COMMISSIONING OF A BPM SYSTEM FOR THE LNLS BOOSTER TO STORAGE RING TRANSFER LINE

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Abstract

In order to increase the number of diagnostics and make possible studies of beam position effects in the injection efficiency, a beam position monitoring system was designed to equip the BTS (booster to storage ring) transfer line employing the long striplines BPM´s. The log-ratio technique was applied using a commercial electronics module (LR-BPM) from Bergoz Instrumentation. Currently the system is integrated to the LNLS control system, database and ready to be used routinely during the injections. This work describes the system topology, details about the hardware and software, bench tests and measurements performed with electron beam. Future plans to improve the injection efficiency will also be presented.

INTRODUCTION

The Brazilian National Synchrotron Light Laboratory (LNLS) is integrated to the National Research Center for Energy and Materials (CNPEM). Its main facility is a 1.37 GeV electron storage ring operated for users since 1997. The injection system comprises a 120 MeV linear accelerator and a 500 MeV booster synchrotron. The low energy top-up injections occurs twice a day.

In order to minimally disturb the storage ring and beamlines thermal stability, there is a constant effort to keep the injection time reduced. In the last years typical injections last about 20 minutes [1].

The bigger the number of diagnostics in the injection system, the faster a fault condition can be identified and solved. Consequently, tracking the beam position at the BTS transfer line helps to preserve the injection efficiency. For this sake, four stripline BPMs available in the BTS were used with LR-BPM electronics, provided by Bergoz Instrumentation.

The Linac to booster (LTB) transfer line also counts on stripline BPMs, but due to our long electron gun pulses (hundreds of ns) and to the non-repeatable pulses observed at the BPMs, the LR-BPMs are not suitable for the this transfer line. Fortunately we can postpone the installation of devices to measure the position in the LTB transfer line thanks to the good injection efficiency achieved in the past years.

SYSTEM DESCRIPTION

The system is based on commercial modules LR-BPM and long stripline type BPM block. Four monitors installed in the BTS transfer line were used.

The following sections present the system details encompassing transfer line layout, strip line BPMs geometry, processing electronics, installation layout and monitoring software.

The BTS Transfer Line

Figure 1 shows the components' arrangement at BTS transfer line, highlighting mainly dipoles, quadrupoles, steering magnets and beam position monitors.

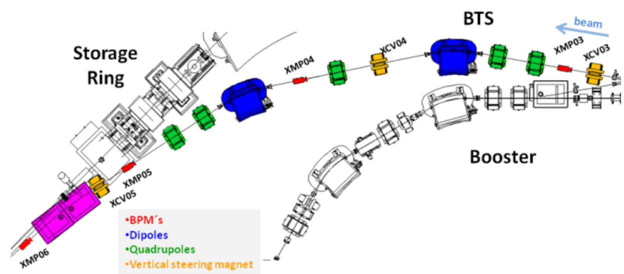

Figure 1: BTS (booster to storage ring) transfer line.

Experiments using the vertical and horizontal steering magnets were performed, basically checking the correlation between steering magnets current variation and the beam position. The results will be showed in the Beam Experiments section.

The Stripline BPM

Button-type BPM show better mechanical properties when compared to stripline type, but due to its higher sensitivity, single shot measurements usually use this kind of monitor. Figure 2 shows the mechanical design of the BPM block. The BPMs employed in this project were installed in 2001 for commissioning the booster synchrotron [2]. In the last years these monitors were in disuse.

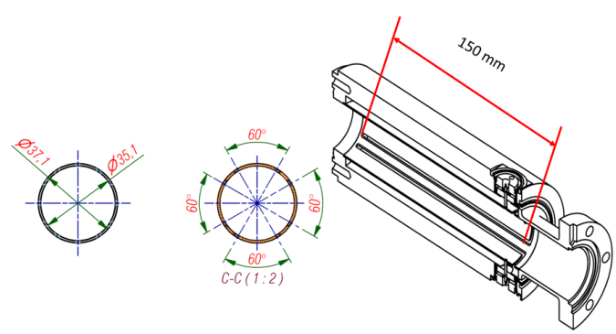

Figure 2: BTS stripline BPM.

