Status of the CW optical synchronization system

LLRF Collaboration Workshop

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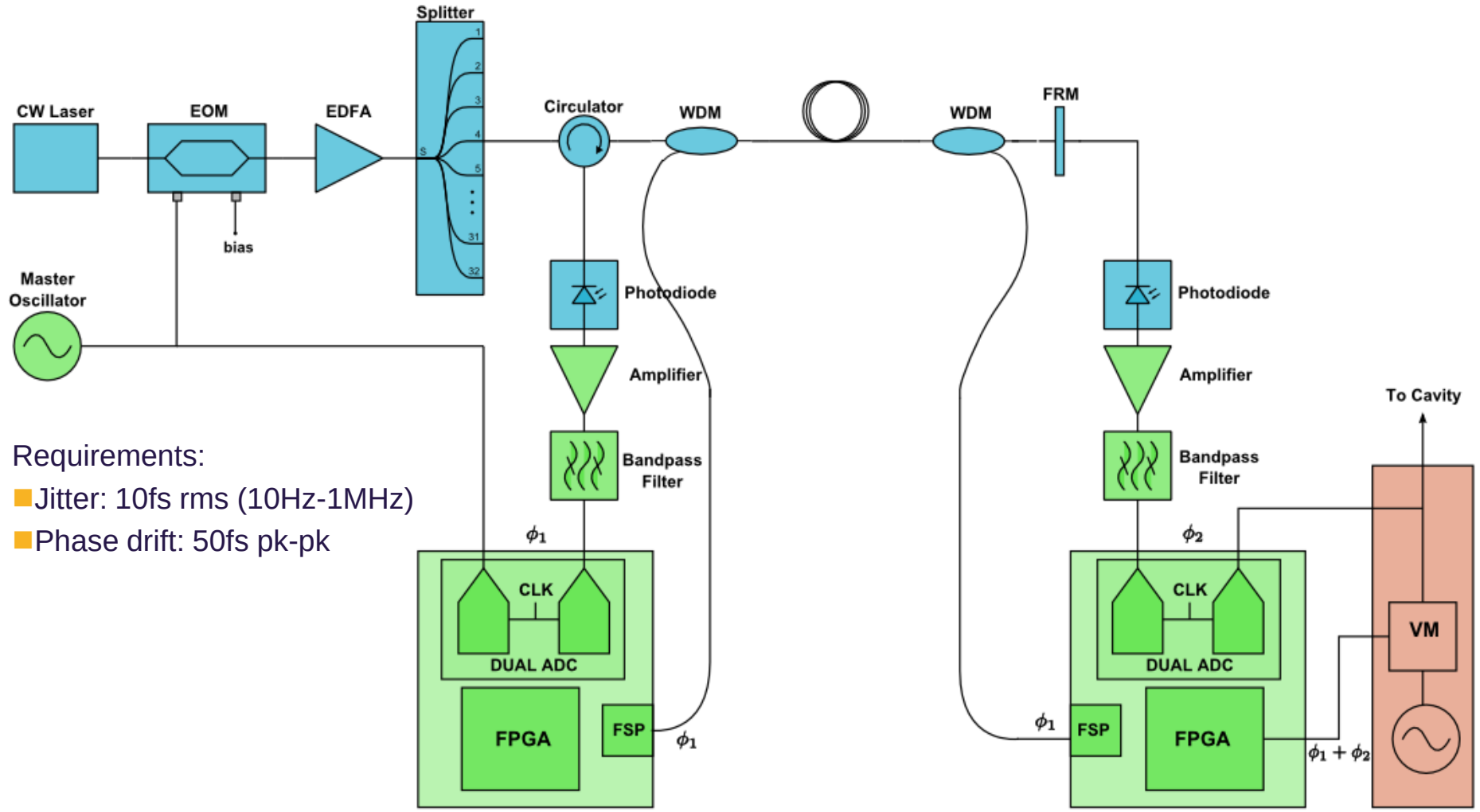
ISE/WUT

CW synchronization system scheme



Requirements:

- Jitter: 10fs rms (10Hz-1MHz)
- Phase drift: 50fs pk-pk

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Important issues for the system performance

- MZI bias-point drift
- AM-PM conversion of photodiodes
- Relative Intensity Noise (RIN) of optical signal and its influence on link phase noise
- CW link residual phase noise
- Phase drift due to humidity variation
- RF signal phase detection

