Libera Sync

Sebastjan Zorzut, Primoz Lemut, Libera Workshop 2011, Solkan

sebastjan.zorzut@i-tech.si, primoz.lemut@i-tech.si

Instrumentation Technologies

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- Libera Sync units
- Why optical fiber
- What is Libera Sync and how it operates
- Evaluation methods and results
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Reference Clock Distribution

- Tight requirements for clock distribution for FEL machines
- Clock distribution is also needed for synchrotron machines
- High quality reference means having low jitter → minimize jitter during the signal transfer
- Long-term stability, minimal drift is allowed

Libera

Libera Sync Units

- Libera Sync 3 GHz (2998 MHz and 2856 MHz) are supported with the same design.

- Libera Sync 500 / 352 MHz version is available from Spring 2011

- Phase detector 0 – 3GHz is in development

  2fs RMS in 5 days @ 3 GHz

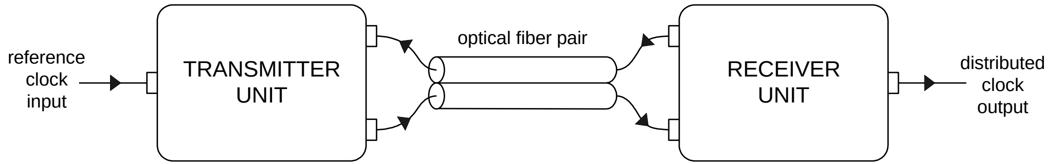
  5fs RMS in 2 days @ 500 MHz

Why Use Optical Fiber?

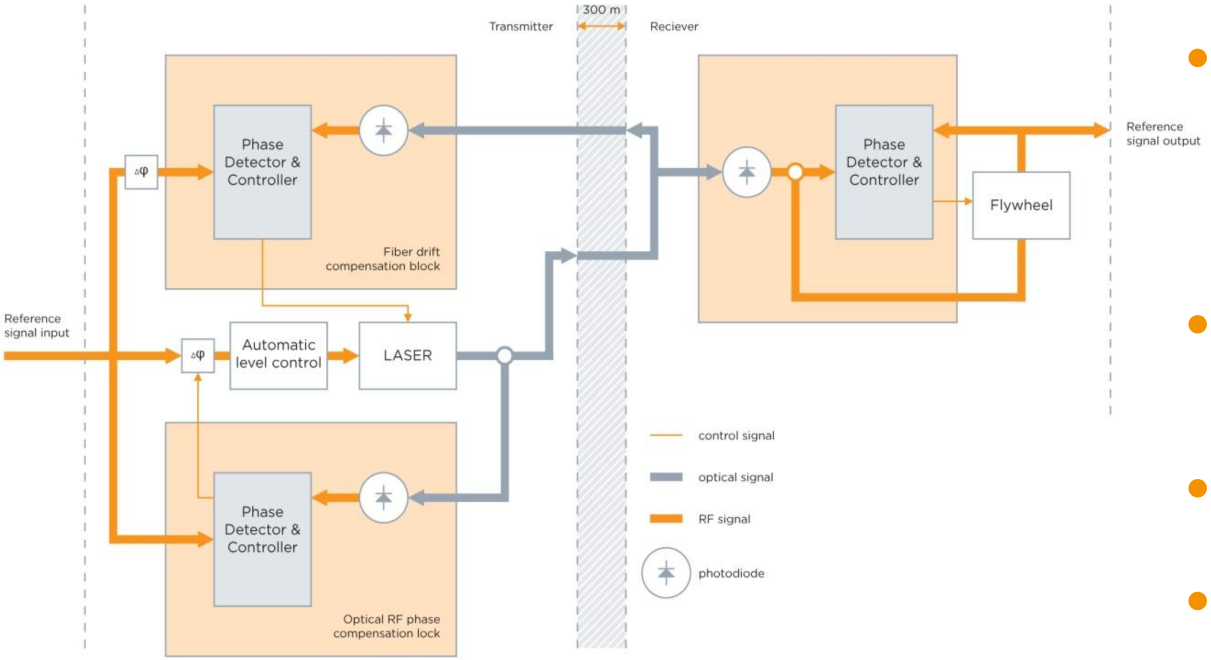
- High quality optical fiber is much more affordable than quality RF cables
- Optical fiber is low loss
- Extension coefficient is roughly the same as for high quality RF cables, but the compensation techniques can be realized for them
- Optical fibers require less room for installation
- Low PMD fiber (<0.1 ps/√km) according to G.652B or G.652D is a standard telecom fiber
- Not vulnerable to EM noise
- Replacement of bulky coax connections @ 352/500 Mhz in synchrotrons

Libera Sync

- Libera Sync is a system for the distribution of a high quality clock (RF) signal from the source to a remote location.
- It is using optical fibers for clock distribution.
- Optical path between the transmitter and the receiver is compensated.



