



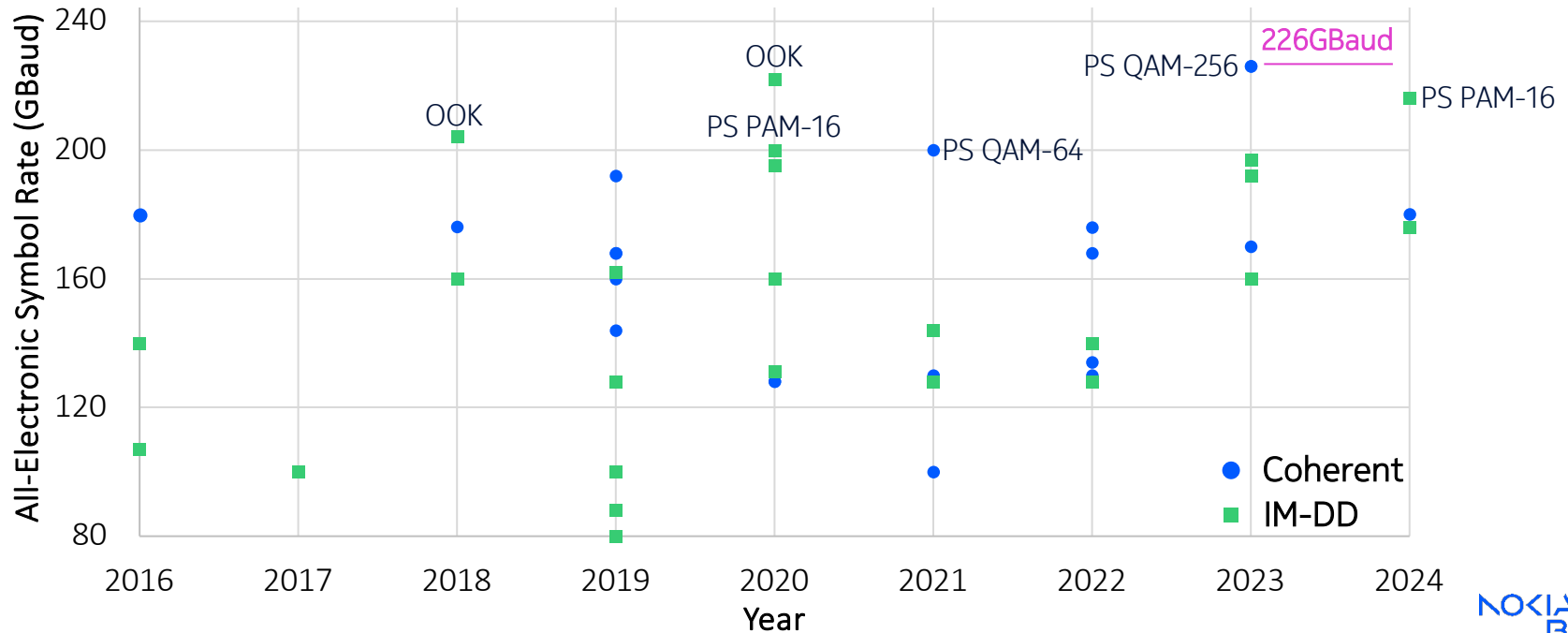
314-GBaud Single-Wavelength Signaling Generated All-Electronically by a 158-GHz Digital-Band-Interleaved DAC

