ORBIT FEEDFORWARD AND FEEDBACK APPLICATIONS IN THE TAIWAN LIGHT SOURCE

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Abstract

Taiwan Light Source (TLS) is a 1.5 GeV third-generation light source with circumference 120 meters. TLS is operated at 360 mA top-up injection mode. The storage ring is 6-fold symmetry with 6-meter straight sections for injection, RF cavity, and insertion devices. There are three undulators were installed in three straight sections to delivery VUV and soft X-ray for users. Beside there undulators, a conventional wiggler (W200 installed at straight sections to provide hard X-ray to serve user. Working parameters of hard X-ray sources are fixed without cause problem on operation. However, undulators should be changing its working parameters during user experiments performed. These undulators during its gap/phase changing will create orbit perturbation due to its field errors. Orbit feedback is main tool to keep orbit without change. However, some correctors setting of the orbit feedback system are easy to saturation due to large perturbation come from U90. To keep functionality of the orbit feedback system working in good condition, combines with orbit feedback and feed-forward is proposed and reported in this conference.

INTRODUCTION

The current orbit feedback system was deployed in ten years ago. There are various correctors are installed in the storage of TLS. The corrector open loop gain is from 30 Hz to 100 Hz with vacuum chamber. Therefore, the orbit feedback system cannot be operated at full bandwidth. These correctors are shared with same power-supply for close orbit correction and feedback. The main setting range of corrector is for close orbit request. There is one fifth setting range of full scale for orbit feedback. That is easy to saturate for corrector. The main orbit perturbation source is from insertion device by the operation experience during the past twenty years. To accommodate fast operation of various insertion devices and provide better orbit stability, the BPM electronics and corrector power supplies are replaced step by step. Figure 1 shows the beam position reading during the phase change of EPU5.6 undulator with and without orbit feedback response at the R1BPM0 and R1BPM8 which are equipped with Libera Brillance [1,2]. Orbit perturbation due to EPU5.6 is suppressed by feedback system while high speed operation of the insertion devices is still restrained by low closed loop bandwidth of the orbit feedback system. The feed-forward orbit control for insertion is also applied with orbit feedback system to reduce corrector strength of orbit feedback and keep from saturation.

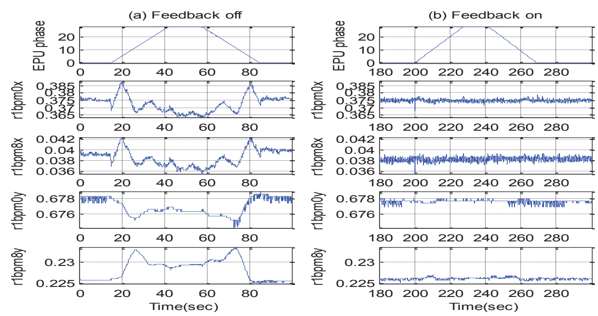

Figure 1: Effectiveness of the orbit feedback loop versus phase change of the EPU5.6 undulator. (a) without feedback; (b) with feedback.

To satisfy stringent orbit stability requirement of the TLS, low noise corrector power supply, and reliable orbit feedback system for long-term operation are necessary.

FEEDBACK SYSTEM

BPM Electronics

Libera Brilliance's integration had risen from 2007. The migration is gradually deployed not to interfere with the routine operation. To reduce GbE jitter and achieve better performance, numbers of Libera Brilliances are grouped together to produce a packed GbE UDP packet to reduce the number of IP packets. All Libera Brilliance will be grouped together [3].

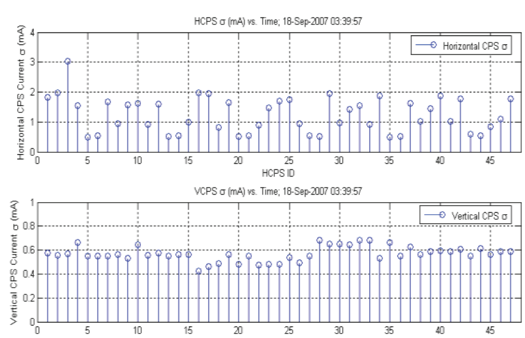

Figure 2: Power supply performance of the old power supply and the MCOR 30 power supply.

The corrector power supply is already replaced by MCOR 30. Standard deviation of the vertical power supplies (vertical corrector) and horizontal power supplies (horizontal corrector) in 100 sec readings are shown in Fig. 2. The power supply current readings of the vertical corrector power supply have the around 0.5 mA standard deviation since it is limited by the 16 bit ADC module.

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Power supplies performance can be better than 16 bits. Each MCOR crate can be equipped 8 MCOR 30 power supply modules to save space. System bandwidth is determined by a whole of power supply, corrector and the vacuum chamber from 30 Hz to 100 Hz with difference plane.

