PHOTON BEAM POSITION MEASUREMENTS BY LIBERA PHOTON USING COPPER BLADE SENSORS AT SOLEIL SYNCHROTRON

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Abstract

Libera Photon is the new Photon Beam Position processor (PBPM) from the Instrumentation Technologies. First measurements on real beam have been done at SOLEIL Synchrotron. The module was connected to a PBPM installed on the DIFFABS bending magnet beam line. Three different beam position experiments were done: measurement of position at beam bump (+/- 500 µm), beam current dependence and filling pattern dependence. Measurements were done with internal BIAS voltage source set to -70 V. Measured current was in the range up to 250 µA on the sensor. Measurements were done on standard 100 kS/s, 10 kS/s and 10 S/s data flows with different bandwidths. The article discusses the results and consequential improvements of the device.

INSTRUMENTATION

Libera Photon is a photon beam position processor, which features current-to-voltage conversion, digitalization and signal processing. The output data flows are delivered with different rates (100 kS/s, 10 kS/s and 10 S/s) and can be accessed simultaneously. The acquisition can be performed using Matlab, Tango or EPICS clients.

Input currents were in the range up to 200-250 µA per input. Libera Photon features Automatic Range Control (ARC) with 7 ranges: ±2 nA, ±20 nA, ±200 nA, ±2 µA, ±20 µA, ±200 µA and ±1,85 mA. ARC adapts the I/U converter values automatically according to the input signal level. During our tests, the measurement range was set manually.

Blade sensors were copper type. It requires BIAS voltage to extract the photons. BIAS voltage was supplied by the Libera Photon unit and was set to -70 V. There were 2 XBPM sensors placed in the storage ring front-end: Libera Photon unit was connected to the first one (XBPM1), whereas Soleil analog device was used on the second one (XBPM2) to be used as a comparison. XBPM1 sensor is placed 4,7 metres from the source point, XBPM2 is placed 7,73 metres from the source point.

MEASUREMENTS

The following measurements were done on the beamline: beam bump measurement, beam current dependence measurement, filling pattern dependence measurement and noise measurement. Beside tests in the beamline, beam current dependence and noise measurements were done also under laboratory conditions.

All data, presented in this paper, were acquired at 10 kS/s (DD buffer) or at 10 S/s (SA) data rates.

Beam bump measurement

Slow orbit feedback and Fast orbit feedback in the storage ring were disabled in order to be able to displace the photon beam. Transverse feedback was enabled all the time. Filling pattern was multi bunch 4/4. Photon beam was displaced from -500 µm to +500 µm by steps of 100 µm using correctors to create a bump on the electron beam. Position was read by Libera Photon on XBPM1 and analog device on XBPM2 and compared to the position at source point using electron BPM. Results are presented in Figure 1.

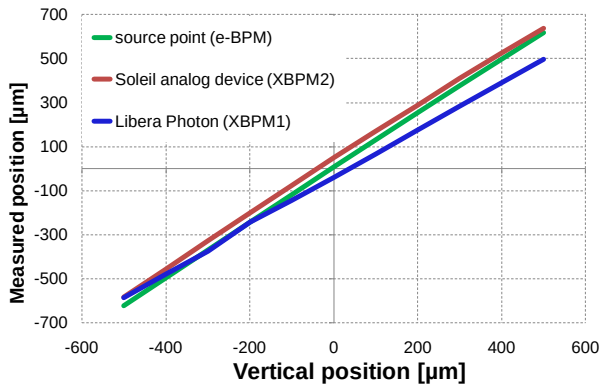

Figure 1: Beam bump measurement.

The analog device shows good correlation with the source point. Libera Photon, however, shows different slope in the measurement. There was no calibration or compensation used in Libera Photon. The slope and the offset can be set for each input channel individually. This must be done during instrument set up and then saved to the configuration file.

Beam current dependence measurement

With orbit feedbacks ON, the current in the storage ring was increased from 0 to 400 mA by steps of 50 mA (injections) and then scrapped down to 0. Measuring range used on Libera Photon was ±200 µA.