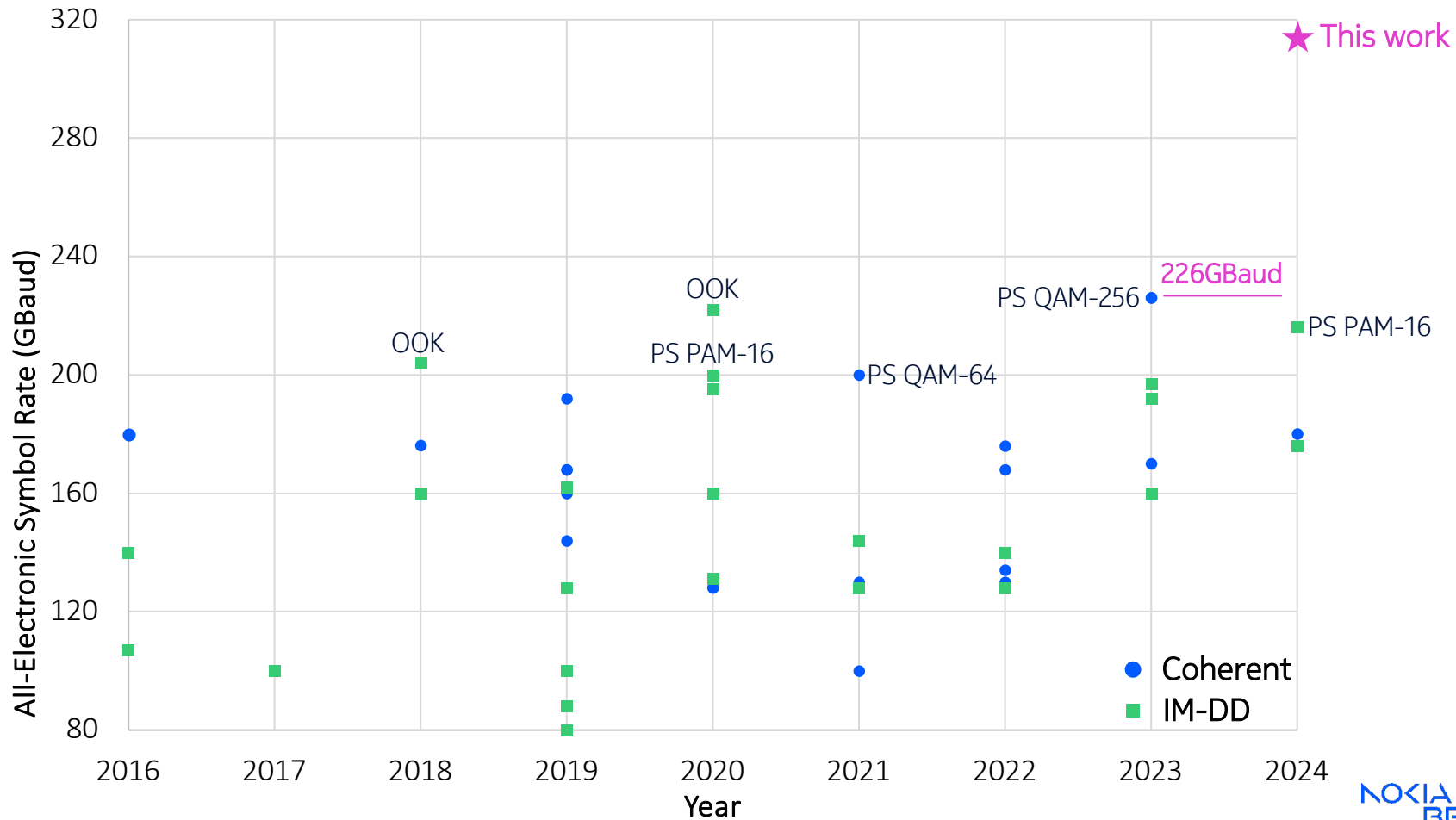
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