DEVELOPMENT OF LOCAL ORBIT FEEDBACK FOR TAIWAN LIGHT SOURCE

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ABSTRACT

A highly-effective local orbit feedback system (LFB) in the Taiwan Light Source (TLS) has been developed to steer photon beam and eliminate the effect orbit various disturbances. This system consists of four corretor magnet to form a local orbit bump, two BPM to be feedback sensor, a control algorithm and digital filter that are embedded in VME form factor. Appropriate control algorithm is used to reduce the effects of noise and disturbance, improve stability and extend feedback bandwidth in this system. Digital filtering is used to reduce the noise in photon beam position monitor (PBPM) readings. The hardware of local feedback system is combined with the global feedback of operation type.

1 INTRODUCTION

Taiwan Light Source (TLS) in Synchrotron Radiation Research Center (SRRC) is one of the third-generation synchrotron light sources which are characterized 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 also make some infulences for the electron orbit and the lattice of storage ring. Any vibrations and orbit drift that lead to distoritions 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 that can degrade the experimental advantages of synchrotron. Cancel these negative local bump are main purpose for the local orbit feedback of development [1].

2 HARDWARE STRUCTURE FOR ORBIT FEEDBACK

The hardware configuration of LFB 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 bus and A/D interface cards. The CPU board consists of a PowerPC microprocessor, 32 megabytes on board memory, two RS-232, PMC sites and Ethernet ports. 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 bus is between reflective memory and CPU board that support wide bandwidth transfer rate. A PowerPC based server system is used as TFTP file server for downloads OS and mounted disk of network file server (NFS). All application programs are put on server disk. These programs are developed and debugged on client node to relief loading of server. The real-time multi-tasking kernels are embedded in a single board computer of the VME bus. It provides a satisfactory performance, relability, and a rich set of system services. The system can automatically boot and install PMC driver. The configuration of feedback system is presently distributed in two VME crates. In the future,

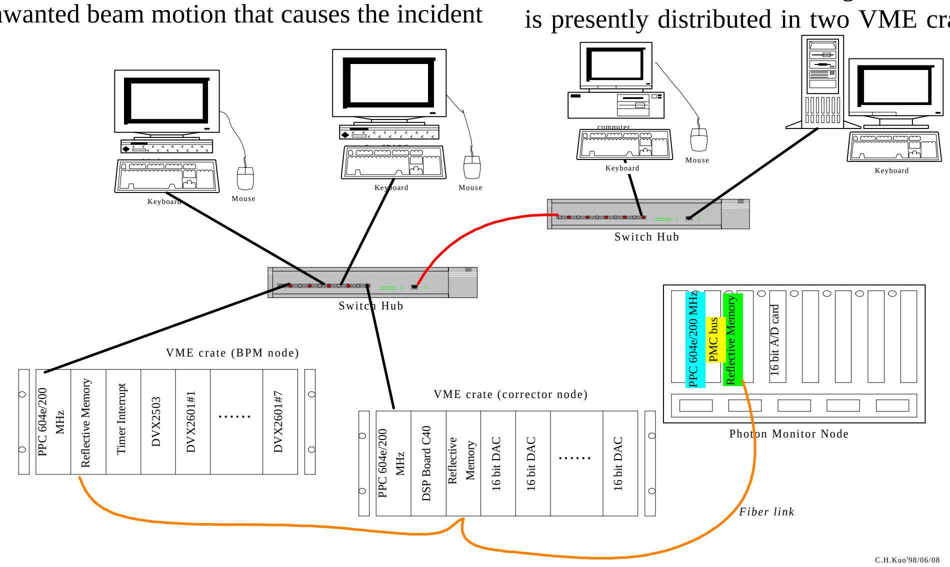


Figure 1: Hardware diagram for orbit feedback

it will be configured to three nodes. The BPM node handles feedback control system timing generation, electron beam orbit reading and data processing. The inputs of orbit reading are by multiple 16 bit high precision A/D cards. The host computer of BPM node will generate a system clock to other nodes and acquire orbit information when receive signal from timer interrupt interface card. So, the feedback system clock is easy to modify. Another is corrector node that handles a feedback control loop, corrector reading and setting. The sampling rate of system is 1 KHz now. The inputs and outputs interface are all 16 bit high precision card to support exact corrector control. The photon monitor reading system of beamline are distributed in many the photon monitor nodes. This node processes and send data to control system of storage ring when receive a system clock from BPM node. In the meantime, photon monitor data is also sent to feedback system.

