DIAGNOSTICS FOR THE 1.5 GeV TRANSPORT LINE AT THE NSRRC

K. H. Hu, Jenny Chen, C. J. Wang, Demi Lee, C. H. Kuo, Y. T. Yang, K. T. Hsu

NSRRC, Hsinchu 30076, Taiwan

Abstract

Electron beams at 1.5 GeV were extracted from a booster synchrotron and transported via a transport line and injected into a storage ring. This booster-to-storage ring transport line was equipped with stripline beam position monitors, integrated current transformers, fast current transformer and screen monitors. Commercial log-ratio BPM electronics were adopted to process the 500MHz bunch signal directly. The position of the passing beam was digitized by VME analog interface. An integrated current transformer was applied to measures the transmission efficiency. Screen monitors were used to support routine operation. This study summarizes the system architecture, software tools and performance of the BTS diagnostic system.

INTRODUCTION

A 1.5 GeV electron beam was extracted from a booster synchrotron and transported via a 70 m long transport line before being injected into a storage ring. Various diagnostic devices were installed along the transport line, as illustrated in Fig. 1. These devices included seven stripline type beam positions monitors, three integrated current transformers (ICT) [1], a fast current transformer (FCT) [1] and seven screen monitors. Commercial log-ratio beam position monitor (LR-BPM) electronics [1] were adopted to process the 500MHz bunch signal directly. The passing beam position was digitized by VME analog interface. The transmission efficiency was measured by an integrated current transformer. Screen monitors were applied to support routine operation. Several test screen monitors equipped with a short decay time, a YAG:Ce scintillator and an optical transition monitor with an aluminium file were also installed for various R&D tests.

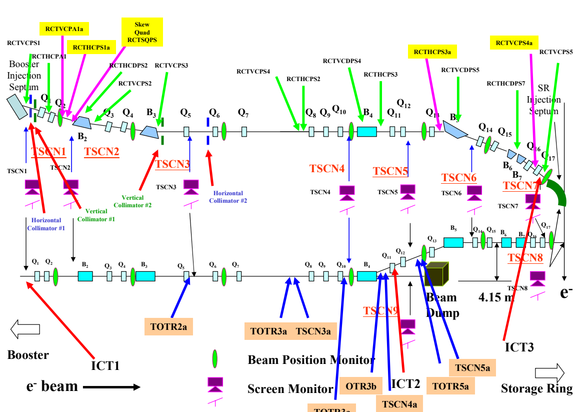

Figure 1: Transport line diagnostic devices layout

BEAM POSITION MONITOR

Seven stripline type BPMs were installed in the transport line to measure the beam trajectory, as shown in Fig. 2. The stripline was mounted on the circular vacuum chamber with a 63 mm inner diameter. The stripline was 10 mm wide and 150 mm long. The beam intercept angle was around 10°. Each BPM had a sensitivity was about 1 dB/mm near the beam pipe centre.

