Libera

Libera Sync

Further developement and Evaluation

Primož Lemut, Libera Workshop, October 2012, Solkan

Content

- Basics on reference clock transfer systems
- Libera Sync – principle of operation
- Libera Sync critical parameters + environmental constraints
- Performance measurement principles
- Measurement results
- Future work and improvements

Where reference clock transfer systems are nedded?

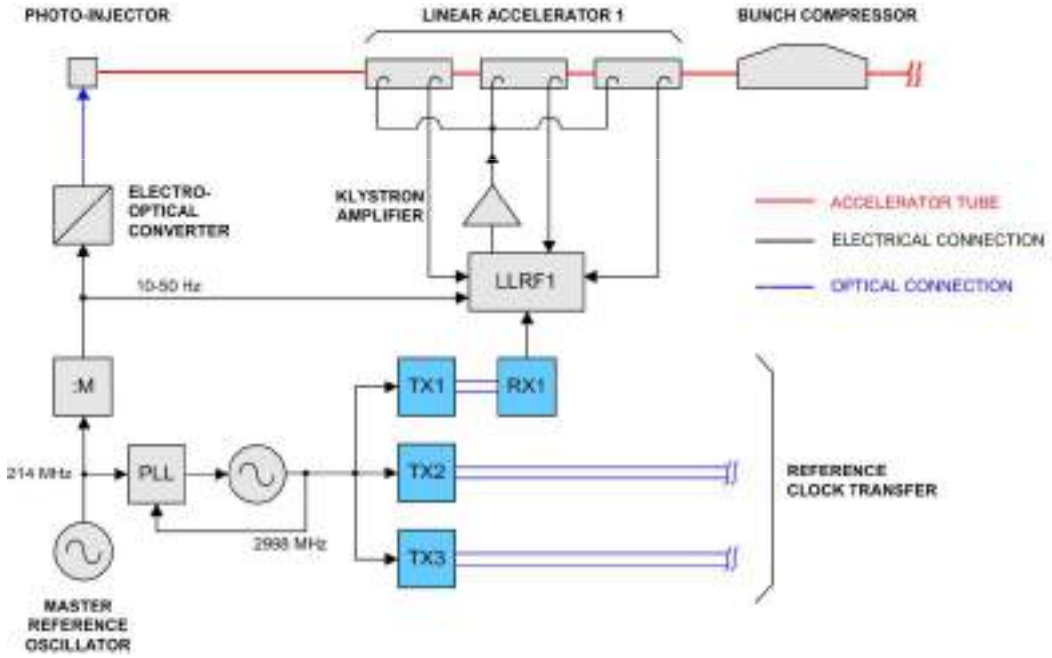
In geographically distributed systems

- Particle accelerators

- Array of telescopes

Example of reference clock distribution in a FEL

Generalized block diagram



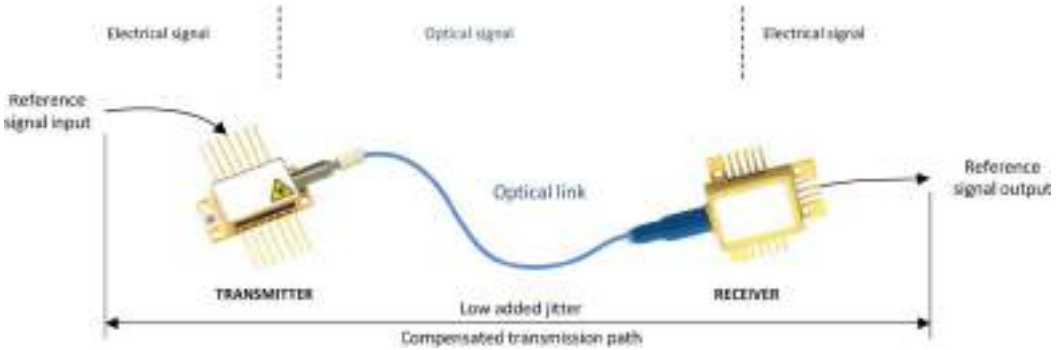
Different approaches towards clock distribution *

- Optical CW system (Berkeley)
- Optical pulsed systems (MIT)
- Optical analogue modulated system (I-Tech)

* M.Vidmar, Optical-fiber time-transfer & synchronization systems: advantages, physical limitations and practical implementations, Libera Workshop 2009.