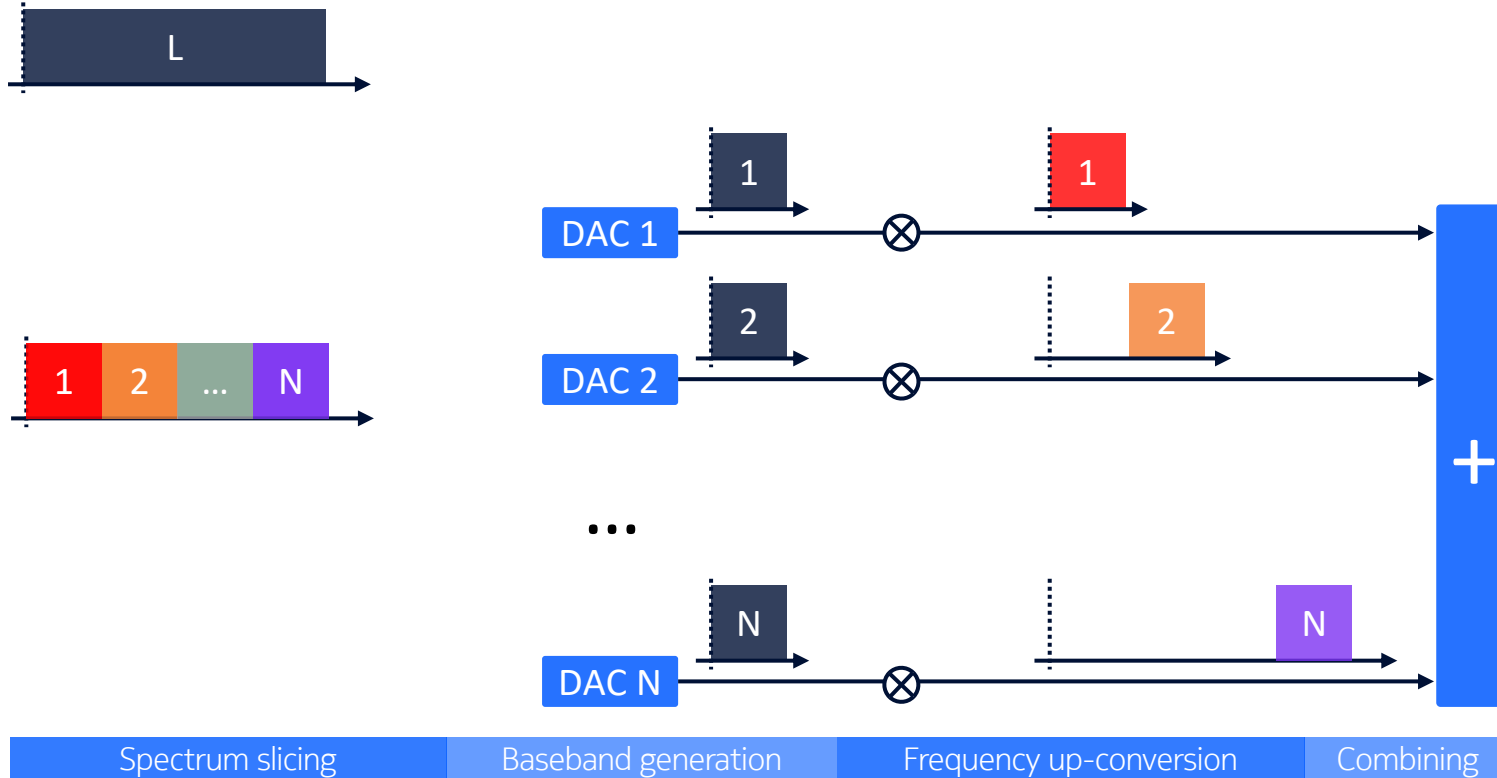
ECOC'2024, PD Th3B.4

