LIBERA BRILLIANCE AND LIBERA PHOTON WORKING TOGETHER IN FAST ORBIT FEEDBACK

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Abstract

Libera Brilliance is already a standard Beam Position Processor system, which provides data flows at different sampling rates and bandwidths. It is widely used in the Fast Orbit Feedback (FOF) system. For this purpose the fast acquisition data flow (called FA) at ~10 kHz sampling rate is used. Two standard protocols can be employed for integration, GB Ethernet or DLS Communication Controller, the later being developed at Diamond Light Source.

Libera Photon is a new photon beam position processor, which is used on blade-based XBPMs. Similar to Libera Brilliance, it provides dataflow at different sampling rates. Sampling frequency of the Libera Photon FA was carefully chosen to exactly match the Libera Brilliance FA.

This enables a smooth and simple integration of both devices into the same Fast Orbit Feedback. Since both devices also share the same control system interface, their combination in the same system provides a firm foundation for further stabilization of the beam.

INTRODUCTION

During last few years, many synchrotron light sources are successfully implementing local and global FOF. The use of the FOF suppresses various noise sources significantly and minimizes the RMS of the electron beam position oscillations in the frequency range up to ~200Hz, finally resulting in the improved stability of the photon beam. To obtain even better stability, it is required to monitor the photon beam and therefore the inclusion of the photon beam position monitor in the FOF loop(s) was proposed. The photon beam position monitors can be used to monitor only the vertical position of the beam (in the bending magnet beam lines) or to measure also the horizontal position of the beam (after the insertion devices).

As a result a better optimized correction matrix for driving corrector magnets of electron beam is obtained and more stable photon beam is measured at the target. The analysis of the later was discussed in [1].

The use of Libera Brilliance and Libera Photon in the same FOF offers several benefits:

- Full and straightforward synchronization of data streams from both devices. The data is automatically synchronized to RF frequency as well.
- Fast data @ ~10 kHz sample rate and 2 kHz bandwidth.
- The fast data stream can be implemented via either GB Ethernet protocol or DLS Communication Controller, both being proved as reliable and easy to use solutions.

LIBERA BRILLIANCE

Libera Brilliance is well known state of the art instrument for electron beam position processing on synchrotron light sources. Its superb metrological characteristics and the supported flexibility in software have made it the BPM electronics of choice. The instrument is constantly improved through software release policy, new features and applications being suggested by both, by users and by development staff. The device has several possibilities to interface the accelerator control system.

One of the main strengths of Libera Brilliance is its performance and flexibility when it is used as the data source (or even controller) for FOF. The so-called fast acquisition (FA) data stream, which is used as the input to the correction matrix, has the sample rate of ~10kHz (accelerator dependent) and the 3dB bandwidth of exactly 2kHz. The specified beam position RMS of this data stream is 0.25µm for the input signals above -20dBm, and is usually kept even lower.

LIBERA PHOTON

Libera Photon is a recently developed photon beam position processor for electrical current output based sensors. Its performance is being tested on Soleil and ESRF. In terms of functionalities it is similar to Libera Brilliance, except that it is used for photon beam position monitoring. Due to the principles used it lacks the turn-by-turn (TBT) data. Anyhow it is of most importance, that Libera Photon shares the same FA data output as the Libera Brilliance.

The Libera Photon is an All-in-one device, so it features:

- Current to voltage conversion
- Digitalization of analogue signals
- Digital signal processing

Four current inputs of the instruments may be used in different configurations. The internal bias voltage source may be used to bias the potential of the inputs. Still, the choice of external bias voltage is provided if higher voltage is required.

The internal calibration current source is built-in in the instrument; the calibration itself takes less than 10 seconds. The long term measurements conducted have shown excellent stability though.

Libera Photon covers broad range of the input signal levels. The input signal amplitude span is divided into seven ranges, as presented in table below.

