ORBIT STABILITY OBSERVATION OF THE TAIWAN LIGHT SOURCE

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Abstract

Since the diagnostic functionality built with the new BPM system upgrade in TLS, we can observe and analyze the orbit stability more clearly and systematically. The disturbances to cause orbit fluctuation mainly come from power supply ripple, ground vibration, ID effects and etc. Removing the disturbed source is a straightforward, effective but inactive solution. Orbit feedback system is therefore adopted to suppress the remaining noise. In this report, we will evaluate the orbit stability in TLS and present the efforts we have done to improve the orbit stability.

INTRODUCTION

The stabilization of the electron orbit has been becoming an emphatic issue at the recent synchrotron light source because it directly affects the intensity of the photon beam delivered to beam lines. In general, micron level beam stability beam is required especially in vertical plane. To achieve such stringent requirement, various efforts and studies have been continuously performed such as orbit feedback system implement, corrector power supply and BPM electronics upgrade. However, due to hardware limitation, fast disturbances such as orbit excursion due to septum field leakage are hardly removed by the orbit feedback system which has just limited capability to suppress noise from DC to several Hz. As a result, besides migration to a new fast orbit feedback system [1], efforts to identify various sources and minimize their effects on orbit stability are under way. In the following paragraph, we will present the current orbit stability status of the TLS and summarize the disturbed sources to make orbit motion. Next, a simple scheme is proposed to localize the single disturbed source. Finally, to reduce the orbit excursion due to septum leakage, one dedicated magnet is installed to stabilize electron beam during injection.

ORBIT STABILITY STATUS

The linear type corrector power supply was replaced by MCOR 30 [2] both in the horizontal and vertical planes. Performance of the new MCOR30 power supply is 5 times better than the old one in noise level and has large small signal bandwidth. After corrector power supply upgrade, orbit stability in the vertical plane has been improved from integrated PSD 8 μm^2/Hz to around 2 μm^2/Hz; horizontal orbit has also been more stable with integrated PSD around 7 μm^2/Hz from DC to 100Hz. Orbit stability comparison between prior and posterior to the power supply upgrade is shown in the below Fig. 1 and Fig. 2. Generally, this stability has satisfied 10 % beam size stability requirement for the synchrotron light source. To further improving stability down to submicron for more stringent requirement in the future, however, various efforts have continued.

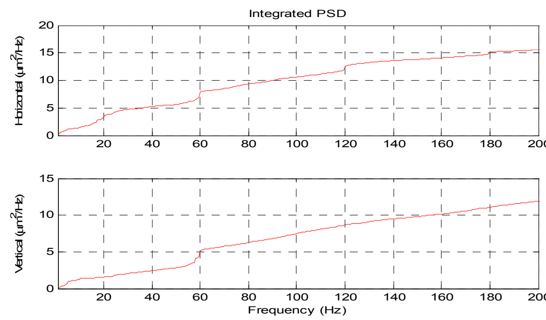

Figure 1: Integrated orbit stability before horizontal power supply upgrade.

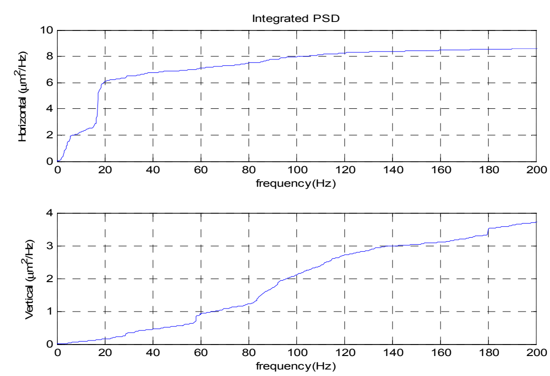

Figure 2: Integrated orbit stability after horizontal power supply upgrade.

VARIOUS DISTURBED SOURCES

After commissioning of the new BPM system in 2008, we can observe orbit motion systematically in the range from DC to 5 kHz with better resolution. Through a period of track and study, it can be concluded that the orbit motion is contributed mainly from some ill power supply, ground vibration, and septum field leakage during injection.

Ill Power Supply Example

One strong 120 Hz power line and its corresponding harmonics of a problem power supply was observed, its spectrum and corresponding orbit spectrum is shown in Fig. 3 and Fig. 4 respectively. This disturbance induced orbit swing above 10 micron with several hundreds of Hz spectrum lines. Locating and removing this kind of source is simple, direct but efficient. In the next section, we will present a scheme to localize the single noise source.

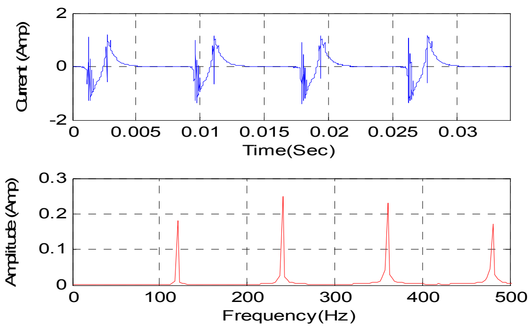

Figure 3: Superconducting wiggler power supply current readings and its spectra amplitude.