- Noise figure of the fiber link
- Intermodulation products (products of mixing of 1.3GHz signal with relaxation oscillation peak of the laser)
- SNR penalty due to fiber dispersion
- Phase-to-intensity noise conversion

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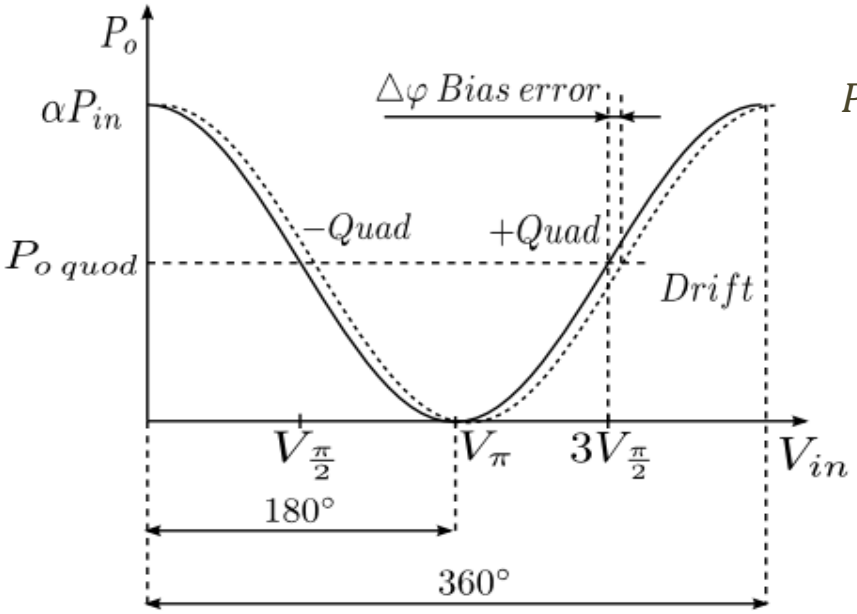
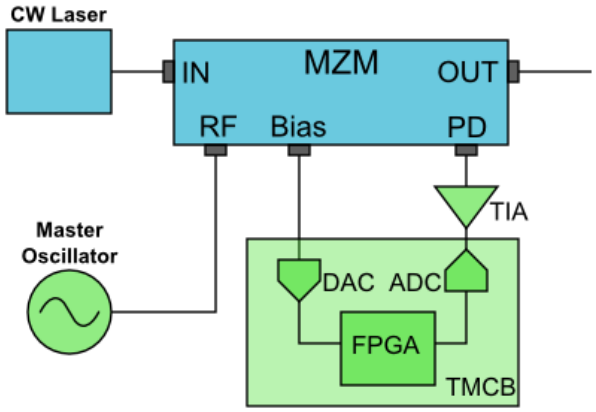
MZM bias-point drift





$$P_o = P_{in}\frac{1}{2}\left[1+\cos\left(\frac{V_{bias}}{V_{\pi_{DC}}}\pi+\frac{V_{RF}}{V_{\pi_{AC}}}\cos(2\pi f t+\varphi)\pi\right)\right]\alpha$$

Bias-point drift measurement (Covega MZM):

- 20 hours
- Temp. variations: <0.15℃
- RH variations: ~10%
- V_{bias} - const.

