BEAM POSITION MONITORING SYSTEM FOR THE 1.5GeV TRANSPORT LINE OF NSRRC

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Abstract

The extracted 1.5 GeV electron beams from the booster synchrotron are transported via a transport line and injected into the storage ring. This booster-to-storage ring transport line equipped with seven stripline beam positions monitors. Commercial log-ratio BPM electronics were adopted to process the 500MHz bunch signal directly. The position of the passing beam is digitized by VME analog interface. This report addresses the system architecture, software tools, and performance of the BTS trajectory measurement. This system will provide an elegant tool for optimizing the performance of the transport line. Preliminary results and possible applications are included.

1 INTRODUCTION

The booster-to-storage ring transport line (BTS) of the NSRRC (formerly the SRRC) consists of seven stripline-type BPMs for measuring the trajectory of the beam. The BPMs are a complementary tool to fluorescence screen monitor for the operation of transport line. A logarithmic-ratio signal processing technique is commonly use for monitoring the position of the beam. It provides the advantages of a normalized real-time response, and an excellent dynamic range of intensity and position measurement. It is based on the inexpensive integrated circuit family of demodulating logarithm amplifiers, manufactured by Analog Devices, Inc. Log ratio electronics were recently adopted for use as the BPMs to provide a convenient means of operating the transport line.

2 LR-BPM

Commercially log-ratio beam position monitors (LR-BPM) [1] are used to measure the beam position in the BTS of the NSRRC. The functional block diagram of the LR-BPM is shown in Figure 1. The log ratio processor is a two-channel device. This module consists of a low-pass filter, a band-pass filter, a log-ratio amplifier, a sample & hold (S&H) circuit, a timing control circuit, and a position and intensity signal processing circuit. For details about the principles and implementation, please refer to reference [2].
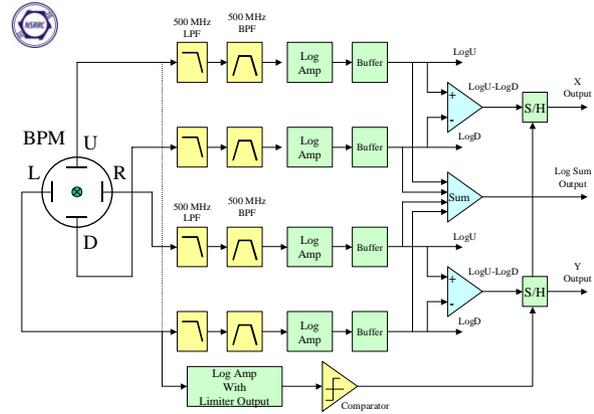

Figure 1: Functional block diagram of the LR-BPM.

3 TRANSPORT LINE LOG-RATIO BPM SYSTEM

The 1.5 GeV electron beam is extracted from the booster synchrotron and transported via a 70 m long transport line before being injected into the storage ring. Seven stripline-type BPMs are installed in the transport line, as shown in on the Figure 2. The striplines are mounted on the circular vacuum chamber with 63 mm inner diameter. The striplines is 10 mm in width and 150 mm long. The beam intercept angle is about 10 Degrees. The sensitivity of the BPM is about 1 dB/mm near the center of the chamber
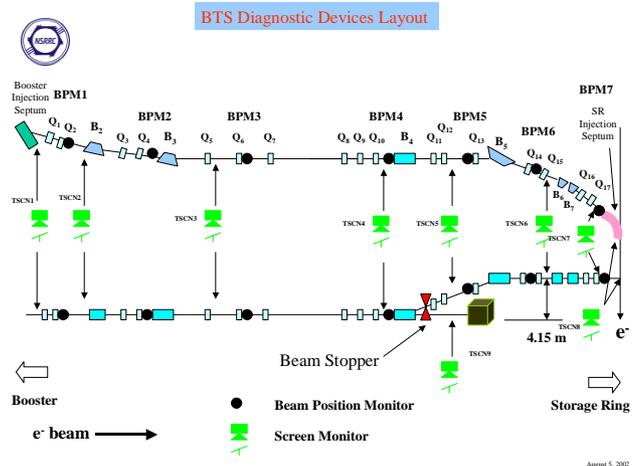

Figure 2: Transport line layout and the BPM installation.

