PRELIMINARY EVALUATION OF THE MTCA.4 BPM ELECTRONICS PROTOTYPE FOR THE PETRA IV PROJECT

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Abstract

Within the PETRA IV project at DESY, the synchrotron radiation source PETRA III will be upgraded into a low-emittance source. The small beam emittance and reduced beam size imply stringent requirements on the machine stability. To meet the requirements on position measurement and orbit stability, a high-resolution BPM system will be installed in the new machine, with about 800 BPMs and MTCA.4-based readout electronics.

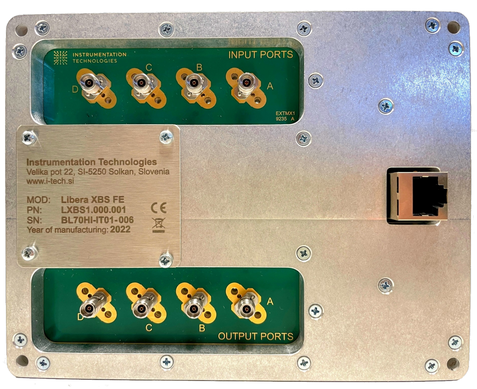
In the TDR phase of the project, I-Tech and DESY are cooperating on the realization of a BPM prototype that will demonstrate the feasibility of reaching the PETRA IV requirements. Several analog, digital and SW parts are taken from the Libera Brilliance+ instrument and are reused in the MTCA.4 BPM prototype, with some innovations. One of them is the separation of the RF switch matrix used for long-term stabilization: placing it near the BPM enables also the long RF cables to be stabilized. An 8 channel RTM board, able to acquire signals from two BPMs was developed and is also tested.

This paper presents an overview of the BPM electronics prototype and the promising test results achieved in the Instrumentation Technologies' laboratory with the first boards produced.

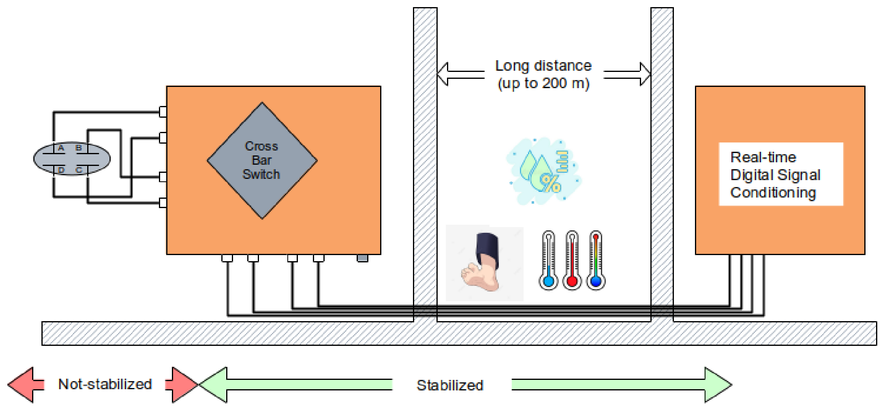
Performance Requirements

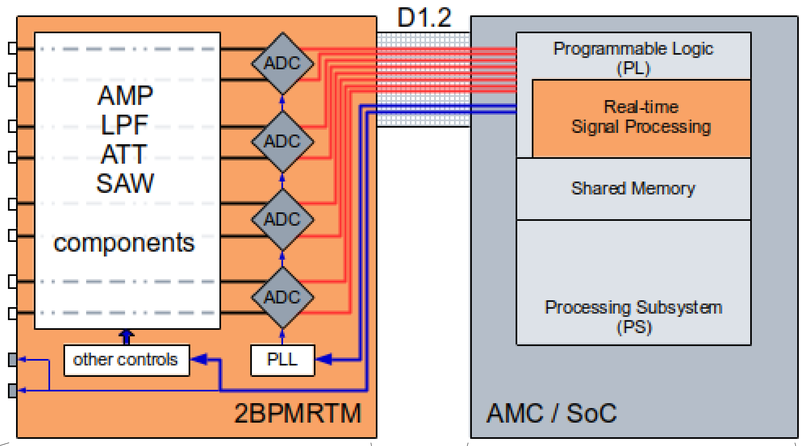
Parameter	Requirement
Resolution on single bunch/turn	< 20 µm RMS at 0.5 mA
Resolution on closed orbit	< 200 nm RMS at 200 mA in 1600 bunches, 300 Hz bandwidth
Beam current dependence	± 2 µm in 0 to -60 dBm range
Long-term stability	< 1 µm in 6 days, ± 1°K
FOFB latency	≤ 3 turns (~23 µs)

Developments: Libera XBS FE and 2BPMRTM, platform management



Libera XBS FE is remotely powered and controlled cross-bar switching module.



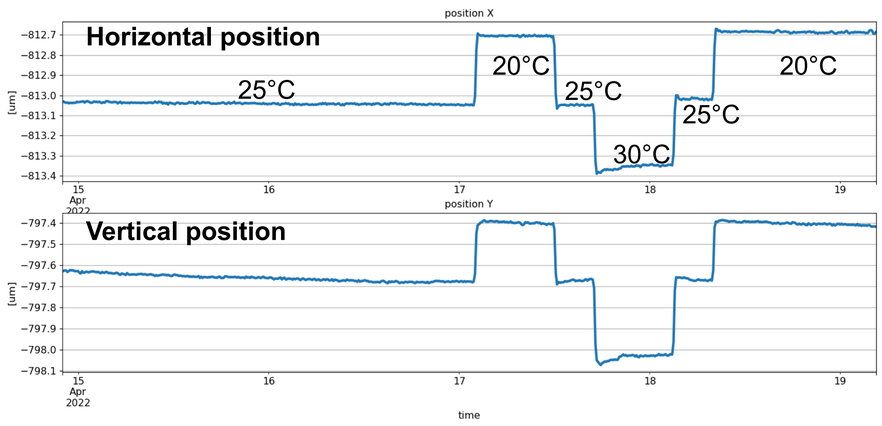


2BPMRTM module supports the readout from 2 BPMs (8 channels). It controls 2 Libera XBS FE devices.