Symbol rates over the years





Extending Bandwidth with Digital Band Interleaving (DBI)



Electronics drives Optics: A story behind TFLN

TFLN: thin-film Lithium Niobate

Th5C.5.pdf

OFC Postdeadline Papers © OSA 2016

All-electronic 100-GHz Bandwidth Digital-to-Analog Converter Generating PAM Signals up to 190-GBaud

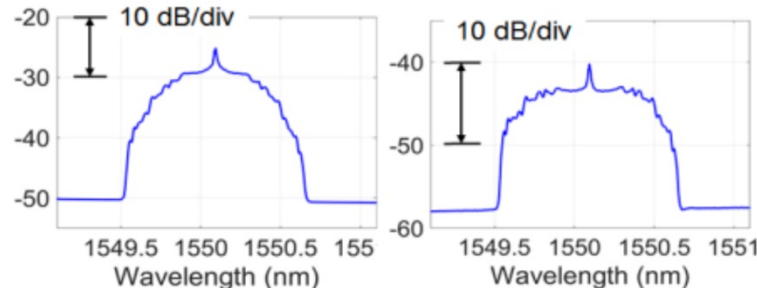
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5. Summary and Discussion

We have demonstrated a 100-GHz electrical bandwidth, 240-GS/s DAC based on DBI. Using this DAC, we have generated **190-GBaud electrical PAM** and **140-GBaud optical BPSK**, the highest all-electronically generated symbol rates reported to date. More sophisticated digital compensation of various impairments will significantly increase