Libera Sync reference clock distribution system (I)

Basic idea of clock distribution using optical fiber



- High quality optical fiber is much more affordable than RF cables
- Optical fiber is low loss
- Optical lines require less room for installation
- Compensation techniques can be easily realized for optical fibers
- Low PMD fiber according to G.652B or G.652D is a standard telecom fiber

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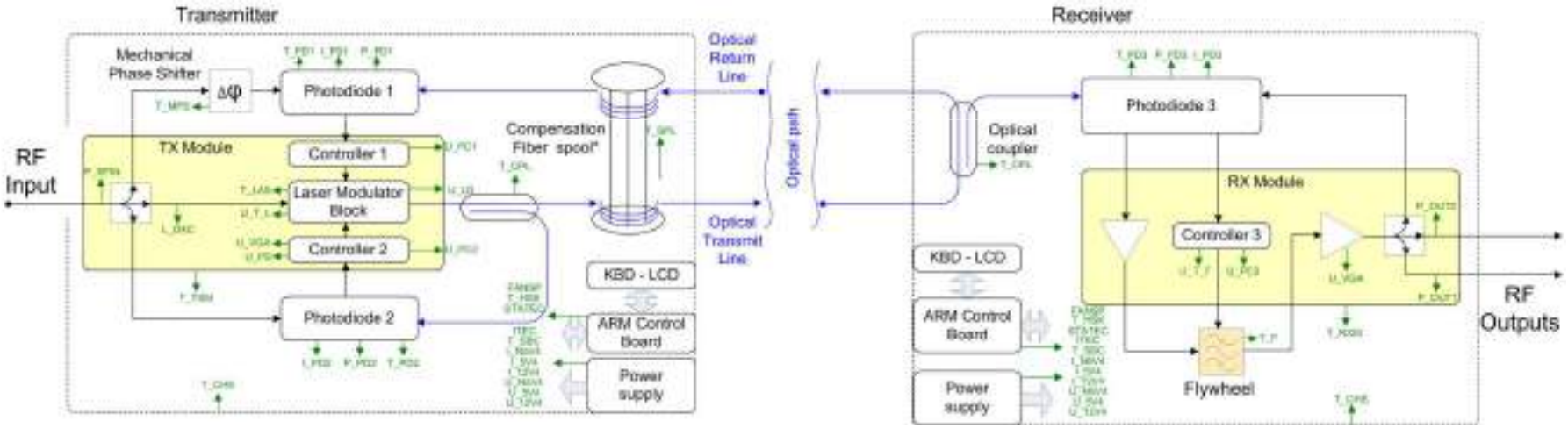
Libera Sync reference clock distribution system (II)

Advanced concept with compensated optical path, actual implementation



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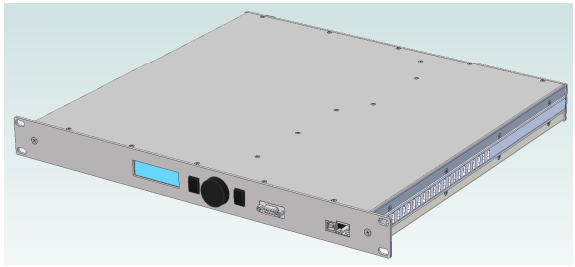
Libera Sync reference clock distribution system (III)