Table 1: Input Current Ranges

Range	Input current
0	<2 nA
1	2 nA – 20 nA
2	20 nA- 200 nA
3	200 nA – 2 uA
4	2 uA – 20 uA
5	20 uA – 200 uA
6	200 uA – 1.8 mA

The ranges can be set either manually or automatically. Automatic gain control is based on observation and quick analysis of the ADC buffer, the principle was proven on the Libera Brilliance already. A hysteresis is introduced to avoid frequent switching between adjacent ranges.

The Libera Photon preliminary position RMS performance was measured at four lower ranges, the setup and the results are outlined below:

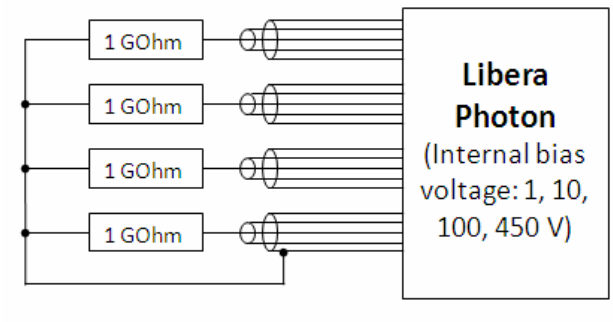

Figure 1: The measurement setup at lower ranges.

Table 2: The RMS at Lower Current Ranges

	Position RMS [um]		
Range	ADC	FA	SA
0	1.7	0.75	0.1
1	0.22	0.1	0.03
2	0.13	0.04	0.02
3	0.1	0.05	0.03

Libera Photon also uses the same software structure as the Libera Brilliance; the same principles are used for interaction with the control systems. This makes the integration into common operational system even more straightforward.

LIBERA PHOTON AND BRILLIANCE WORKING TOGETHER

Among the main ideas during the Libera Photon development was to make it compatible with Libera Brilliance from the FOF point of view. A lot of effort was in creation of the mechanism for the synchronization of the data streams. The only non-synchronized data available from the two devices is the ADC rate data; anyhow this is obvious since the ADC sample rate on Libera Brilliance is at ~115MHz (16bit), while the ADC rate on Libera Photon stays typically at ~100KHz (24bit).

FA data rate

The FA data rate is used as an input to the FOF correction matrix. When the Libera Brilliance is customized (specific requirement of each light source to adjust to the particular revolution time, retrieving so called TBT data), a suitable FA data rate is chosen at around 10kHz rate. Exactly the same data rate is used on Libera Photon. This makes the integration of both devices into the FOF straightforward. The integration of Libera Photon into a Libera Brilliance based FOF, is just the same as an addition of yet another Libera Brilliance.

The synchronization of the FA rate is realized in the same way on both devices; they are based on the same timing inputs. First, the synchronization in frequency is achieved through the Machine Clock. Then, on the Set-time trigger, the synchronization of phase is done by tweaking the phase-locked loop on sampling VCXO. The process is schematically shown on the figure below:

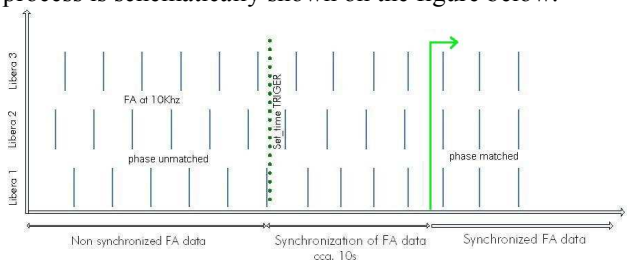

Figure 2: The FA data synchronization process.

In addition to perfect synchronization of phase and frequency, the FA data packets are equipped with 16bit counters. These are reset on the set-time trigger to assure that the samples originating from the right moment in time are taken into account for the correction calculation.

