MEASUREMENTS ON LIBERA ELECTRON AND LIBERA BRILLIANCE BPM ELECTRONICS

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Abstract

ALBA synchrotron light source is a 3rd generation machine being constructed by the CELLS consortium near Barcelona, Spain. Orbit correction system will be based on the Libera Brilliance electronics and its goal will be the stabilization of the beam at the submicron level. Important parameters to reach such corrections have been measured and are reported in this document, like electronics resolution, beam current dependence, latency (among others). Comparison of the two different Libera products offered by the company (Libera Electron and Libera Brilliance) is also reported in order to analyze the benefits of choosing Libera Brilliance.

INTRODUCTION

Synchrotron machines constructed nowadays require beam position stability in the order of hundreds of nanometres. Such stabilities can only be accomplished with a dedicated system, usually known as Fast Orbit Feedback System (FOFB). The FOFB system is in charge of the following:

- Measurement the beam position drifts around the machine.
- Transmission of all the position measurements to the computational unit/s.
- Calculation of the correction values and actuation on the beam through corrector magnets.

ALBA will use the Libera Brilliance electronics, developed by Instrumentation Technologies company, to perform the measurements and the transmission of the beam position [1]. Brilliance are an upgraded version of the already existing Libera Electron units. A vast laboratory test has been done on each of the units in order to check their specs and prove the Brilliance improvements vs. the Electron.

LABORATORY MEASUREMENTS

Here are reported some of the results obtained during the Site Acceptance Test [2] (SAT) of the electronics. Until now, a total of 31 Electron units and 66 Brilliance ones have been tested.

Laboratory Setup

Units were tested one by one using the test setup showed in Figure 1. A remote industrial PC sets the Libera parameters and retrieves the data through a Matlab based GUI [3] (both slow rate and fast rate data). An RF generator simulates the electron beam, while two function generators are used to generate the needed clock signals and events. A small modification of that setup allows us to perform latency measurements using the Libera interlock output.

We report here the measurements done on the Brilliance units. Electron units results are showed on the comparison chapter.

Electronics Resolution

Vertical RMS resolution of 8 Libera units is showed on Figure 2. As seen, the needed sub-micron resolution is achieved on the electronics down to ~5.5mA beam current (-45dBm Libera input), on a 10kHz measurement rate.

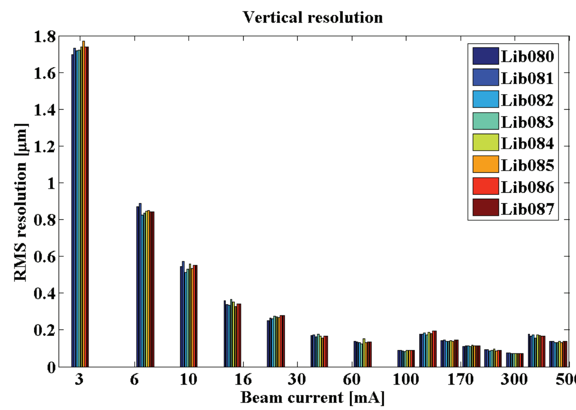

Figure 2: Vertical resolution of 8 Liberas @ 10kHz rate

Resolution is improved a factor 10 for slower rates, i.e. at 10Hz rate for control systems acquisitions.

Beam Current Dependence

Beam Current Dependence (BCD) of the position readings on the stored beam has been improved on the Libera Brilliance electronics (Figure 3).

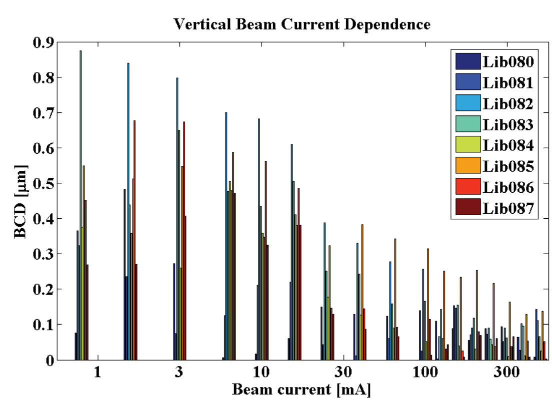

Figure 3: Vertical BCD of 8 Liberas @ 10kHz rate

Position measurement dependence, or independence, remains below 1µm even at very low beam currents. Once ALBA will be running on Top-Up mode, the BPM

