of the transport line. Moreover, BPM sum reading of the storage ring is also developed to provide 10 kHz waveform display every one second. Operators could utilize it to estimate efficiency more precise, quickly and easier.

Introduction

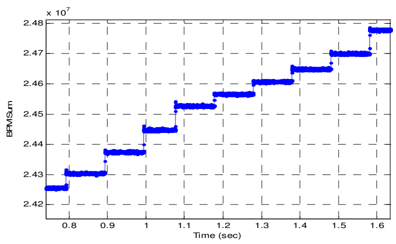
- TLS had changed from decay mode to top-up mode in 2005.
- In the top-up mode, maintaining stable storage ring current has become important for users' experiments. This stability should need both stable booster current and injection efficiency.
- In general, the overall injection efficiency from booster to storage ring was around 41.6% while it deviated from time to time for different conditions.
- Some new diagnostic tools to observe storage ring and transport line current intensity will be introduced and the procedure to estimate the injection efficiency will also presented. Moreover, the possible causes which effect on efficiency will also be investigated.

Single Pass BPM to Measure Transport Line Beam Position and Intensity



- TLS booster to storage transport line has 7 orthogonal BPMs which could be used to measure beam position and intensity.
- Brilliance Single Pass which provides a standard solution and has useful functions of threshold and pretrigger & posttrigger is chosen.
- It also supports EPICS environment and provides various data flow for multiple purposes.
- One unit of Libera Brilliance Single Pass was installed at the first BPM of the booster to storage ring transport line of the TLS for evaluation purpose.
- The above figure also shows one button ADC raw data. The valid portion of the data is extracted according to three parameters THREHOLD, PRETRIGGER and POSTTRIGGER.
- The beam extracted from the booster synchrotron is about 200 pC in change distributed in 50 nsec bunch train (~ 25 bunches).

BPM Sum as an Indicator of Storage Beam Current



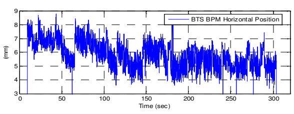
➢R1BPM3 10 kHz sum readout.

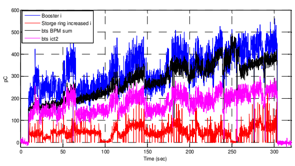
- DCCT provides high accurate current readout of the storage ring while 10 Hz readings could not clarify some fast transient phenomenon.
- A diagnostic tool which is embedded with EPICS IOC and based on BPM sum reading is developed to provide 10 kHz waveform display every one second.
- However, it should be very careful that using BPM sum as an indicator of beam current intensity should consider the effect of position dependency.
- R1BPM3 with lower βx andβy is thus chosen for BPM sum readout.
- The above figure shows R1BPM3 10 kHz sum data. It is clearly observed that septum effect completely disappears and kicker effect is hardly observed either.

Injection Observation

• 360 mA Beam Store Injection

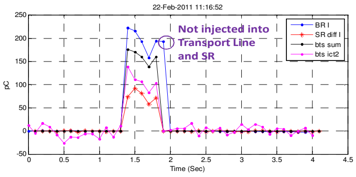
- The right figure shows an example of these charges during injection. It takes around 5 minutes of this injection when storage ring current is accumulated from zero to 360 mA.
- The average injection efficiency actually is around 18.3% in this injection process.
- The booster charges gradually increased while the storage ring charges didn't. It seemed that machine condition varied (see BTS horizontal position also gradually drifted).
- It is expected that more diagnostic tools developed to help to clarify the unclear process.



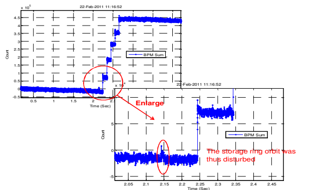


➢Booster, BTS BPM sum and hor. position and DCCT and Storage ring increased charges.

• Top-up Mode Injection



➢Booster, Transport line BPM sum and DCCT and Storage ring charges during top-up injection.

