COMPARATIVE MEASUREMENTS OF LIBERA BRILLIANCE AND BSP-100 *

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Abstract

The Advanced Photon Source (APS) is a third-generation synchrotron light source in the United States. The beam position monitor (BPM) electronics plays an important part in the beam stability control. This paper presents comparative measurements of two BPM electronics: Libera Brilliance and the APS FPGA-based BSP-100. Some important parameters such as beam-current dependence, electronics resolution, and fill-pattern dependence have been measured. These measurements were carried out in the lab and in the real system. The results will be useful for deciding which BPM electronics to deploy in the APS upgrade project.

INTRODUCTION

The APS upgrade project will upgrade the APS to higher beam current, requiring stricter beam position stability. Libera Brilliance, a BPM processor developed by Instrumentation Technologies [1], is being evaluated for use in the upgrade project. A similar experiment was done last year for NSLS II here at APS [2]. An Experimental Physics and Industrial Control System (EPICS) driver from Diamond Light Source [3] is installed in this newly delivered electronics, and SDDS [4] tools are used for data acquisition and analysis. The performance of the Libera Brilliance was compared to the BSP-100, a BPM processor made in-house at APS [5]. The BSP-100 is a field-programmable gate array (FPGA) -based, single-width C-size VXI data acquisition module. It is integrated with a Coldfire CPU module, which runs EPICS on RTEMS for control and remote monitoring. It can receive position and intensity data from four monopulse receivers. Some comparative measurements are made in the lab. Other measurements are done in the real system.

LABORATORY MEASUREMENTS

To compare the performance with simulated partial fill patterns for the two electronics, a test setup was deployed in a lab at the APS.

Measurement Setup

Figure 1 shows the setup for the BSP-100. To implement partial filling, the 351.9-MHz rf signal output goes through a switch, whose on time is controlled by a DG535 digital delay generator and synchronized with the APS revolution clock at 271.5 kHz. The signal is then connected to a four-way splitter with each signal path connecting to a remotely controllable attenuator to simulate the four BPM button signals. The four signals — TI, TO, BI, and BO — are fed into a filter comparator. The primary function of the filter comparator unit is to convert the voltage impulse from the buttons into pulse-modulated signals at 351.9 MHz, the ring's rf frequency. It also compares the four rf signals to create a beam intensity signal and two difference signals, one for the x-axis and one for the y-axis [6]. The monopulse BPM receiver generates normalized beam position and intensity signals for the BSP-100 to perform signal processing and data acquisition operations.

The rf generator power, the DG535 gate duration, and the attenuator are controlled by a soft EPICS Input/Output Controller (IOC) through a LanGPIB gateway HP E5810A and GPIB bus.

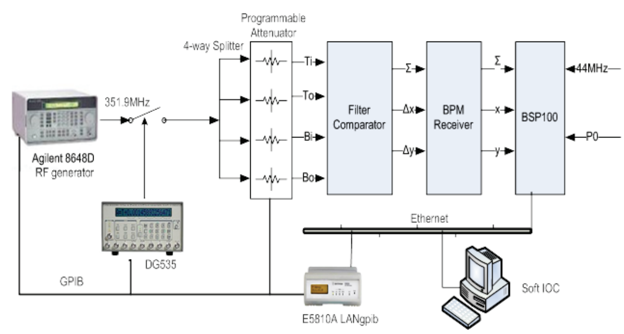

Figure 1: Lab setup for the BSP-100.

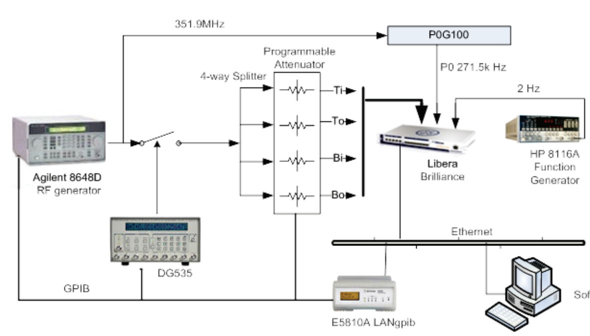

Figure 2: Lab setup for Libera Brilliance.

The setup for Libera Brilliance is shown in Figure 2. The rf signal feeds into a VXI module P0G100 to generate a synchronized revolution clock signal for the

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Libera Brilliance's machine clock input. A 2-Hz trigger signal is generated by an HP 8116A function generator.

With different duty cycles from 10% to 70% and all of the attenuators set to 0 dB, the standard deviation with each power scan is shown in Figure 3.