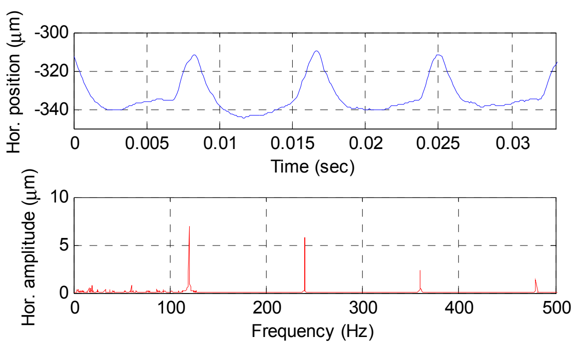

Figure 4: Orbit motion due to the ill superconducting wiggler power supply.

Septum and Kicker Field Leakage

TLS is now operated in top-up mode. During the period of injection, the leakage filed of septum and kicker will cause the orbit excursion and make effects on the light source strength and precision where it is shown as Fig. 5 and Fig. 6. The experimental station should exclude the sampled data during injection by the provided gating signal. In the later section, we will introduce a simple method to eliminate orbit excursion less than one-tenth.

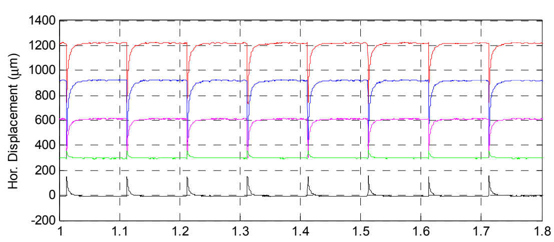

Figure 5: Orbit motions of 5 BPM during injection caused by kicker and septum.

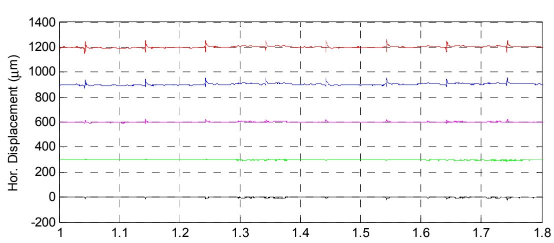

Figure 6: Orbit motions of 5 BPM during injection caused by kicker only.

Ground Vibration

In the third synchrotron light sources, the machines are designed with strong focusing. The orbit amplification factors of qadrupoles are usually as high as 50 or more. Therefore, the vibrations of quadruple are most critical as we investigate in the Fig. 7. Its spectrum shows quite wide-band and spreads between 15~25Hz. Each qaudrupole is characterized by its location at different girders. Fig. 8 shows the BPM disturbance caused by the corresponding ground vibration where its spectrum also spreads between 15~25 Hz. Orbit movement contributed by vibrations is around 1 μm and it can be suppressed to at least the half by fast orbit feedback system [1].

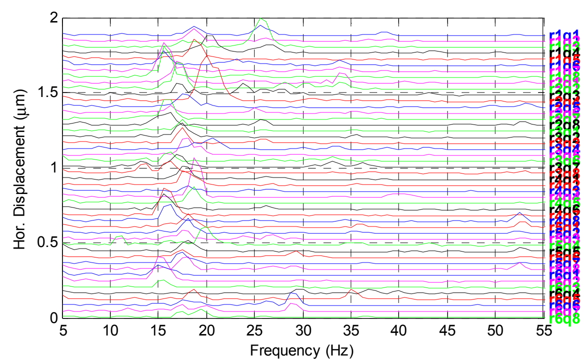

Figure 7: Quadrupole horizontal vibration.

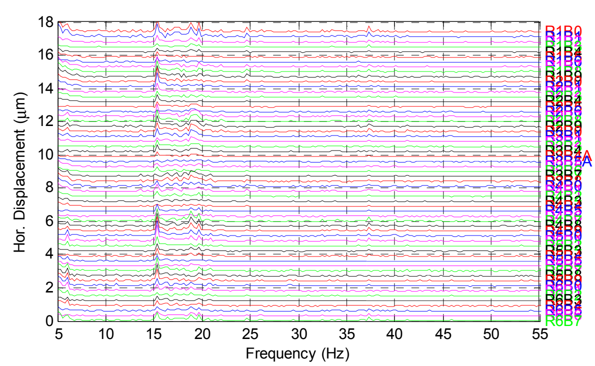

Figure 8: Horizontal orbit motion spectrum. The noise spreading between 15~25 Hz is correlated to the ground vibration.

A SIMPLE METHOD TO LOCALIZE THE SINGLE SOURCE

The method to localize a single noise source is demonstrated below. A response matrix can map all correctors to all BPMs in the ring. Through a trigger mechanism built in the Libera, we can collect all BPM synchronous waveform and get its spectrum. The amplitude and phase part of the spectrum at a frequency of interest is extracted. By multiplying amplitude by sign of phase, we construct an AC orbit at the single frequency [3]. This AC orbit correlates with the response matrix and the location of the unknown noise source can be reconstructed. To validate the method, an example is described.

