Libera

Libera Sync 3

Ready for installation

Primož Lemut, 10.04.2014

Content

- Brief on the reference clock transfer systems
- Libera Sync 3 – principle of operation
- Libera Sync 3 is finished, recent improvements
- Performance measurements
- Acceptance criteria and measurement results

Where reference clock transfer systems are needed?

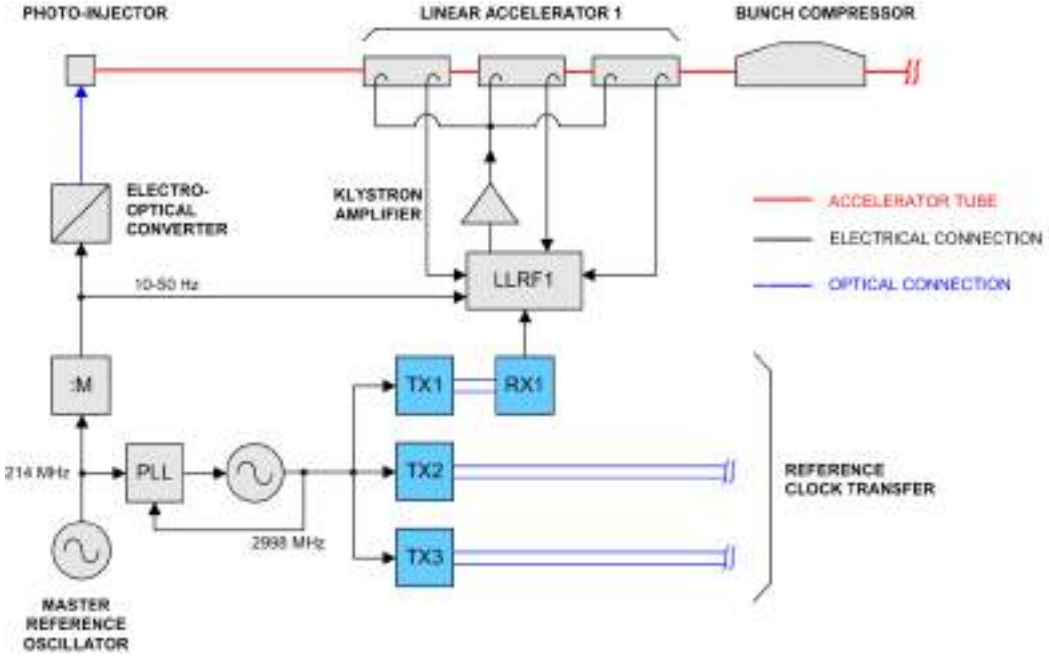
In geographically distributed systems

- Particle accelerators

- Array of telescopes

Example of reference clock distribution in a FEL

Simplified block diagram



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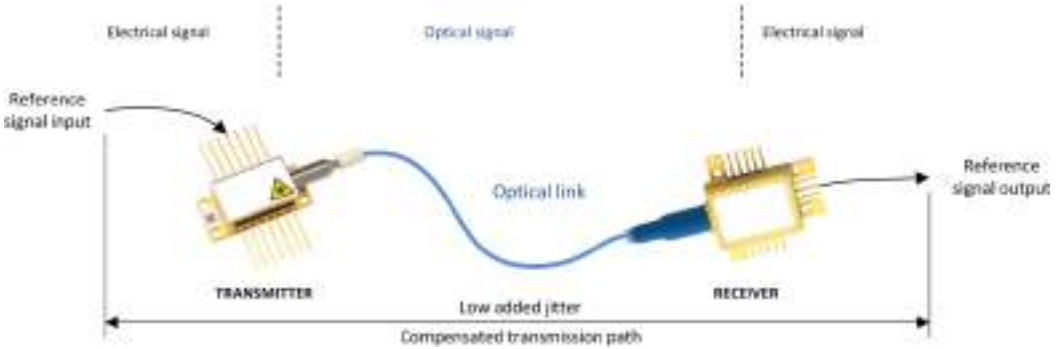
Libera Sync 3 reference clock distribution system (I)