Both instruments (Libera Photon and Soleil analog device) measured changes in the position for several microns. The beam was really moving because of the machine current dependence (thermalization, eBPM beam current dependence,...). So this method could not be used to measure the beam current dependence of the Libera Photon electronics.

The current dependence measurements were done also under laboratory conditions. Both centered and off-

centered beam positions were simulated. The test setup consisted of 4 resistors with same (centered beam) and different (off-centered beam) resistance values. Current through resistors was changed by using external voltage supply. Libera Photon unit was configured with maximum range (n° 6) to cover the range up to 1800 µA for both measurements.

With a simulated centered beam, results were 0,1 µm in horizontal and 0,25 µm in vertical direction.

With a simulated off-centered beam, the highest average current measured was 1,28 mA. One of the inputs was already in saturation if the current was raised even more. The current dependence was 4 µm in horizontal and approximately 3 µm in vertical direction. Results are presented in Figure 2.

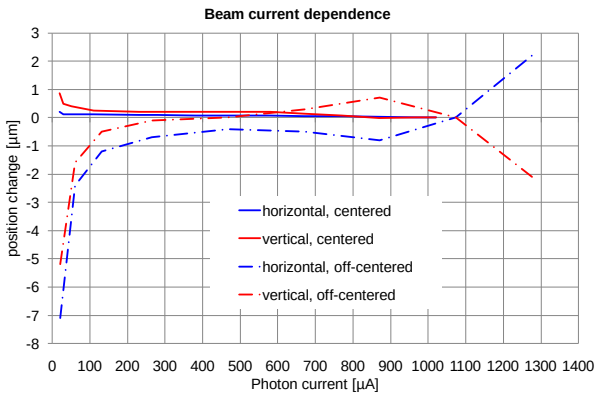

Figure 2. Beam current dependence measurement in the laboratory.

The current dependence at off-centered beam did not reach the specification as for centered beam (< 1 µm). Therefore, more investigation will be done to understand the phenomena and achieve better results.

Bunch pattern dependence measurement

Orbit feedbacks in the storage ring were enabled during the measurement. Storage ring current was set to approximately 50 mA. Amplitudes and position were read for 2 different filling patterns: multi bunch with 4/4 filling and 8-bunches. Data from Libera Photon was acquired at 10 kS/s data rate. Mean positions of both acquisitions are the average of 10 second measurement (100 kSamples) and are presented in Table 1.

Table 1: Fill pattern dependence.

Fill pattern	Vertical position
Multi bunch 4/4	-61529 nm
8-bunch	-60999 nm

The measured filling pattern dependence is around 500 nm, which is very satisfying. Moreover, we can not certify that the measured movement was not really on the beam. Indeed, the machine has its own filling pattern dependence (mainly caused by e-BPMs). So the filling pattern dependence of the Libera Photon is probably below 500 nm.

Results are presented in Figure 3.

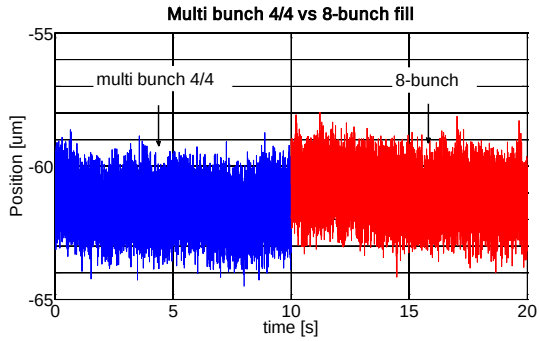

Figure 3: Multi bunch vs 8-bunch fill pattern.

Resolution measurement

At first, the noise in the position measurement was measured in the beamline. Data at 10 kS/s was analyzed. Measured noise was in the range of 700 nm. By analysing the data using a FFT, it was clearly seen that the main component was in the 50 Hz spectrum line (~500 nm). Results are presented in Figure 4. In parallel, SA data was acquired. Noise was lower for approximately a decade. Results are presented in Table 2.