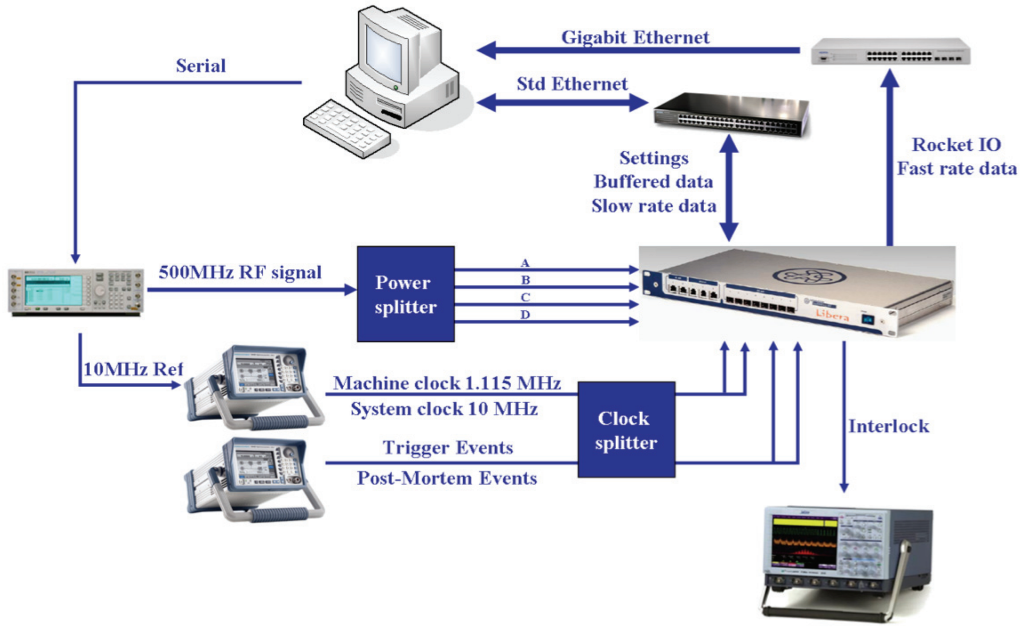

Figure 1: Laboratory test setup for Liberas measurements

readout electronics contribution to the BCD will be negligible. After testing all the 161 Libera units that ALBA has purchased, a sorting of best quality Liberas will be done for those machine places where a better BCD and/or resolution are needed.

Synchronization Stability

Global acquisitions of position reading around the ring are synchronized over the revolution clock (1.1153MHz for ALBA storage ring). Each Libera accomplishes the synchronization using an internal phase locked loop (PLL) locked to the revolution clock. Figure 4 shows its stability during 24 hours.

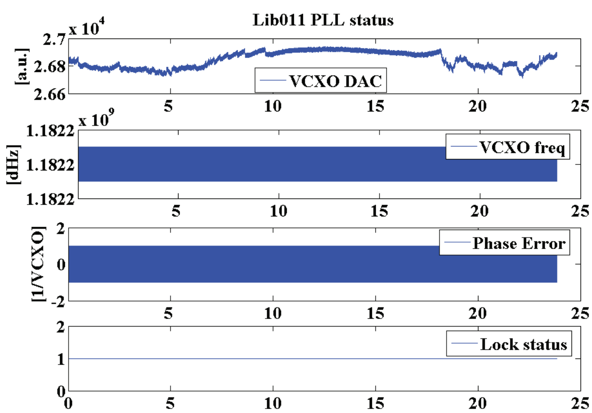

Figure 4: PLL stability during 24 hours.

The PLL remains “locked” during the whole time, as well as the phase error never gets out of the +1/-1 stable region. It can be recognized the night period when the temperature in the lab was more stable and therefore the DAC voltage driving the oscillator didn’t change much.

Latency Measurements

Latency is a key parameter when implementing global beam correction systems, as it determines how fast we can run the FOFB system. The BPM electronics turned out to be one of the main contributors to the overall latency on the FOFB.

Interlock output of the Libera was used to measure the latency. Figure 5 illustrates the test setup.

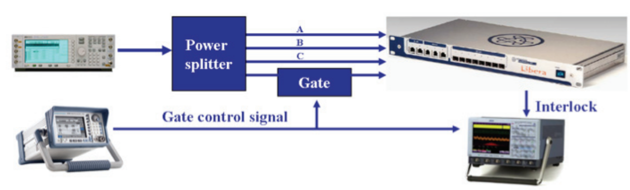

Figure 5: Test setup for latency measurements

A steep change on the Libera inputs moves the position readings out of thresholds, triggering the interlock output. Time difference between input change and interlock trigger determines the latency value.

Table 1: Latency for different interlock thresholds on an offset corrected beam

Threshold [mm]	Min Latency [µs]	Max Latency [µs]	Δ [µs]
700	132	255	123
800	153	260	107
1000	173	268	95
1200	181	297	116
1500	205	308	103

Difference around 100µs between min and max latency results are inherent to the interlock source. Interlock signal is triggered based on 10kHz fast data positions.