Basic idea of clock distribution using optical fiber – optical analogue modulated system*

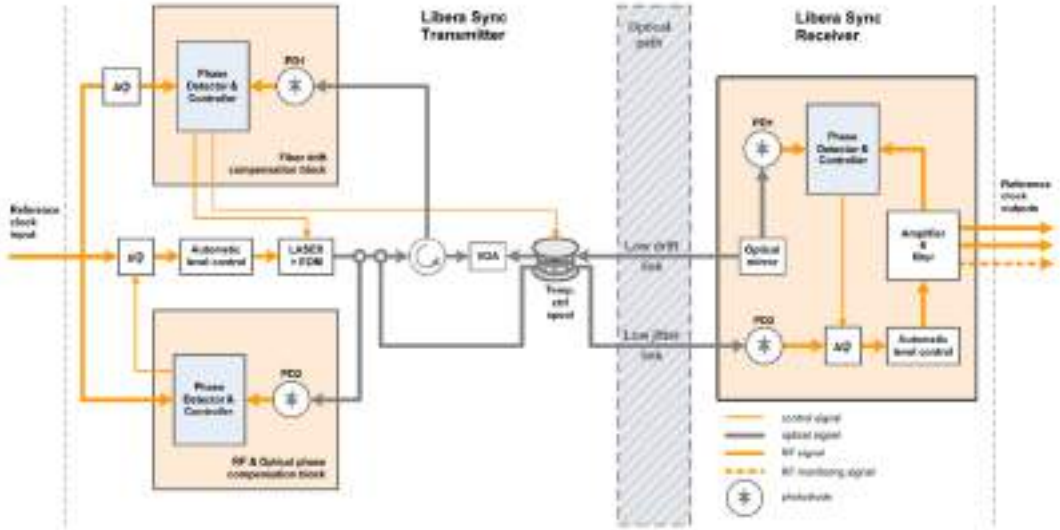


- High quality optical fiber is much more affordable than RF cables
- Optical fiber is low loss
- Optical lines require less room for installation
- Compensation techniques can be easily realized for optical fibers
- Low PMD fiber according to G.652B or G.652D is a standard telecom fiber

* other: Optical CW system (Berkeley), optical pulsed systems (MIT)

Libera Sync 3 reference clock distribution system (II)

Advanced concept with low jitter and compensated optical path, actual implementation



- Operating frequency 2998.8 MHz (customizable)
- Transmitter RF Input power +15 dBm ± 1 dBm
- Receiver RF Output power +15 dBm ± 0.5 dBm

Two fibers, each for its own purpose!

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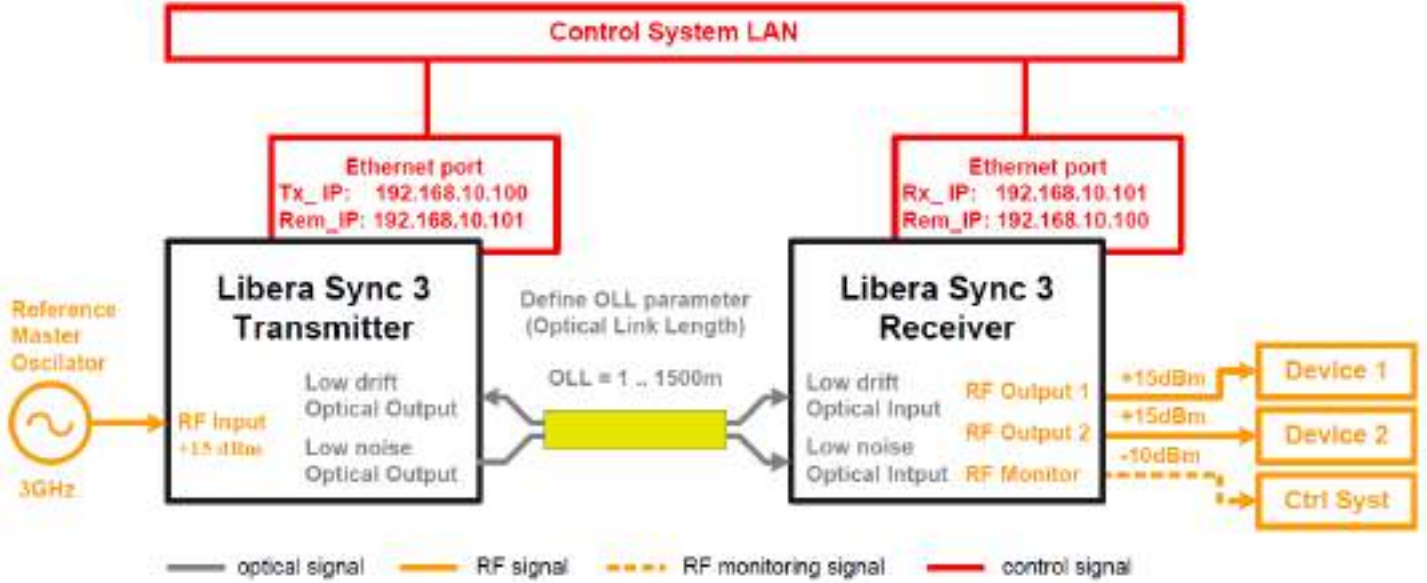
Libera Sync 3 reference clock distribution system (III)

