IMPROVEMENT OF HARDWARE AND SOFTWARE SETUP FOR THE ACQUISITION AND PROCESSING OF SIAM PHOTON SOURCE BPM SIGNAL

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Abstract

Data acquisition and processing system has been developed for the Siam Photon Source (SPS) storage ring BPM system in order to improve monitoring and logging performances. BPM readout, i.e. scanning of BPM electrode voltage outputs and subsequently converting to X-Y position values, is now performed by an upgraded Programmable Logic Controller (PLC) with higher bit resolution (16-bit) analog-to-digital converter (ADC). Moving averaging is then performed on the obtained BPM data utilizing a LabVIEW code to reduce background noise during on-line measurement. All data is then stored on a dedicated computer serving as a central data logging system, which can be remotely accessed via a network communication link. In this report, details of the new setup will be presented, and comparison will be made between the performance of the new and previous setups, together with suggestions on further improvements.

INTRODUCTION

The Siam Photon Source (SPS) is the first synchrotron light source of Thailand. The accelerator complex consists of a 40 MeV electron linac, a 1.0-GeV injector and a 1.2 GeV electron storage ring, the configuration of which is based on a four-fold symmetric double bend achromat (DBA) lattice. [1-3] In recent years, the demand for better beam position stability has continually increased. To address this issue, the machine group has undertaken a number of coordinated efforts, for e.g., improving sensor systems in the storage ring, stabilizing ambient and cooling water temperatures, improving the diagnostic beamline setup, developing a slow orbit feedback system, among others. One of the most important tasks in this undertaking is undoubtedly the improvement of the orbit measurement and monitoring systems.

The improved SPS storage ring BPM system has provided the machine group with the possibility to improve the beam quality by providing accurate and reliable reading, assisting the group in making correct analyses. The new logging and retrieval systems also help making the correlation between the monitored beam fluctuation and any machine parameters easier. It is also a vital part of the slow orbit feedback system, which had not been possible to implement since the machine produced its first synchrotron light. [4, 5]. This report describes the improvement of BPM data acquisition and processing system, the development of a new logging system, along with the upgraded hardware and software configurations. The measurement results before and after the improvement will be presented and discussed.

HARDWARE CONFIGURATION

Figure 1 shows a schematic block diagram of the developed BPM signal processing for the SPS storage ring. The BPM electrode signals processed by the BPM electronic modules are passed to the programmable logic controllers (PLC). Signal averaging and data logging are then performed by two dedicated computer servers.

BPM System

BPM pickups are installed in 20 locations next to the quadrupole magnets along the 81.3 meters long circumference of the SPS storage ring. Each BPM block consists of four electrodes. Raw signals from the electrodes will be sent to the *BPM electronic modules* where they are processed to provide horizontal (X) and vertical (Y) beam position outputs, simultaneously [4, 5].

Programmable Logic Control

The PLC has to accomplish several tasks. First, the output signals from BPM electronic modules are converted by a new 16-bit ADC (Allen Bradley 1756-IF6I) in the PLC's module at 40 Hz sampling frequency. The X-Y beam positions are calculated and subsequently fed into the PC-Average and PC-Logger computers. All PLC and BPM modules, as well as all electronic devices for data acquisition are installed in the same rack, situated just outside the storage ring in the experimental hall area.

Computers

The two processing computers are located in the machine control room. The data processing server (PC-Average) and the data acquisition server (PC-Logger) are connected to each other via a LAN network.

SOFTWARE CONFIGURATION

As mention in the previous section, the software development and implementation are divided into two parts: (i) the data processing (moving average) part on PC-Average computer, and (ii) the data acquisition (data logging) part on PC-Logger computer.

