

# Fiber link

## Fiber stabilization

## Scheme

**PTB** Physikalisch-Technische Bundesanstalt  
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### Multiple Frequency Dissemination and Fiber Brillouin Amplification for the Optical Fiber Link PTB-Hannover

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**Optical Fiber Link PTB-Hannover**  
Main Goals:  
 • Transfer optical frequency (~194 THz) referenced to a primary clock [1]  
 • Transfer to several places in Hannover using a single link [2,3,5]  
 • Transfer instability below  $10^{-16}$  at 1 s of averaging time  
 • Transfer uncertainty  $\delta\nu/\nu$  below  $10^{-16}$   
 • Tests with transportable Sr optical clock [4] and new transportable cavity stabilized laser.

**Multiple Frequency Dissemination**  
Main Link:  $\nu_{out} = \nu_{in} + 2f_{acm} + 2f_{frm} + 2f_{pd}$   
 Extraction Box:  $\nu_{out} = \nu_{in} + f_{acm} + f_{frm} + f_{pd}$   
 User Secondary Link:  $\nu_{out} = \nu_{in} + f_{acm} + f_{frm} + f_{pd}$

**Performance of Link and Extraction Box**  
 Fig. 3: Overlapped Allan Deviation ( $\sigma_{ADEV}$ ) [6], i.e. a counting with 1 s gates and applying the ADEV of the inloop, remote and extracted signal, test setup: see inset, signal extraction at the "end" of the link.

**Quadruple Fiber Brillouin Amplifier**  
 Forward propagating: Monitoring Signal (270 MHz)  
 Backward propagating: Monitoring Signal (270 MHz + 10 MHz)  
 PD: Beat @ 11 GHz  
 Off-set Lock: Master Laser (270 MHz + 10 MHz)  
 Frequency Shift (20 MHz ACOM)  
 PD: Photo Detector  
 ACOM: Acousto-optical modulator, FRM: Faraday-Rotating Mirror, PD: Photo Detector

**Fiber Brillouin Amplification**  
 Fig. 5: Fiber Brillouin amplification benefits from a combination of high gain and narrow bandwidth. The setup has been demonstrated both in the lab and in the field [7,8].  
 Fig. 6: View of the optical part and the complete fiber Brillouin amplifier.

**Conclusion**  
 • Successful implementation of fiber Brillouin amplifiers  
 • Successful extraction of a signal from a stabilized 140 km link  
 • Instability of  $4 \times 10^{-16}$  at 1 s allows tests of transportable cavity stabilized lasers (instability  $\sim 10^{-16}$  at 1 s)  
 • Instability and uncertainty  $\sim 7 \times 10^{-16}$  at 10000 s (allows tests with the Sr optical lattice clock [4]) (uncert.  $\sim 3 \times 10^{-16}$  and uncertainty at low 10<sup>-16</sup> level)

**References**  
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## Next steps (06.10.2016)

- Comparison measurement with strontium/caesium
- Link to AEI (contact partner: Michael Tröbst?)
- Link HighTec, but how? 😊

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Last update: **2017/04/14 11:17**

