Instrumentation Technologies
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# Libera Sync

## System Overview, Installation & Measurement Results

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Libera WORKSHOP 2009

17 September 2009

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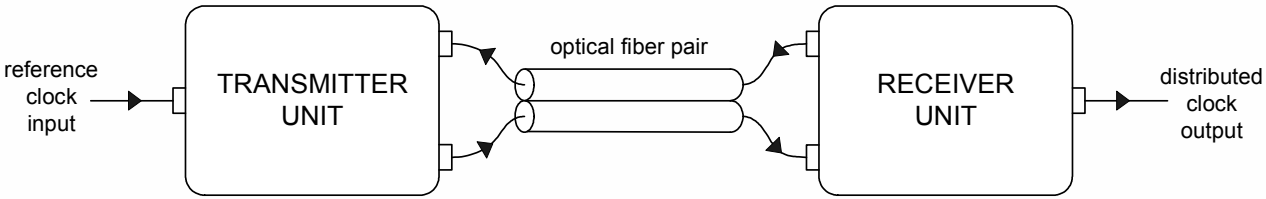
# What is Libera Sync

- **Tight requirements for clock distribution for FEL** machines




- **High quality reference means having low jitter → minimize jitter during the signal transfer**
- **Long-term stability, minimal drift is allowed**
- **Libera Sync is a system for the distribution of a high quality clock (RF) signal from the source to a remote location**

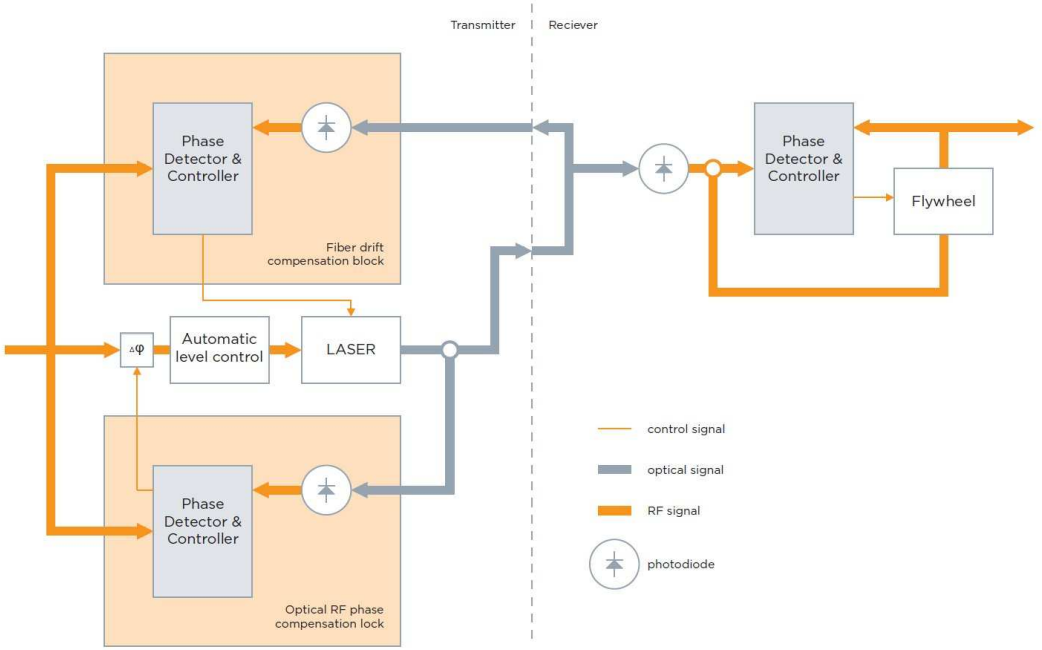
# Why Use Optical Fiber?