➢ Optical power stability: ~15%

In-loop optical power stability: ~60ppm

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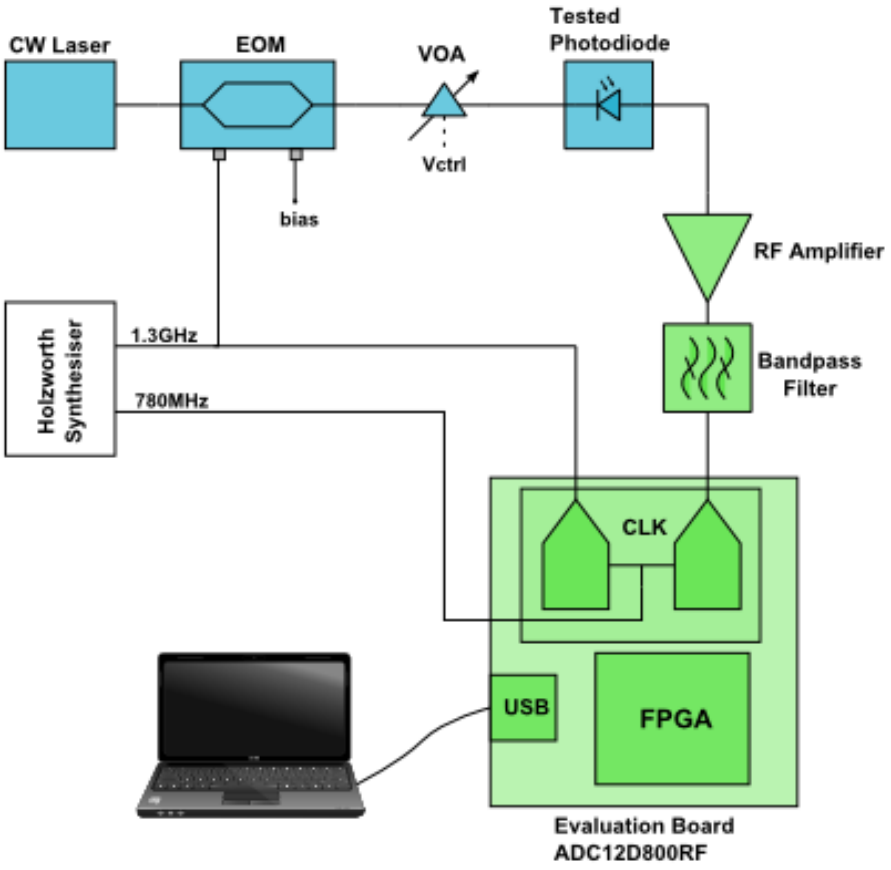
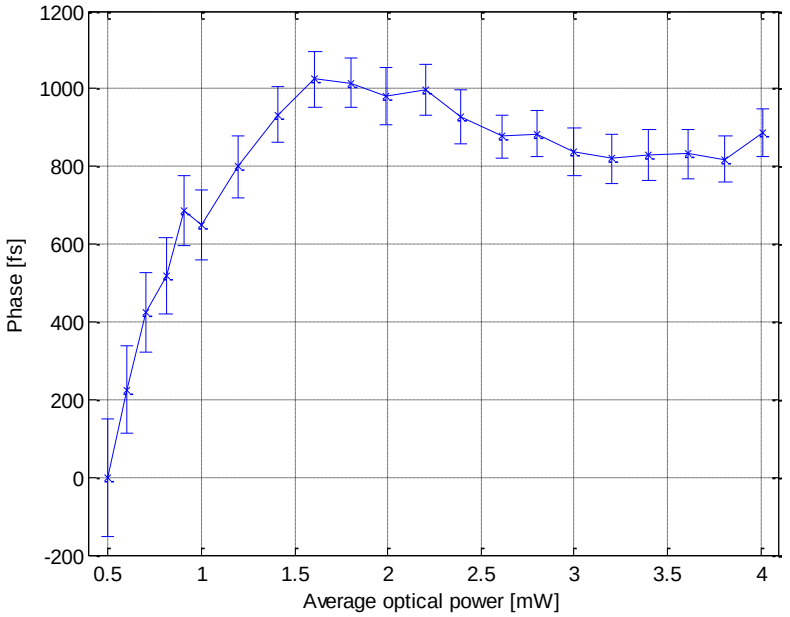
AM-PM conversion

Measurement setup





- $\alpha\left[{}^{ps}/_{dP/P}\right]$<1
- Phase drift (${}^{\Delta P}/_{P} = 60ppm$): <0.06fs
- Phase noise: below residual link noise

$$L(f)^{*} = RIN + 20\log\left(\alpha\left[{}^{rad}/_{dP/P}\right]\right) - 3$$

*J. Taylor, S. Datta, A. Hati, C. Nelson, F. Quinlan, A. Joshi, S. Diddams, *Characterization of Power-to-Phase Conversion in High-Speed P-I-N Photodiodes,* IEEE Photonics Journal