Principle of Operation

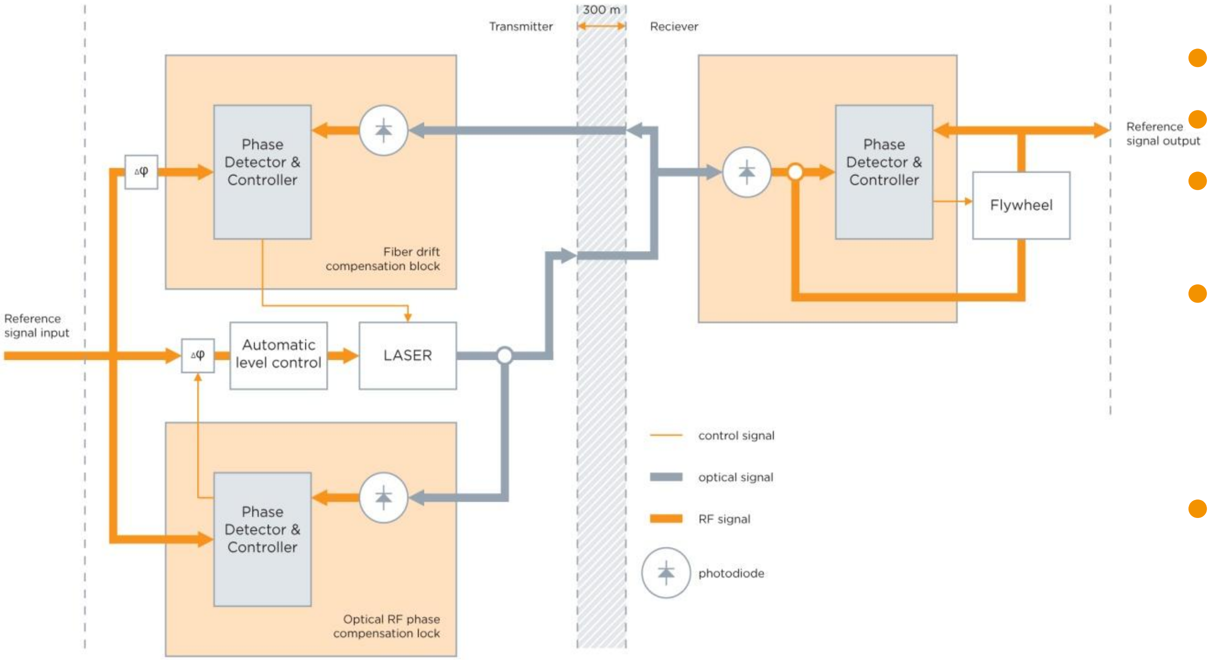


Transmitter

- 1550 nm laser, intensity modulated by the RF reference, wavelength control by temperature within laser
- Compensation of the modulator and electronic changes in first loop
- Compensation of the optical line in the second loop
- Thermally stabilized critical components

