POZNAN SUPERCOMPUTING AND NETWORKING CENTER

Time and radio frequency transfer using the optical ELSTAB system

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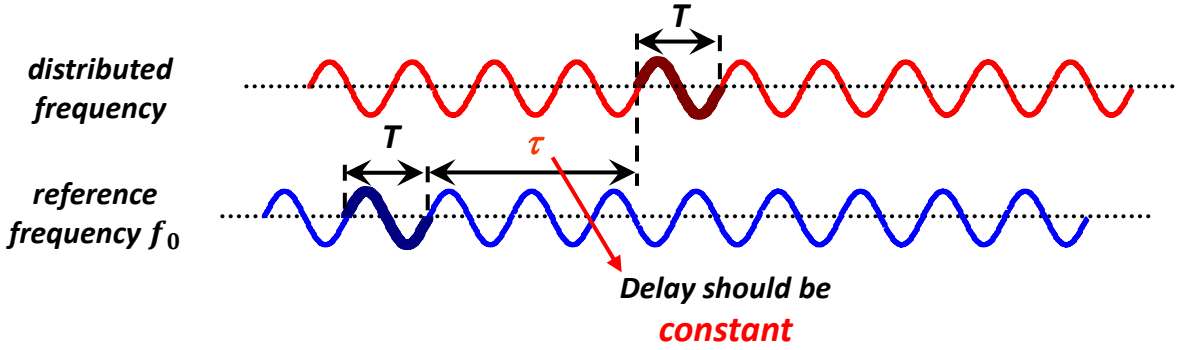
Main difference between frequency and time dissemination

Frequency dissemination

f = 5 MHz, 10 MHz,..., optical frequency (~194 THz)

