Stability Tests with Pilot-Tone Based Elettra BPM RF Front End and Libera Electronics

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The Elettra Pilot-Tone RF front-end

A low-phase-noise PLL (7) generates the pilot tone (frequency and amplitude are programmable), which is split into four paths by a high-reverse-isolation splitter (6) that guarantees more than 52 dB of separation between the outputs. A coupler (2) sums the tone with the signal from the pick-ups, adding further 25 dB of isolation to prevent inter-channel crosstalk from the path of the pilot tone. At this point, all the signals pass through a bandpass filter (3), centered at 500 MHz with a bandwidth of 15 MHz, and two variable-gain stages, composed of low-noise, high-linearity amplifiers (5) (G=22 dB, F=0.5 dB, OIP3=+37 dBm, P1dB=+22 dBm) and digitally controlled attenuators (4) (7 bits, up to 31.75 dB of attenuation, steps of 0.25 dB).

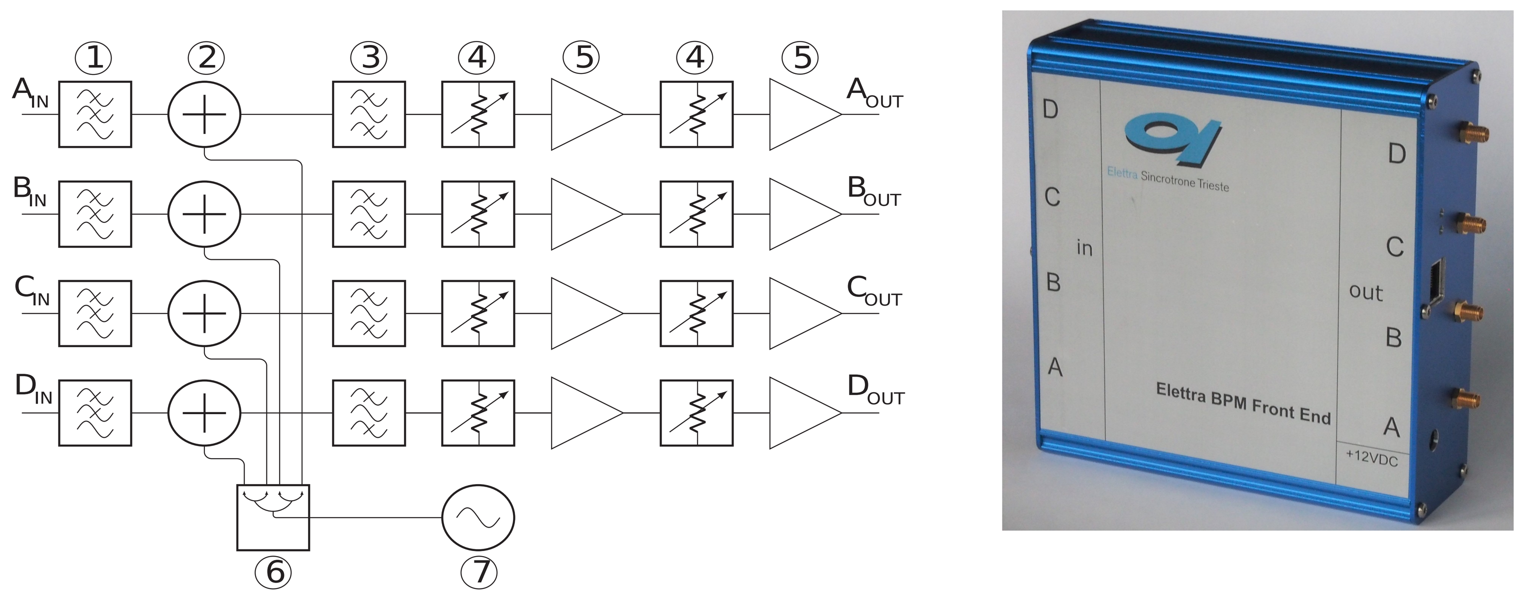

Figure 1: Elettra Pilot-Tone RF front-end and its block diagram.

Libera Spark ERXR readout electronics

The Libera Spark ERXR [2] was modified to process both the carrier RF frequency at 499.654 MHz and the pilot tone frequency at 501.282 MHz. This was done through a new parallel digital-down-conversion (DDC) processing branch introduced in the FPGA of the Libera Spark.

