LOCAL FEEDBACK APPLICATION IN TLS

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Abstract

The various orbit perturbations are enhanced after many insertion devices are installed in the storage ring of TLS. These sources will interfere to system performance. The local orbit feedback system is used to suppress miscellaneous local orbit perturbation. 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 same hardware with 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. The result is shown in this report.

1 INTRODUCTION

Taiwan Light Source (TLS) in Synchrotron Radiation Research Center (SRRC) is one of the third-generation synchrotron light sources, which are characterised by low emittance of the charged particle beams and high brightness of photon beams radiated from insertion devices. These insertion devices are useful for the brightness and spectrum of beam, but are also make 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 brightness reduction, unwanted beam motion that causes the incident light position and angle to vary can degrade the experimental advantages of synchrotron. Cancel these negative local bump are main purpose for the local orbit feedback of development [1]

2 SYSTEM STRUCTURE

2.1 Hardware structure

The hardware configuration of local feedback (LOFB) system is shown in figure 1. The photon BPM reading systems are combined in photon BPM node. This node includes a PowerPC 604e/200 MHz CPU board, reflective memory with PMC, VME bus and A/D interface cards. The PBPM signals are connected to current amplifier inputs and then outputs are connected to the front-end of PBPM node interface card. The PMC or VME bus is between reflective memory and CPU board that support wide bandwidth transfer rate. The configuration of feedback system is presently distributed in two VME crates. The orbit readings are by multi-channels 16 bit high precision A/D cards. Sampling rate of system is 1 KHz now. The inputs and outputs interfaces are all 16 bit high precision cards to support exactly corrector control [2].

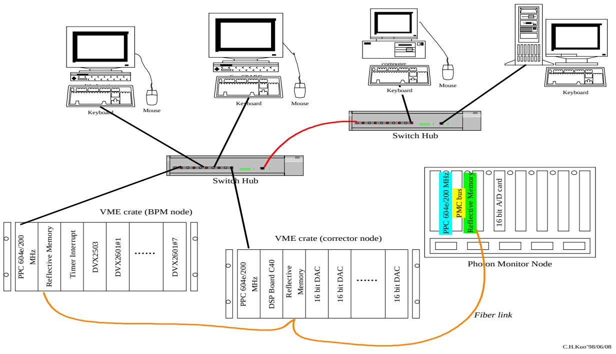

Figure 1: Hardware diagram for orbit feedback.

There are two orbit feedback systems in this control loop. One is local feedback, and other is global feedback. Integrating these two feedback loops for better co-operation, bandwidth of 10 - 100 Hz is necessary to suppress vibration and power supply ripple related beam motion, etc. These feedback systems are integrated with the existed control system. BPMs data and correctors readback are updated into control system dynamic database in the period of 100 msec. Local feedback system is bounded on I/O as well as computation. It is important to arrange the real time task and to arbitrate computer bus properly in order to optimise system performance.

2.2 Software structure

A local feedback system has been developed to suppress orbit disturbances caused by low-frequency drift and insertion devices. First, a local bump of four magnets ratio is measured by taking beam position monitor (BPM)

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reading in outside of bump when the corrector are individually perturbed. The feedback controller is based on PID algorithm [3]. Infinite impulse response digital filtering (IIR) [4] techniques were used to removed noise of electron beam position reading, to compensate eddy current effect of vacuum chamber, and to increase bandwidth of local feedback loop.

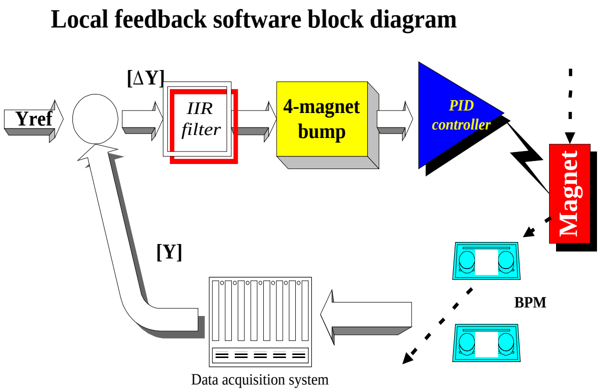

Figure 2: Software diagram for orbit feedback

3 LOCAL BUMP

3.1 Four- magnets local bump

The four-magnets are combined by two independent three-magnet bumps a and b. Let θ_1, θ_2, θ_3, and θ_4 be the kick strength on four corrector, then we have