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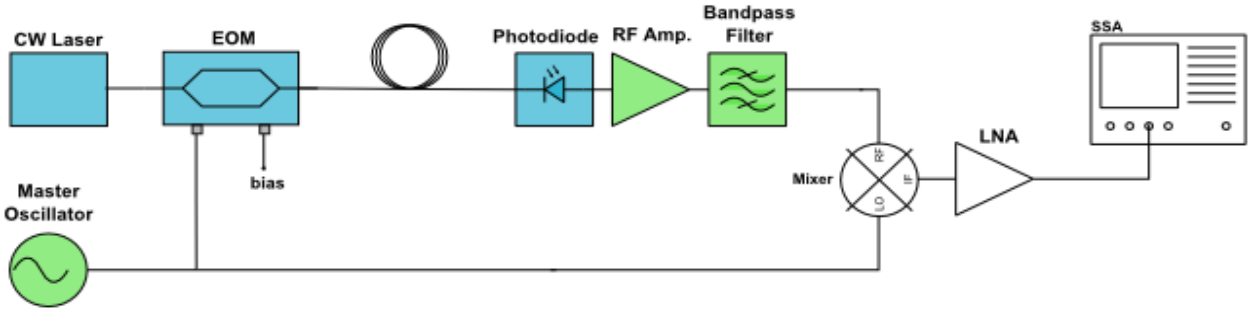
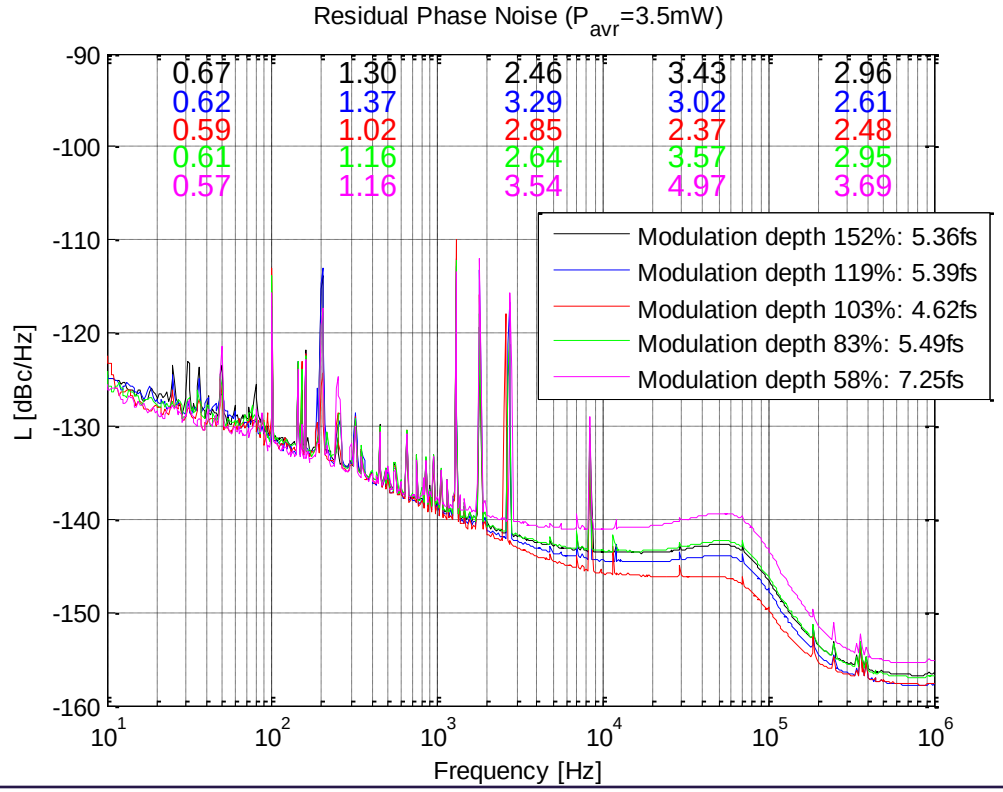
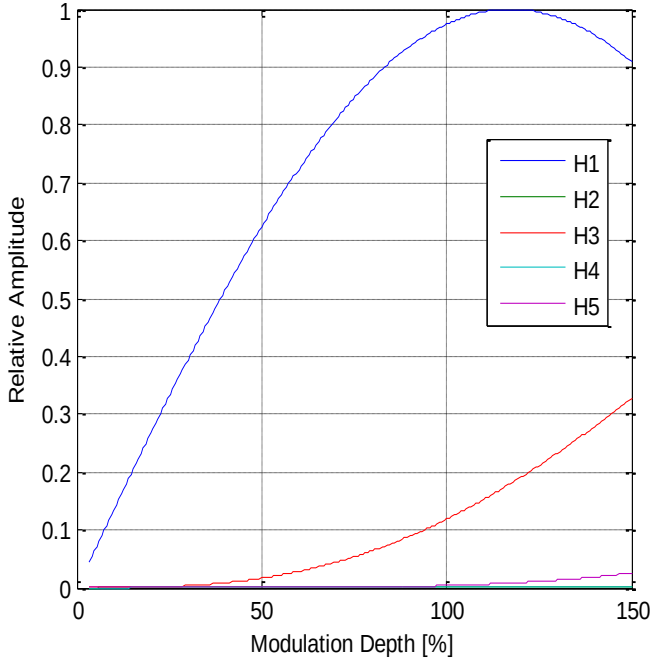
Residual phase noise (1)







