BEHAVIOR OF THE BPM SYSTEM DURING THE FIRST WEEKS OF SOLEIL COMMISSIONING

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Abstract

SOLEIL, a new synchrotron light source built near Paris in France, is pioneering a new high resolution electron Beam Position Monitor (BPM) system in order to achieve beam stability at the micron level. The same BPM system can also measure the turn-by-turn beam position for various machine physics studies. It combines the high stability characteristics of multiplexed input channels and the flexibility of a digital system. Instrumentation Technologies developed a chassis called "Libera electron" upon SOLEIL proposals and requirements. The first weeks of the Storage Ring commissioning have been very successful thanks in large part to the BPM system that was operational from the first day. The system is being progressively evaluated and debugged. Although not all requirements are yet fulfilled, we are confident that it will operate at full performance after the necessary improvements are implemented by SOLEIL and by Instrumentation Technologies.

INTRODUCTION

SOLEIL is a third generation light source built near Paris (France)[1]. It is designed for delivering very bright and stable photon beams mostly in the soft X-ray range. Its Beam Position Monitoring (BPM) system [2] is based on a new digital electronics, the "Libera Electron" [3], manufactured by Instrumentation Technologies. The quick commissioning of the Booster last fall was greatly helped by a system of 22 BPMs that worked well. However, the Libera needed some major firmware rebuilding in order to make all 161 hardware units working reliably before the Storage Ring commissioning. This was done on time. This paper reports on the BPM system behavior during the Storage Ring commissioning[4]. The turn-by-turn measurements have been successfully used for tuning the first turn and the stored beam orbits. It also provided the tune information with a Libera connected to an additional BPM as part of the tune monitor. The position interlock system for machine safety, based on the Libera interlock output signal, has also been successfully tested.

FUNCTIONS TESTED

The functions tested during the first commissioning phase are:

- Turn-by-turn/First turns data source: it is for commissioning the machines and for machine physics applications (machine model, non linear beam dynamic studies) and for tune measurements. Beam positions are measured at the revolution frequency (846 KHz). The system must accommodate low currents on a single beam passage.
- Slow acquisition data source: gives the mean position for a stored beam. The system must accommodate large current variations and several different bunch patterns; it has to provide a good accuracy and a very good resolution in order to allow closed orbit drift correction
- Interlock: when the beam goes outside a predefined position range at any selected BPM, the BPM electronics gives an interlock signal which is used to kill the beam and prevent possible damage to the machine.

MEASUREMENTS ON THE RING

Turn by Turn Data Source

- The first application of the Turn by turn data source was the position measurements at the beginning of the commissioning. From day one with the first electrons in the ring until the beam has been stored. Turn by turn data allowed to progress step by step in the injection process and make position corrections that worked as expected. At first, it allowed to understand quickly that the kickers were connected in the opposite direction. It also helped investigate the location of obstacles in the beam path with local orbit bumps. The resolution even at the lowest injected currents is much better than specified.
- As soon as we had several turns in the machine, it became important to get all 120 BPM data of a same turn without crosstalk between consecutive turns. A first problem has been to synchronize all Liberas in turn by turn measurements on a one-turn beam.

By default, after a reboot, the 120 Liberas are not synchronized to their external Machine Clock (MC) at the revolution frequency. They just use the Machine Clock as a frequency reference in order to lock their internal oscillator that clocks the ADC sampling. However, an internal process that can be started remotely allows all Liberas to synchronize their measurement period to the machine revolution frequency, in phase with the MC.

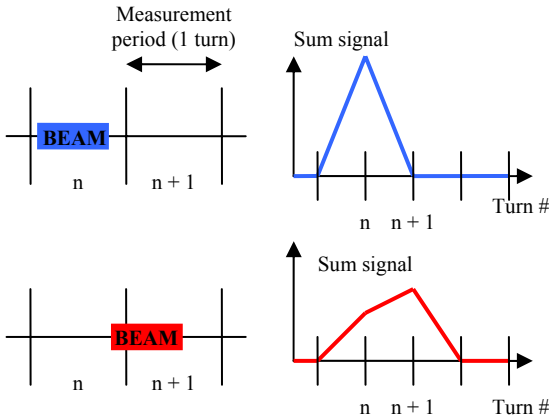

Figure 1: One-turn Sum signals on two BPMs with different phases of the beam with respect to the Machine Clock (MC).

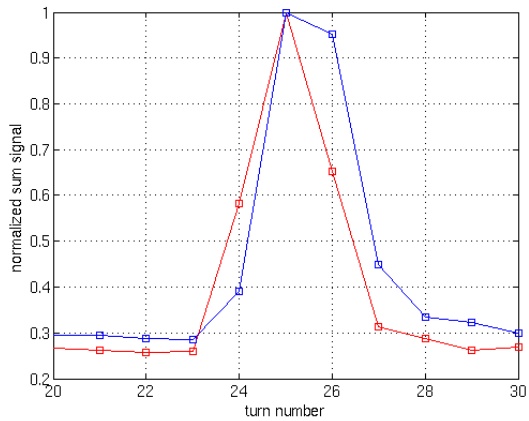

Figure 2: Good beam phase with respect to the MC (red curve) and wrong beam phase (blue curve).