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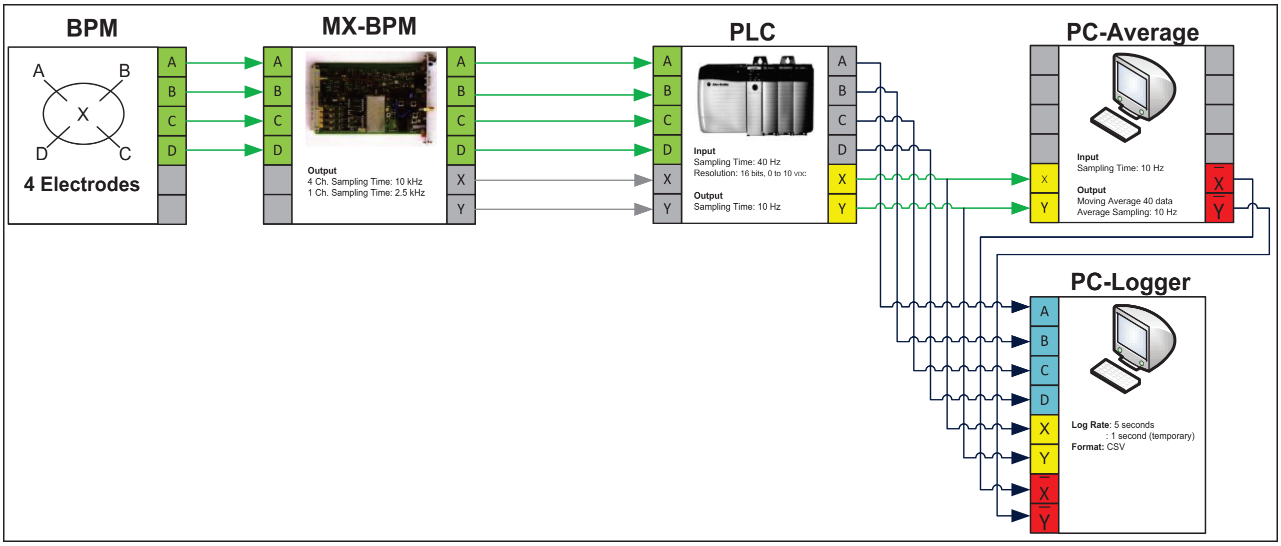

Figure 1: Schematic block diagram of BPM signal acquisition and processing system.

The BPM signal processing codes are developed by the machine group based on Microsoft Windows platform and LabVIEW programming development environment.

Moving Averaging

Moving averaging is a basic and useful tool for reducing background noise on a real-time measurement. It is commonly used with time series data to smoothen out short term fluctuations by averaging a number of points from the input signal. More specifically, it is described as:

$$y[i] = \frac{1}{M}\sum_{j=0}^{M-1} x[i-j]$$

where x is the input signal, y is the output signal, i is the output index and M is the number of points used in the averaging. In our case, $M=40$, and the sampling interval is 100 ms (Figure 2).

The sampling interval of 100 ms (0.1 s) is sufficient to provide the orbit position control with an on-line data. The feedback control loop in the SPS orbit feedback system just amounts to 10 s [5].

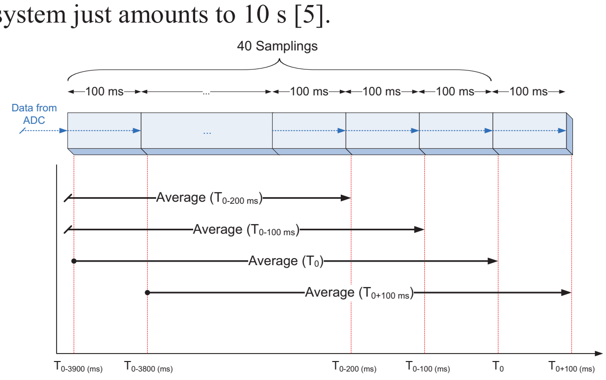

Figure 2: Moving averaging diagram.

Data Logging

The PC-Logger computer manages most of the data transfer from the PLC and PC-Average computer via an OPC server and NI shared variable protocols. The logging process is executed every 5 sec. The logged data is then written to the database in a comma separated value (CSV) file format (Figure 3).

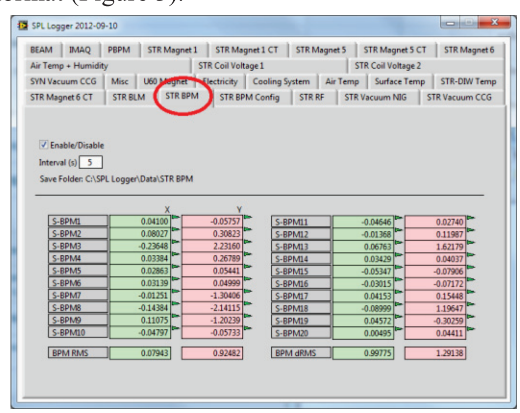

Figure 3: The LabVIEW-GUI of SPS data logger system.

The *PC-Logger computer* used for data logging is an HP Proliant ML350 G4 with Intel Xeon 3.2 GHz/800 MHz FSB/1 MB L2 cache, 1 GB of memory, and 72 GB SCSI hard disk drive with RAID1 (mirror), serving as a central data logging system. It can be remotely accessed via a network communication link.

