ORBIT CONTROL AND IT'S STRATEGIC IN TAIWAN LIGHT SOURCE

C. H. Kuo, C. J. Wang, Jenny Chen, K. T. Hsu
No. 1, R&D Road VI, Hsinchu Science-Based Industrial Park, Hsinchu 30077, Taiwan, R.O.C

Abstract

The beam quality is a critical requirement for the stability and repeatability of the third generation synchrotron radiation light source. There are various issues which affect the beam quality such as, mechanical vibration, BPM performance, control environment, local bump leakage, insertion devices gap or phase motion, dynamic helicity devices operation, utility issues, etc. The control and suppression technique are based on orbit feedback, local feedback, and feed-forward control mechanism. The Orbit control issue to eliminate various perturbations will be reported at this conference.

1 INTRODUCTION

There are more and more insertion devices in the Taiwan Light Source (TLS). These insertion devices are useful for the brightness and spectrum of beam, but have also some influences for the electron orbit and the lattice of storage ring. Any vibrations and orbit drift that lead to distortions in the closed orbit will result in a larger effective emittance. Together with the reduction in brightness, any unwanted beam motion that causes a variation of the light position and angle can degrade the experimental performance of synchrotron. There is an orbit control mechanism in each device to reduce the orbit motion, but the interaction among these devices to control the orbit is complicated.

2 ORBIT CONTROL STRUCTURE

There are two difference orbit control mechanisms that are applied for insertion devices. One is feed forward system; another is feed back system.

2.1 Feed-Forward System

Originally, the orbit control of all insertion devices and elliptical polarization beam position system (EPBM) belonged to this mechanism [1]. The orbit perturbation of the EPBM system is due to eddy current of the vacuum chamber and the power-supply control. There is a correction table depending on the polarization angle that is used to compensate these effects. The system block is shown in figure 1. The compensation system is combined with a programmable waveform generation card, fast beam position reading system and correction table. This correcting table of the compensation block is obtained by the measurement method that is shown in figure 2. The orbit control for the insertion device operation method is the same.

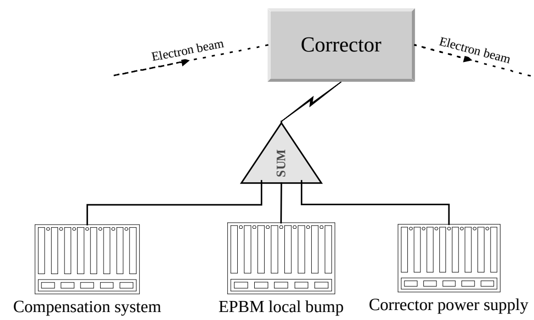


Figure 1. EPBM system block.

The correction table is sufficient to control the orbit if there are no external perturbation sources such as, repeatable mechanic backlash and magnetic field. There are more and more insertion devices in TLS. They will interact with each other if all devices are operating. This correction table needs them to be modified dynamically. That is complicated, so orbit control of feedback is now gradually applied.

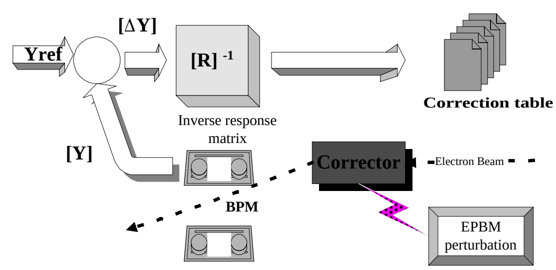


Figure 2. Correction table of EPBM compensation system block.

2.2 Feedback System

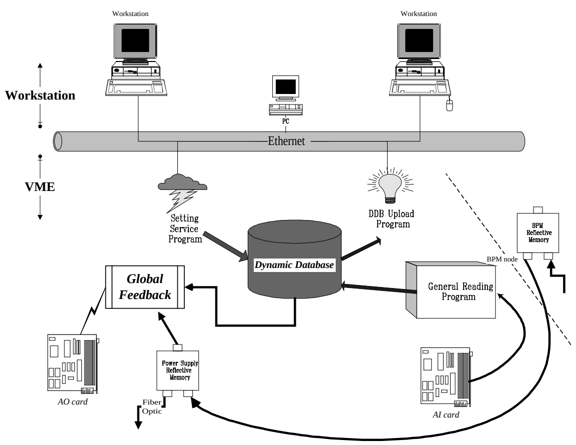
There are two types of feedback system for orbit control. One is local feedback system [2,3]; another is global feedback system [4].

2.2.1 Local Feedback

The local orbit feedback system is used to suppress miscellaneous local orbit perturbations. The feedback system consists of sensor, and feedback control loop. The sensors are electron beam position monitor (BPM) and photon monitor of elliptical polarization undulator (EPU). The feedback control loop architecture share the same hardware with the global orbit feedback. The VME-based crates, interconnected with high performance daisy-chained global reflective memory networks, are used to share position data with DSP.

2.2.2 *Global Feedback*

Figure 3. Global feedback system block.