ELECTRON VS. BRILLIANCE

One objective of the reported study is the analysis of Libera Brilliance benefits versus Libera Electron. The hardware difference between them is mainly on the analog board, which has improved its Analog to Digital Converters (ADC) from 12 to 16 bits. There's in principle no software difference, which make both units compatible from the controls point of view.

Electronics Resolution

Figure 6 shows a comparison of the vertical resolution between the units (very similar results are obtained for the horizontal).

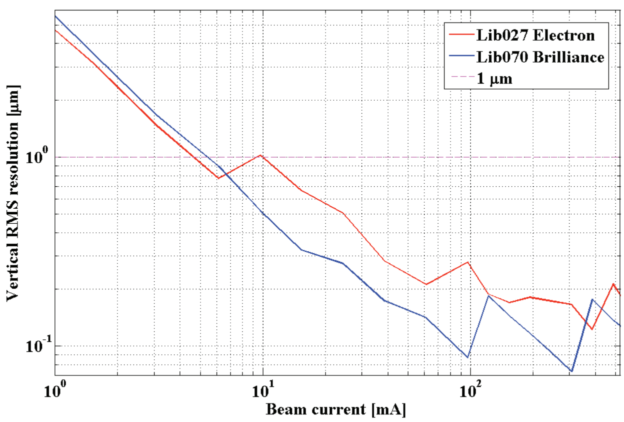

Figure 6: Comparison of the vertical RMS resolution

A non substantial resolution improvement from the Electron has been achieved on Brilliance; nevertheless both units have excellent results.

Beam Current Dependence

Highest improvement on Brilliance is on the BCD (Figure 7). The higher dynamic range of the ADCs allows them to stay working in a more linear area, reducing the position dependence function on the electronics input signal level.

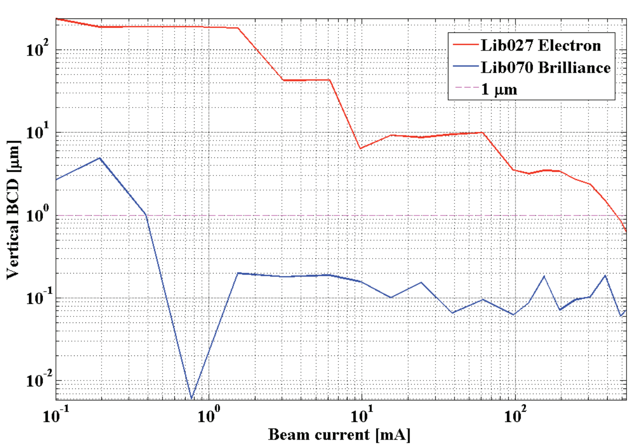

Figure 7: Comparison of the vertical BCD

Note that with Electron the BCD is always above the micrometer level (for ALBA, the maximum current is 400mA) while the Brilliance unit is almost independent of the beam current (based on a simulation of 100% filling).

Filling Pattern Dependence

Since we have introduced the filling pattern issue, Figure 8 shows the comparison between the two units function of different patterns.

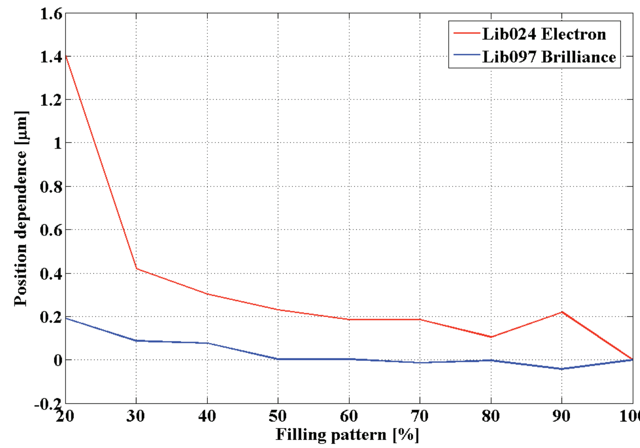

Figure 8: Comparison of filling pattern dependence

Electron results were already quite good and they have been improved a bit on the Brilliance units.

CONCLUSIONS

Laboratory characterization of all the BPM electronics showed that the Brilliance units should fulfill the requirement of a 3rd generation light source in terms of resolution, stability and beam dependence.

Changes on the analog board of the Libera Electron to make it Brilliance improve the long term parameters, easing the electronics calibration when changing the current or the filling patterns of the machine.

REFERENCES

[1] A. Olmos, "ALBA Fast orbit feedback topology", CELLS internal document AAD-SRDIFOFB-A-0001, February 2008

[2] A. Olmos, "Liberas 2nd batch SAT", CELLS internal document AAD-SRDILIBERA-A-0002, March 2008

[3] www.cells.es/Divisions/Accelerators/RF_Diagnostics/Diagnostics/OrbitPosition/eBPM_Readouts/MatlabLiberasGUI/