The fast BPM data delivery of the orbit feedback system is by reflective memory that is employed to shares fast orbit data without consuming extra CPU resource. The orbit data will be acquired by several VME G4 PowerPC CPU modules equipped with two GbE ports. The orbit data will be shared by the reflective memory mounted to the 5 VME nodes for beam position acquisition, feedback engine and the diagnostics node. After the migration completed, higher sampling rate (5 KHz or 10 kHz will be determined according the computing power of existed CPU module) is planned rather than the current 1 kHz sampling rate [4, 5, 6].

Noticeable jitter will introduce if 10 kHz rate UPD packages transmitted by many Liberas and processed by a G4 PowerPC CPU module running LynxOS. This may degrade performance of feedback system and even lead to instability. The Libera group which packs numbers of Liberas payload data into a single UDP packet to reduce the GbE traffic is therefore concluded and its operation is being in implementation phase. It is planned that each PowerPC CPU will receive an UDP package from a group of Libera Brilliance to eliminate the problem of processing jitter.

Since there are no dedicated fast correctors at TLS, setting of the DC closed orbit control and the fast correction signal will sum in an analogue way. It will be implemented by an in-house made interface card mounted to the leftmost slot of MCOR crate which adds the setting command and feedback correction setting to the power modules. Since the switching power supplies will replace all of the current linear power supplies, we expect the integration will be accomplished in the meanwhile. New corrector power supply combined with magnet and vacuum provide an about 100 Hz and 30 Hz open loop bandwidth in vertical and horizontal plane respectively. Closed loop bandwidth can achieve 100 Hz in vertical plane without problem. To achieve more than 60 Hz or higher bandwidth in horizontal plane, a compensator is in study.

Capture fast orbit data for 10 seconds are valuable to the orbit performance monitoring, system modelling and post mortem analysis for some unexpected events. A diagnostics node will be setup for this purpose. The captured data will be analysis in Matlab environment. Hardware and software trigger mechanism with pre-post transient recorder will support. Combined with post mortem buffer for turn-by-turn data inside the Libera Brilliance and data captured by this diagnostic node might be very useful for clarifying various reasons of beam trip, this is essential to improve system reliability.

BPM Data Access and Grouping

There are several data format flows are provided by the Libera Brillance with EPICS interface including of 10 Hz rate data for DC closed orbit correction, turn-by-turn data with software/hardware trigger and on demand access for accelerator physics study, streaming 10 kHz fast data for orbit feedback application. The fast data is also very useful for beam diagnostic.

FEEDFORWARD SYSTEM

There is only slow corrector in the TLS. The corrector power supply for both orbit feedback and close obit control in the range of ±10 Amp corresponding to +/- 30 μrad and 600 μrad maximum kick angle respectively. These power supplies will be controlled by analogue interface directly. The most corrector strength is for close orbit control request. There is ±2 Amp that is reserved for orbit feedback. The maximum orbit perturbations are from insertion devices in the routine operation. The U9 gap moving with orbit perturbation is shown in the Figure 3, 4. There are few hundreds micro meter orbit difference when U9 gap is from open to minimum gap.

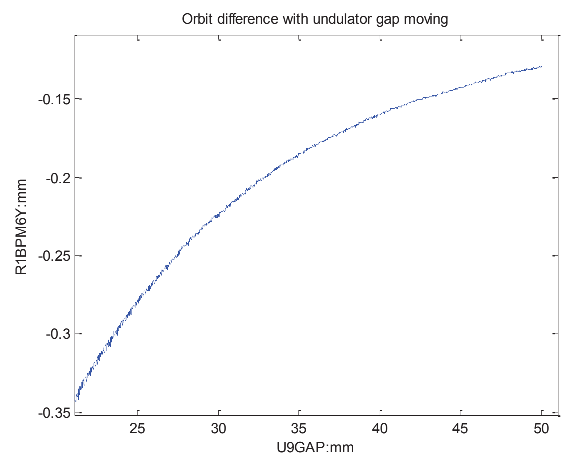

Figure 3: U9 gap moving without orbit feedback. There is 200um orbit perturbation in the R1BPM6Y.