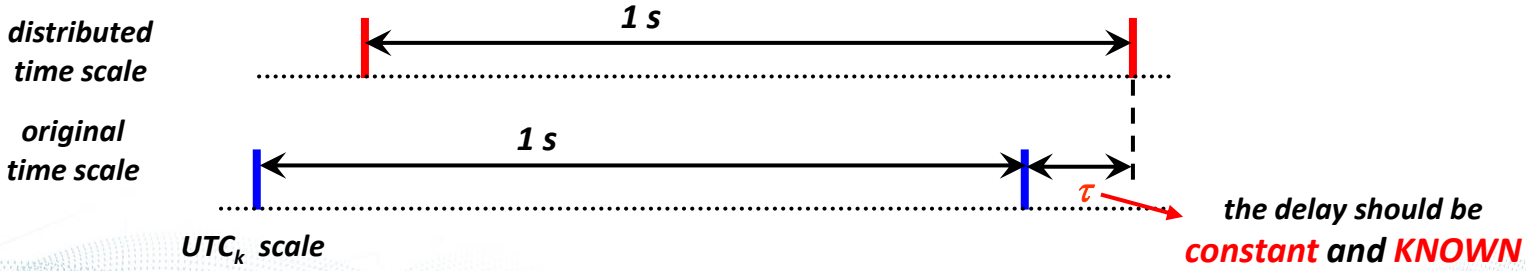


delay changes lead to frequency changes

$$\Delta f(t) = f_0 \frac{d\tau(t)}{dt}$$

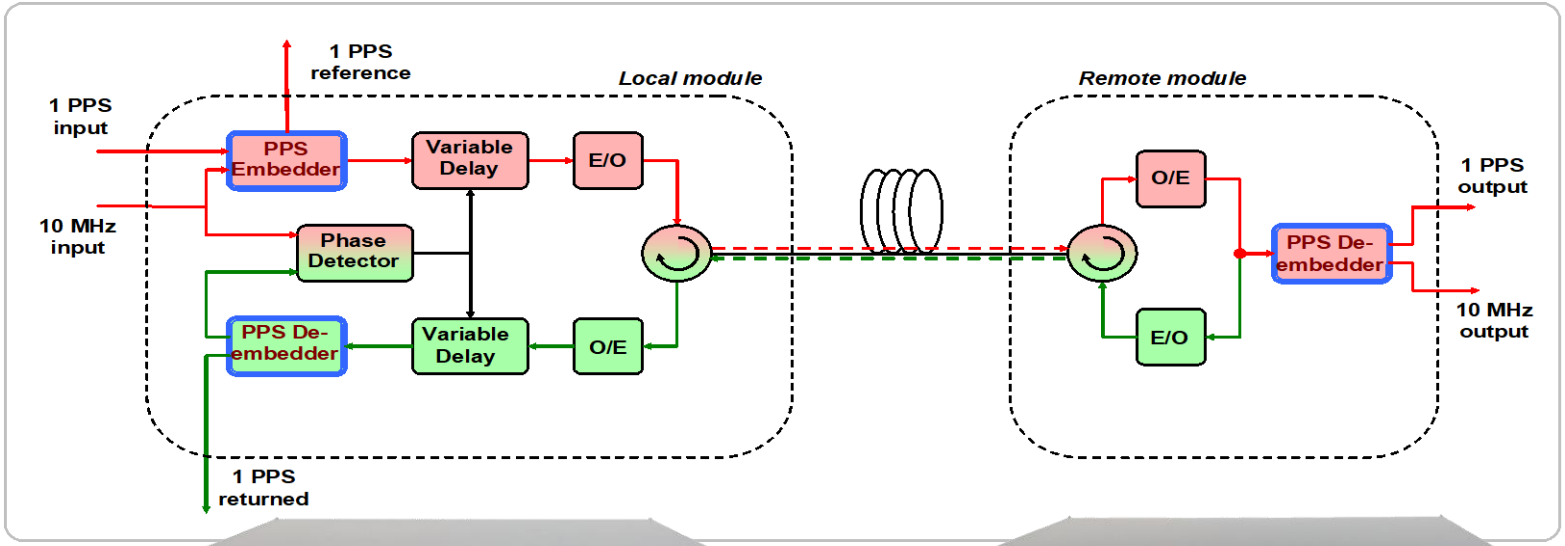
Time SCALE dissemination

1 PPS (Pulse Per Second)



ELSTAB fiber T/F distribution system

ELectronically **STAB**bilized fiber T/F distribution system



AGH

System developed by AGH University of Science and Technology

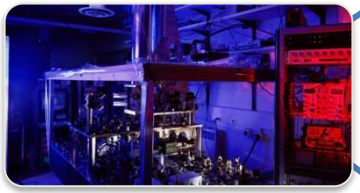
Time and RF Frequency dissemination in Poland

Current status

- T&F users
- T&F repository
- UTC Laboratories
- DWDM T&F links
- Dark Fibre T&F links
- PIONIER Network

Time and Frequency dissemination - areas of responsibility

Source of siganals
(UTC_k LABs)



Local module

N x BiDir EDFAs

Remote module

PIONER Network
(managed by the PSNC)

Local module

DWDM
Network

Remote module

End
Users

Time and Frequency dissemination - areas of responsibility

UTC_k LABs are responsible for:

- **Maintaining the time and frequency reference clocks**
- **Generation of reference signals (1 PPS and 10 MHz)**
- **Absolute time calibration (determination of total link delay)**

Time and Frequency dissemination - areas of responsibility

PSNC is responsible for:

- **Fibre optic network maintenance**
- **Management and monitoring of T&F transfer devices (Local + Remote + EDFAs)**
- **Support in time calibration (for cascaded links)**

Management and monitoring of T&F transfer devices

Parameters monitored at the Local (transmitting) module:

- Presence of input signals (1 PPS, 10 MHz)
- Received optical signal level
- System status (status of proper operation of the stabilization system)

Using a time interval counter (TIC)
it is also possible:

- Measure/monitor the round trip time delay
- Perform calibration measurements

Management and monitoring of T&F transfer devices

Parameters monitored in BiDir EDFA amplifiers:

- Levels of optical input and output signals
- Amplifier Gain
- Amplifier pump current
- Module temperature

Modifiable parameters:

- Operation mode, Gain, pump current

Possibility to transfer T&F+OC in a single fibre (the same amplifiers)

Management and monitoring of T&F transfer devices

Parameters monitored at the Remote module:

- Received optical signal level
- System status
  (state of the stabilisation system)

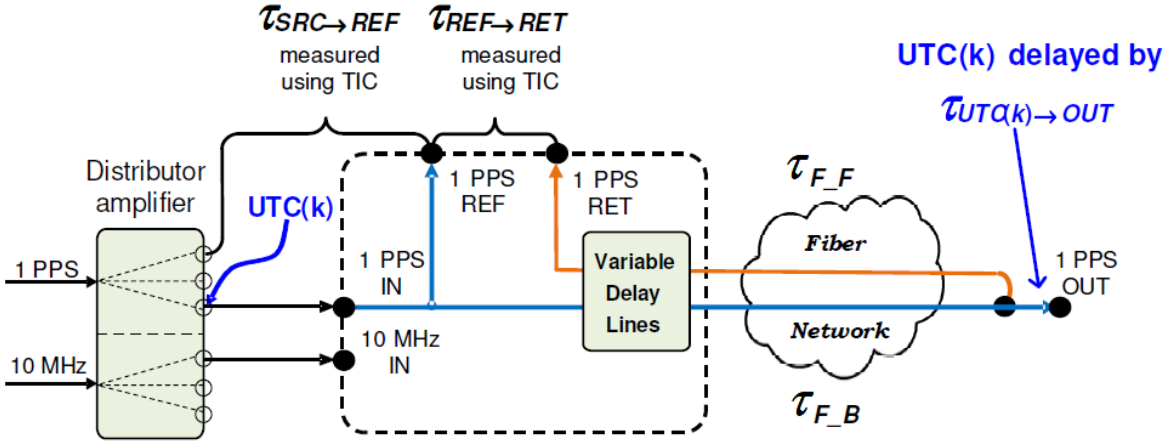
Management and monitoring of T&F transfer devices

Communication interfaces/protocols:

- Access via „out of band” and/or „in band” channel
- SSH
- SNMP v2c/v3, SNMP Traps
- Access to device management with different authorisation levels
- Local or radius user authentication
- Event logging, syslog server ...