The LR-BPM is configured in self-beam trigger mode. The electronics include a two-channel sample & hold circuit for X and Y output. A log sum output signal is also available. An in-hosed made peak detector module in VME form factor is used to hold of the log sum output. In Figure 3 shows the signal processing circuitry of the log sum hole module. The input signal is firstly inverted. When the inverted log sum signal amplitude is more than the output of the peak detector, the peak detector operates in the sampling mode and the output follows the input; otherwise, the peak detector operates in the hold mode. The drop rate of the fast peak detector is rather high so a second sample & hold stage is need to keep output of the sum up to 100 msec. The timing circuit provides an S/H command for the slow S/H and to trigger the ADC modules.
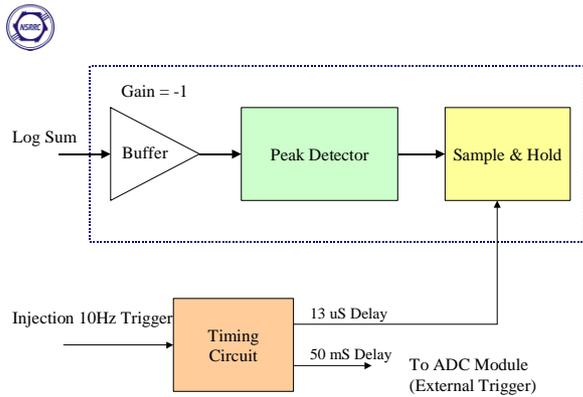

Figure 3: The peak detector circuit for log sum signal.

A 32-channel, 16-bit VME ADC module acquires the data from seven LR-BPMs. The position data are holding on the S/H on the LR-BPM module, and a peak detector holds the log sum value. A PPC CPU module running LynxOS and controls the operation of the VME crates. Collected data are sending to a control database every 100 msec to be displayed and fed to various applications. The LR-BPM in S/H mode with self-beam trigger is working correctly when the signal is sufficiently strong to activate the trigger circuitry. There is no indication whether the trigger is happen or not. To address the problem of data correctness, the log sum signals are used to check the data validation of the position data. If the log sum signal is large than some presentable level, it can ensure the LR-BPM is working properly and provide reliability data. The application software can do this check in control system easily.
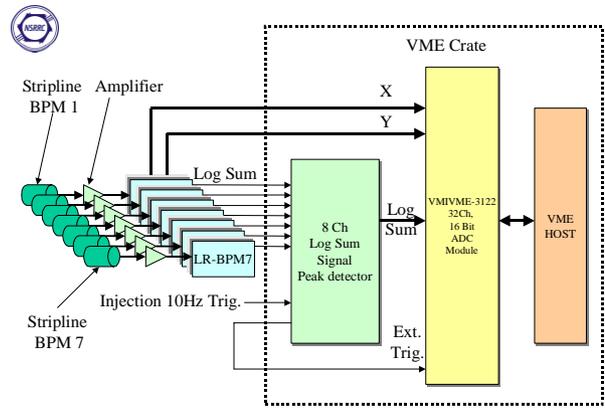

Figure 4: Data Acquisition System for the BTS LR-BPM.

4 PRELIMINARY TEST RESULTS

A preliminary beam test was recently conducted to check the functionality of the BTS LR_BPM system. Figure 5 show the log sum of LR-BPMs along the beam transport line. The data is not corrected for the attenuation of cables. The cable for BPM 1 is the longest. The drop of log sum after BPM 5 is the results of a beam stopper (for safety purpose) is close to prevent mistake injection, the location of the beam stopper is shown in Figure 2. Figure 6 shows the log sum of LR-BPMs along the beam transport line of a routine injection scenario. The trigger of electron gun will stop immediately when the storage ring stored beam accumulated to 200 mA corresponding to the machine cycle near 120. The intensity variation of the transport line will reveal the performance of the booster synchrotron. Figure 7 shows the log sum of BPM 7 during a routine injection scenario. The estimated variation in the intensity of the booster beam is less than 25%. The log sum information can complement the screening to optimize the operating conditions of the transport line and the extraction conditions of the booster synchrotron, even if is not sufficiently accurate. The information also provides the loss of the beam along of the transport line.