- High quality optical fiber is much more affordable than RF cables
- Optical fiber is low loss
- Extension coefficient is roughly the same as for high quality RF cables without compensation
- 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

# Principle of Operation I

## Transmitter

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



# Principle of Operation II

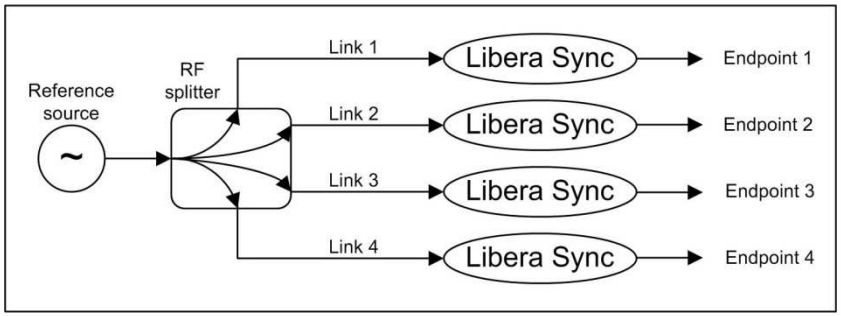
**Receiver**

- **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**

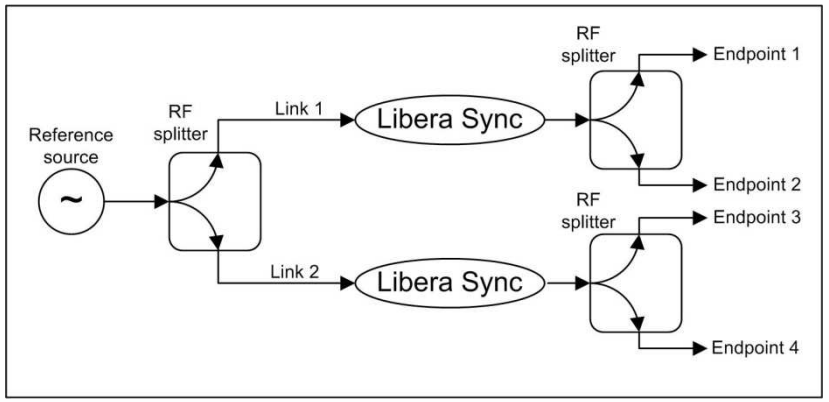
**More details in prof. Vidmar's presentation on Friday**

# Clock Distribution Topologies with Libera Sync

## Multi point-to-point



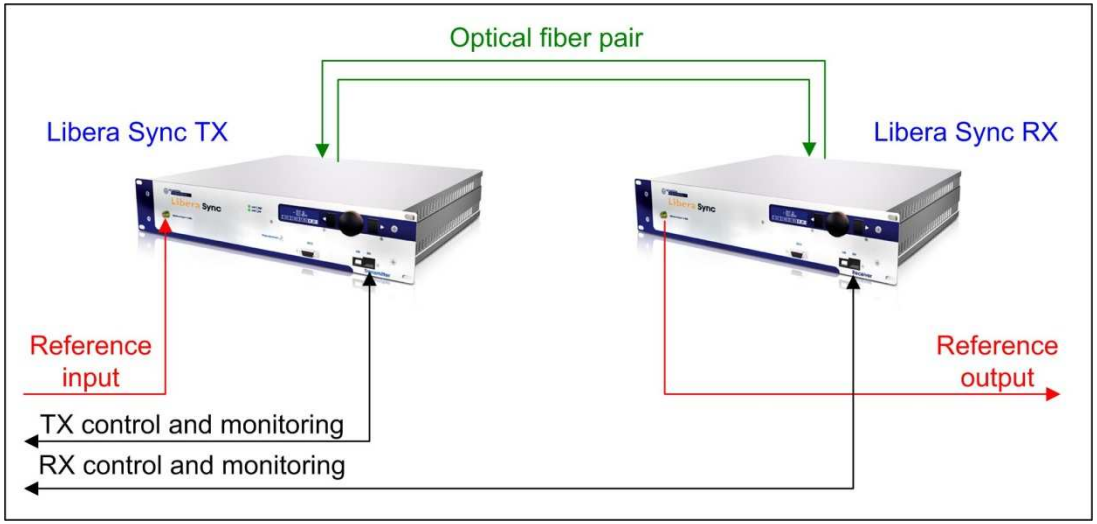

## Hybrid




Each topology has Pros and Cons

# Installation (Requirements & Procedure) I

- 19” width, 2U height, 400 mm depth for TX and RX
- A moderately temperature stabilized environment is required
- Installation environments must be checked for vibrations