Example of SNMP monitoring

Time calibration



All the calibration measurements are done at the local side only

Basic calibration formulas:

$$\tau_{REF\rightarrow OUT} = \frac{1}{2}\left[\tau_{REF\rightarrow RET} + \left(\tau_{F\_F} - \tau_{F\_B}\right) + \tau_C\right]$$

$$\tau_{UTC(k)\rightarrow OUT} = \tau_{UTC(k)\rightarrow REF} + \tau_{REF\rightarrow OUT}$$

Fiber forward-backward asymmetry:

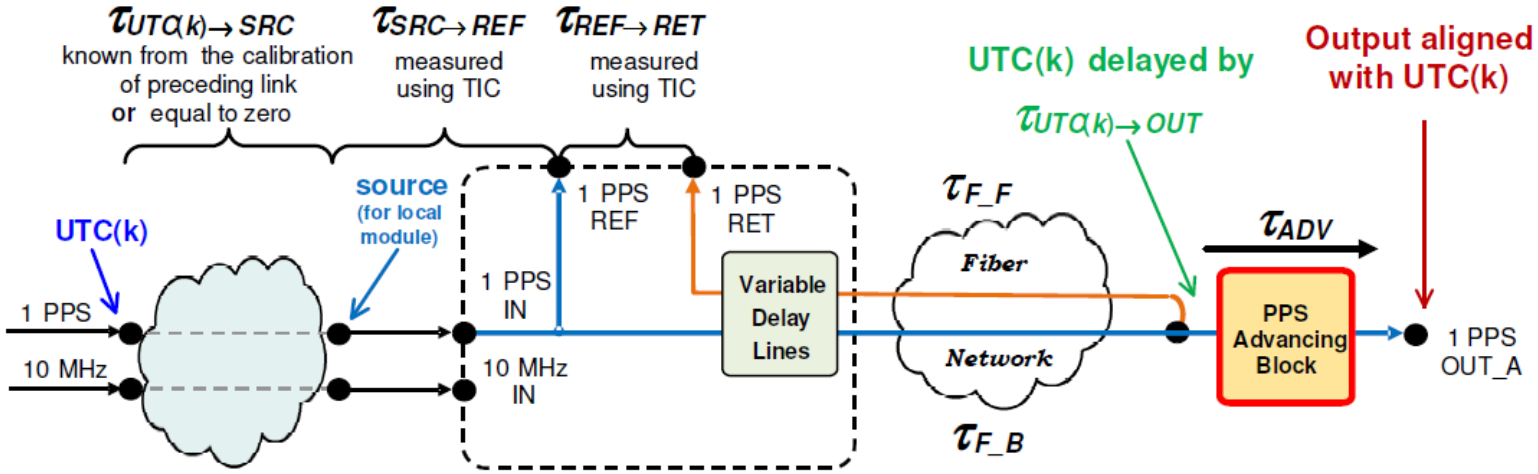
$$\tau_{F\_F} - \tau_{F\_B} = D_T\left(\lambda_F - \lambda_B\right) \pm \frac{4\omega A_E}{c^2} + \tau_{BIR}$$

Local & remote modules asymmetry:

$$\tau_C = \left(2\tau_{REF\rightarrow OUT} - \tau_{REF\rightarrow RET}\right)\Big|_{PATCHCORD}^{SHORT}$$

Source: https://www.clonets.eu/clonets-posters0.html?&no_cache=1&cid=6513&did=15429&sechash=d24f500e