Libera

Principle of Operation

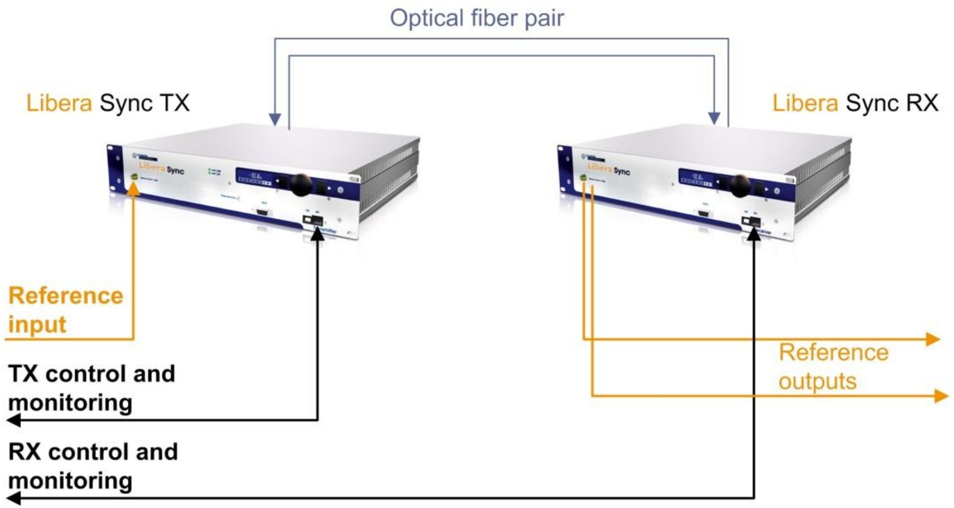


Receiver

- Photodiode
- Amplifiers
- High Q (narrow) filter to clean the output signal = flywheel
- Another control loop to maintain the output phase invariant to the flywheel behavior
- Thermally stabilized critical components

Installation Requirements @ 3GHz

- 19” width, 2U height, 400 mm depth for TX and RX
- Moderately temperature stabilized environment (±2°C) is required

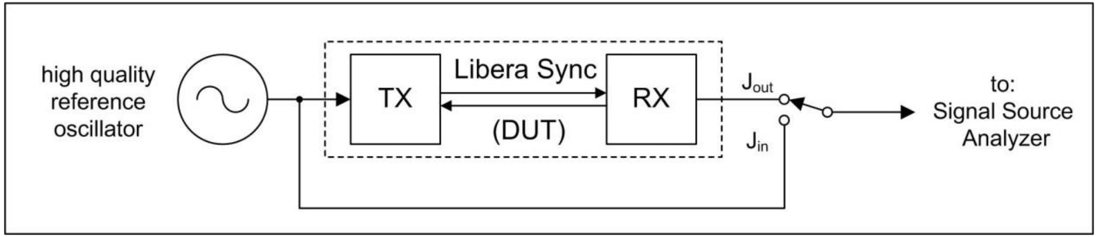


Installation Procedure

- Measurement of input RF signal properties (level & phase noise)
- Measurement of optical fiber pair properties
- Power up
- Warming up (30 minutes)
- Coarse phase setting (during 1st start-up or after an optical path changes)
- Monitoring of all parameters (10 minutes)
- Measurement of output RF signal properties (level & phase noise)

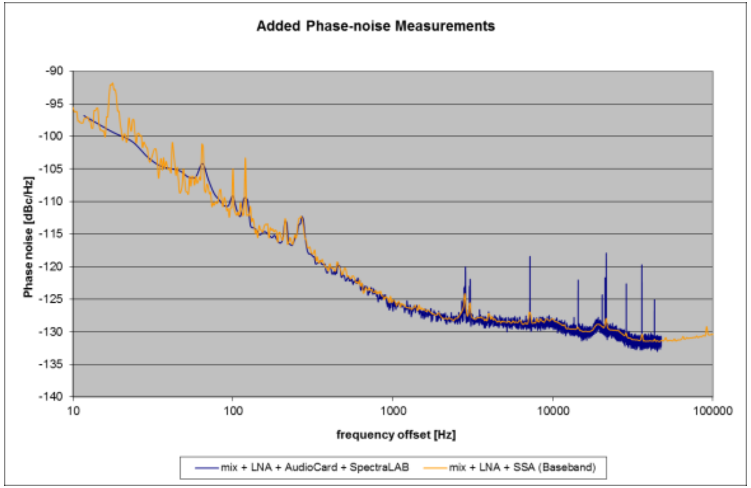
If the system configuration does not change, the RF output phase is maintained constant at every startup without tuning!