The DDC chain for the RF signal was tuned to the 32.38 MHz component which is filtered and decimated in stages to provide the user with turn-by-turn data, fast data (10-30 kHz) and slow data (10-40 Hz) with narrower bandwidth. The additional chain for the pilot-tone is tuned to the 34.01 MHz component, for this test the four amplitudes (PTA, PTB, PTC, PTD) were highly averaged and provided to user space with slow update rate of 8.8Hz. The compensation was done on-line in the upper software layer (EPICS).

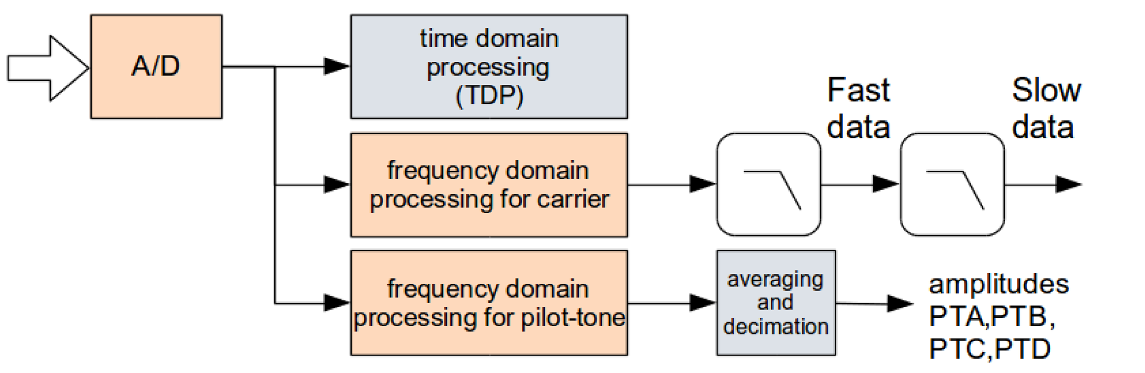

Figure 2: Parallel DDC implemented inside of the Libera Spark electronics.

Temperature compensation

Measurement 1: at 25 ◦C stable temperature over 20 hours. All equipment, including the RF generator and splitter was placed inside the temperature chamber. Position data was taken every 1 second.

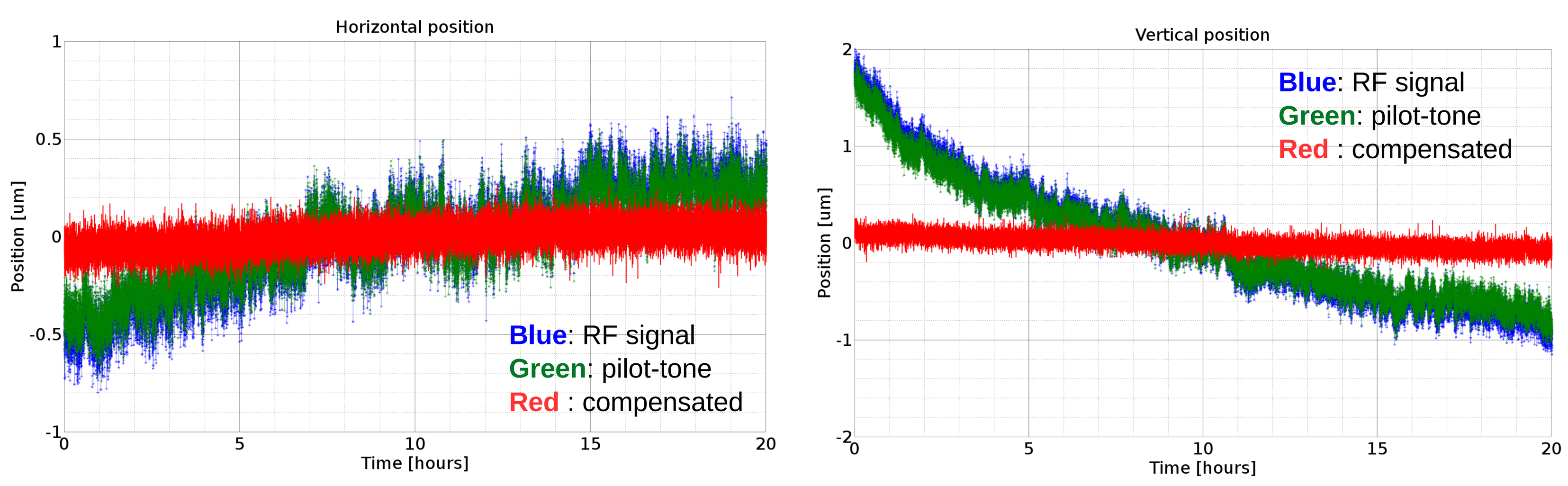

Figure 3: Horizontal and vertical position drift at 25 °C stable temperature.

