

# New Digital BPM Electronics for Single Pass Applications

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## Abstract

Monitoring and subsequent optimization of electron Linacs and transfer lines requires specific beam position data acquisition and processing. Libera Single Pass E is the newly developed instrument intended for position and charge monitoring in basic and multi-mode operation LINACs. Development, initial measurements and verification of the instrumentation performance were conducted in the Instrumentation Technologies' laboratories, followed by the characterization measurements of the unit carried out at KEK Linac facility. Currently the on-the-beam measurements and final tests are being performed by KEK Linac scientists. In the last step the instrument performances will be evaluated with the 3 BPM method – canceling the beam movements.

## Introduction

Libera Single pass E is the result of successful collaboration between KEK Linac and Instrumentation Technologies. KEK Linac provides electrons and positrons to various machines at KEK. The performance of these machine depends on the injection quality [1]. The BPM system therefore has to provide a continuous high precision monitoring of position for various beam species. Based on external event announcing it adapts to the beam charge and pattern and can consecutively process various beam structures (single bunch, narrow dual bunch, trains, continuous wave) with large dynamics (over 40 dB).



Figure 1: Libera Single Pass E front panel

## Data processing

Data processing is initiated by the external event signal. The short signal from the detector is first shaped by the analog front end filtering, designed in relation to the accelerator parameters. Further signal processing is defined by various parameters defining the processing window for a certain beam mode. The signal energy is calculated from the signal as defined by the processing window. After calculating all four amplitudes, position is calculated using formulas for X and Y. Four options can be used for position calculation:

Orthogonal pickup orientation

Linear formula

Polynomial formula - 3rd order

Diagonal pickup orientation

Linear formula

Polynomial formula - 3rd order

$$X = X_{OFFSET} + \sum_{ij=0}^3 K_{Xij} \left( \frac{(V'_A - V'_C)}{(V'_A + V'_C)} \right)^i * \left( \frac{(V'_B - V'_D)}{(V'_B + V'_D)} \right)^j$$

$$Y = Y_{OFFSET} + \sum_{ij=0}^3 K_{Yij} \left( \frac{(V'_A - V'_C)}{(V'_A + V'_C)} \right)^i * \left( \frac{(V'_B - V'_D)}{(V'_B + V'_D)} \right)^j$$

In the case of longer beam structures a similar data processing is used – based on the appropriate signal windowing [3]. The data calculation is initiated on the external trigger event and is automatically stopped after the bunch structure is over. The decimated batch of data is available for transmission to the control system. In the case of CW operation, the unit continuously processes and outputs the stream of decimated beam position data.

## Event reception

Libera Single Pass E [3] detects the events announced by the accelerator timing system in order to set the data processing parameters optimally for the expected bunch structure. Libera Single Pass E enables the event reception via the optics/wire event reception in the EVRX module or alternatively via external interfaces (EPICS protocol event generator).

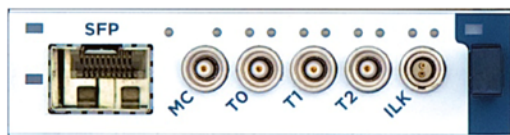


Figure 2: Event – receiver module

The EVRX module receives the optical signal through the SFP transceiver, identifies and extracts the 16 bit event code. Once the code has been extracted, the EVRX module decodes the event identification code and triggers specific functions at low latency.

## Performance

Measurement performance mostly depends on the Libera front-end configuration [2]. Its parameters are set in accordance with other accelerator parameters. At normal beam charges the position measurement resolution is close to 1 micrometer for a single bunch beam structure.

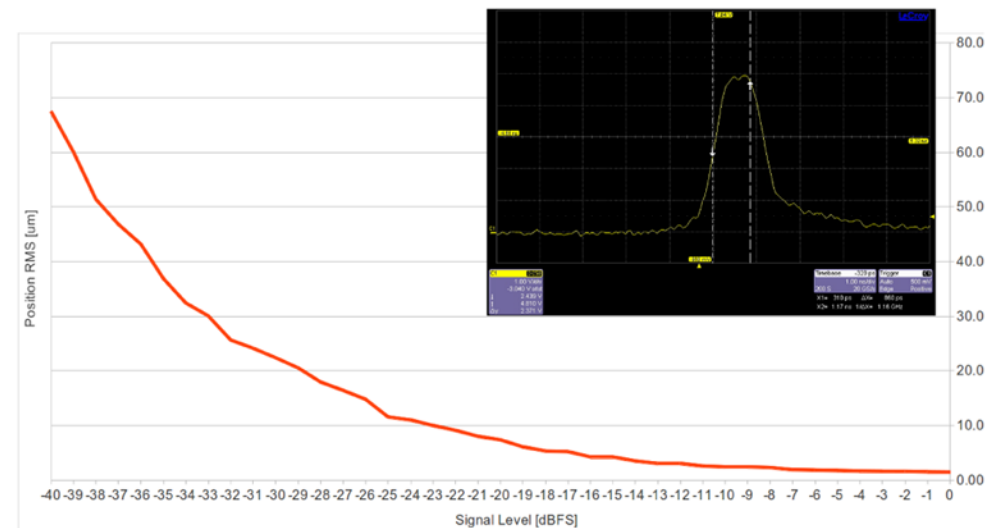


Figure 3: Measurement performance vs. input signal level

## Control system integration

On the top layer, Libera Single Pass E provides the Measurement and Control Interface (MCI) with a development package and Command Line utilities for open interaction in different control systems. The unit operation parameters are effectively controlled with the EPICS EDM graphical user interface.



Figure 4: A set of example EDM panels for easy & intuitive instrument control

## Conclusion

First Libera Single Pass E units have been tested at Instrumentation Technologies with a pulsed signal source. The extensive laboratory tests gave clean and expected results with an excellent position measurement accuracy, resolution and stability on various input signal types. On-the-beam tests are currently running at KEK Linac. Besides the general configuration and test of the unit performances, the compatibility test with the event system is in progress.

A successful collaboration needs to be emphasized between users (KEK Linac) and development & manufacturing of the instrument (Instrumentation Technologies).

## References

- [1] Dr. Masanori Satoh, "BPM Data Acquisition for KEK e-/e+ Injector Linac", Libera Workshop (2012)
- [2] Matjaz Znidarcic, "Libera single Pass E", Libera Workshop (2012)
- [3] Instrumentation Technologies, Libera Single Pass E User Manual v1.00, Solkan, September 2011