3 SIGNAL PROCESSING

3.1 BPM node

The host compuer of BPM node handles electron and photon BPM reading in per milliseond, but control system clock of storage ring is 100 ms. So, down sampling is necessary. There are two task that handle these procedure in PowerPC with LynxOS. One is data acquisition and broadcast, another is decimation and database service of control system. Two task is communicated by share memory each other. In the meantime, it supports per millisecond orbit information for other application, such as EPBM compensation [2].

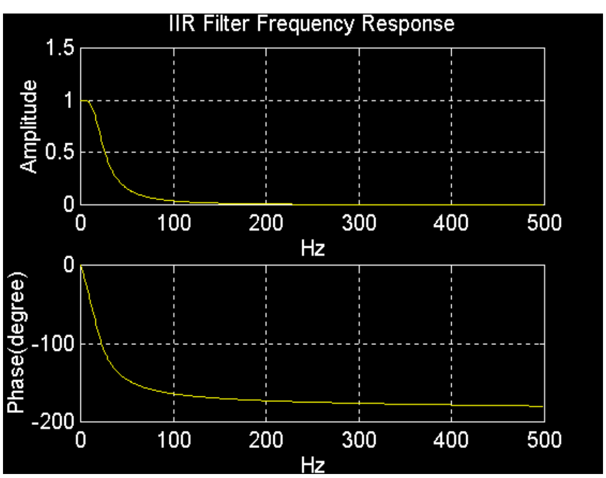
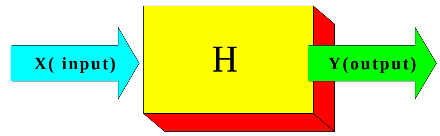


Figure 2: Frequency response of IIR filter.

3.2 Corrector node

The host compuer of corrector node handles two task. One is corrector reading, another is corrector control and feedback status control. It include that LFB is turned on and off, paused, and PID parameters are tuned [3][4]. The reading task is synchronized by central databse of control system . It is 100 ms now. The control task handles normal corrector setting when receive a event from ethernet network.



$$H(z)=\frac{B(z)}{A(z)}=\frac{b(1)+b(2)z^{-1}+\cdots+b(n+1)z^{-n}}{1+a(2)z^{-1}+\cdots+a(n+1)z^{-n}} \qquad (1)$$

$$Y(z)=X(z)*H(z)$$

The DSP handles operation of feedback control algorithm, such as digital filtering, PID controller and fast corrector control. The digital filter is infinite impulse response filter (IIR) that is based on analog filter of 2 order butterworth [5]. The filter transformation function is given in equation 1. The frequency and phase response is shown in figure 2, where a and b are filter coefficients. The bandwidth of filter is designed in 20 Hz that is only simple to test filter performance. This filter purpose keeps from noise to interfere feedback loop and extend feedback bandwidth. The steady state error is close to zero when open loop gain is large enough. The feedback system stability is controlled by that modify parameters of PID controller. There are three prameters in this controller, proportional, integral, and derivative. Between orbit and corrector of tranformation is by the inverse response matrix operation. The analog ouput card is directly controlled by DSP with VME bus after filtering, PID processing and response matrix caculation. The block diagram is shown in figure 3.

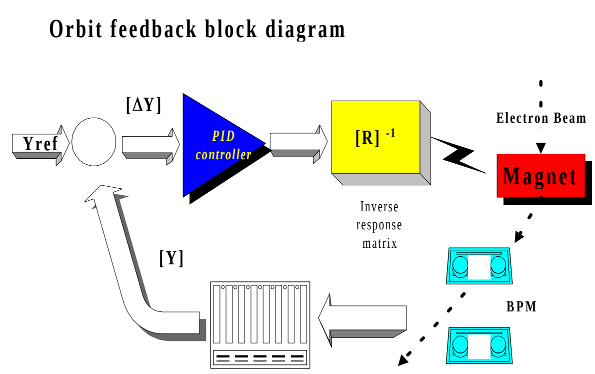


Figure 3: Local orbit feedback block diagram

3.3 Photon BPM node

This node handles photon data acquisition in photon monitor of beamline. It include that I_0 of low energy spherical grating monochromator beamline (LSGM) and photon BPM (PBPM) of elliptical polarization undulator (EPU) beamline. The embedded processor on PBPM node calculates the normalized vertical position from plate sensor, and then broadcast to other nodes. The calculation equation is