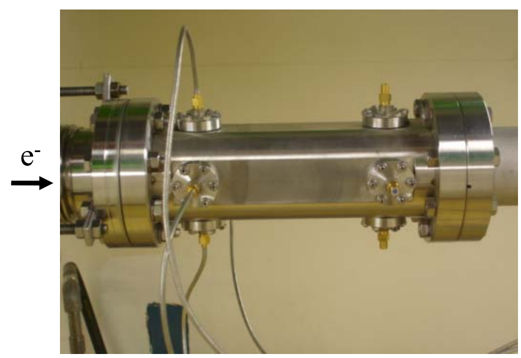

Figure 2: Stripline type beam position monitor

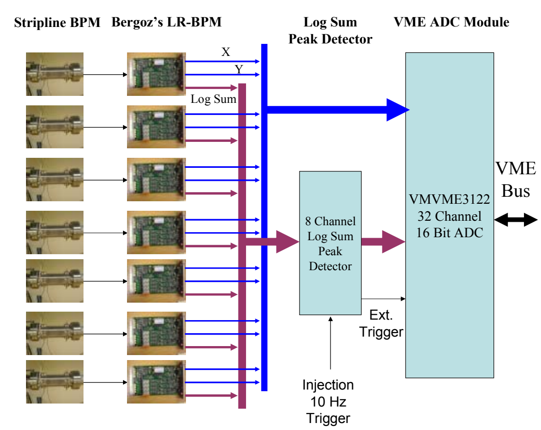

Figure 3: Data Acquisition System for the BTS LR-BPM

Log-ratio BPM electronics were used to measure the beam position in the BTS of the NSRRC [2]. The log ratio processor was a two-channel device. This module consisted of a low-pass filter, a band-pass filter, a log-ratio amplifier and sample & hold (S&H) circuits. The S&H circuits were a timing control circuit, and a position and an intensity signal processing circuit. The transport line beam position data acquisition system, with a 32-channel, 16-bit VME ADC module acquired data from seven LR-BPMs, is illustrated in Fig. 3. The S/H position data are held on the on the LR-BPM module, and a log sum output signal is also available. An in-hosed made peak detector module in VME form factor was used to ensure that the total log output was at least 100 msec. A PPC CPU module running LynxOS and controlled the operation of the VME crates. The collected data were transmitted 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 considered to be working correctly when the signal is strong enough to activate the trigger circuitry. The LR-BPM indication is given whether the trigger occurs. To consider the problem of data correctness, the position data were validated using the log sum signals. If the log sum signal exceeds a given presentable level, then the LR-BPM is working properly and can provide reliability data. The application software can easily perform this check in the control system.

A beam test was conducted to verify the functionality of the BTS LR_BPM system. Fig. 4 shows the log sum of LR-BPMs along the beam transport line of a routine injection scenario. The trigger of electron gun stops immediately when the storage ring stored beam increases to 200 mA in 170 seconds, corresponding to the machine cycle near 120. The intensity variation of the transport line reveals the performance of the booster synchrotron. The log sum, even if it is not very accurate,, together with the screening, can optimize the operating conditions of the transport line and the extraction conditions of the booster synchrotron. The log sum can also be used to measure the loss of the beam along the transport line. The input current of the correct magnet power supply controls the beam position. HC1 denotes the first horizontally correct power supply, and VC1 denotes the first vertically correct power supply. Fig. 5 illustrates the results of varying HC1 with the position of X. Fig. 6 illustrates the results of varying VC1 with the position of Y.

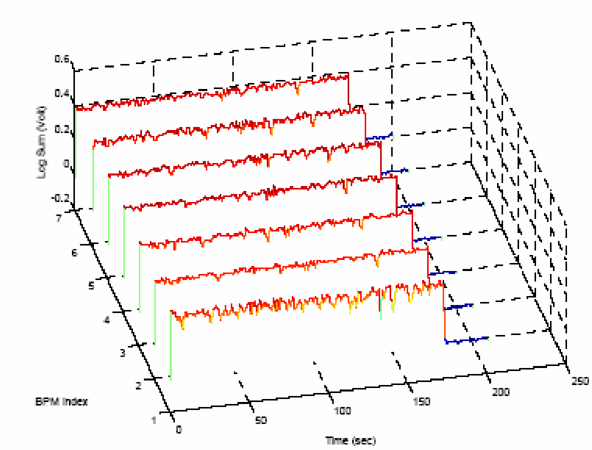

Figure 4: The BTS beam intensity (log sum) distribution as function of time in a routine injection scenario. This figure is shown the log sum output or BTS LR-BPM during injection, the stored beam current of the storage ring is started form 0 mA accumulated to 200 mA about 170 seconds.

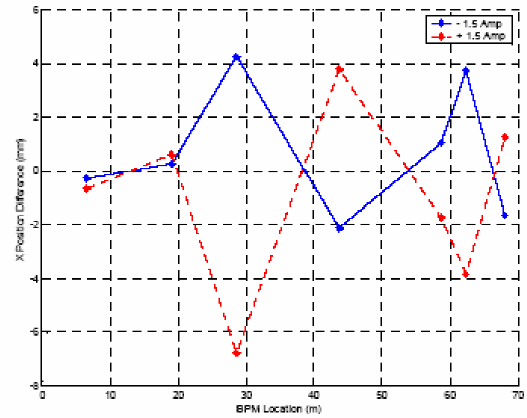

Figure 5: Horizontal trajectory difference when the HC1 change ± 1.5 A.

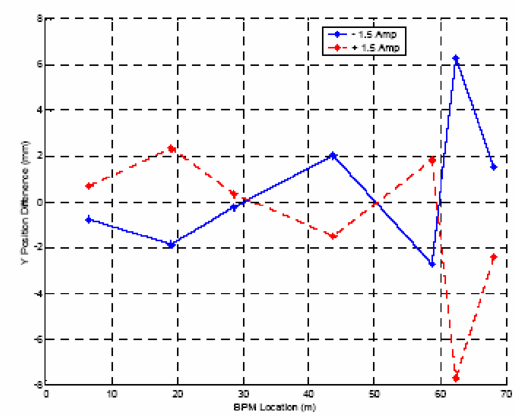

Figure 6: Vertical trajectory difference when the VC1 change ± 1.5 A.