The filter comparator introduces 14 dB of attenuation relative to the Libera setup. Calibration factors used correspond to the highest sensitivities for APS small-aperture pickup electrode geometries used near insertion device source points.

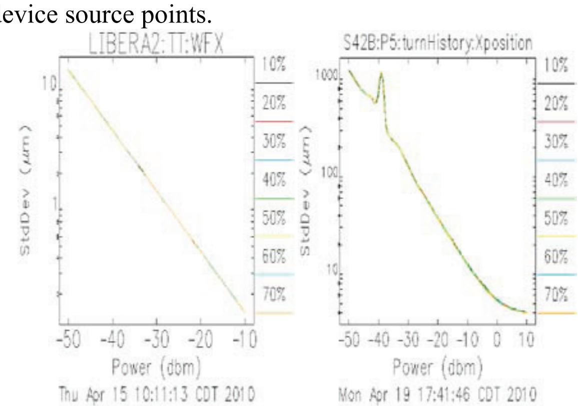

Figure 3: Standard deviation for different partial filling with power scan for BSP-100 (right) and Libera Brilliance (left).

MEASUREMENTS IN REAL SYSTEM

Both sets of electronics were attached to sets of 4-mm-diameter capacitive pickup electrodes mounted on the small-aperture insertion device vacuum chamber at the APS 35-ID undulator source point. Both the BSP-100 and the Libera Brilliance were calibrated before measurement.

Electronics Noise Resolution

To measure the noise floor, the BSP-100 and the Libera Brilliance were attached to real pickup buttons. A four-way splitter was attached to a single button for each of the two electronics. White noise of 1 nm, 10 nm, and 100 nm per root Hz were plotted as a reference.

Figures 4 and 5 show Integrated rms noise for the BSP-100 and the Libera Brilliance in the horizontal and vertical planes. The beam was steered horizontally as a proxy for beam intensity change. Figure 6 show integrated rms noise for various signal intensities. In this case, the beam was steered horizontally to change the single-button intensity level.

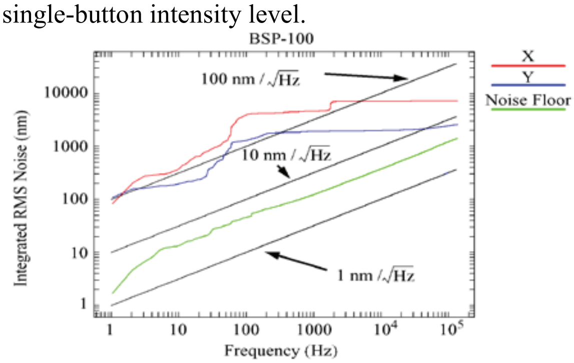

Figure 4: Integrated rms noise for the BSP-100.

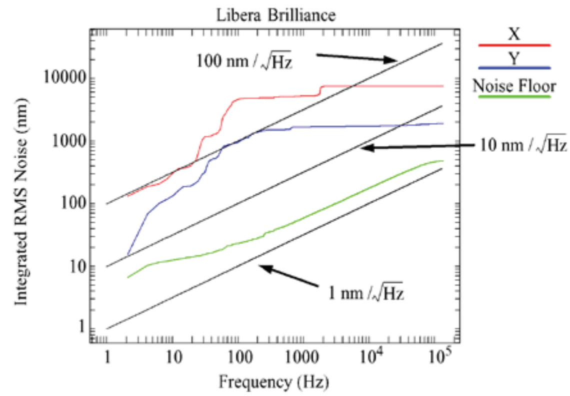

Figure 5: Integrated rms noise for the Libera Brilliance.

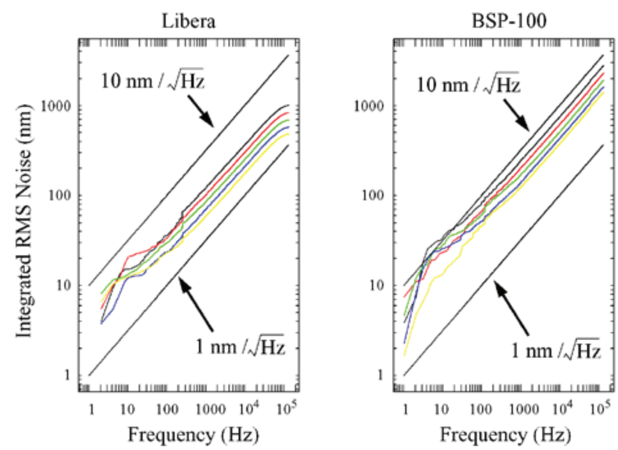

Figure 6: Integrated rms instrumentation noise for the BSP-100 and the Libera Brilliance.