Measurement 2: Temperature was changed in the range from 20 ◦C to 30 ◦C in steps of 1 ◦C. Complete temperature profile is shown in Fig. 4. For this test, the RF generator and a 4-way splitter were put out of the temperature chamber and left at room temperature.

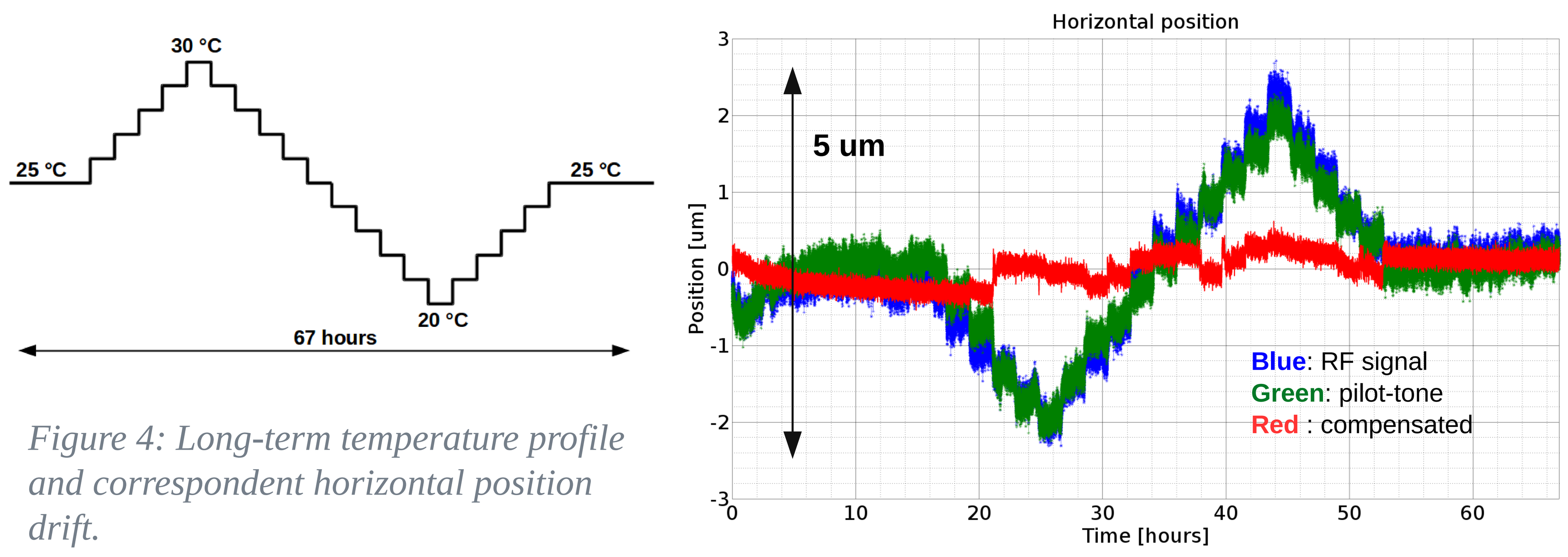

Figure 4: Long-term temperature profile and correspondent horizontal position drift.

Cable compensation

A coaxial cable connected between the front end and the Libera Spark was bent and wobbled.

Fig. 5 shows the position variation of the carrier and the pilot during this operation, with a peak-to-peak deviation of about 6 µm. Compensated position have a deviation 10 times smaller.

