XFEL RF SYNCHRONIZATION SYSTEM

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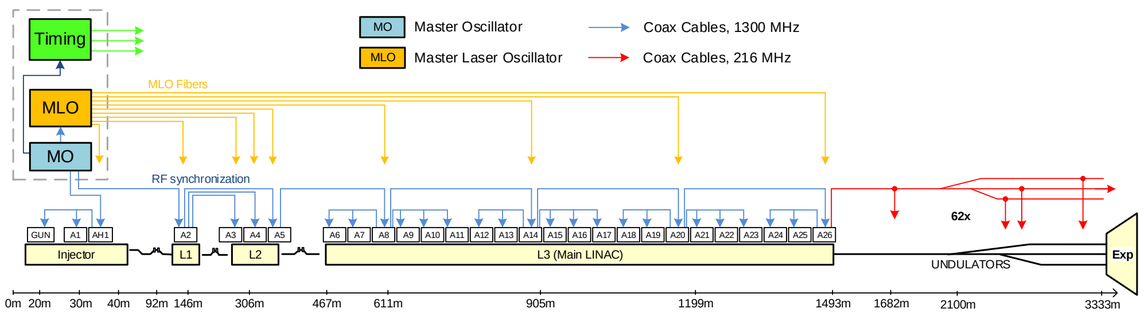
Introduction

Fulfilling high requirements concerning amplitude and phase RF field stability in the European XFEL facility is a very challenging task. Thousands of electronic and RF devices must be precisely phase synchronized. We describe the architecture of the Phase Reference Distribution System designed to assure high precision and reliability.

A system of RF cable based interferometers supported by femtosecond-stable optical links will be used to distribute RF reference signals. We present first packaged interferometer based modules providing phase drift suppression factors higher than 100. Modules were designed to distribute a long-term stable RF reference signal over distances of few hundred meters.

System Diagram



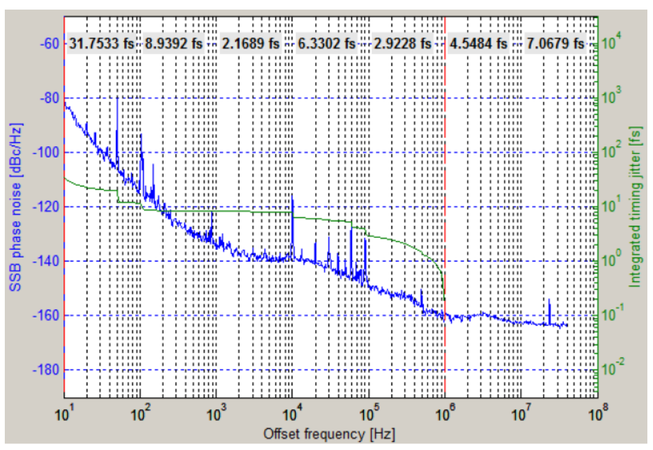
Phase Reference Distribution System is a combination of 2 main systems:

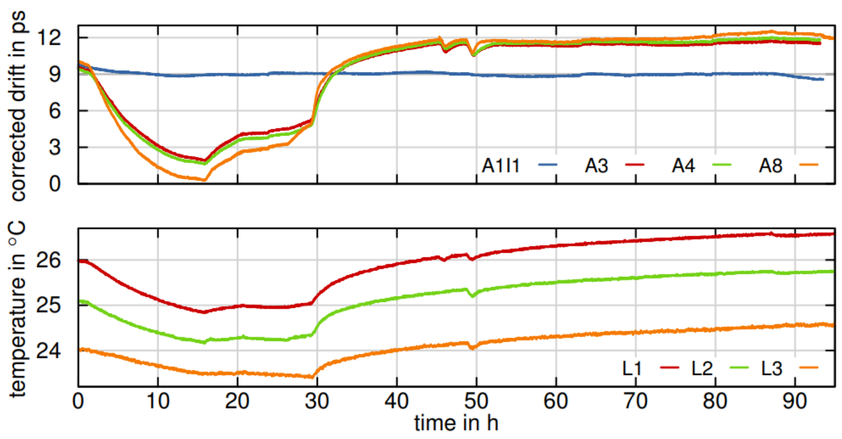
- RF Distribution [1] - currently passive coaxial system in terms of phase drifts – interferometer links as an upgrade,
- Optical Synchronization [2] – links with phase stability better than 10fs to re-synchronize RF Distribution in 9 locations.

System Performance

Phase noise @A5M:

- 33fs [10Hz,1MHz],
- phase noise spectrum the same as a MO spectrum [10Hz,400kHz],
- data before MO upgrade.