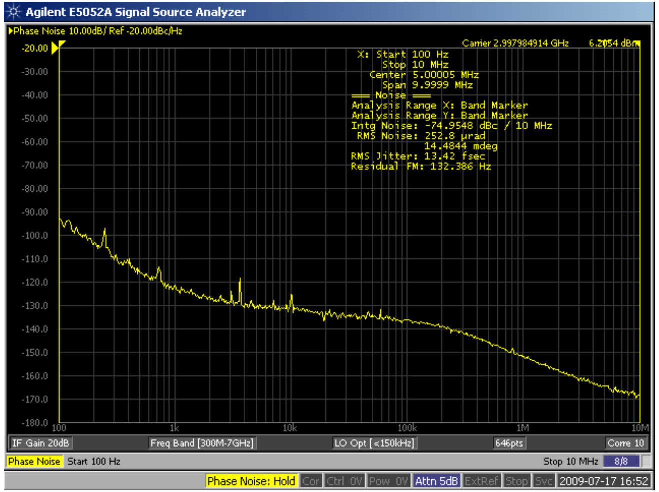
Added Jitter Measurement



$$RJ_{out} = \sqrt{\left(RJ_{in}^{2} + RJ_{DUT}^{2}\right)}$$

Added Jitter Measurement Results





10 Hz-10 MHz:

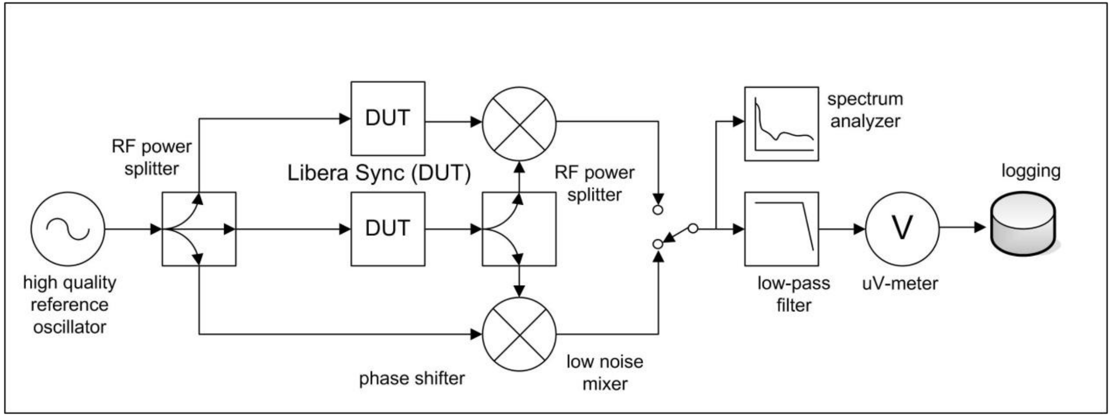
RJ_{DUT} < 10 fs @ 3 GHz

100 Hz-10 MHz

RJ_{DUT} = 5.5 fs @ 3 GHz

RJ_{DUT} < 35 fs @ 500 MHz

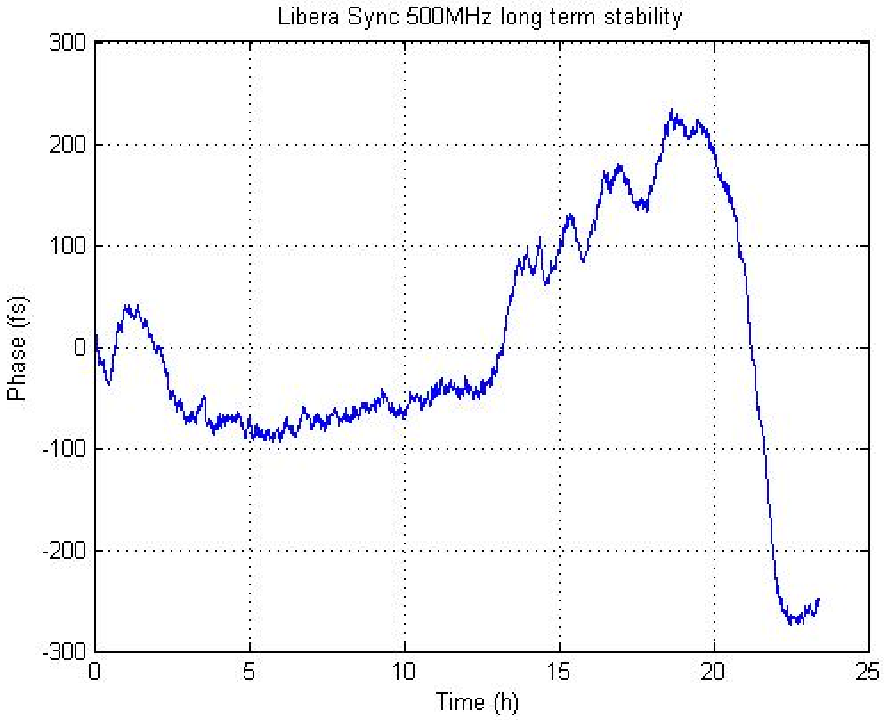
Long-Term Stability Measurement



20 fs RMS in 24h @ 3 GHz!