Several months ago, we observed a strong power line horizontal noise at 120 Hz. Its orbit amplitude, phase and the corresponding AC orbit at 120Hz is as Fig. 9. Comparing the AC orbit with all of the horizontal corrector response, we can figure out the largest correlation of the noisy AC orbit and the respective corrector is R5HC3 as Fig. 9 and Fig. 10. It can be concluded that noisy source may locate nearby R5HC3 and finally, we find out the noise produced from one power supply of Superconducting Wiggler 6, which exactly is nearby R5HC3.

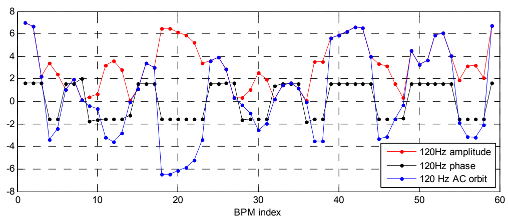

Figure 9: 120 Hz horizontal BPM amplitude, phase and AC orbit.

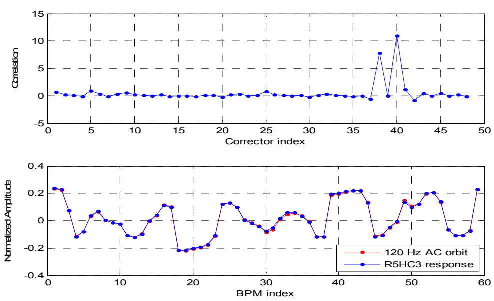

Figure 10: The above figure is correlation between 120 horizontal AC orbit versus all horizontal correctors. The below one shows the AC orbit and its most relevant corrector (R5HC3) response.

ORBIT EXCURSION DUT TO EDDY CURRENT INDUCED BY THE SEPTUM FIELD LEAKAGE AND EFFORTS TO ELIMINATE THIS EFFECT

A dedicated air core corrector to compensate for the orbit excursion caused by eddy current due to septum leakage is installed near the location of the septum. A waveform generator is triggered synchronously with the injection trigger. As Fig. 11 shown, it can compensate for the orbit excursion maximum amplitude from several hundreds of microns down to tens of microns.

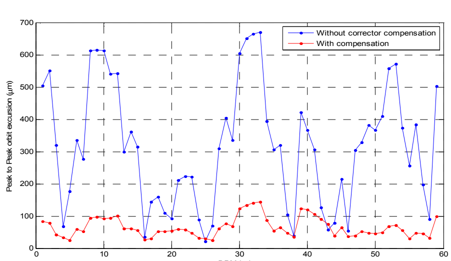

Figure 11: Maximum orbit excursion amplitude due to septum and compensated by the correctors.

To understand the residual orbit excursion, we carefully analyze the behaviour of the septum and kickers and discover both of them induced eddy current which excites the orbit excursion as in Fig. 12. The kicker-caused excusion is much smaller than the septum and hardly compensated by a simple air core corrector due to its quite fast response for the TLS case. The experience will be beneficial for the future TPS injection system design.

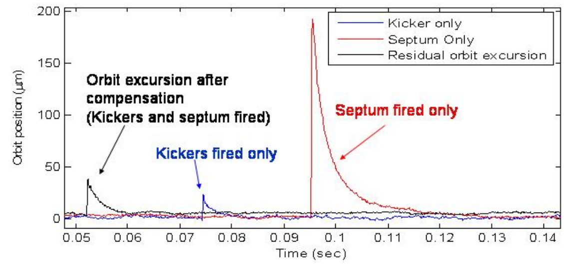

Figure 12: Orbit excursion of R6B7 due to septum only, kickers only and the residual orbit after compensation by the dedicated corrector.

CURRENT EFFORTS

Orbit stability requirement for TLS has been achieved to less than 10% of beam size while various efforts still continue to further improve orbit stability. Fast orbit feedback system upgrade is one of the most primary works. In the mean while, identifying source hardly removed by feedback system is also proceeded. It is expected that these will aid for the TPS project.

SUMMARY

BPM electronics and switching power supply are employed to improve orbit stability and it has been shown a great result of integrated PSD from 8 μm^2/Hz to 2 μm^2/Hz in the vertical plane; from 10 μm^2/Hz to 7 μm^2/Hz in the horizontal plane from DC to 100 Hz. A scheme for extracting AC orbit and locating the noisy source responsible for the fixed frequency orbit has been developed. This method has been proven to be applied successfully to identify the location of an ill power supply with 120Hz ripples. Moreover, to eliminate orbit excursion caused by the eddy current due to septum leakage, a horizontal power supply is installed and has reduced effectively horizontal orbit excursion from hundreds of micron to tens of micron.

REFERENCES

[1] C.H. Kuo, et al., “Fast Orbit Feedback System Upgrade in the TLS”, Proceedings of ICALEPCS 2007.
[2] http://www.bira.com/.
[3] Xiang Sun, et al., “Localization of Noise Sources in the APS Storage Ring Using the Real-time Feedback System”, Paper ID TUPTPF016, Proceedings of the 2008 Beam Instrumentation Workshop.