Courtesy T. Lamb

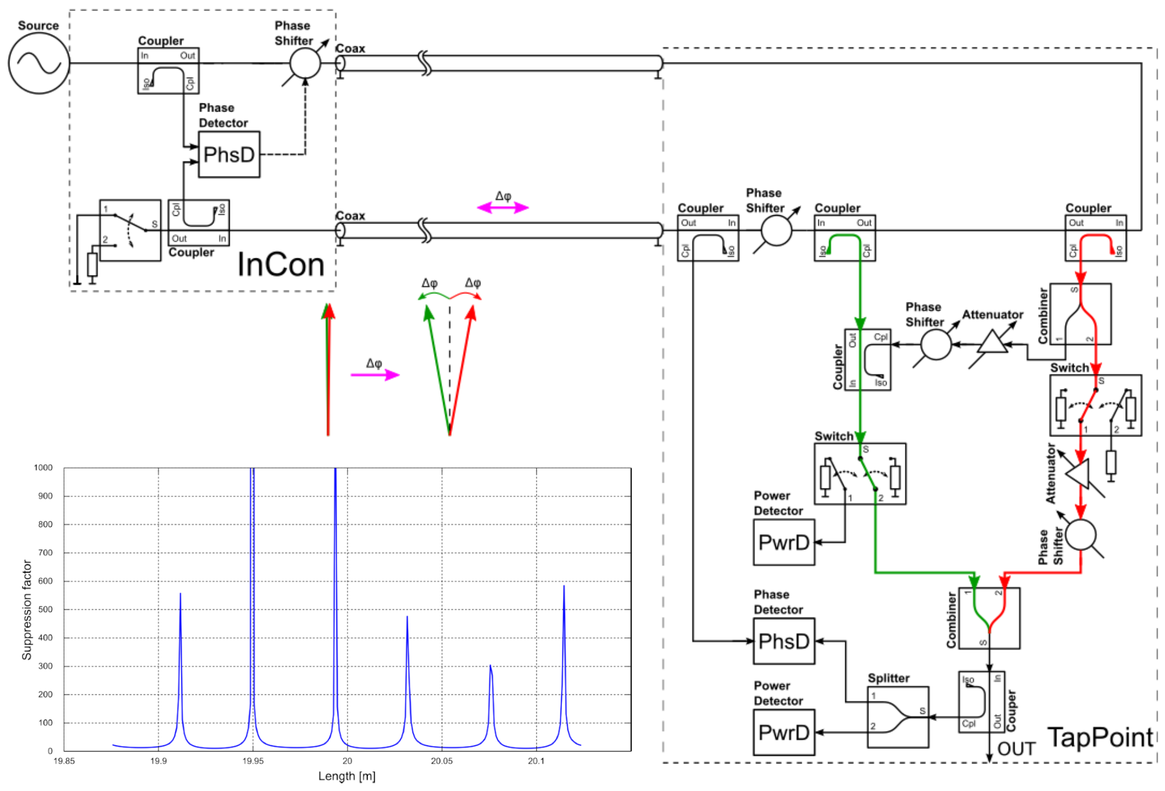
Phase drifts:

- measurement started after 2 days of downtime,
- 12.3ps corrected at A8 station by REFM-OPT.

References

1. K. Czuba, D. Sikora, RF Phase Reference Distribution for the European XFEL
2. T. Lamb, Laser-to-RF Synchronization with Femtosecond Precision
3. E. Cullerton, B. Chase, 1.3 GHz Phase Averaging Reference Line

Interferometer Basics



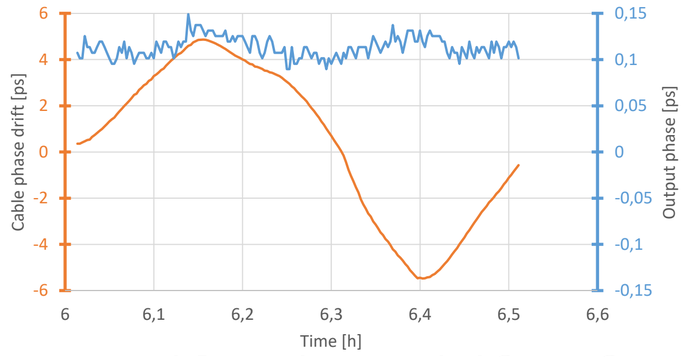
Interferometer link concept [3] was developed to provide automatic adjustment of the operating point operated with maximum suppression factor.

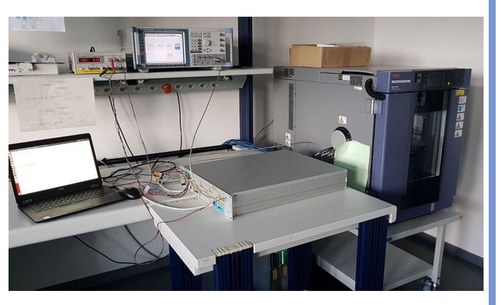
Interferometer link conditions:

- constant phase shift at the short (InCon)
- equal signals at output combiner (TapPoint)
- proper distance between short and TapPoint (it's searched by the algorithm with help of phase shifter in the TapPoint main line)

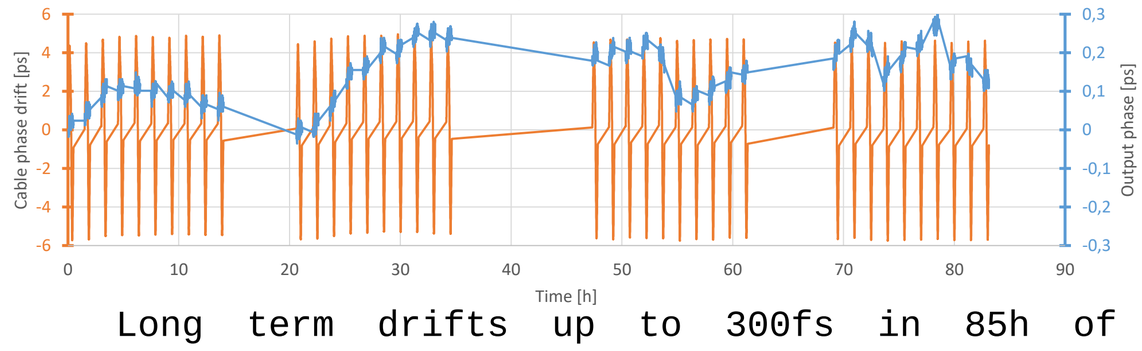
InCon and TapPoint modules are sealed and temperature stabilized.

Interferometer Test Results





Cable phase drift of 10.5ps suppressed to 50fs at the interferometer output (suppression factor higher then 200).



Long term drifts up to 300fs in 85h of measurement.

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