# Installation (Requirements & Procedure) II

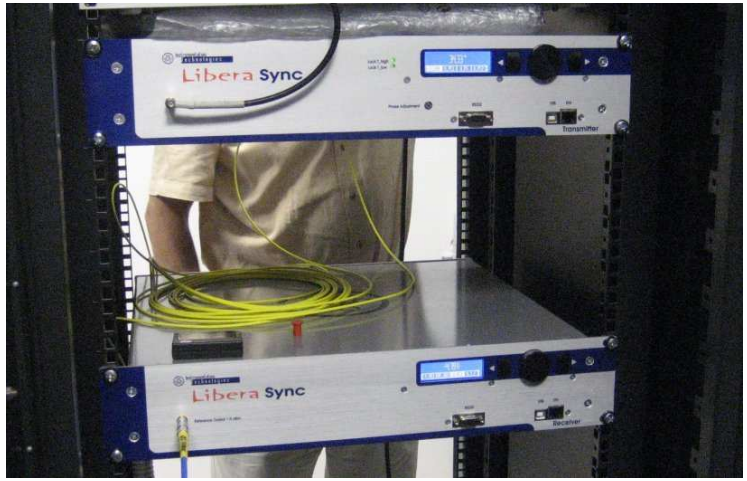
- Measurement of input RF signal properties (level & phase noise)
- Measurement of optical fiber pair properties
- Power up
- Warming up (30 minutes)
- Coarse phase setting (during 1st start-up or after a change of fiber)
- Monitoring of all parameters (10 minutes)
- Measurement of output RF signal properties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

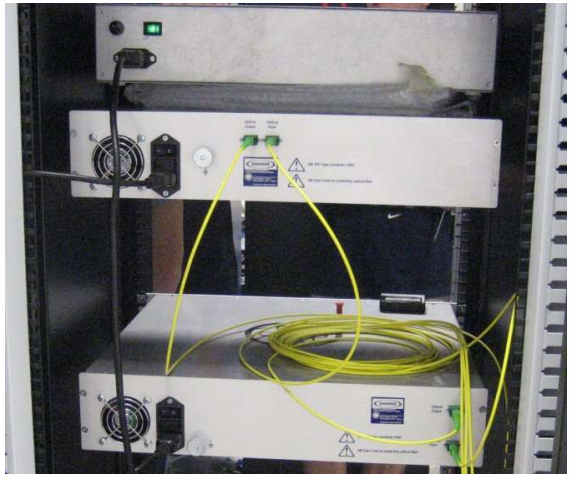
If the system configuration does not change the RF output phase is maintained constant at every startup without tuning.