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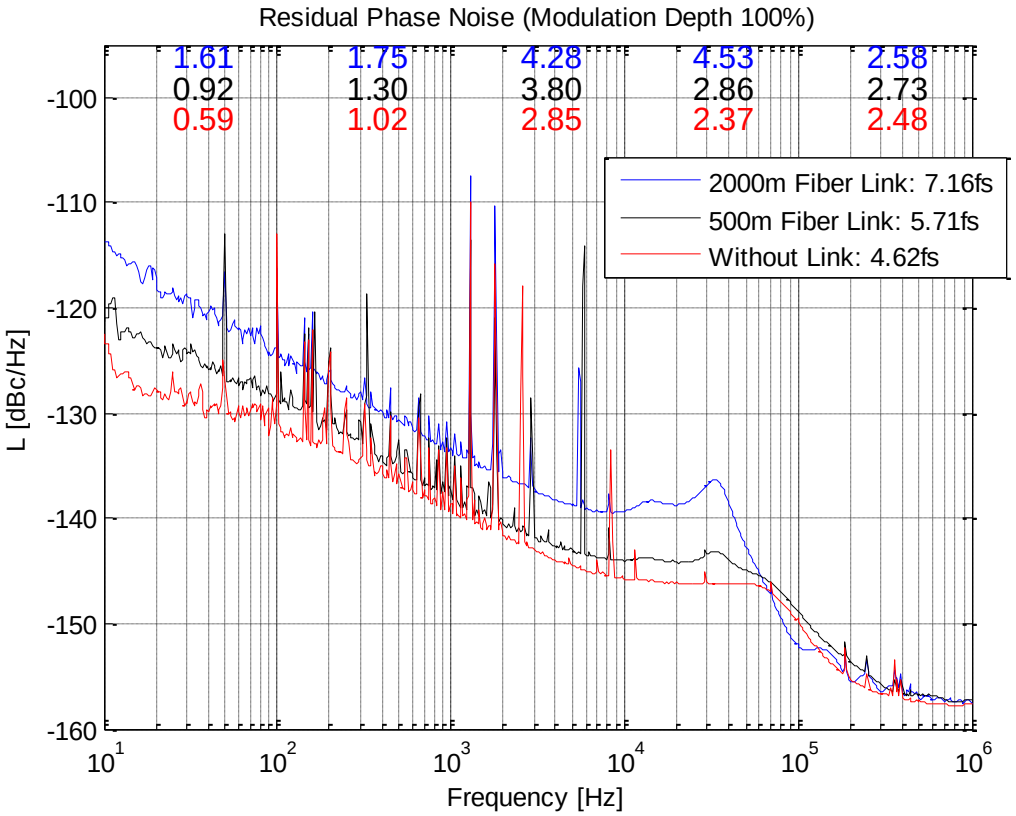
Residual phase noise (2)