MEASUREMENT RESULTS

Figures 4 and 5 compare the X and Y orbit positions with and without moving averaging during beam position scan. The fluctuation (noise) of the X and Y orbit measurements without signal moving average was rather large (Figs. 4(a) and 5(a)). The fluctuation was reduced from more than 10 μm down to about 3 μm with the moving averaging (Figs. 4(b) and 5(b)).

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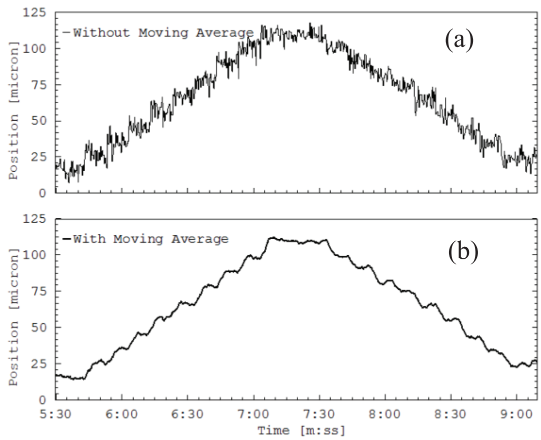

Figure 4: X orbit fluctuation with and without moving averaging during beam position scan.

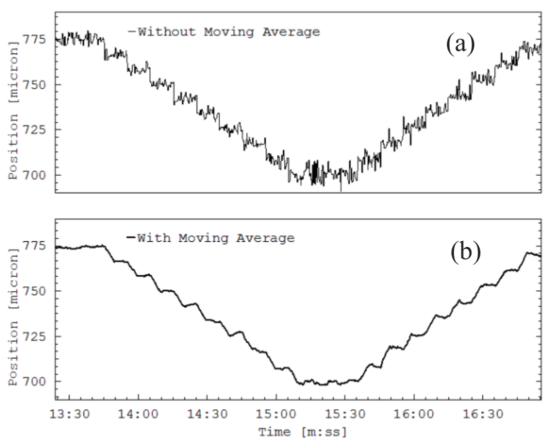

Figure 5: Y orbit fluctuation with and without moving averaging during beam position scan.

Figures 6 and 7 show the standard deviations of X and Y orbit positions obtained from all the BPMs with and without moving averaging. The filled and open bars correspond to the standard deviations of the BPM readings with and without moving averaging, respectively. The results show that the moving averaged data provides good real-time orbit performances with 10 Hz refresh rate, with the level of signal fluctuation reduced to approximately one-tenth of that of the raw signal.

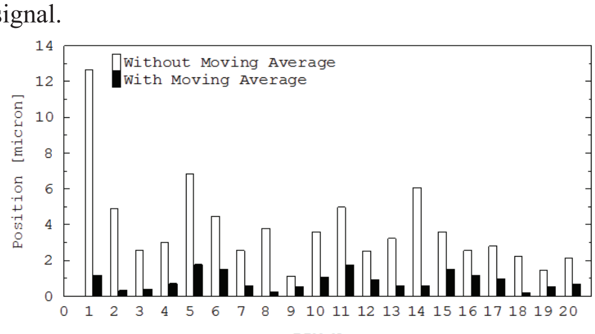

Figure 6: The standard deviations of the X orbit positions with and without moving averaging.

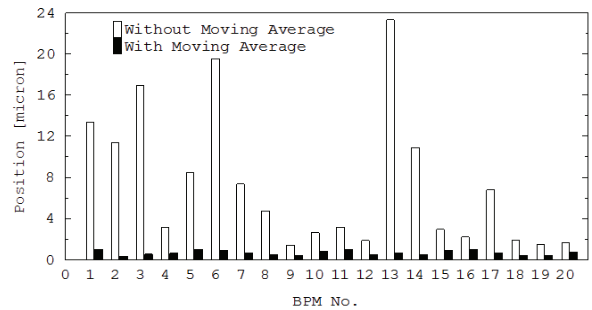

Figure 7: The standard deviations of the Y orbit positions with and without moving averaging.

CONCLUSION

The new acquisition and processing system at the Siam Photon Source has been developed to improve the functionality of the storage ring BPM system. Major upgrades on both the hardware and software have been undertaken. The system architecture and design is straightforward, resulting in short development time, but possess excellent flexibility, expandability, and maintainability. The system has been successfully implemented along with the orbit feedback system in the beginning of 2012. The results show significant improvement of the BPM system performance.

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