After that, two problems remain:

1. Filter bandwidth for turn by turn data: with well synchronized Liberas and only one turn in the Ring, the Sum signal is high for at least 3 turns (figure 2). This means that the filter built in the FPGA is too narrow. The next software release due in July will correct this problem.
2. Machine clock delay adjustment: We have to make an adjustable delay on the MC Libera inputs in order to accommodate the time the beam needs to go from the first to the last BPM. This will be done either by SOLEIL as an addition to its timing system or internally to the Libera timing system by IT

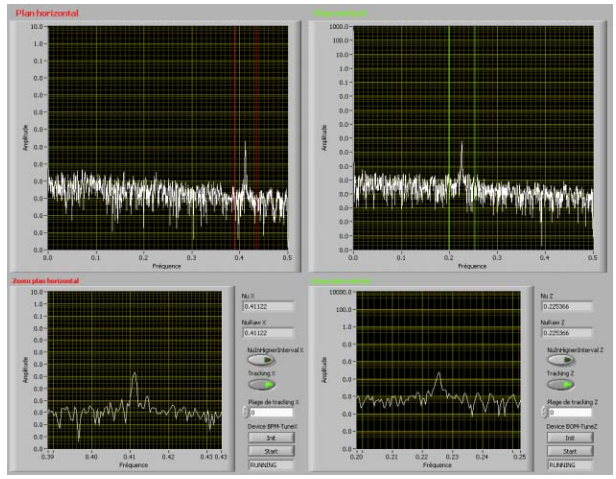

Figure 3: Tune measurement with FFTs performed on Libera Turn-by-Turn data.

An important application of the Turn-by-Turn data is the tune measurement. An additional BPM with its Libera is dedicated to the tune measurement. It provides a "vector" of turn by turn data that yields the tune after an FFT (fig. 3).

This function was extensively used during the first weeks of SOLEIL commissioning, as soon as a few tens turns were injected, speeding the proper tuning of the Storage Ring. The tune measurements accuracy has not been accurately measured, but it seems to be much better than 5. 10^{-4}.

Slow Acquisition Data Source

The slow acquisition has been used these last days for testing the Beam Based Alignment application. We observed a resolution between 2 and 9 µm in horizontal and between 4 and 14 µm in vertical. These results are still suspicious. Because of late delivery, bench measurements couldn't be performed in the Slow Acquisition mode before the tests with beam.

Subsequent tests with a signal generator on 8 Liberas in Slow Acquisition mode showed rms noises well under 1µm (fig. 4).

Further investigation has to be performed in order to understand the discrepancy between these measurements.

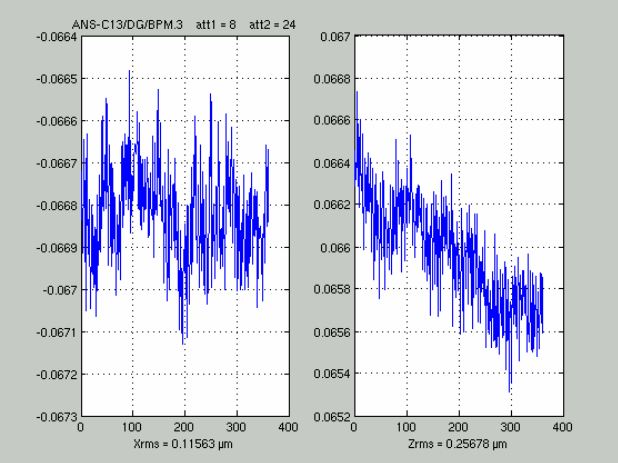

Figure 4: Libera noise in Slow Acquisition mode: Xrms = 0.11µm, Zrms = 0.25 µm (360 acquisitions in 180 s).

Interlock

The interlock functionality provided by the Libera has the following characteristics:

- when the beam goes outside a predefined range in horizontal or vertical plane, an interlock signal is provided by the Libera. This signal is 10 ms long.
- if one ADC is saturated, the interlock is provided.
- the interlock can be gain-scheme dependant, meaning that the attenuation of the RF chain needs to be upon a predefined range to authorize the interlock.

The present interlock functionality has been delivered as a preliminary release. Nevertheless, it was implemented and used on the SOLEIL Storage Ring as soon as 20 mA was stored in the Ring.

The problem encountered with the position interlock is when we switch the RF chain attenuators when the current in the Ring changes. An attenuator change produces a position measurement spike that may reach 1 mm even with only a two dB step. This will be discussed and solved with Instrumentation Technologies.

CONCLUSION

SOLEIL BPM system has been operational from the first day of the Storage Ring commissioning It greatly contributed to a relatively easy and quick commissioning. A few problems were identified and will soon be corrected with the help of Instrumentation Technologies that designed and manufactured the "Libera" BPM electronics.

ACKNOWLEDGEMENTS

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REFERENCES

[1] J.-M. Filhol et al., "Overview of the Status of the SOLEIL Project", these proceedings.
[2] J.-C. Denard, "Preliminary Tests of a New Kind of BPM system for SOLEIL", DIPAC'05, Lyon, June 2005.
[3] A. Kosicek, "Libera Electron Beam Position Processor", PAC'05, Knoxville, May 2005.
[4] A. Nadji et al., "First Results of the Commissioning of the SOLEIL Storage Ring", these proceedings.