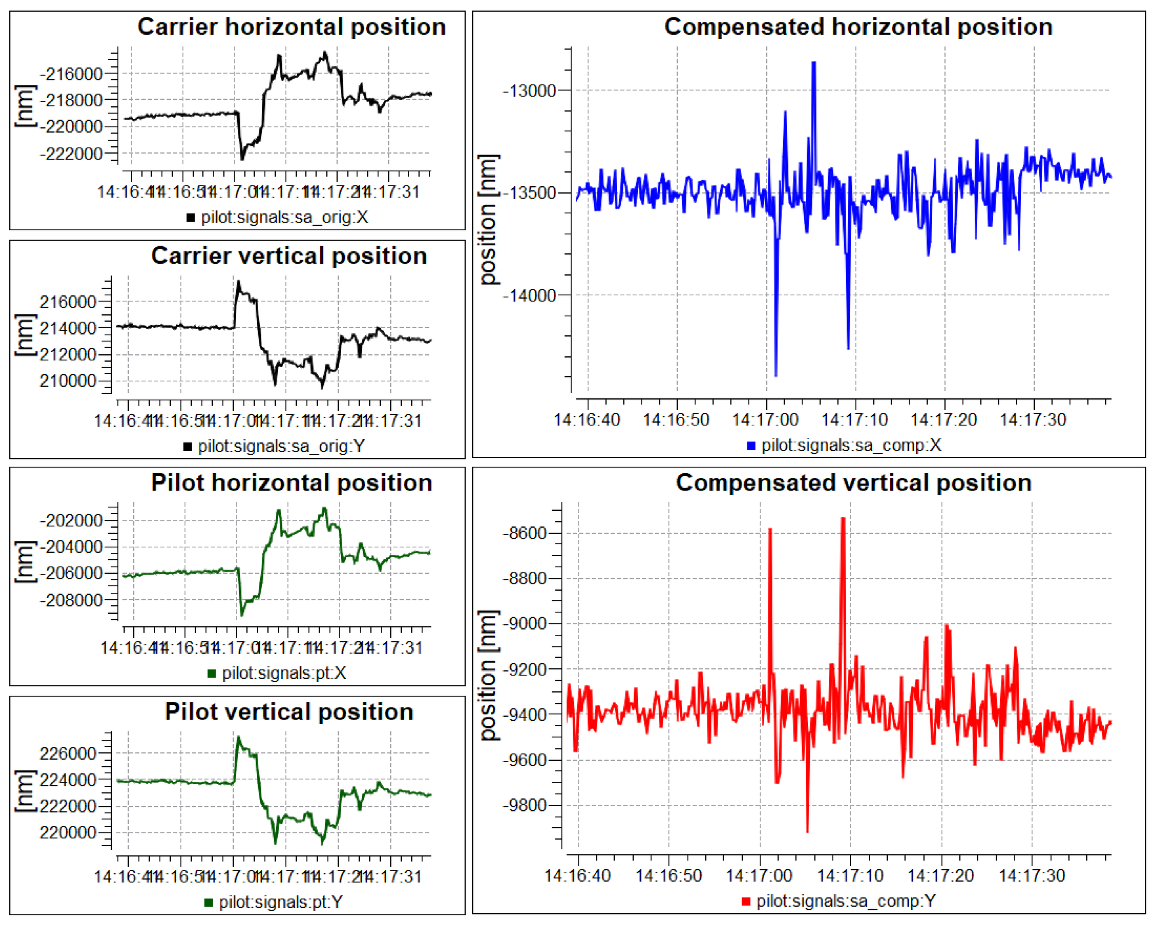

Figure 5: carrier, pilot-tone and compensated position deviation while wobbling cables.

Quality of the measure

The pilot tone is a constant-level signal and can give information whether the BPM system is working correctly. In Figure 6 the carrier signal is reduced by a factor of 10 while the RMS of the pilot-tone signal remains at the expected level.