The stripline BPM theoretical sensitivity, for a cylindrical geometry, is given by the expression 1. The position linearity is much better using the logarithmic method of processing [3].

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$$S_x = \frac{160}{\ln 10} \times \frac{\sin\frac{\theta}{2}}{\theta} \times 17.55 mm^{-1} = 1.89\ \mathrm{dB}/\mathrm{mm} \qquad (1)$$

Processing Electronics

The LR-BPM modules were applied to process the single shot beam position at BTS. This electronics uses the log ratio technique between opposite antennas to perform the position measurement. Signals from the pickups crosses tuned helical filters, the signal oscillates and produces burst. Four parallel logarithmic amplifiers detect the burst envelopes, then opposite log signals are subtracted [4]. Figure 3 shows the LR-BPM simplified diagram.

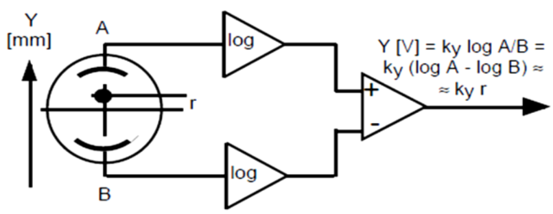

Figure 3: Simplified functional LR-BPM diagram.

The log ratio technique has excellent features, especially a wide dynamic range and better linearity compared with other measurement methods [5]. It also provides a greater bandwidth, which allows to process single-shot beam, turn-by-turn and continuous beam. The modules are equipped with a sample & hold circuit to hold the single-shot position up to 100 ms after processing.

Installation Layout

In order to adequate the data from the monitors to the LNLS control system and data logging system, a second sample & hold circuit was designed. It was necessary due to the lack of a standard control system ADC board capable of performing external triggered data acquisitions. Figure 4 shows the schematic diagram of the final installation of the LR-BPMs in the LNLS control system.

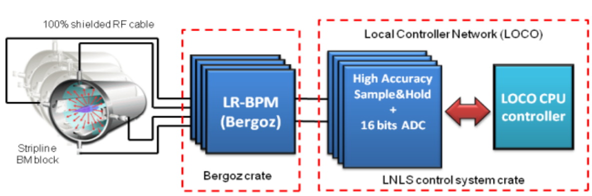

Figure 4: Installation diagram.

The cables that connect the BPM´s to the LR-BPM boards are Heliax ¼ corrugated cables from Andrew. They are connectorized with SMA connectors. In one of the BPMs we used a standard coaxial cable with no 100% shielding (LMR195).

Monitoring Software

In order to monitor the measurements at LNLS control room, an application was developed in Delphi, the standard language of the LNLS control system. Figure 5 shows the screen during a dispersion test made with a pulse generator. The program is being routinely used during the injection time and basically shows a position versus time (lower graph) and a XY graph (upper). In the figure, the XY graph vertical scale is 20 mV, and converting to position it is approximately 0.2 mm.

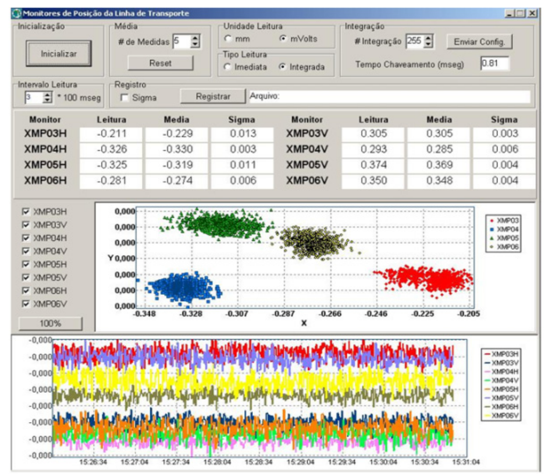

Figure 5: Monitoring software user interface.

MEASUREMENTS

Bench Tests

Bench top measurements where performed to verify the electronics performance. The resolution versus the input signal amplitude and the dynamic range were evaluated. Figure 6 shows a test performed at three different offset values, where the amplitude of the input signals was scanned.

