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FOR 2863 Meteracom
Metrology for
THz Communications

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Technische Universität Braunschweig

A1: Metrology of a direct detection based optical sampling system for THz applications

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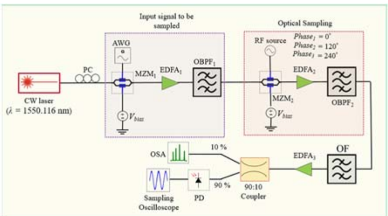
Direct detection (DD) systems

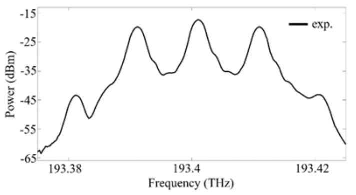
- **Applications:** data centers, THz bandwidths signal detection.
- **Advantage over coherent detection:** simple hardware, no THz LO [1].
- **Requirements:** optical filter (OF) [2] with Δf bandwidth, single photodiode.
- **Problem:** sampling quality degradation for comb ripple, different filter shapes.
- **Investigation**: sampling deterioration in 3-line OFC for: (a) comb ripple, (b) optical filter roll-off for orthogonal sampling (OS); valid for THz-DD systems.

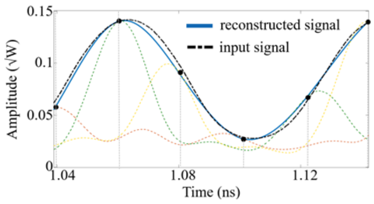
Orthogonal sampling benefits

- High bandwidth (BW), low clock jitter at high data rates.
- High BW signals $\xrightarrow[\text{conversion}]{\text{down}}$ parallel low BW signals.
- Signal processing with low BW electronics [3].

Experimental setup, results

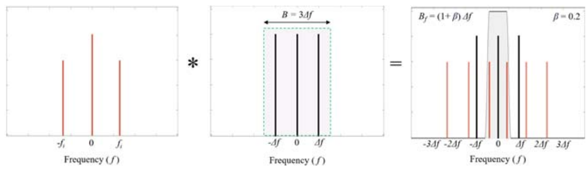




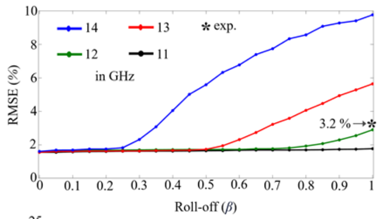


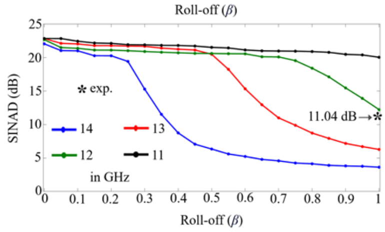
- Input frequency (f_i) = 12 GHz
- Comb spacing (Δf) = 16 GHz (comb ripple), 10 GHz (OF roll-off)

Concept



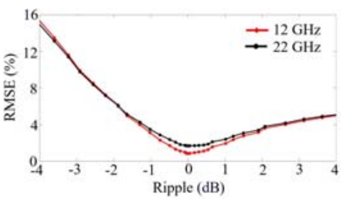
Simulation results (roll-off β)

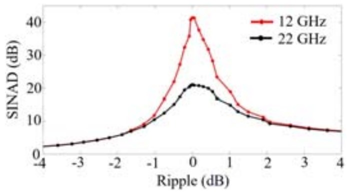




- For sinusoidal f_i
- ADC jitter = 100 fs

Simulation results (comb ripple)





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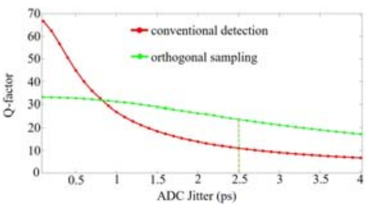

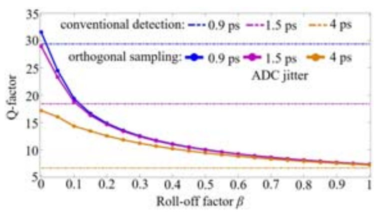

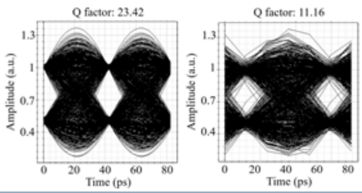

- Input PRBS data rate = 24 Gbps
- OF BW Δf = 8 GHz
- At 2.5 ps ADC jitter, β = 0: OS better eye diagram
- $\beta\uparrow$, Quality factor (Q-factor)$\downarrow$

Summary

- High comb ripple leads to compromised sampling quality.
- For sinusoidal f_i, sampling quality degrades after reaching a certain OF roll-off (β) threshold.
- 1.5 × bandwidth improvement vs conventional detection.
- High ADC jitter: better Q-factor even for higher OF roll-off (β).
- Results scalable to THz-DD systems.

References

1. C. Sun *et al.*, *IEEE PTL,* 32(10), 585–588, (2020).
2. S. De *et al.*, *IEEE PTL,* 33(21), 1189–1192, (2021).
3. J. Meier *et al.*, *IEEE PJ,* 14(2), 1–7, (2022).