Electronics drives Optics: A story behind TFLN

TFLN: thin-film Lithium Niobate


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Integrated lithium niobate electro-optic modulators operating at CMOS-compatible voltages

[Cheng Wang](#), [Mian Zhang](#), [Xi Chen](#), [Maxime Bertrand](#), [Amirhassan Shams-Ansari](#), [Sethumadhavan Chandrasekhar](#), [Peter Winzer](#) & [Marko Lončar](#) 

Nature **562**, 101–104 (2018) | [Cite this article](#)

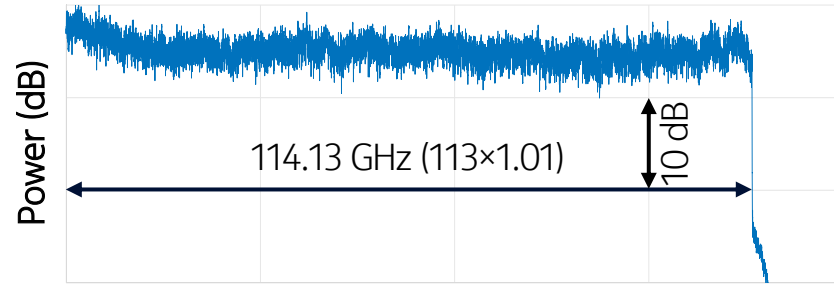
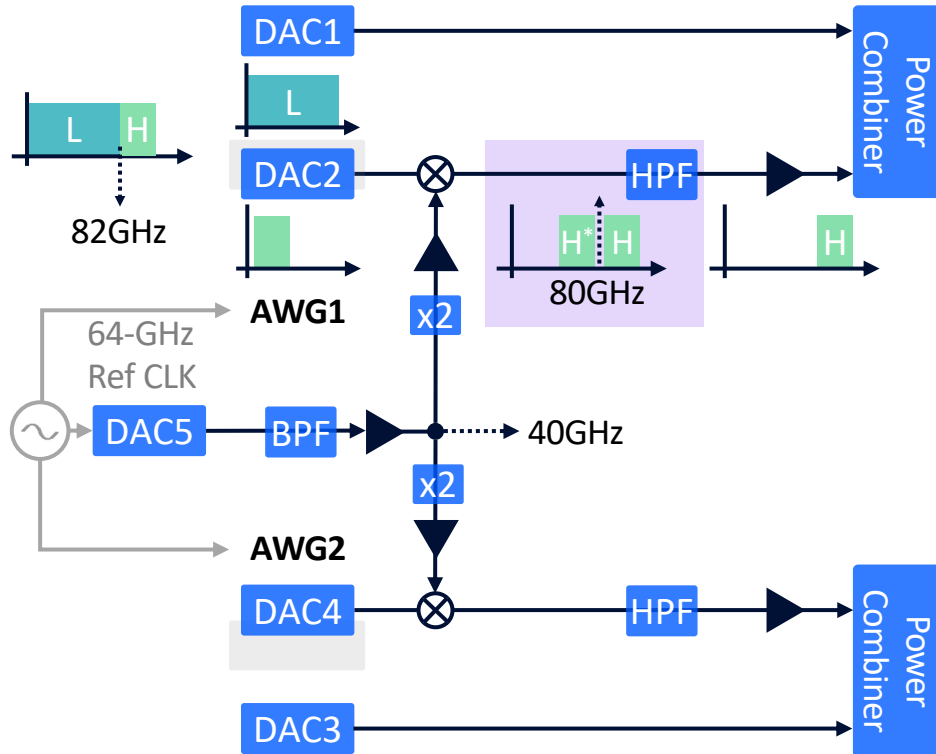
61k Accesses | **1325** Citations | **104** Altmetric | [Metrics](#)

Abstract

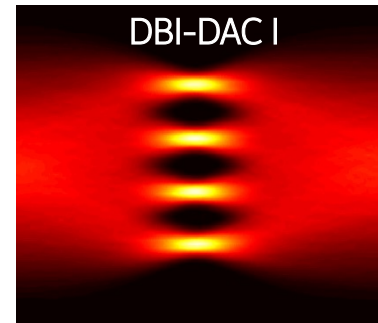
Electro-optic modulators translate high-speed electronic signals into the optical domain and are critical components in modern telecommunication networks^{1,2} and microwave-photonic systems^{3,4}. They are also expected to be building blocks for emerging applications such as