Beam Current Dependency

To compare the beam current dependency, four-way combiners and splitters were connected to the Libera Brilliance and filter comparator for the BSP-100 as shown in Figure 7. Beam was injected into the storage ring with a 24-bunch singlet fill pattern to a level of 101 mA. By using a scraper, the beam positions were logged while the beam was gradually scraped down. To simulate a DC position offset, three 3-dB attenuators and one 6-dB attenuator were connected to the receiver input, the same for both the Libera Brilliance and the BSP-100. The Libera Brilliance implements an automatic switching between its four ADC channels, which is supposed to improve the beam current dependence and long-term stability. This switching feature can be turned on and off. The BSP-100 module provides an analogous switching feature that commutates the rf phase of the rf sum signal on alternate turns to reduce the effects of electronic offsets. In addition, the rf front end upstream of the BSP-100 module multiplexes between horizontal (X) and vertical (Y), but can be placed in X only or Y only modes.

With different setup combinations, the results for beam current dependence measurement are shown in Figures 8 and 9.

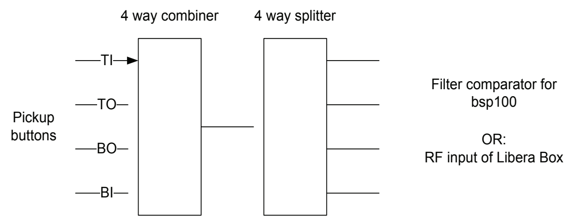

Figure 7: Four-way combiner and splitter.

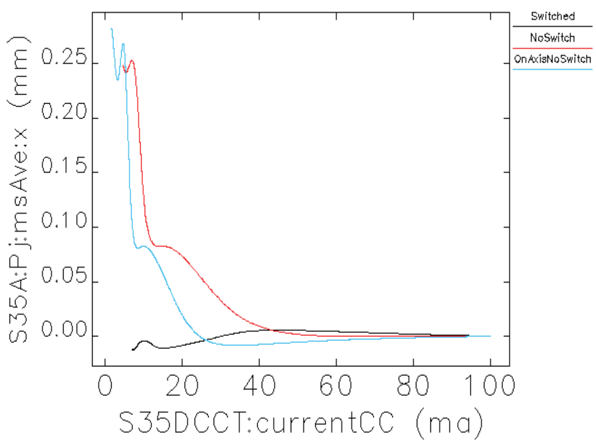

Figure 8: Beam current dependency measurement for the BSP-100.

The Libera Brilliance has significantly better overall beam current dependency than the BSP-100.

The blue and red lines in Figure 8 show the BPM position measured by the BSP-100 configured without commutation, without and with DC position offset, respectively (the data for offset beam is displaced vertically to better show intensity dependence). The black line shows the result with commutation mode and with DC position offset. Use of the commutation mode results in better overall beam current dependency for the BSP-100.

The blue line in Figure 9 shows 0.52-µm position change with beam current from 20 mA to 100 mA in the horizontal plane with switching turned off and no DC offset. With DC offset, the Libera Brilliance shows increased beam current dependency as shown by the black and red lines. With switching turned off, the red line shows more glitches compared with the black line.

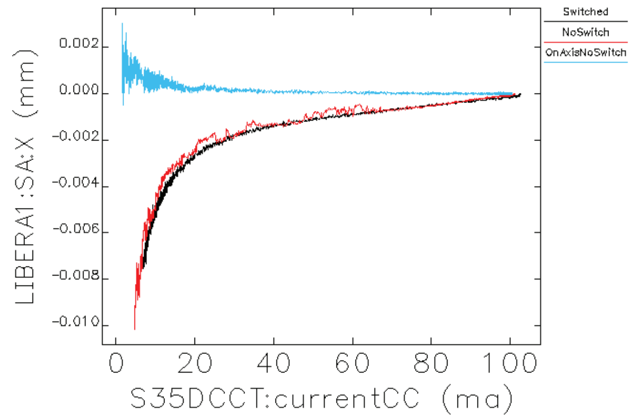

Figure 9: Beam current dependency measurement for the Libera Brilliance.

CONCLUSION

The Libera Brilliance shows equivalent partial filling dependence, less electronics noise and better beam current dependence than the BSP-100. A few important parameters need to be compared in the future, e.g., long-term drift. The BSP-100 has the capability to connect four BPM receivers while the Libera Brilliance can only connect one; the Libera Brilliance is also more expensive. Another consideration is how to connect the Libera Brilliance to the storage ring real time feedback system. These factors will affect the selection of BPM electronics for the APS upgrade.

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