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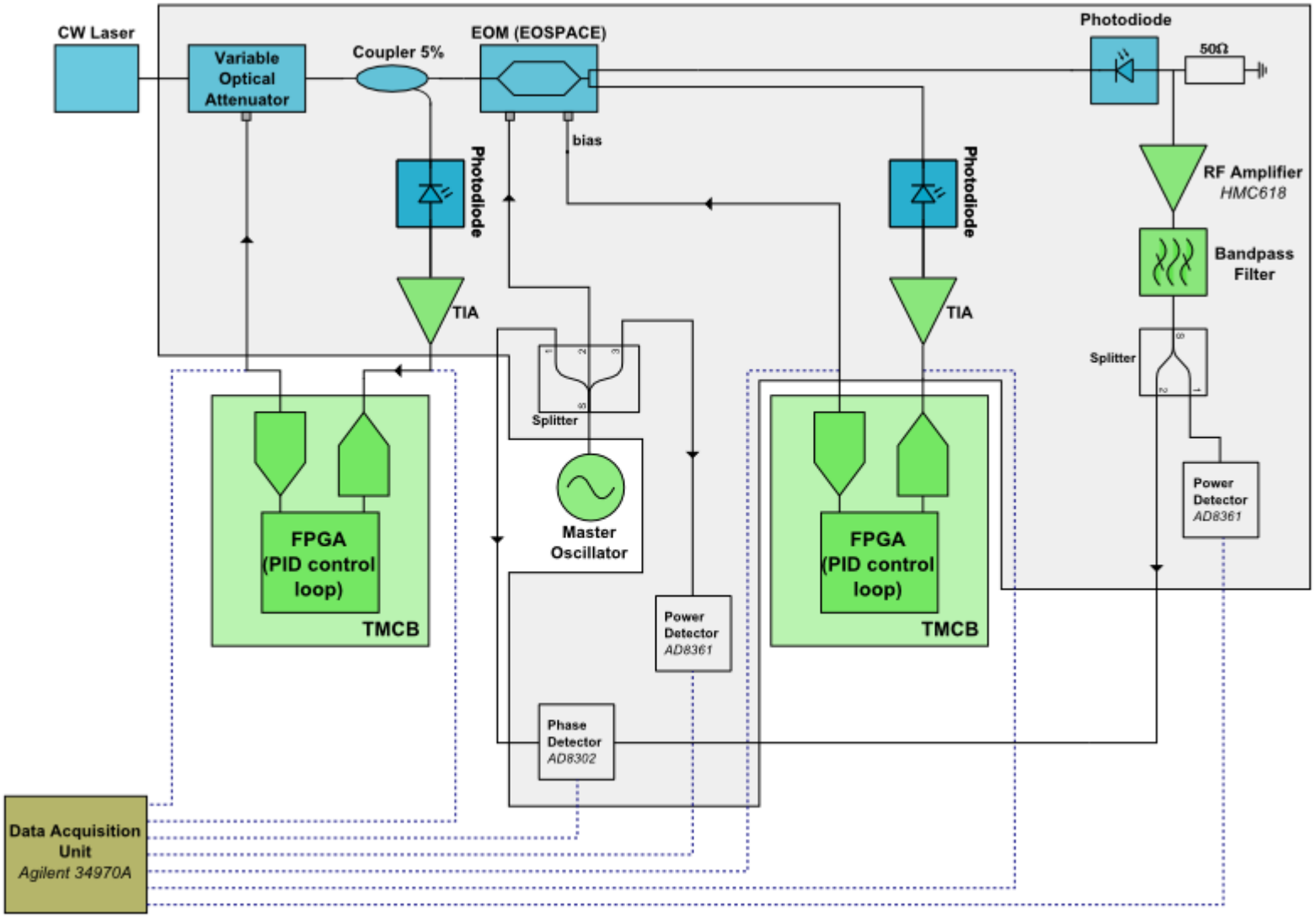
Phase drift due to humidity (1)