# Libera Sync in Operation

- Numerous diagnostic points within Transmiter and Reciever

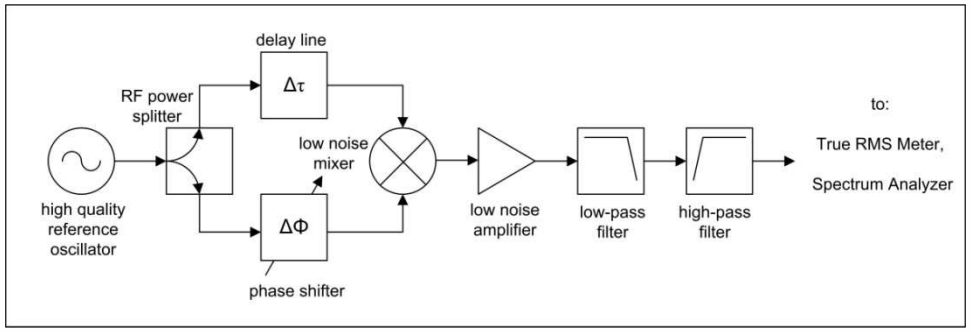




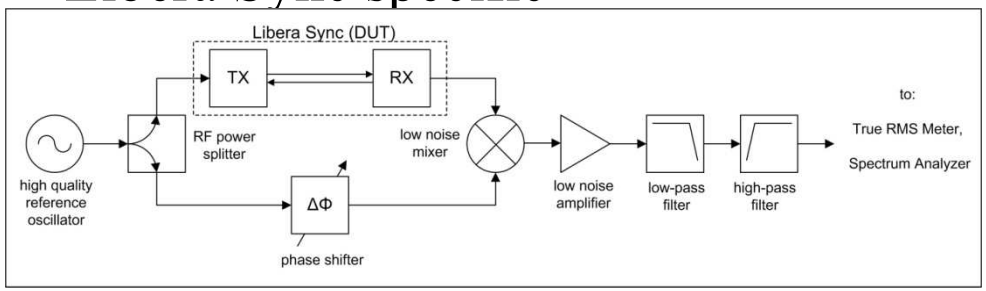
# Added Jitter Measurement I

- General

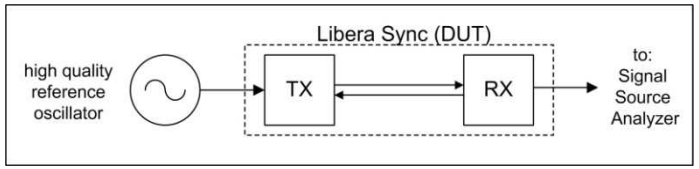



$$RJ_{out} = \sqrt{(RJ_{in}^2 + RJ_{DUT}^2)}$$

- Libera Sync specific



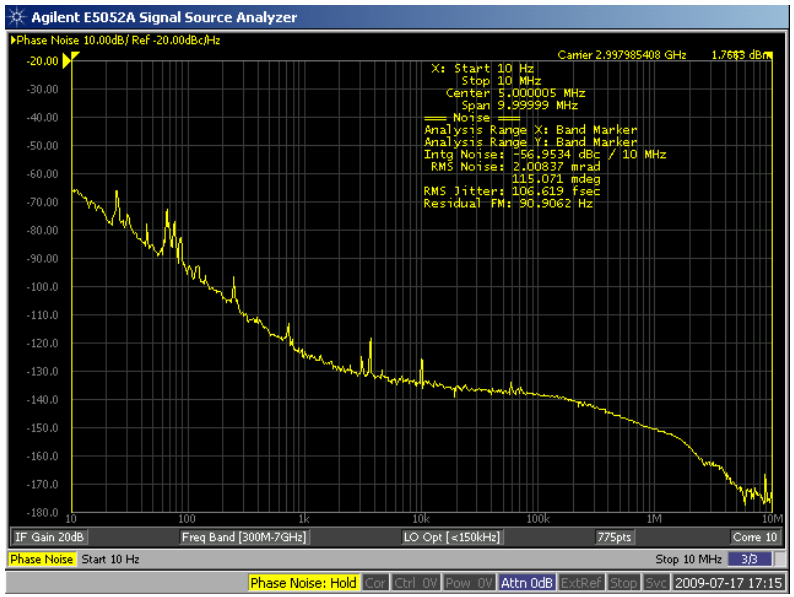