500 MHz



3 GHz

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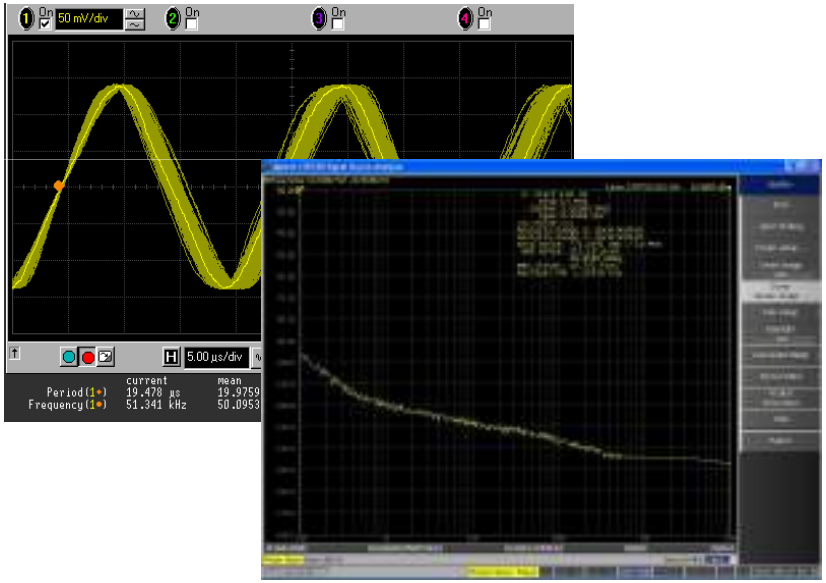
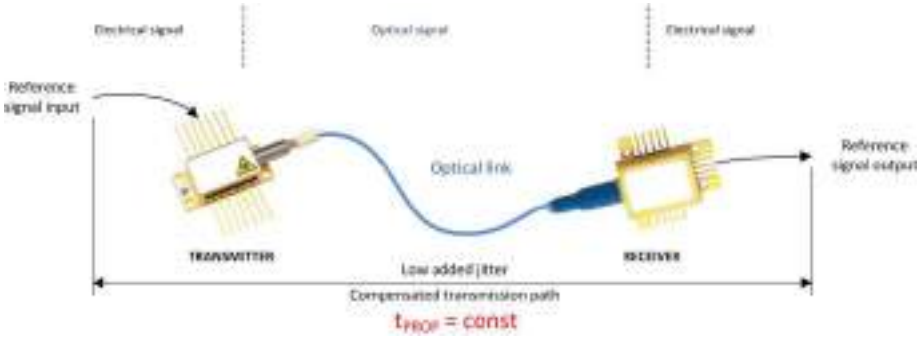
Clock distribution system – critical parameters

Jitter in time domain



Phase noise in frequency domain

Phase drift



www.i-tech.si

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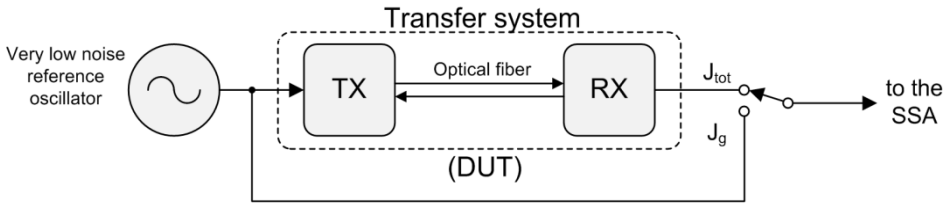
Installation conditions for the Libera Sync system

- Moderately stabilized environment for TX and RX
- Use of standard telecom fibers according to G.652B/D (or better)
- Temperature of the optical path stabilized to office conditions, wider temperature range upon request

Performance measurement principles (I) *

Added jitter measurement – not possible in time domain

Phase noise measurement in frequency domain (→integrated)