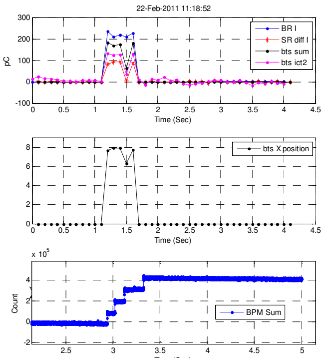


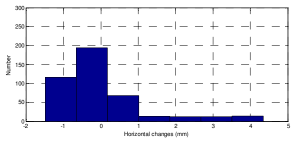
➢R1BPM3 10 kHz sum readout. The red circle of the below picture remarks that booster has no current but pulse magnet still fired caused the orbit disturbed.

- In TLS top-up mode operation, the injection cycling is 10 Hz and the injection time is 1.8 sec in every minute.
- The above left figure shows an example during top-up where the charge number decrease gradually due to loss. It can be observed that the injection efficiency is much related with booster current.
- Otherwise, the booster charges weren't injected into the transport line in the last time injection. The phenomenon almost be appeared at each injection and inferred due to pulse magnet timing.
- Another pulse magnet trigger problem was also observed by the storage ring BPM sum 10 kHz data as the above right figure. The orbit was disturbed before 100 msec of injection start where BPM sum value was increasing. However, at the first time pulse magnet was actually fired while booster had no current such that the orbit was disturbed but no current increase at the storage ring.

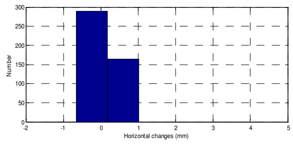
Several Possible Parameters to Effect on Efficiency

- Energy variation which could affact injection efficiency is observed by horizontal position change at high dispersion location
- The right figure shows during the 4th injection the charges were hardly captured and accumulated at the storage ring for its possible energy mismatch causes the 2/3 charges loss at the first entrance of the transport line and the rest 1/3 charges completely loss at the end.
- This possibly related horizontal position change or energy variation.



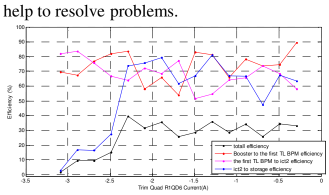


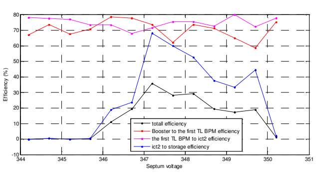
➢LTB BPM1 (high dispersion) horizontal position change.



➢LTB BPM4 (low dispersion) horizontal position change.

- To investigate the energy vibration effects on injection, two locations of transport line with the respective high and low dispersion was chosen and look at the position stability at every shoot of injection.
- The leftt two figures shows the histograms of the BTS BPM1 and BPM4 horizontal position change during 3 hours. Since horizontal variation (σ≒1.25 mm) is respectively larger than low dispersion BPM4' horizontal changes (σ≒0.30 mm), it can be inferred that it should be probably resulted from energy vibration.
- The position deviation over 2 mm will significantly deteriorate injection.
- Septum charging voltage and trim quadrupole strength are the other two factors which are used to optimize injection efficiency. The below two figures show these two factors changes effect on injection efficiency respectively between different transmissions.
- The two factors have major influences on the end transport line to the storage ring while less impact on the other transmission path.
- The acceptable settings are allowed quite big range. However, if the threshold is across, the efficiency drops dramatically.
- The TLS injection efficiency is not so well while the lack of diagnostic tools lead it difficult to find out the exactly influential cause to improve efficiency. The future expansion is expected to really help to resolve problems.





Summary

- The injection efficiency from the booster to the storage ring could be tuned and optimized up to 42% while it had often been lower than 20% when the machine condition is drifted or parameter settings are reset improperly.
- It is expected that more diagnostic tools could be developed to determine the precise efficiency and help to improve the injection efficiency.

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