3 GHz Transmitter

3 GHz Receiver

The only industrialized optical analogue modulated (=microwave) system in the market!

Libera Sync 3 reference clock distribution system (IV)



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Installation conditions for the Libera Sync 3 system

- Moderately stabilized environment for TX and RX
- Use of standard telecom fibers according to G.652B/D (or better), check temperature dependence (cabling!)
- Temperature of the optical path stabilized to office conditions, max 1000 ps of compensation
- Longest optical path is 1500 m

Recent improvements in Libera Sync 3 reference clock distribution system (I)

Partially changed principle of operation

- One fiber for path stabilization → better long-term performance
- Additional fiber to avoid Reyleigh back-scattering → lower added jitter

Superior temperature stabilization

- High long-term stability
- Wider temperature range of operation (drift of external RF cables is more critical than the unit)
- Increased weight (14 kg each unit)

Design in cooperation with the PSI, Switzerland

Recent improvements in Libera Sync 3 reference clock distribution system (II)

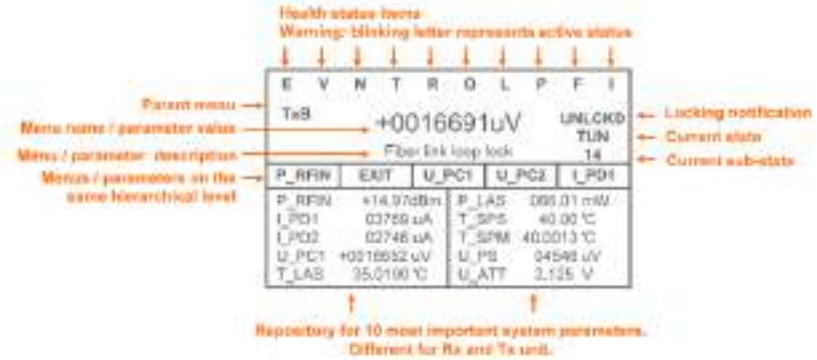
Integrated design (single RF PCB)

- Every single subsystem tested separately for phase noise and long-term stability prior to integration
- Simplified production
- Higher reliability
- Higher repeatability
- Possible interaction between subsystems (not detected)

Recent improvements in Libera Sync 3 reference clock distribution system (III)

Re-designed software

- More monitoring parameters
- Fully-automated startup
- Bigger LCD with more information displayed (by importance)