$$V = k \frac{u - l}{u + l}$$

where V is vertical position, u is upper plate signal, l is lower plate signal, and k is sensitivity.

Photon BPM node can't directly send data to centralized database. ALL distributed photon sensor information is collected to BPM node to support services for database.

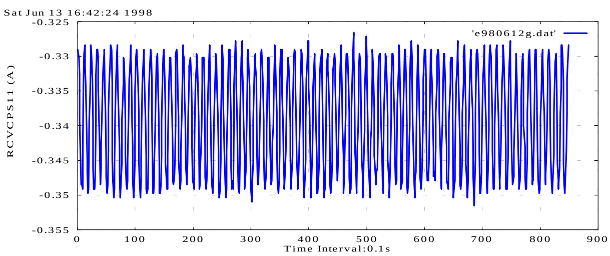


Figure 4.1: Perturbation source for corrector

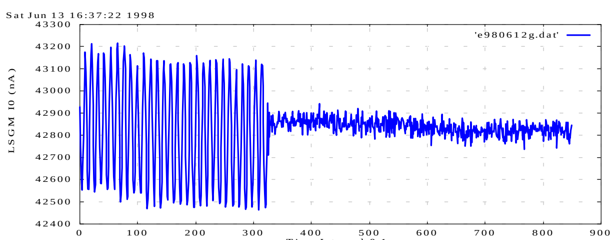


Figure 4.2: Io intensity with feedback on/off

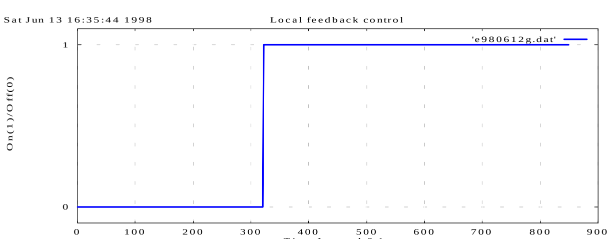


Figure 4.3: LFB control status

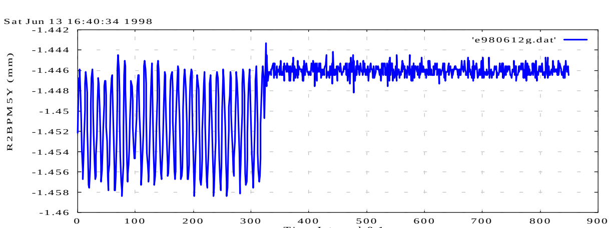


Figure 4.4: R2BPM5Y reading with feedback on/off

4 PERFORMANCE OF LFB

The results of local orbit feedback system have been applied in LSGM and EPU beamline to keep from any orbit perturbations. The performance is shown in figure 4.

The local bump structure consists of four correctors and two electron BPMs in this testing. There is a external perturbation source in outside of local bump. The source is a 0.9 Hz sine wave with strength is 20 *m*A, peak to peak. Two BPMs are used as feedback sensor (R2BPM5Y and R2BPM6Y) which located at the upstream of LSGM source point that are between second and third corrector. The perturbation source of corrector is shown in figure 4.1. The Io intensity is shown in figure 4.2. The LFB control status is shown in figure 4.3. The R2BPM5Y reading is shown in figure 4.4. The perturbations of LSGM I_0 and R2BPM5Y are all suppressed when feedback is turned on.

5 CONCLUSION

Performance of the LFB system will be improved as we gain operation experience and hardware upgraded. The configuration of feedback system will be distributed in three VME crates for operational version. Every crate will play its own role as beam position server, feedback caculation server, and corrector server. This arrangement is convenient for routine machine operation and LFB system development.

6 ACKNOWLEDGEMENTS

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