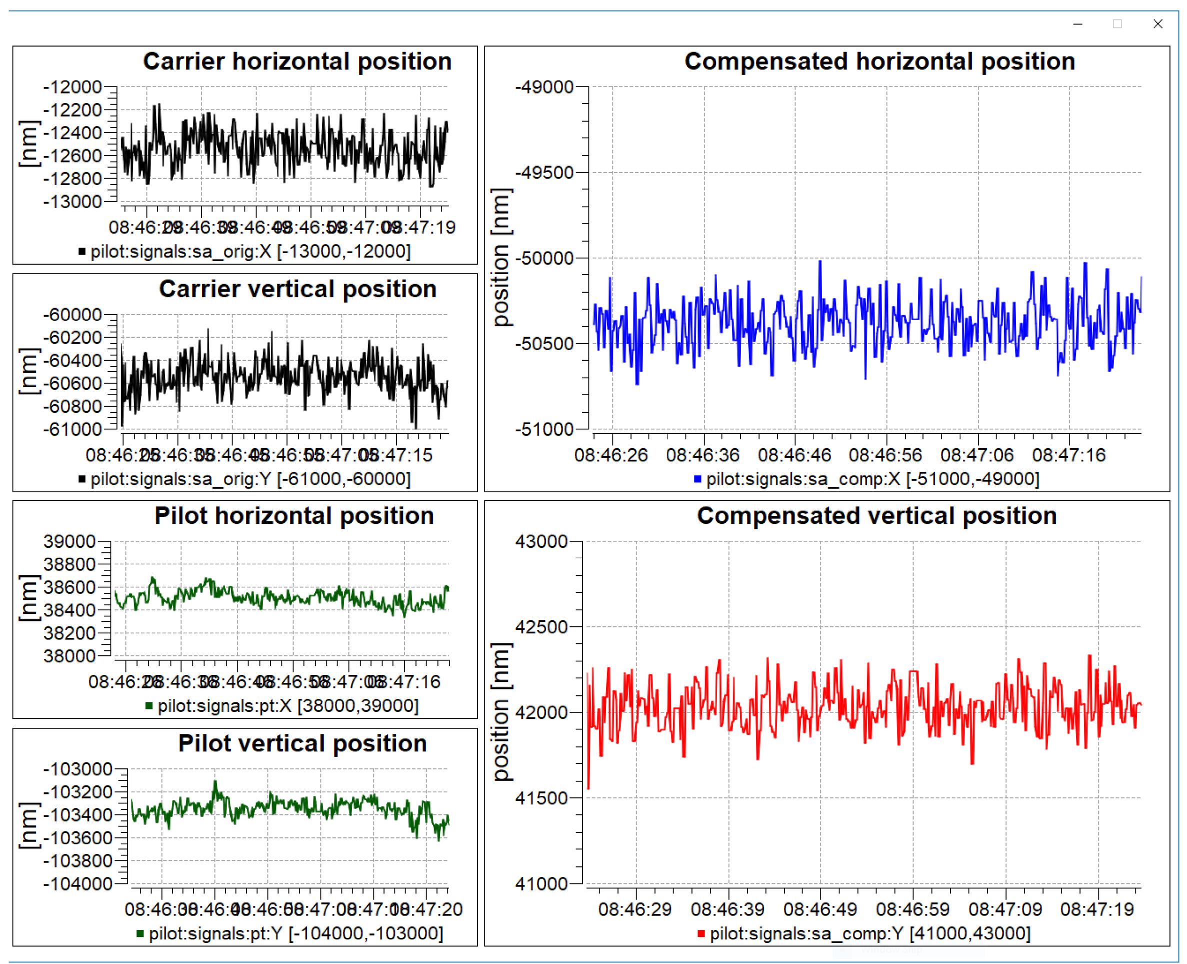

Figure 6: noise on carrier, pilot-tone and compensated signals with reduced carrier signal.

Conclusions

The performed measurements show encouraging results, both in resolution and in long-term performances, compensating external effects, but must be proved with beam.

By modifying the analog front end of the Libera Spark the stability was improved by a factor of 10 or more.

The **next step** will be a software update which will allow synchronous real-time compensation. Furthermore, several new features are foreseen such as dynamic change of the pilot tone’s frequency and online monitoring of the measurement quality.

There is also an option to develop a hardware module that fits in Libera Spark and provides the power, the communication interface and reference clock to the front-end.

References

[1] G. Brajnik, S. Bassanese, S. Carrato, G. Cautero, and R. De Monte, "A Novel Electron-BPM Front End With Sub-Micron Resolution Based on Pilot-Tone Compensation: Test Results With Beam", in Proc. IBIC2016.
[2] M. Cargnelutti and B.K. Scheidt, "Commissioning Results Of The New BPM Electronics Of The ESRF Booster Synchrotron", Proc. IPAC2015.

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