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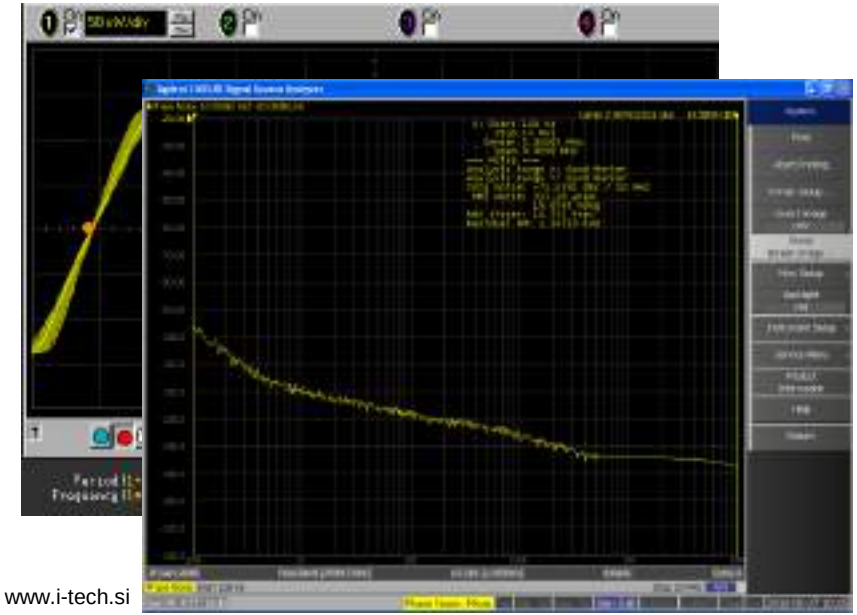
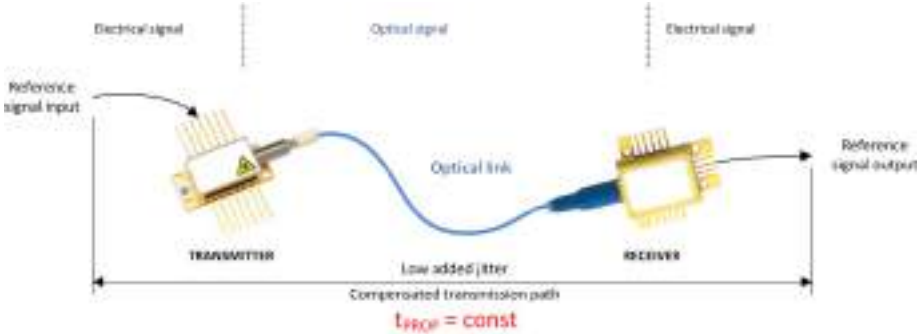
Clock distribution system – critical parameters

Jitter in time domain



Phase noise in frequency domain

Phase drift



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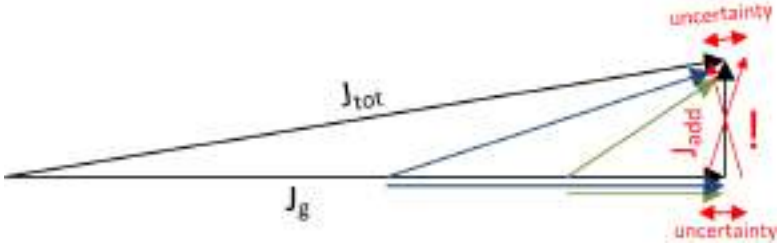
Performance measurements (I)