2.4-Tb/s coherent transmission based on DBI

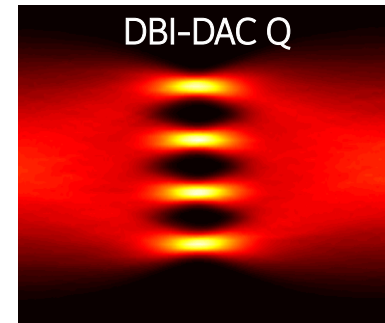
D. Che et al., "2.4-Tb/s single-wavelength coherent transmission enabled by 114-GHz all-electronic digital-band-interleaved DACs," ECOC'2023, PD.C.2.5



226-Gbaud PAM-4 (RRC 0.01)



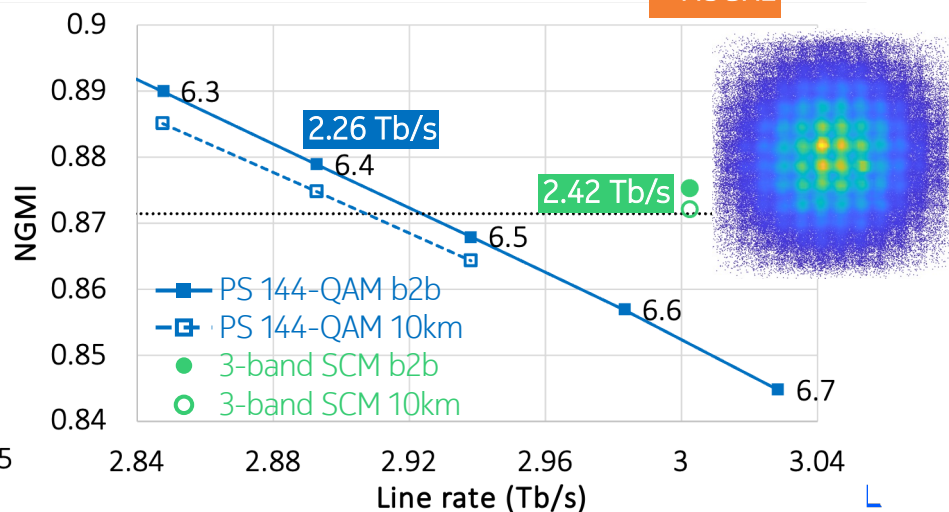
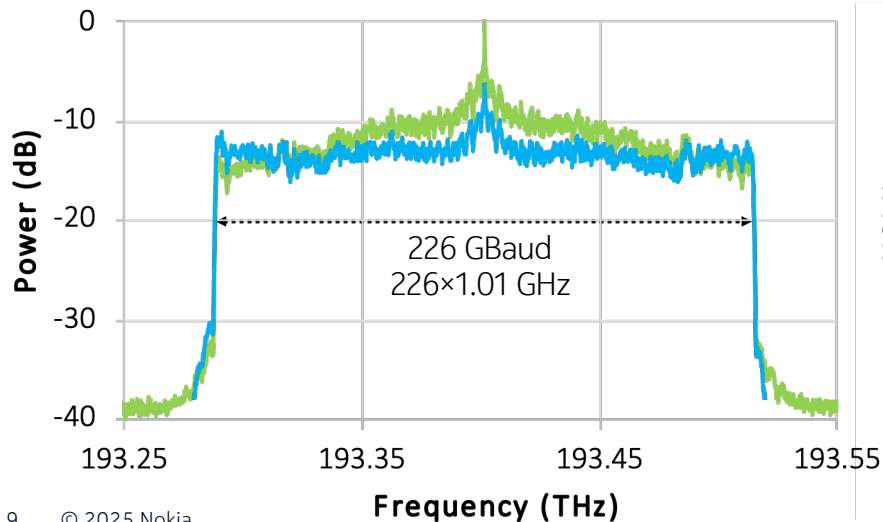
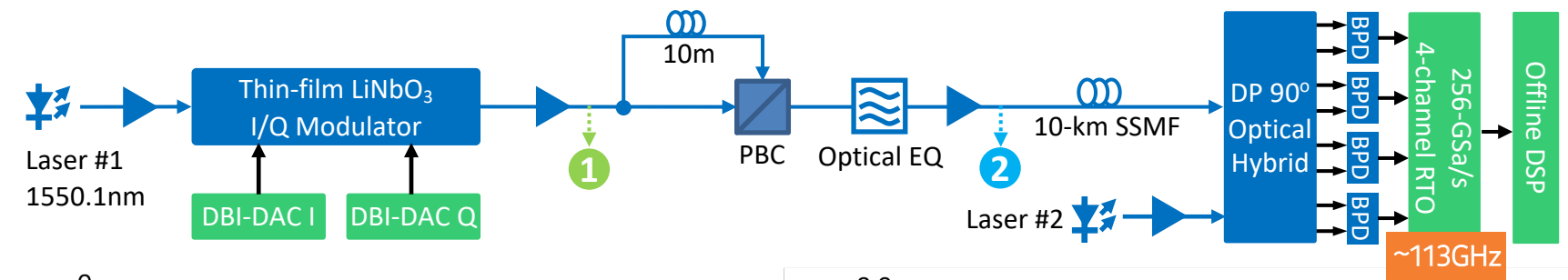
SNR = 18.7 dB