Results in laboratory

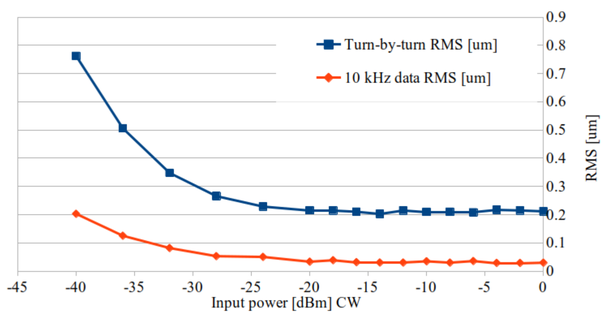
Long-term test in the temperature chamber: 4 days under various temperature conditions

The system (RF generators, cables, instrumentation) was put into the temperature chamber with pre-defined temperature profile.



Property	Value
Position drift at constant temperature	<100 nm peak-to-peak
Position drift under varying temperature	100 nm/°K

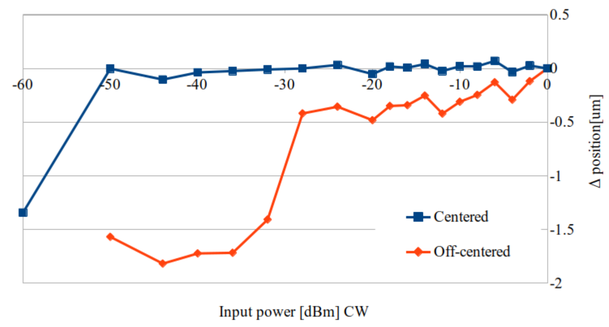
Resolution on closed orbit



Resolution was measured with 500 MHz CW input signal.

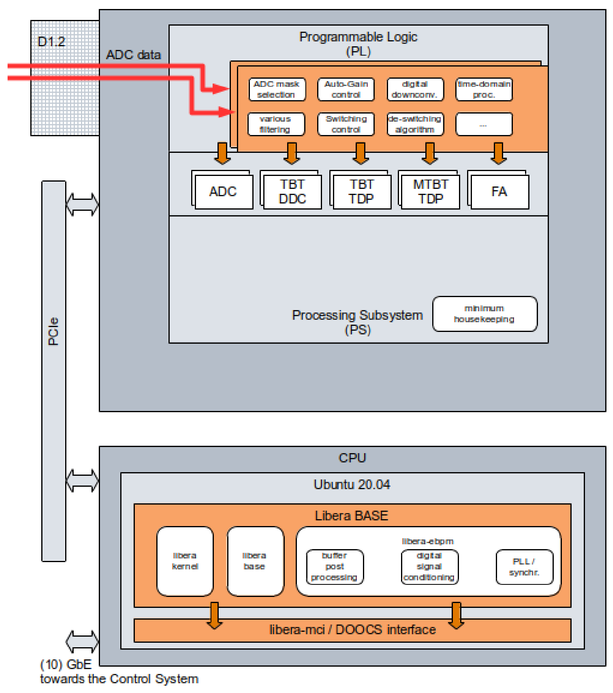
Data	RMS
Turn-by-turn, bandwidth ~45 kHz	<300 nm 0 to -30 dBm
10 kHz data, bandwidth 2 kHz	< 200 nm 0 to -40 dBm

Beam current dependence



Beam current dependence was measured with 500 MHz CW input signal.

Figure presents the performance for centered (blue) and off-centered (red) conditions.



Conclusion

The prototype BPM system for the PETRA IV project has been under development since December 2020. The first RTM module was developed, produced and tested already in March 2022 showing promising results. In the same time frame, the external switching module prototype was produced and tested with both, the Libera Brilliance+ and the RTM module. Its design and performance were confirmed with beam tests at PETRA III machine and the module had been finalized and produced as a final product in May 2022.

The results achieved with laboratory tests confirm the MTCA-based BPM system conforms with the PETRA IV requirements in all related aspects. Further tests with beam were done at PETRA III as discussed in [4]. Verification of the external switching module's radiation resistance is planned along further beam performance tests.

References

[1] https://bib-pubdb1.desy.de/record/426140/files/DESY-PETRAIV-Conceptual-Design-Report.pdf
[2] https://techlab.desy.de/products/amc/damc_fmc2zup/index_eng.html
[3] G. Kube et al., "Tests of the New BPM Long Term Drift Stabilization Scheme Based on External Crossbar Switching at PETRA III", in Proc. IBIC'21, Pohang, Korea, Sep. 2021, paper MOPP30, pp. 123.
[4] https://doocs-web.desy.de
[5] G. Kube et al., "Upgrade of the BPM Long Term Drift Stabilization Scheme Based on External Crossbar Switching at PETRA III", in Proc. IBIC'22, Krakow, Poland, Sep. 2022, paper WEP08, this conference.

INSTRUMENTATION TECHNOLOGIES

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