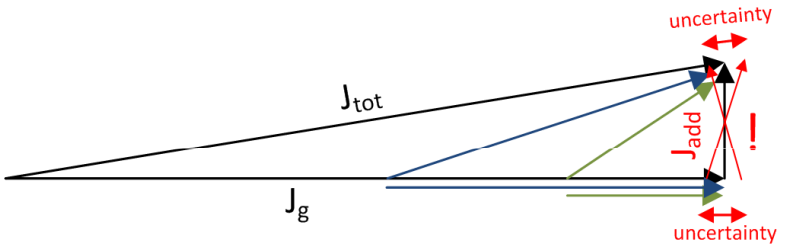


$$J_{add} = \sqrt{J_{tot}^2 - J_g^2}$$

* P. Lemut, B. Batagelj, M. Leskovec, J. Tratnik, S. Zorzut, EVALUATION OF SHORT AND LONG-TERM STABILITY OF THE 2998 MHZ REFERENCE-CLOCK TRANSFER SYSTEM, BIW 2012

Performance measurement principles (II)

Phase noise measurement issues



- Not suitable for the frequency offset less than 100 Hz from the carrier typically
- High performance RF source is required

→ J_{add}=5.1 fs [100 Hz-10 MHz]

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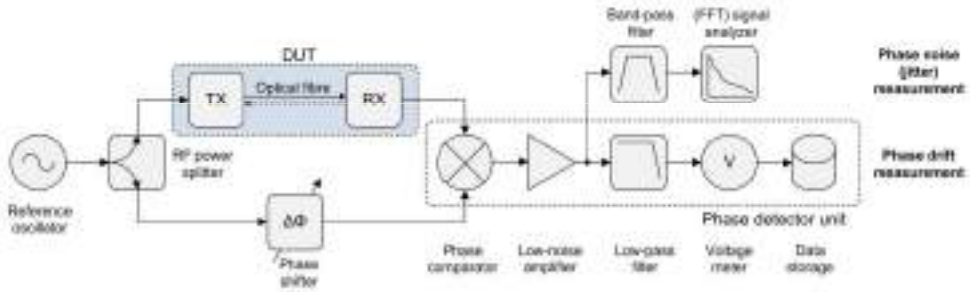
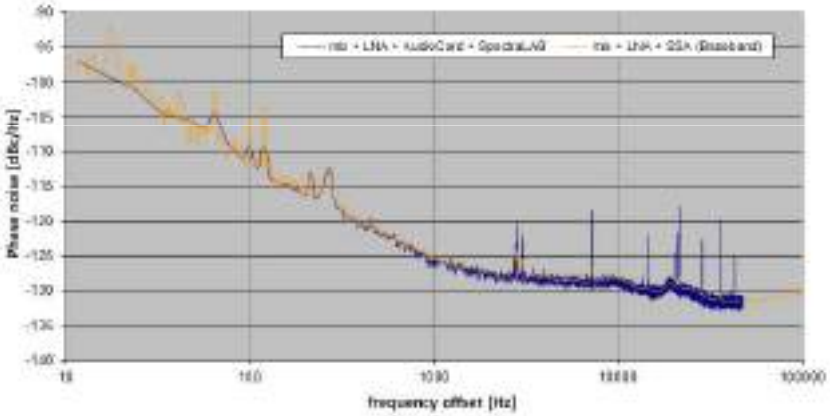
Performance measurement principles (III)

Complementary correlation method – direct result for added jitter





High performance FFT analyzer is required. Very good results can be achieved using reasonable resources.