Setup

Libera Photon and Libera Brilliance are measuring the positions of two totally different types of beam, photon and electron beams. But as the photon beam originates from electron beam, the measurements on photon beam can reveal a lot of information of the behaviour of the electron beam. Having this information, the correction of the electron beam orbit can be significantly better.

To make the FOF containing both devices feasible, a dedicated fast LAN must be in place, connecting all BPM devices around the ring and beamlines. The final architecture of the FOF layout differs from accelerator to accelerator and it takes into the account different criteria like the accelerator size, minimum latency, existing connecting hardware, the amount of data concentrators, etc. Below is the scheme of the local FOF setup involving Libera Brilliance and Libera Photon:

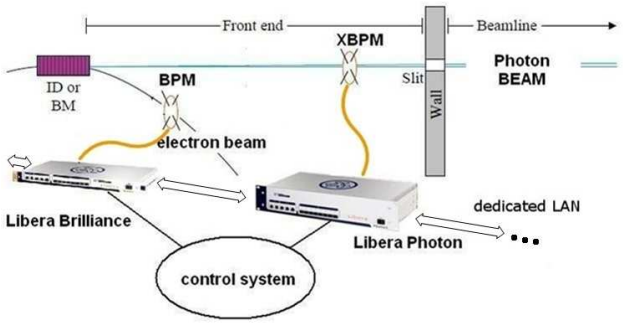

Figure 3: The setup.

As the Libera Brilliance and Libera Photon are identical from the FA point of view, they can be inserted in the setup in arbitrary succession.

The integration into control system

From the Control System point of view, the devices are also very similar. Although the Libera Photon is less rich with settings and options, main parameters are the same. As mentioned, the only data from Libera Photon that differs is the ADC raw data, which is 24-bit deep at 100kHz. Also, there is no TBT data from Libera Photon.

Below is the schematic [1] of the Libera Photon software structure, the architecture is identical with Libera Brilliance:

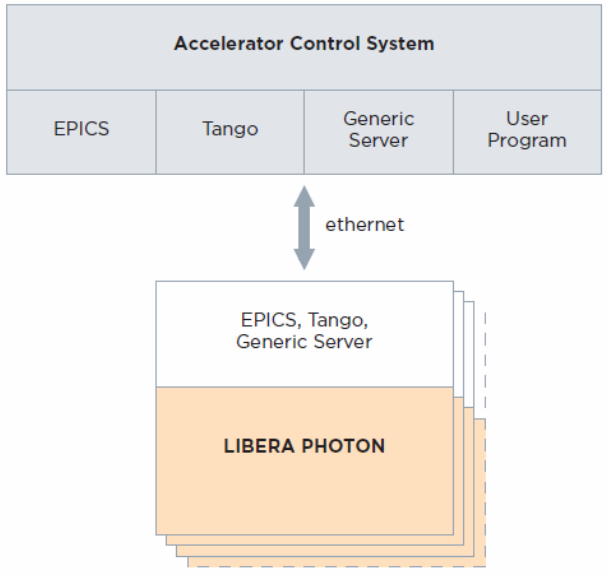

Figure 4: The Libera control system integration structure.

Although this is not a pure "plug and play" solution, for existing Libera Brilliance users this almost identical interface diminishes a lot of the effort and manpower needed for the integration of a new device into the Control System.

CONCLUSION

The addition of Libera Photon to the existing FOF is interesting for users mainly since:

- By having the same data properties it is very simple to extend the correction matrix of the existing Libera Brilliance FOF.
- Its integration into Control System is simple as it is using the same principles as Libera Brilliance.
- It helps to improve the global electron beam stability by adding a new dimension into FOF.
- It measures reliably the photon beam position, which is critical for the quality of the light source.

As already known, users can also count on Instrumentation Technologies extensive technical support during system planning, setup and commissioning.

REFERENCES

[1] D. Tinta, "Libera Photon", ppt presentation, Libera Workshop 2009, Solkan Slovenia, September 2009.