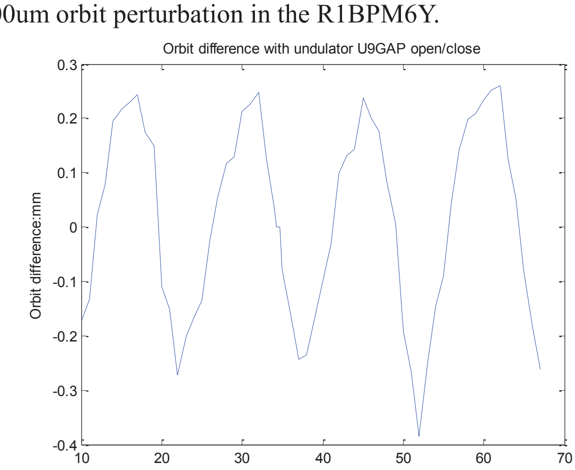

Figure 4: Full orbit difference between U9 gap open and close without orbit feedback and feed forward control.

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These insertion device operations will take saturation of corrector. Feed forward control with gap difference is by the neighbourhood correctors of insertion devices that will be effective to reduce this status. Fig. 5 shows corrector reading difference that orbit feedback is only turned on, or orbit feedback and feed forward of both are turned on when insertion device gap is moving.

The corrector strength is transferred to other correctors successfully from close loop correctors of orbit feedback. The feedback and feedforward is operated together that will lock orbit and keep from saturation. The operation performance is shown in the Fig.6. There is 5 um orbit difference with feedback and feed forward in this best sensible location.

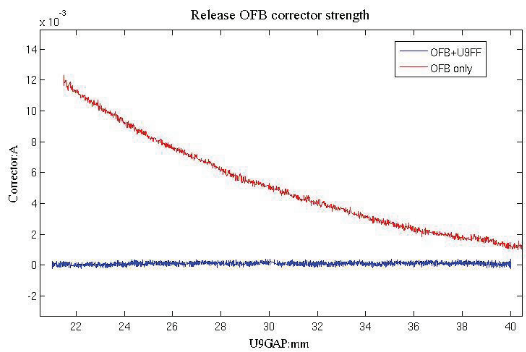

Figure 5: Corrector power-supply reading when U9 gap control with feed forward or feedback system.

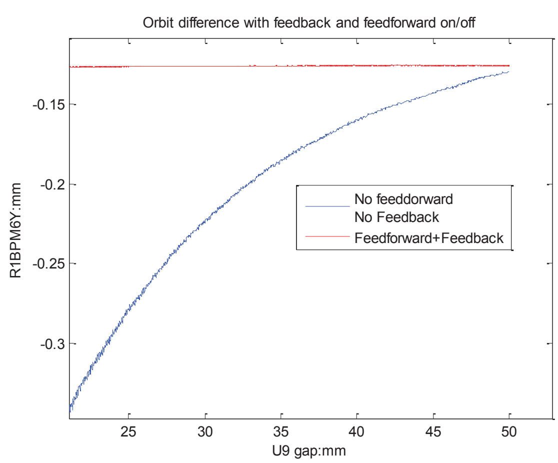

Figure 6: U9 gap control and orbit perturbation with feedback and feedforward on/off. Blue line is no feedback, no feed forward. Red line is feedback and feed forward on.

The feed-forward control has advantage those are simpler in their layout, hence are economical and stable too due to their simplicity. Since these are having a simple layout so are easier to construct. But they are very inaccurate in terms of result output and hence they are unreliable too. Due to the absence of a feedback mechanism, they are unable to remove the disturbances occurring from external sources. It is sensed to lattice variety of storage ring. Fast feed forward table update and easy operation are necessary before the route operation.

The feed forward table build up is shown in the Fig. 7. It takes to 3 minutes roughly from open gap to minimal gap. There are some measurement noises. Polynomial fitting is applied to remove these errors.

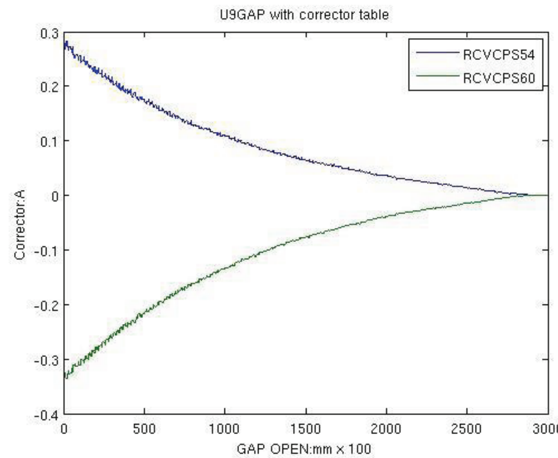

Figure 7: Fast feedforward table establish from minimal gap.

SUMMARY

BPM system and corrector power supply control system both have been integrated and operated in the orbit feedback system. In the most part of orbit perturbation, orbit feedback can process it, but corrector strength isn't enough. Orbit feedback and feed forward both are integrated and code were developed to keep from corrector saturation. Preliminary testing with real beam is ongoing. Graphic user interface will be developed for routine operation in the future.

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