The input current of correct magnet power supply controls the position of the beam. HC1 is the first horizontal correct power supply; VC1 is first vertical correct power supply. The Figure 8 shows result of HC1 versus X position variation. The Figure 9 shows result of VC1 versus Y position variation.
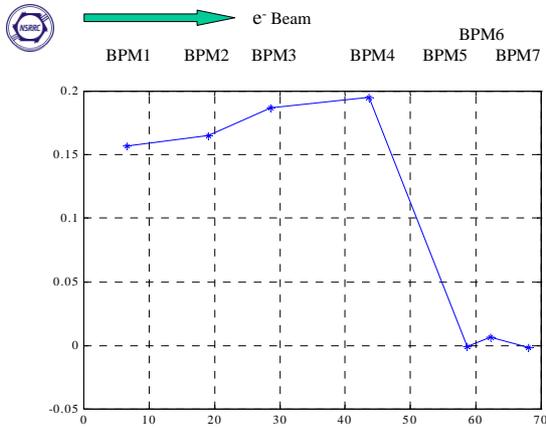
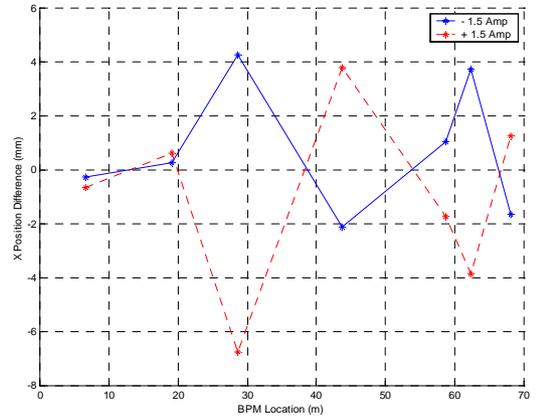Figure 5: The snapshot of the log sum output.

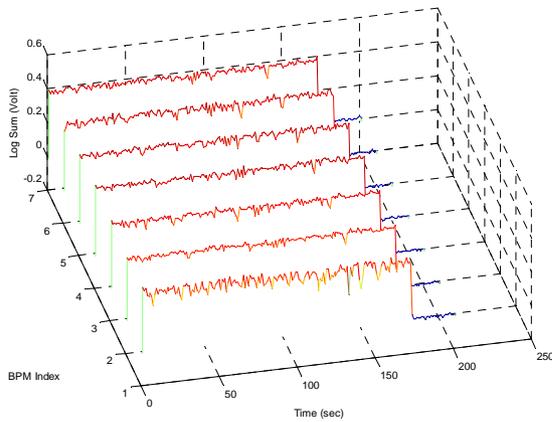Figure 8: Horizontal trajectory difference when the first horizontal corrector (HC1) change ± 1.5 A.

Figure 6: The BTS beam intensity (log sum) distribution as function of time in a routine injection scenario. This figure is shown the log sum output or BTS LR-BPM during injection, the stored beam current of the storage ring is started form 0 mA and accumulate to 200 mA about 170 seconds.
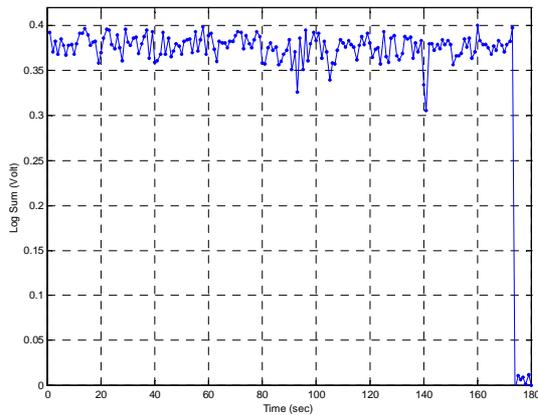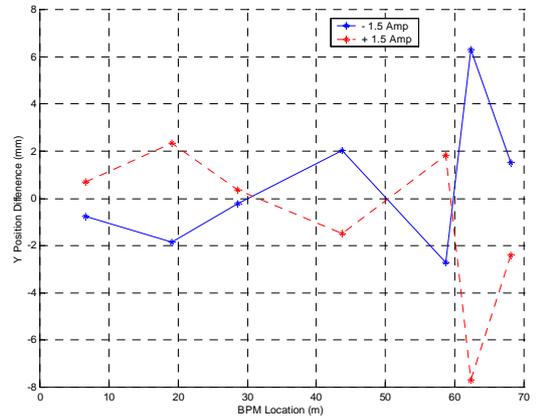

Figure 9: Vertical trajectory difference when the first vertical corrector (VC1) change ± 1.5 A.

5 SUMMARY

The LR-BPM system for the transport line non-destructively measures the trajectory of the beam. It can simultaneously measure the position and the intensity of the BTS in the injection period. The intensity information also provides the loss of the beam along of the transport line. The log sum information complements in optimizing the operating conditions of the transport line and the extraction conditions of the booster synchrotron, improving the efficiency of injection. The system was recently integrated and tested. Further improvements are ongoing. This measurement system is expected to be helpful in optimizing the transport line for routine operation and top-up mode operation in the near future.

Figure 7: The log sum output of the BPM7, which installed at the upstream of the storage ring injection septum in a routine injection.

6 REFERENCES

[1]. Log-ratio Beam Position Monitor – User's Manual, Bergoz Instrumentation

[2]. A. Kalinin, "The Log-Ratio Beam Position Monitor", AIP Conference Proceedings 648, Upton, New York, 2002, pp.384-392.