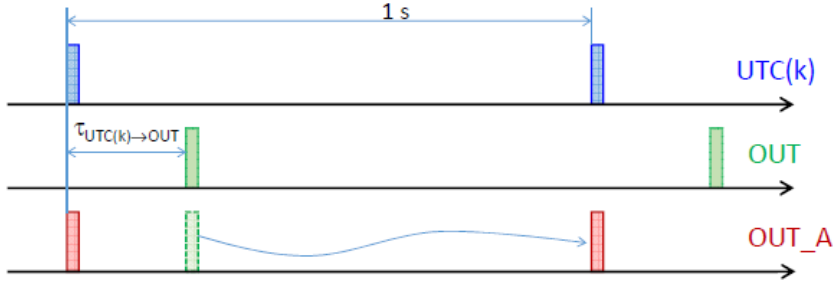
Delay compensation



Calibration formulas:

$$\tau_{UTC(k)\rightarrow OUT} = \tau_{UTC(k)\rightarrow SRC} + \tau_{SRC\rightarrow REF} + \tau_{REF\rightarrow OUT}$$

$$\tau_{UTC(k)\rightarrow OUT\_A} = \tau_{REF\rightarrow OUT} - \tau_{ADV}$$



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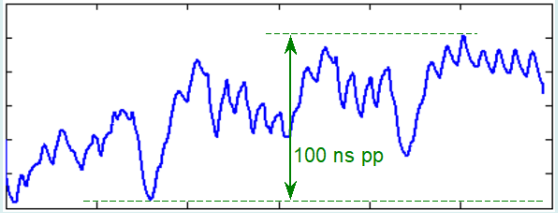
Performance

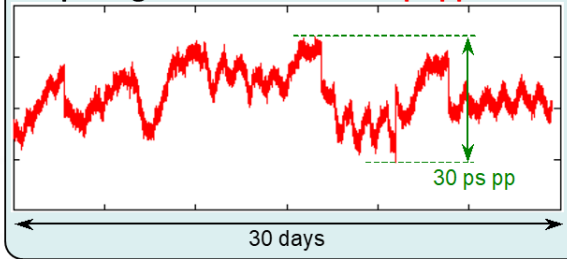
Example:

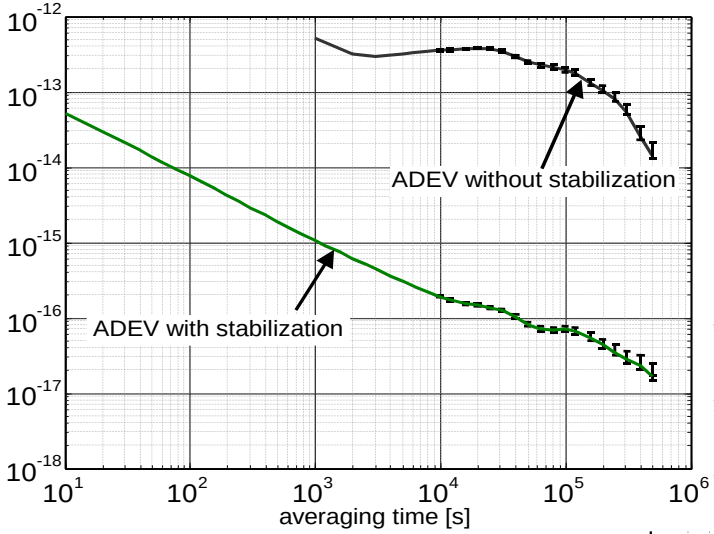
stability of 615 km long-distance transfer using ELSTAB

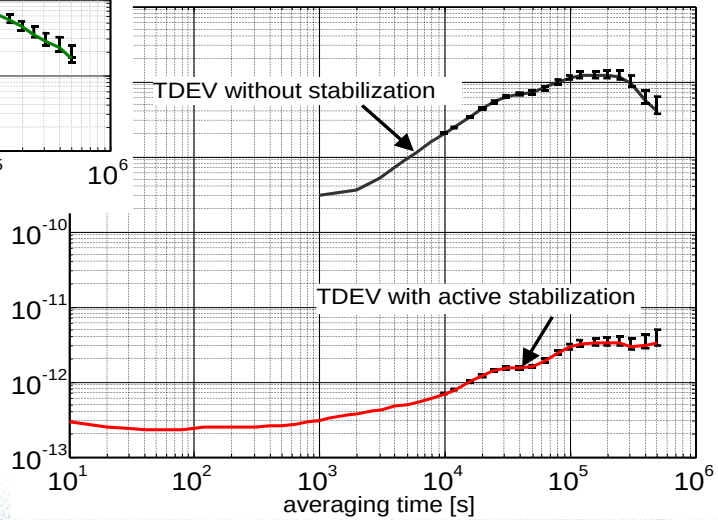
fiber delay fluctuations: 100 ns pp



output signal fluctuations: 30 ps pp







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Time (1 PPS) and Frequency (10 MHz) dissemination

Work in Progress

- T&F Repository - level I
- T&F Repository - level II
- T&F Dissemination Network:
- Future international connections
- PIONIER Network

Optical Carrier dissemination

Work in Progress

- Optical carrier distributing point
- Points of access to the optical carrier

Optical Carrier Network:

- Toruń - Poznań evaluated link
- Poznań - Warszawa, Poznań - Wrocław links
- Future international connections
- PIONIER Network

NLPQT
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