Table 2: Noise measurement in the beamline.

Acquisition type	Position noise (RMS)
DD buffer	702 nm
SA data	57 nm

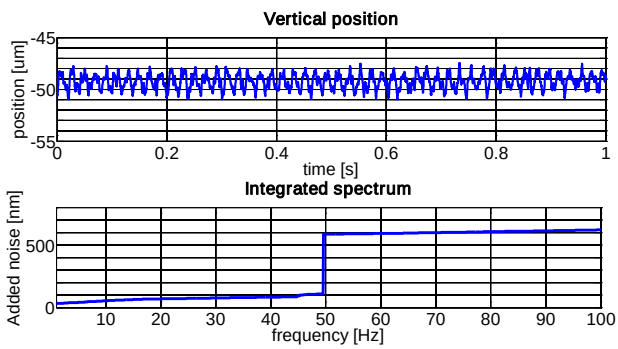

Figure 4: Noise measurement in the beamline.

Then, Libera Photon noise was also measured in the laboratory environment. Test setup consisted of 4 resistors which simulated approximately 350 µm off-centered beam and a voltage generator. Measurements were done

in steady conditions. Data at 10 kS/s and 10 S/s was acquired. We can notice that the 50 Hz component is no more present, so it was not introduced by the electronics. Please see Figure 5 and Table 3.

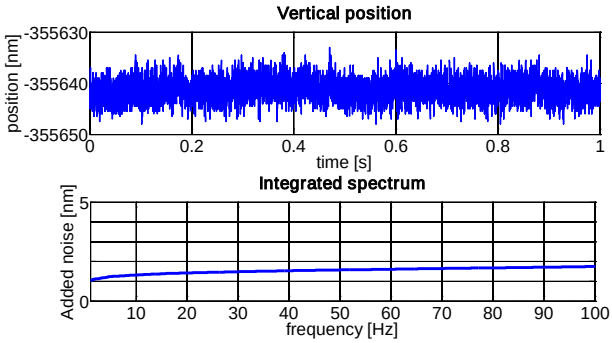

Figure 5: Noise measurement in laboratory conditions.

Results show very low noise on both, the DD buffer data and SA data. The FFT analysis did not show any specific component which would introduce significant noise to the measurement. Noise is not dependent on the absolute position.

Table 3: Noise measurements in laboratory conditions.

Acquisition type	Position noise (RMS)
DD buffer	4,2 nm
SA data	1,7 nm

Issues discovered

There were two issues discovered during the testing on the real beam which could lead to malfunctioning of the unit.

If charged cables are connected to the unit, the energy in the cable can stick the contacts of input relays. The measurements with the unit are still possible but the calibration can not be done anymore. The occurrence of the failure is not high, but may happen if cables are often disconnected/connected. It is suggested at the moment that the cables are connected while the photon current is not present. Anyway, for this case, the input protection is under investigation and will be implemented in the unit shortly.

The second issue is related to unit's restart, reboot or turn OFF. If the bias voltage is used and the unit is restarted, rebooted or turned OFF while the bias voltage is set to some value, the contacts of the switching relay stick. As the consequence, the bias voltage source sees the short circuit and can not provide the voltage. The issue has been already fixed.

CONCLUSION

The first Libera Photon units have been tested with a current source at Instrumentation Technologies and on a real beam at SOLEIL.

During the tests, some problems related to instrument reboot were discovered. These problems have been fixed.

The current dependence is within specification for a centered beam but not yet for a beam off-centered by 0,35 mm in both directions (< 1 µm required). This is going to be fixed very soon.

The other measurements showed good results. The resolution of the position measurement is in the range of nm on DD buffer and SA data. The very low noise, in the nm range, should allow a precise angle monitoring, within a feq nrad, between two XBPMs separated by only a couple of meters.