- Drift contribution of the measurement set-up requires care to avoid the introduction of unwanted artifacts.
- 20 fs RMS measured over 24 hours at FERMI and confirmed at PSI @ 3 GHz

Libera Sync 500 MHz – Long Term Stability Test



- *Test period: 24 hours*
- *509 fs PP (filtered)*
- *118 fs RMS (filtered)*

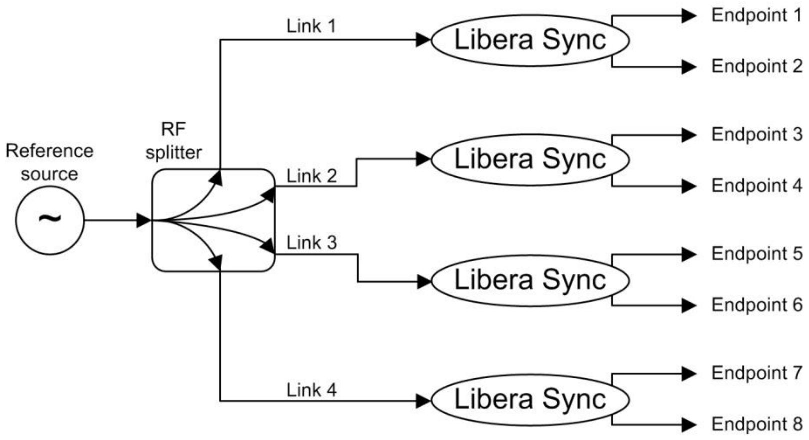
Libera Sync in Operation

- Numerous diagnostic points within Transmiter and Reciever.

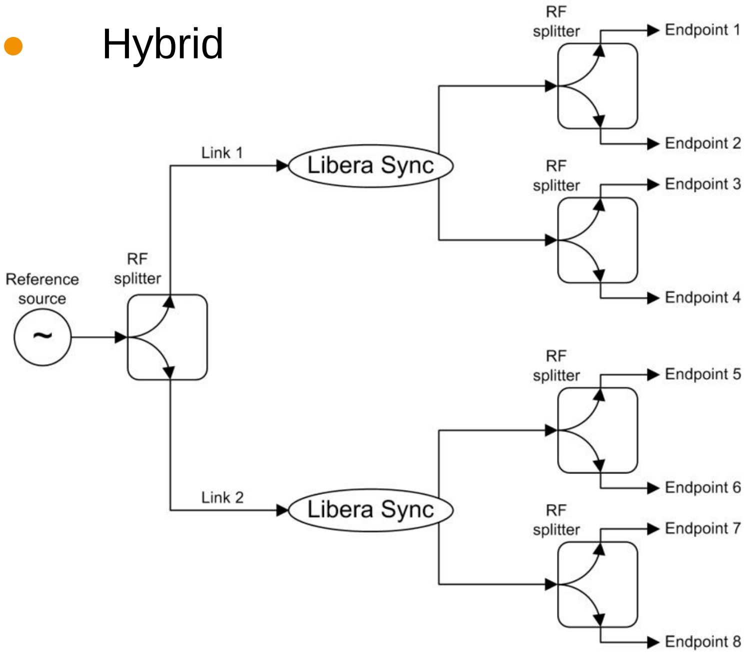
- Transmitter and Receiver mounted in the same rack during measurements.