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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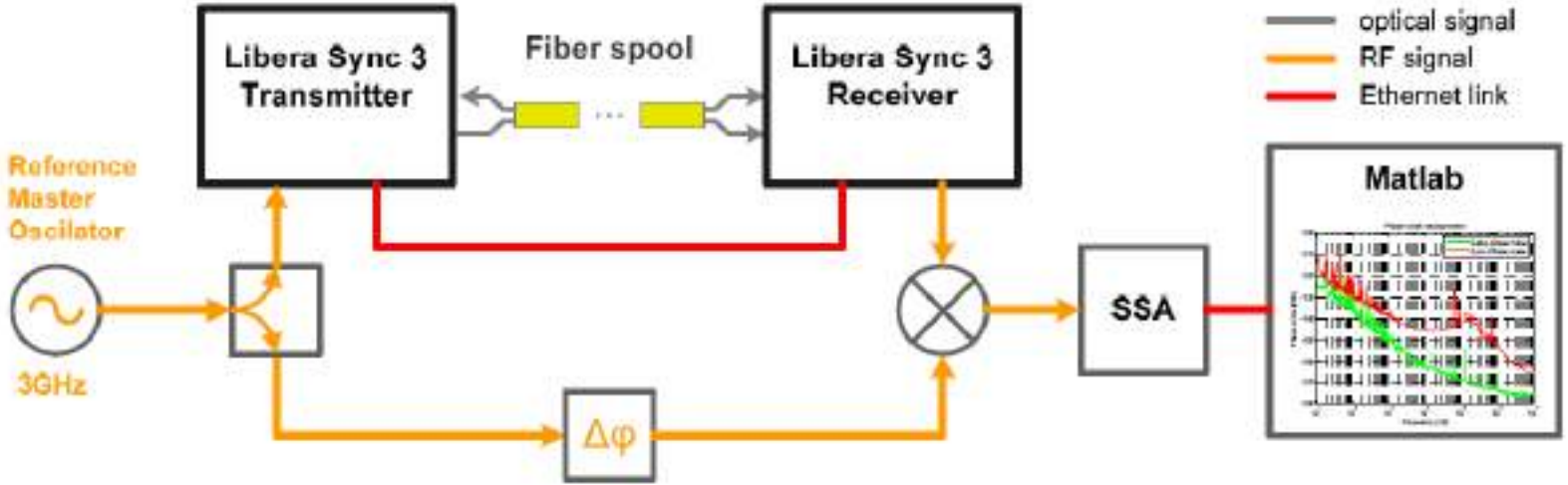
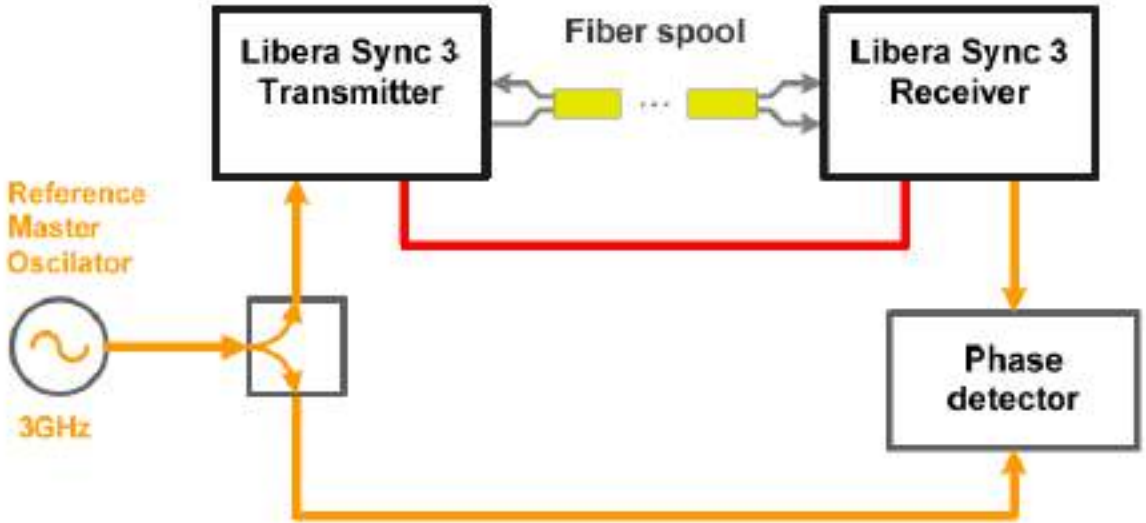
Performance measurements (II)

Differential (correlation) method for low added jitter

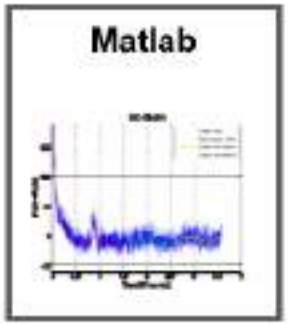


Performance measurements (III)