$$\theta = \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \end{bmatrix} = \begin{bmatrix} k_{a1} & 0 \\ k_{a2} & k_{b2} \\ k_{a3} & k_{b3} \\ 0 & k_{b4} \end{bmatrix} \cdot \begin{bmatrix} \theta_a \\ \theta_b \end{bmatrix} = K \cdot \begin{bmatrix} \theta_a \\ \theta_b \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} \theta_a \\ \theta_b \end{bmatrix} = R^{-1} \cdot \begin{bmatrix} y_a \\ y_b \end{bmatrix} \tag{2}$$

where R is local response matrix. The local response matrix is a linear response matrix that is measured by taking photon monitor or beam position monitor (BPM) reading when the magnet are kicked one by one. K is bump ratio. The local bump coefficient is consisted of inverse local response and bump ratio. That is a four by two matrix.

3.2 DECOUPLING

For independently control two four-magnets bump, de-coupling procedure is necessary. To avoid two-detectors inference each other in feedback loop. The coefficient of bump a and bump b is transferred to

$$k_a^{'} = k_a - \frac{R_{12}}{R_{22}} \cdot k_b \tag{3}$$

$$k_b^{'} = k_b - \frac{R_{21}}{R_{11}} \cdot k_a \tag{4}$$

where R is response matrix, k is bump coefficient.

An idea de-coupled bump only affect one position detector. There is a little difference between photon monitor and BPM for detector of feedback loop inside bump. If the bump is decoupled by BPM, equation 3 and 4 is satisfied to this transformation. If the bump is de-coupled by photon monitor, equation 3 and 4 must be modified to angular bump. So, original equation is transferred to

$$k_a^{"} = k_a^{'} + c_a k_b \tag{5}$$

$$k_b^{"} = k_b^{'} + c_b k_a \tag{6}$$

where c are constant.

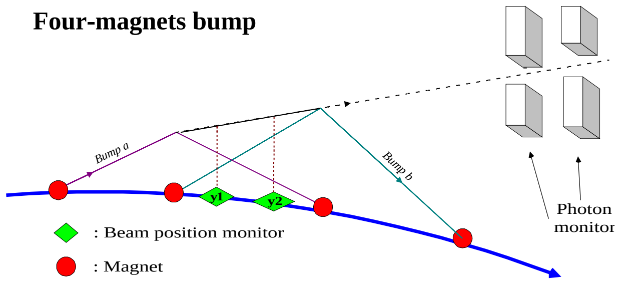

Figure 3: Four-magnets bump.

4 APPLICATION

In this report, local feedback is applied in EPU section. There are perturbation sources in other location of ring, but the photon monitor is stable in beam-line. The BPM of outside bump is shown in figure 4.1. There are two detectors in the inside bump. One is R1BPM9Y that is BPM, other is BL05PBPM1V that is photon monitor. Their behaviours are shown in figure 4.2 and 4.3. Two-photon monitor's status in feedback loop is shown in figure 5.1 and 5.2 when beam is unstable. The unstable beam is shown in figure 5.3.

5 CONCLUSION

In the future, the local feedback system will be merged in beam-line with electron BPMs and photon monitors. An extended feedback bandwidth in local feedback system is necessary to suppress various perturbations. The BPM and photon monitors readings are contaminated by ripple noise. Advance signal processing and filtering technique is applied in LFB that will help to the performance of system.

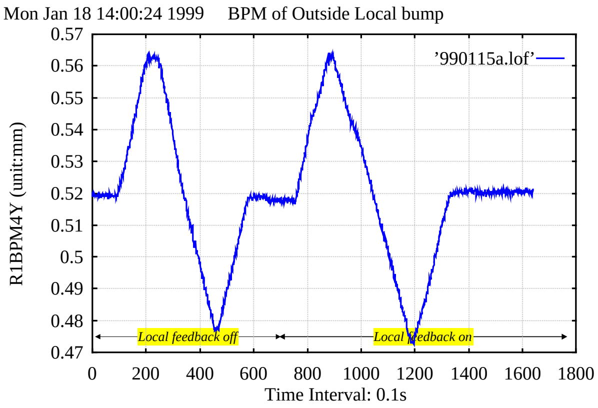

Figure 4.1: BPM out of local bump.