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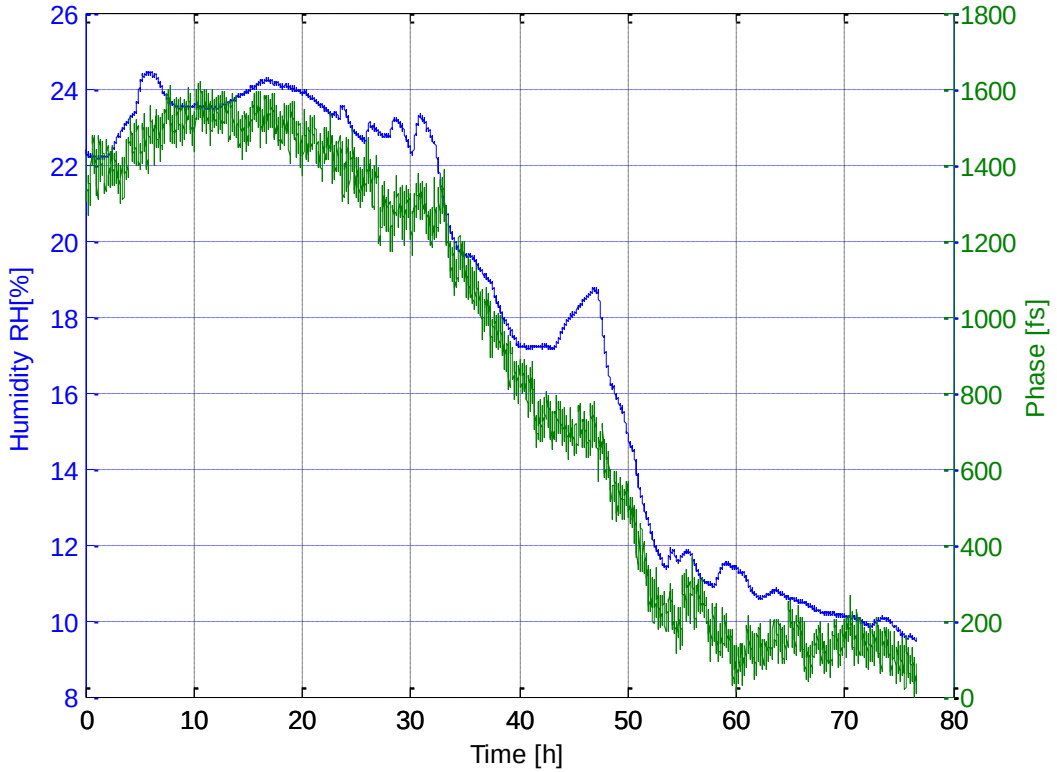
Phase drift due to humidity (2)



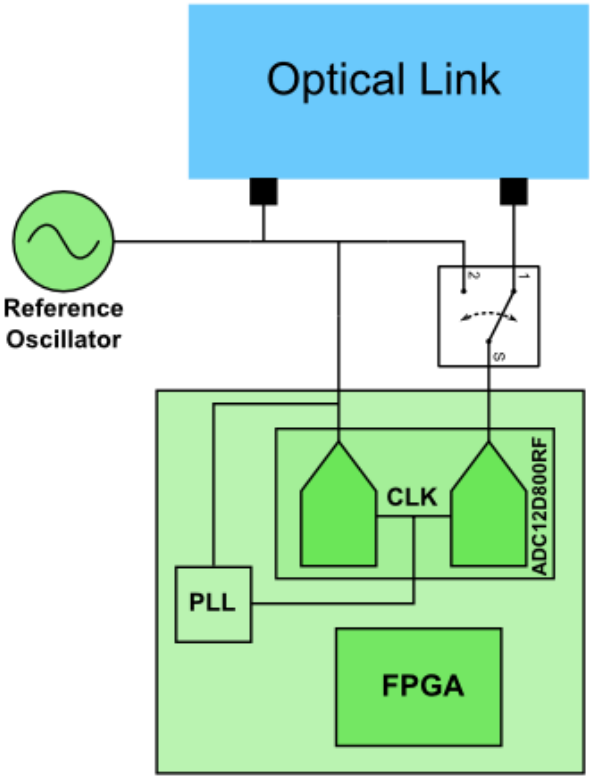
- Phase drift: $100\ ^{fs}/_{\Delta\%RH}$

Phase drift detection (non-IQ algorithm)

- Requirements

  phase instability: $\max. 10fs\ (1\mu Hz - 1MHz)$
- Clock drift common for both ADCs
- High drift of input stage
- Possibility of drift calibration

  (input switching, two-tone calibration)



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Current status

Done:

- Studying the influence of link components parameters on the synchronization system performance
- Selection of system components
- Measurements: residual phase noise, AM-PM conversion in photodiodes, transmitter phase drift, optical power stability, jitter of ADC12D800RF evaluation board, ...

To do:

- Solving the problem with humidity
- CW link tests with the fast ADC board
- Building, testing and optimisation of the final version of the system

Thank you for your attention!