- Simple



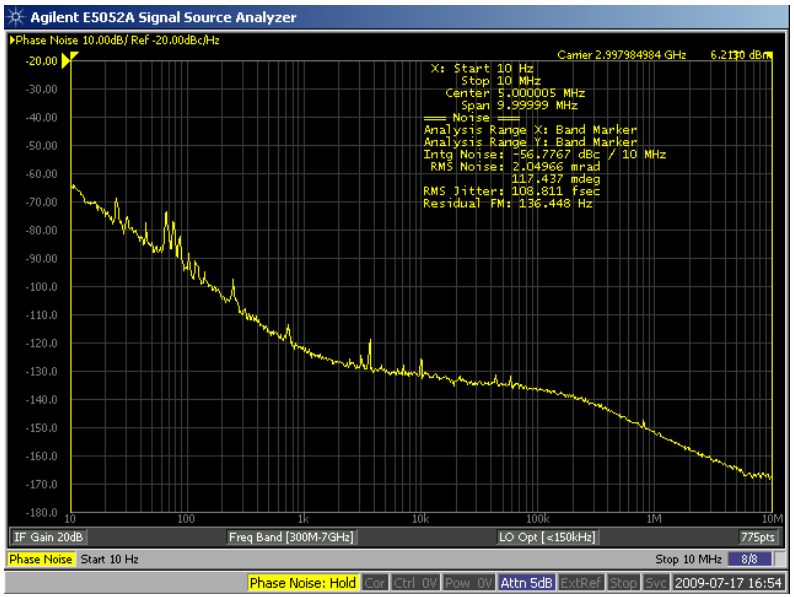
# Added Jitter Measurement II

Added jitter measurement (10 Hz – 10 MHz)

Reference signal




Output signal

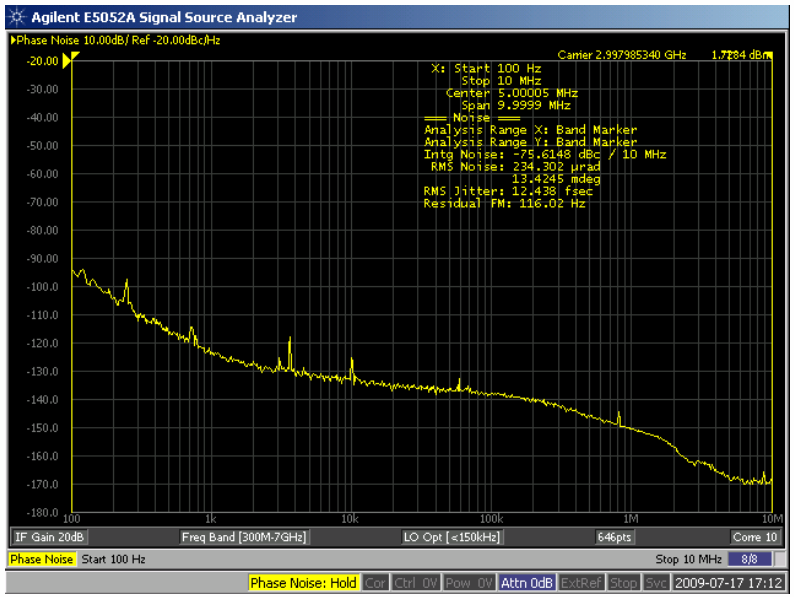



→Added jitter < 40 fs

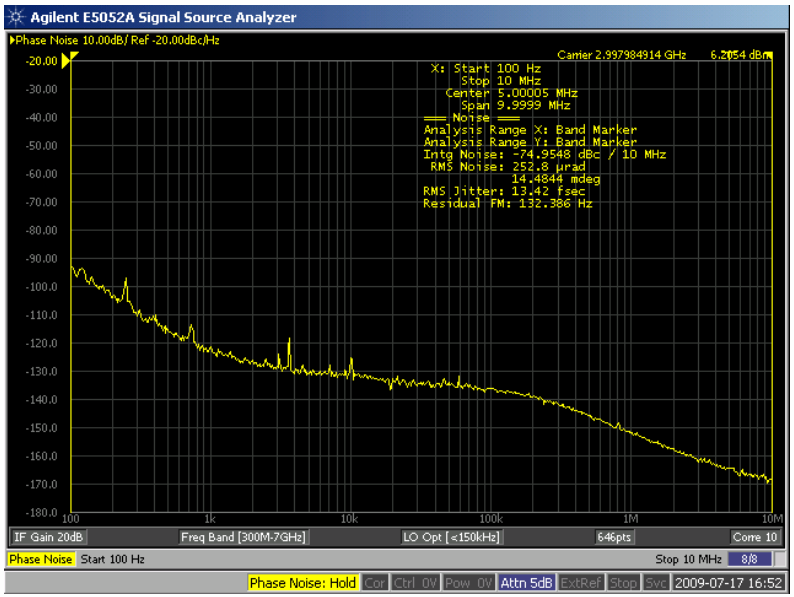
# Added Jitter Measurement III

Added jitter measurement (100 Hz – 10 MHz)