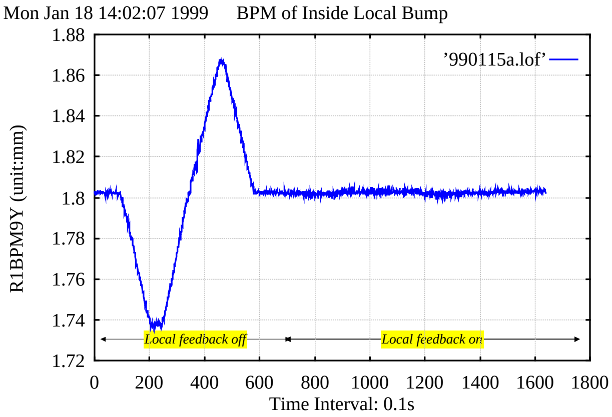

Figure 4.2: BPM in feedback loop.

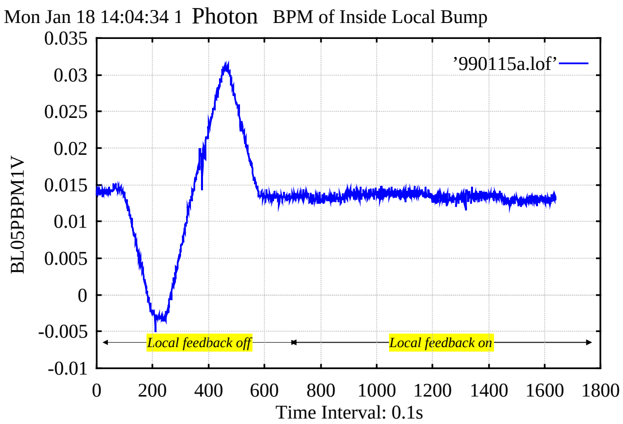

Figure 4.3: Photon monitor in feedback loop.

6 REFERENCES

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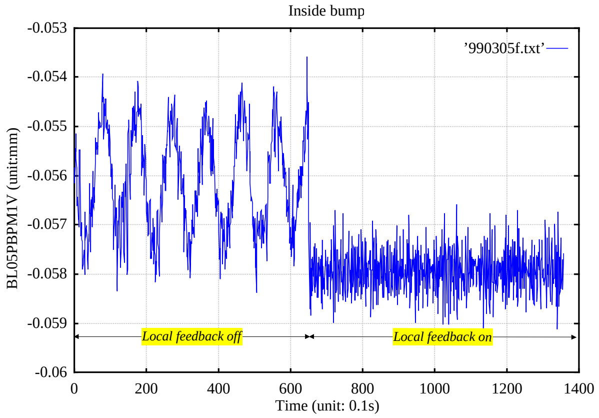

Figure 5.1: Photon Monitor in feedback loop.

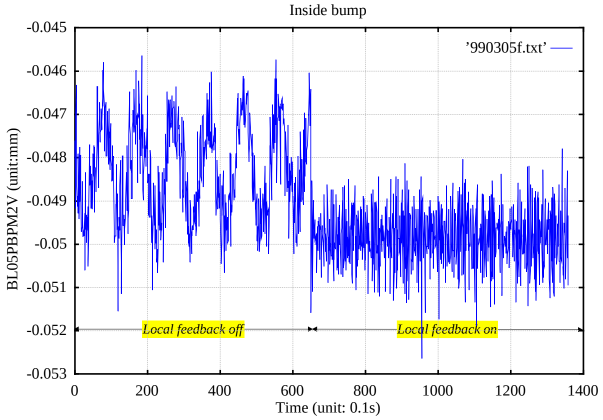

Figure 5.2: Photon Monitor in feedback loop.

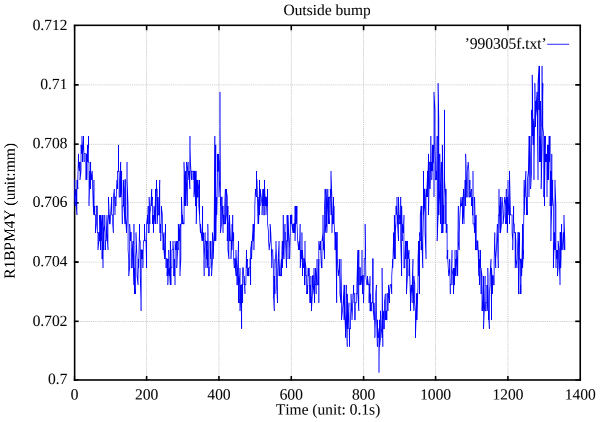

Figure 5.3: BPM out of feedback loop.