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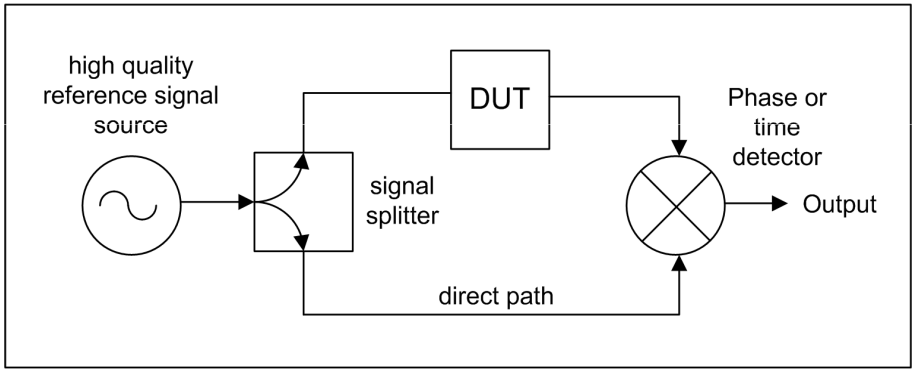
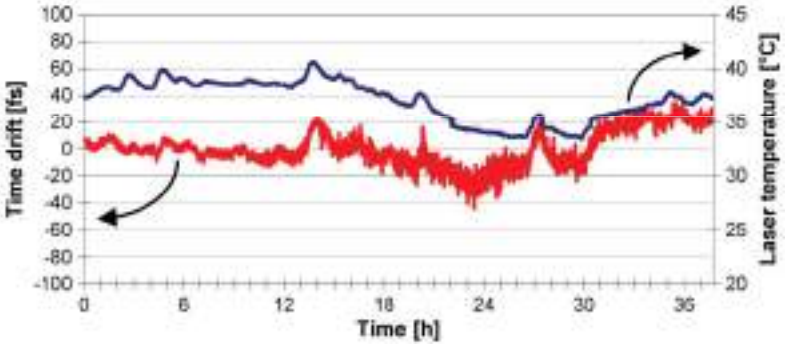
Performance measurement principles (IV)

Drift measurement





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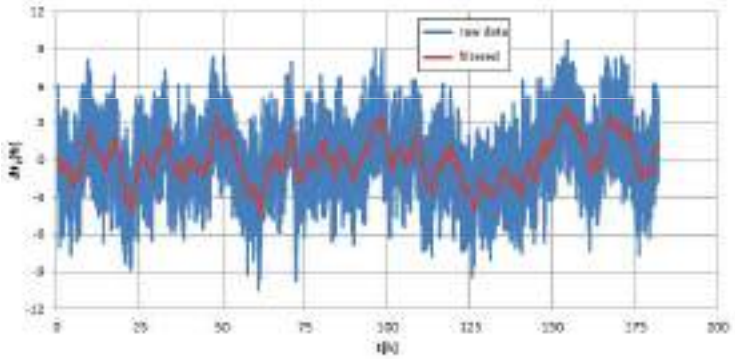
Performance measurement principles (V)

Drift measurement with a dedicated phase detector

Long term stability of the detector (6 days)

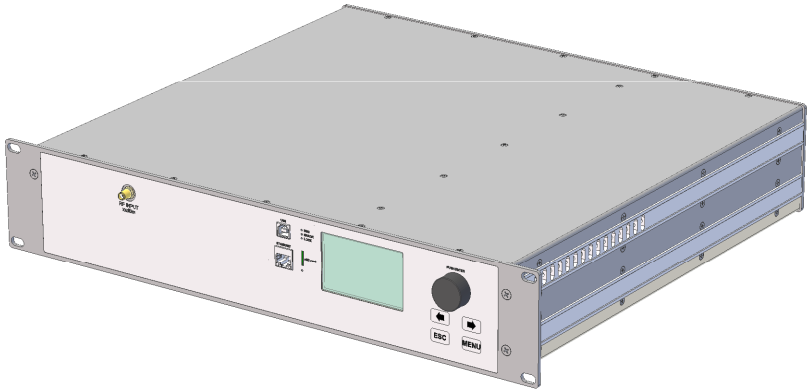


Summary of measurement and expected results

	Libera Sync 500 MHz	Libera Sync 3 GHz	New Libera Sync 3 GHz (expected)
Added jitter(100 Hz – 10 MHz)	30 fs	5.5 fs	N/A
Added Jitter (10 Hz – 10 MHz)	N/A	9.5 fs	<9.3 fs (10Hz-100kHz < 6 fs)
Long-term stability (24 h)	500 fs_{RMS}	130 fs_{pp}	10-20 fs_{pp}

Future work and improvements

- New Libera Sync 3 GHz design in cooperation with the PSI
- Improved phase noise and long term-stability
- Transition to new frequencies (6, 9, 12 GHz)
- Simplified mechanical design
- Improved user interface



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Thank you!

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