Reference signal

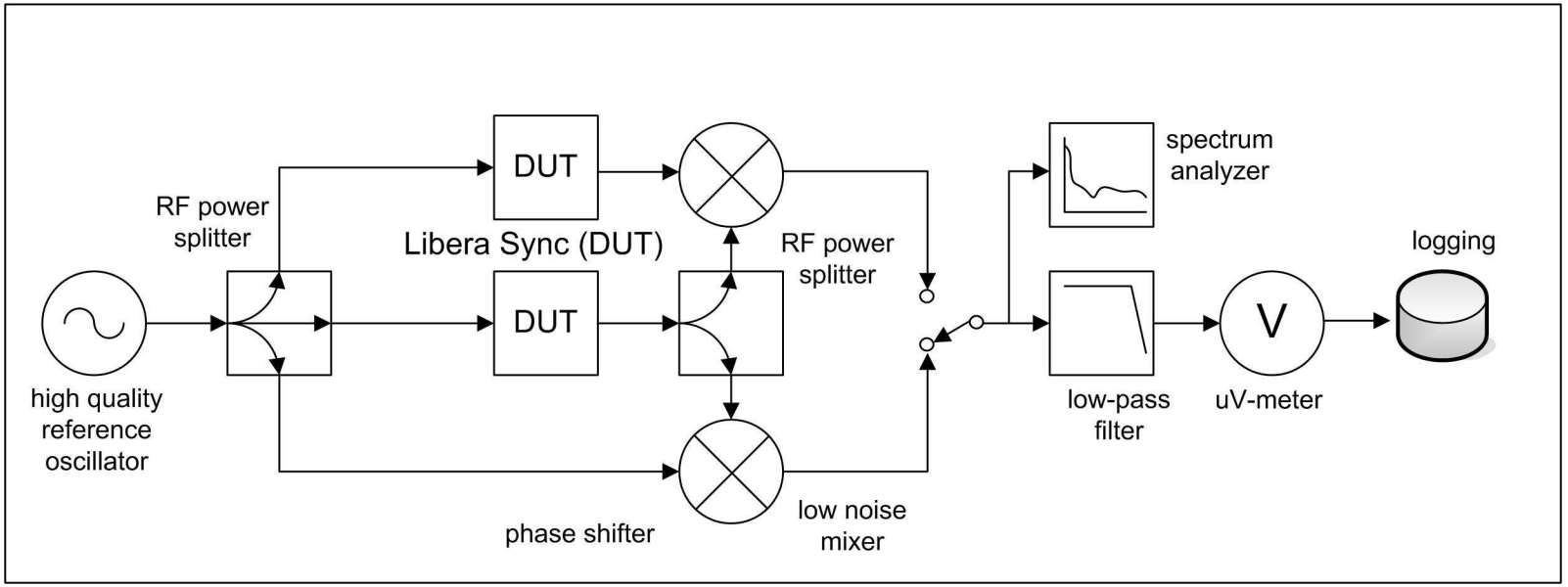



Output signal




→Added jitter < 10 fs

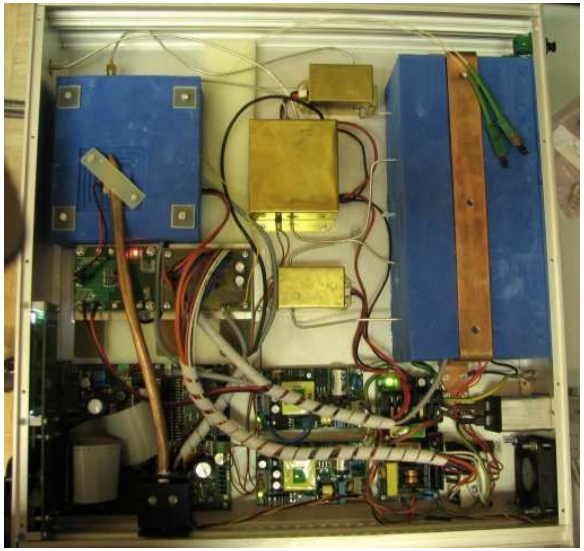
# Long-Term Stability Measurement




- Currently long term stability tests are taking place at FERMI @ Elettra
- Drift contribution of the measurement set-up requires care to avoid the introduction of unwanted artifacts.

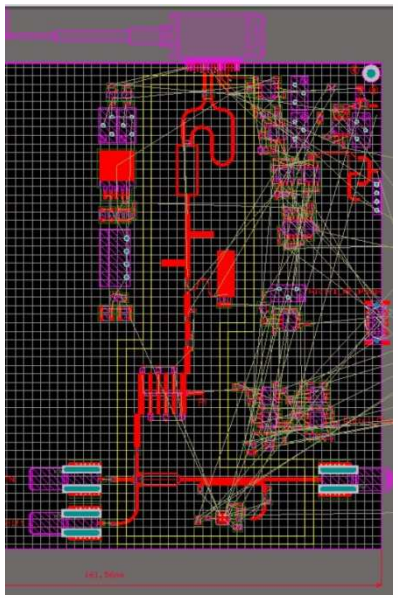
# From Prototype To Regularly Manufactured Units I

- Prototypes operate well, re-design for production has started
- Software functionality has been optimised

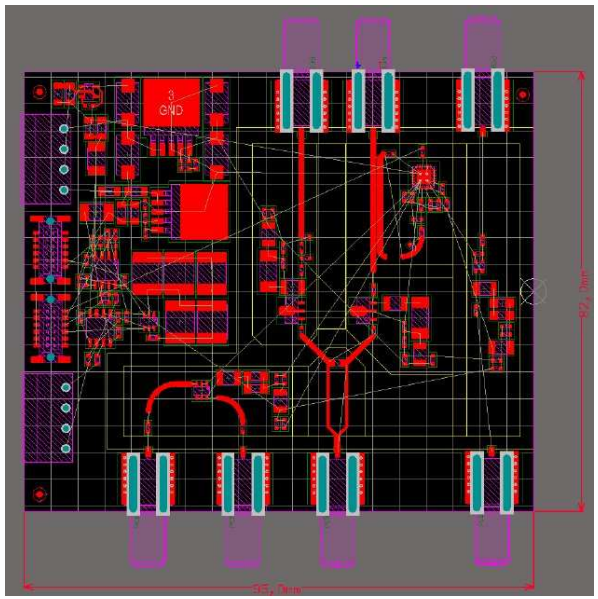



# From Prototype To Regularly Manufactured Units II

Transmitter module



Reciever module



First units will be available in February 2010

# Libera Sync Connectivity

- **RS232**
  - Local diagnostics and setup
  - Software upgrade

- **USB**
  - Local diagnostics and setup

- **Ethernet (Telnet)**
  - Local diagnostics and setup
  - Remote diagnostics and setup
  - Counterpart unit diagnostics

# Libera Sync Versions

- Currently 3 GHz (2998 MHz and 2856 MHz) are supported with the same design
- Special version for 1.3 GHz and 3.9 Ghz
- Current concept enables operation in a frequency range of 1-5 GHz

# Acknowledgements


- Radiation and Optics Lab, Faculty of Electrical Engineering, Ljubljana, Slovenija

  http://antena.fe.uni-lj.si/~lso/

  prof. Matjaz Vidmar and his team

- FERMI @ Elettra, Triest, Italy

  http://www.elettra.trieste.it/FERMI/

  Mr. Mario Ferianis