Long-term stability measurement



optical signal
RF signal
Ethernet link



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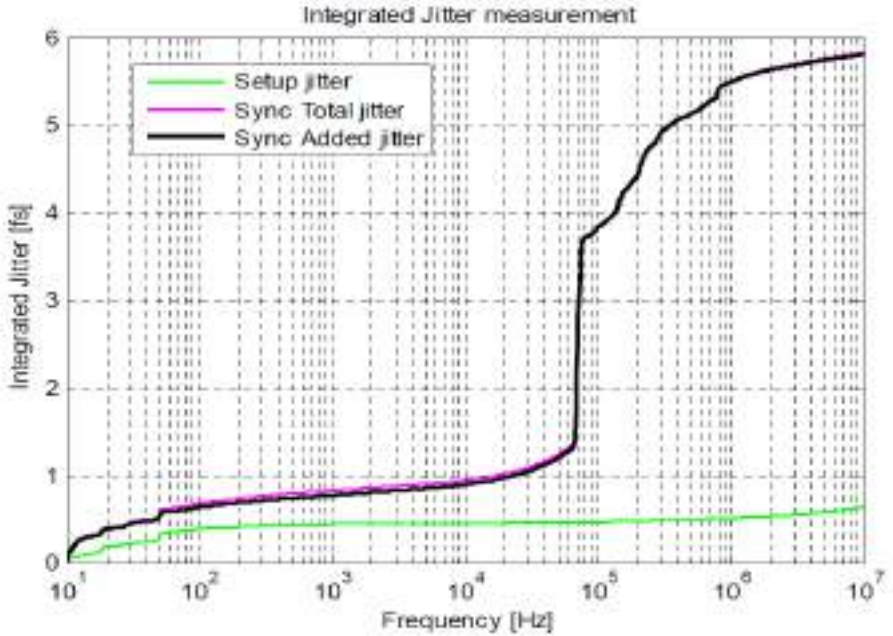
Acceptance criteria

Criteria	Required
Added jitter(10 Hz – 100 kHz)	< 6 fs
Added jitter (100 kHz – 1 MHz)	< 5 fs
Added jitter (1 MHz – 10 MHz)	< 5 fs
Added jitter (10 Hz – 10 MHz)	< 9.3 fs
Long-term stability / day	< 40 fs ± 5 fs

Measured results (I)

Added jitter 10 Hz to 10 MHz



Better than 6 fs

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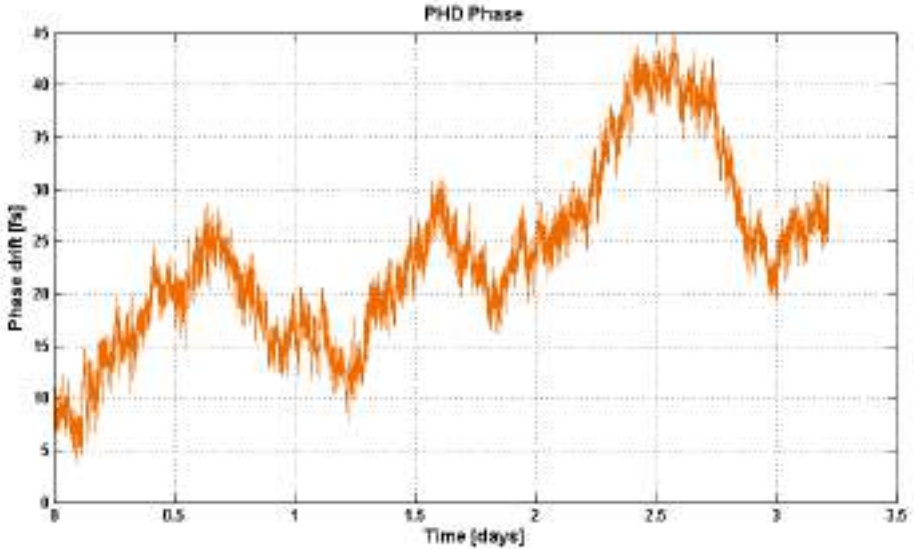
Measured results (II)

Long-term stability



40 fs_{pp} over 3 days

Thank you!