It´s clear that, with low amplitudes and with off-center beam the resolution decrease significantly. The experiment also measures the minimum amplitude detectable by the electronics, which was near from 10 mV. Typically the amplitudes involved in the measurement of LNLS BTS transfer line are between 10 mV and 500 mV.

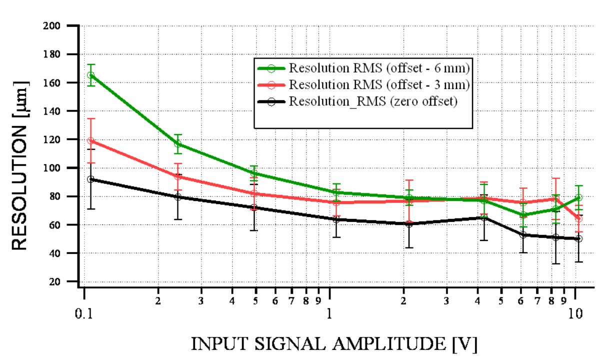

Figure 6: Resolution versus peak-to-peak input signal.

Tests to evaluate the accuracy (offset) and the long term offset variation were not performed, once offset cancellation can be done by adjusts on the LR-BPM boards and the offset long term stability will be monitored after an extended period of time by the database records. The long term offset stability is important to monitor the repeatability of the beam injections along large time intervals. As the resolution changes with the beam offset, it is convenient to keep the beam as close as possible to zero.

Beam Experiments

An attempt to improve the injection efficiency using the position measurement from BTS transfer line, would involve innumerous experiments. Beam position measurements are affected by the transfer line optics, pulsed extraction magnets and repeatability of the booster energy ramp. A series of experiments are will be held even in 2011, taking into account the availability of accelerators to machine study shifts.

Recently, in a series of simple machine experiments, we tried to identify the correlation between the BTS steering magnets and the beam position. Figure 7 shows steps approximately of 0.4A in the vertical steering magnet XCV03 (see figure 1) and coherent variation of monitors XMP04, 05 and 06, all in the vertical plane.

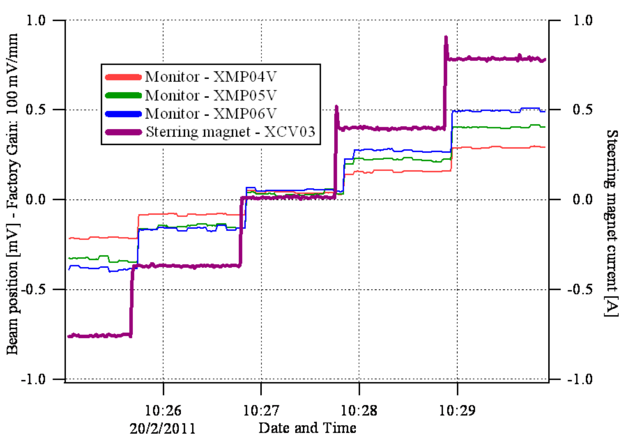

Figure 7: The steering magnet variation experiment.

We were dazzled by the discrepancy between measured positions based on the calibrations from Eq. (1) and expected corresponding values from calculations with a model of the transfer line and with measured integrated fields for the steering magnets. They differ by a factor of 10, in some cases. This should be sorted out in the next few weeks so that commissioning of the system can resume.

In the Horizontal plane, variations in the steering magnets (installed inside quadrupoles) did not produce the expected position response at the monitors. This problem is under investigation. The measurements in the horizontal plane are important to study the energy influence in the BTS beam position.

CONCLUSION AND FUTURE PLANS

A beam position monitoring system for the LNLS BTS (booster to storage ring) was designed. Bench top measurements and preliminary beam experiments were conducted and indicate a robust performance. The system is fully integrated to the LNLS control system and analysis database. The beam position in the BTS is being routinely used during the injection time.

A very carefully calibration is still required and the long term stability has to be observed.

In order to use the position data in the BTS to improve the injection efficiency, various experiments are planned to be carried out. This will take place during machine study shift along the first semester of 2011. Besides, one unit of LR-BPM will be applied in studies of non linear dynamics of the booster using the turn-by-turn operation mode.

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