Clock Distribution Topologies with Libera Sync

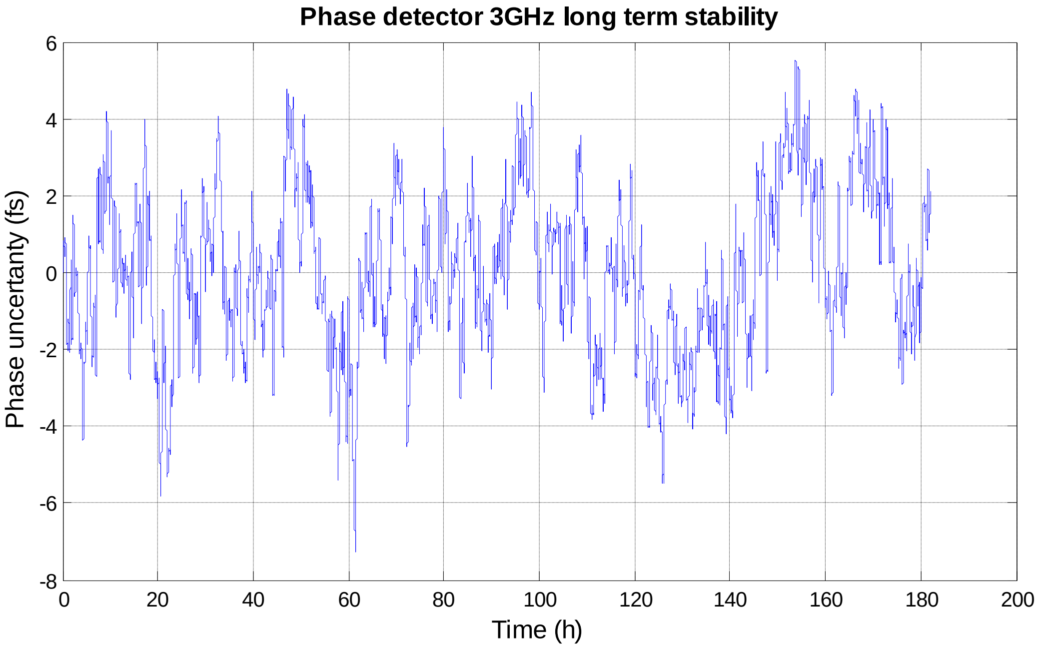
- Multiple point-to-point



- Hybrid

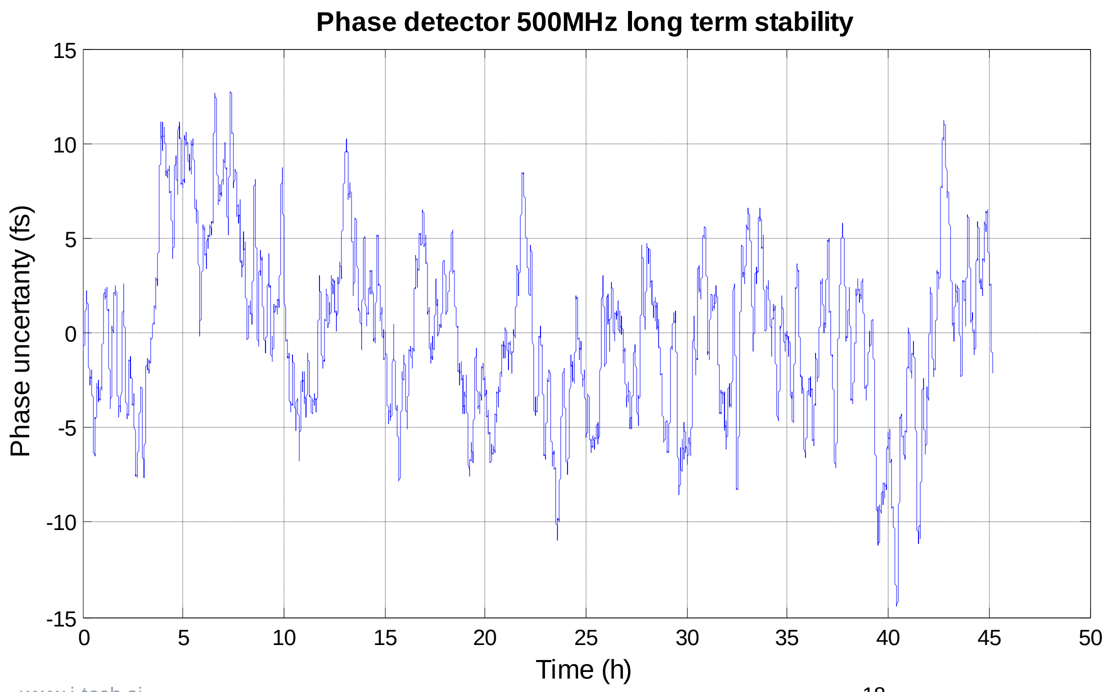


Phase Detector – Long Term Stability @ 3GHz



- *Test period: 7 days*
- *Frequency: 3GHz*
- *12 fs pp (filtered signal)*
- *2.1 fs RMS (filtered signal)*

Phase Detector – Long Term Stability @ 500 MHz



- *Test period: 48 hours*
- *Frequency: 500 MHz*
- *27fs pp (filtered signal)*
- *4.6 fs RMS (filtered signal)*

Summary

- Femtosecond precision
- Libera Sync available for 500 MHz and 3 GHz
- Simple commissioning and use
- Compensation of fiber drifts
- Compact, robust and high-performance device
- Remote diagnostics