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

INTENSITY MONITOR

Two fast current transformers (FCT) and three integrated current transformer (ICT) was installed to measure the beam intensity and to characterize transmission efficiency of the transport line. One FCT was installed at the booster synchrotron, and the other was installed at the upstream of the transport line. The two FCTs were used to measure the booster synchrotron extraction efficiency. The measured results are illustrated in Fig. 7. The upper trace represents the stored beam at the booster synchrotron, and the lower trace represents the extracted beam. The ripple baseline is the interference from the extraction kicker. The extraction efficiency can be calculated from the shape of the beam signal. To measure the transport line transmission efficiency, three ICTs were installed at the upstream and downstream of the transport line and in the middle of the vertical achromatic section around the middle of the transport line. The first and second ICT measured waveforms are illustrated in Fig. 8. The transmission efficiency of the first half of the transport line was nearly 100%.

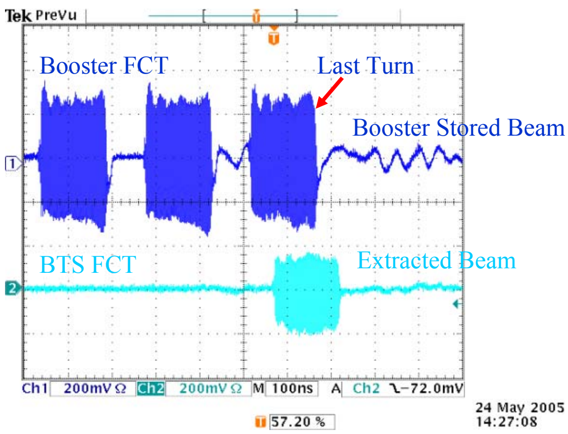

Figure 7: In-flange integrated current transformer

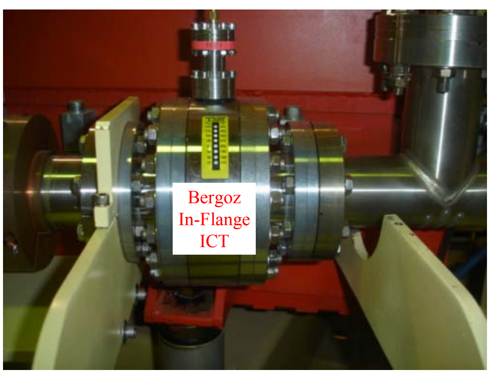

Figure 8: In-flange integrated current transformer

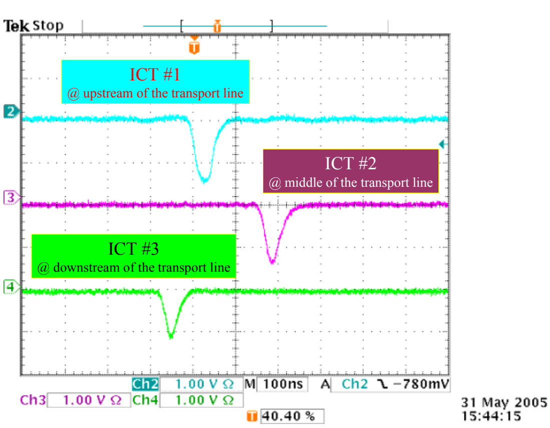

Figure 9: Typical output of the integrated current transformer

SCREEN MONITOR

Eight fluorescent screen monitors were installed at the transport line. Several optical transition monitors and YAG:Ce screen monitors were also installed for testing and evaluation. IEEE-1394 digital cameras were used as the fluorescent screen monitors [3, 4]. The long distance transmission with the digital interface eliminates image distortion, and eliminates the need for a frame grabber in the computer. All cameras can be triggered with the extraction timing. The exposure time is user programmable, providing flexibility when using monitor screens. The emittance was measured by quadrupole scan methods. The measured emittance was around 230 nm-rad, which was consistent with the theoretical value.

SUMMARY

This study summarizes transport line diagnostics, describes devices and functionality, and presents the results of beam testing.

REFERENCES

[1] http://www.bergoz.com
[2] K. H. Hu, et al., "Beam Position Monitoring System fir the 1.5 GeV Transport Line of NSRRC", Proceeding of the PAC 2003 2554 (2003).
[3] C. J. Wang, et al., "Applications of the IEEE-1394 CCD Camera for Beam Diagnostics in NSRRC", AIP Conf. Proc. 732, 462 (2004).
[4] C. H. Kuo, et al., "The IEEE-1394 Digital Camera Application in the Taiwan Light Source", Proceedings of PAC 2005.