The digital global feedback is implemented to suppress orbit drift, low frequency beam motion as well as orbit perturbations due to operation of insertion devices. Measured response matrix and singular value decomposition (SVD) techniques are applied in this experiment. The feedback controller is based on a PID algorithm [5]. Some digital filtering techniques are used to reduce noise of electron beam position, to compensate eddy current effect of vacuum chamber and to increase the bandwidth of orbit feedback [6]. The infrastructure of the digital feedback system is composed of the orbit acquisition system, gigabit fiber links, digital signal processing hardware and software, and high precision digital-to-analog converters.

3 OPERATION RESULTS

3.1 *Long Term Operation*

The feedback system operation result is shown in figure 4. This corresponds to an operation shift of one day. It is machine study shift before 500 minutes. One curve (..\04\r3bpm4y~.188) is the beam position monitor (BPM) with time that isn’t included in feedback loop, another (..\09\r3bpm4y~.188) is included in feedback loop. The orbit drift is successfully corrected.

3.2 *Insertion Devices Perturbation*

There are two insertion devices in this demonstration. One is U9; another is U5. They are all undulator. The orbit is changed when the insertion device operating for that tune of ring is shifting. The tune with U9 gap is show in figure 6. The quantum jumps of tune are due to slow response of the tune monitor when compared to the gap change between 18.5 mm to 30 mm. The tune shift is violently quick in this interval and requires more time in statistic analysis to confirm tune accuracy. The tune with gap is different between up stream and down stream for the backslash mechanism of U9.

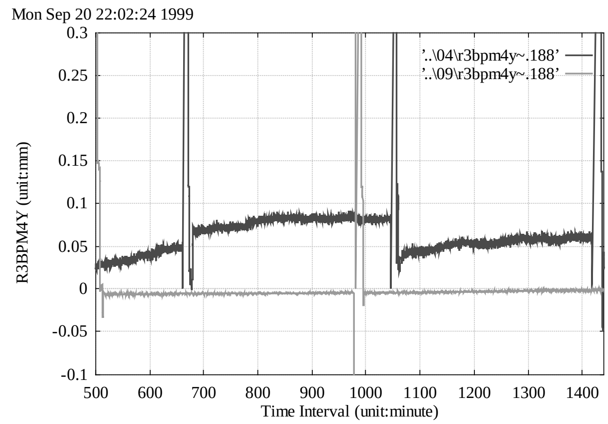


Figure 4. Long term orbit with sensor is included/excluded in the feedback loop.

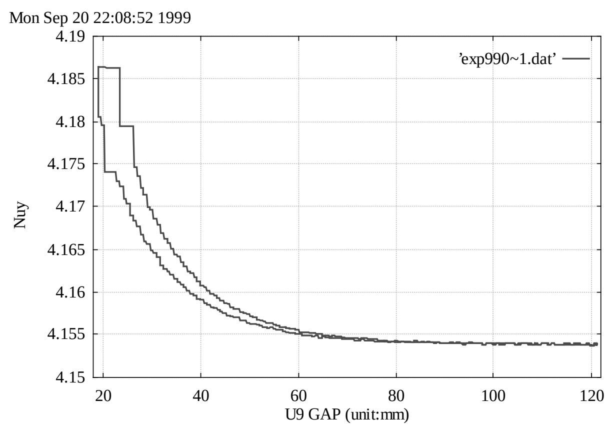


Figure 5. Tune shift versus U9 gap.

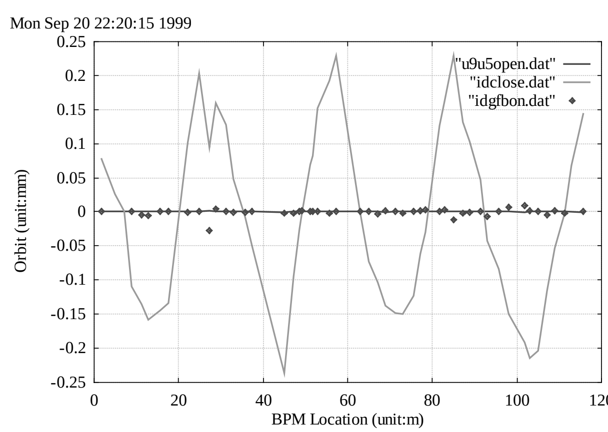


Figure 6. Orbit status with undulators motion and feedback on/off

The orbit perturbation is shown in figure 5 when insertion devices are motions. “u9u5opern.dat” is U9 and U5 in open gap status of orbit. “idclose.dat” is U9 and U5 in minimum gap status of orbit. The orbit perturbation was close to 250 mm. “idgfbon.dat” is orbit of U9 and U5 in the minimum gap with the global feedback turned on. The orbit is almost returned to its original status. The feedback system of the orbit control is less sensitive than the feed forward system. The perturbation can still be compressed even if the tune and response matrix of the storage ring is changed so much.

4 CONCLUSION

All orbit control systems are routinely used. The global feedback and feed-forward system are operating in parallel. The local feedback system will be merged in the beam-line with electron BPMs and photon BPMs to suppress small perturbations. The BPM and photon monitors readings are contaminated by ripple noise. Advance signal processing and filtering technique is applied in the feedback system to improve the performance of the system. Performance of the system will be thanks to our accumulated operating experience and hardware upgrade. The configuration of the feedback system will be distributed in three VME crates for operational version in the future. Every crate will play its own role as beam position server, feedback calculation server, and corrector server. This arrangement is convenient for routine machine operation and feedback system development.

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