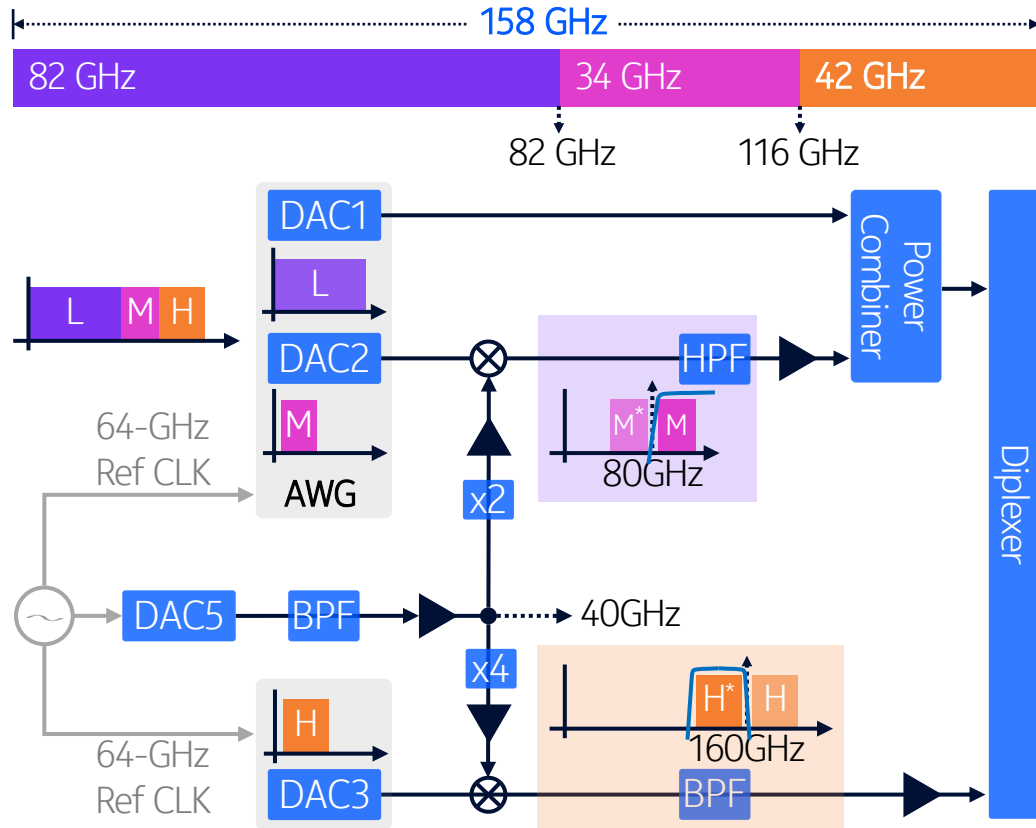
SNR = 18.5 dB

2.4-Tb/s coherent transmission based on DBI

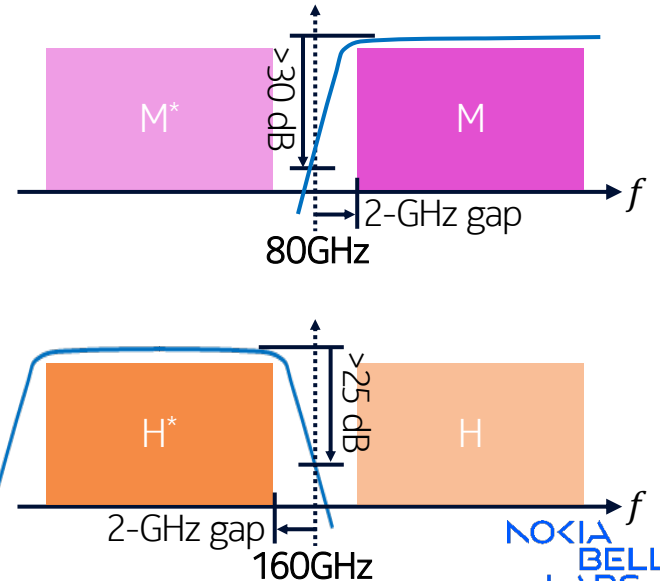
D. Che et al., "2.4-Tb/s single-wavelength coherent transmission enabled by 114-GHz all-electronic digital-band-interleaved DACs," ECOC'2023, PD.C.2.5



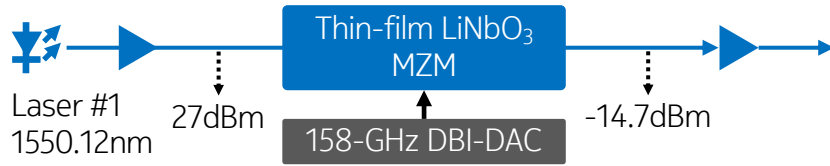
158-GHz DBI-DAC: Architecture



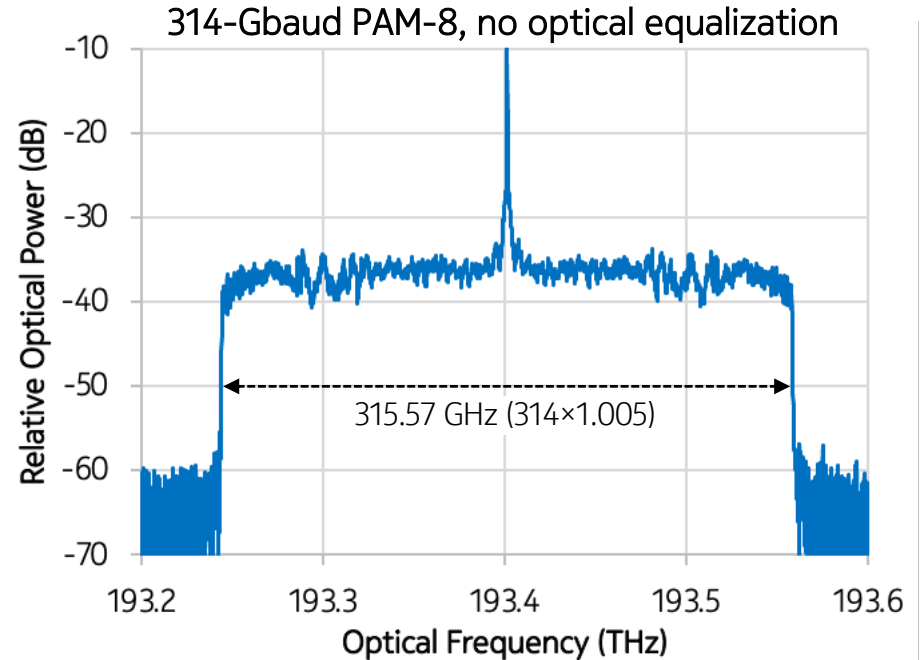
- AWG** Arbitrary Waveform Generator
- DAC** D/A Converter
- L/M/H** Low-/Medium-/High- Frequency band
- BPF** Band-Pass Filter
- HPF** High-Pass Filter
- Ref CLK** Reference clock



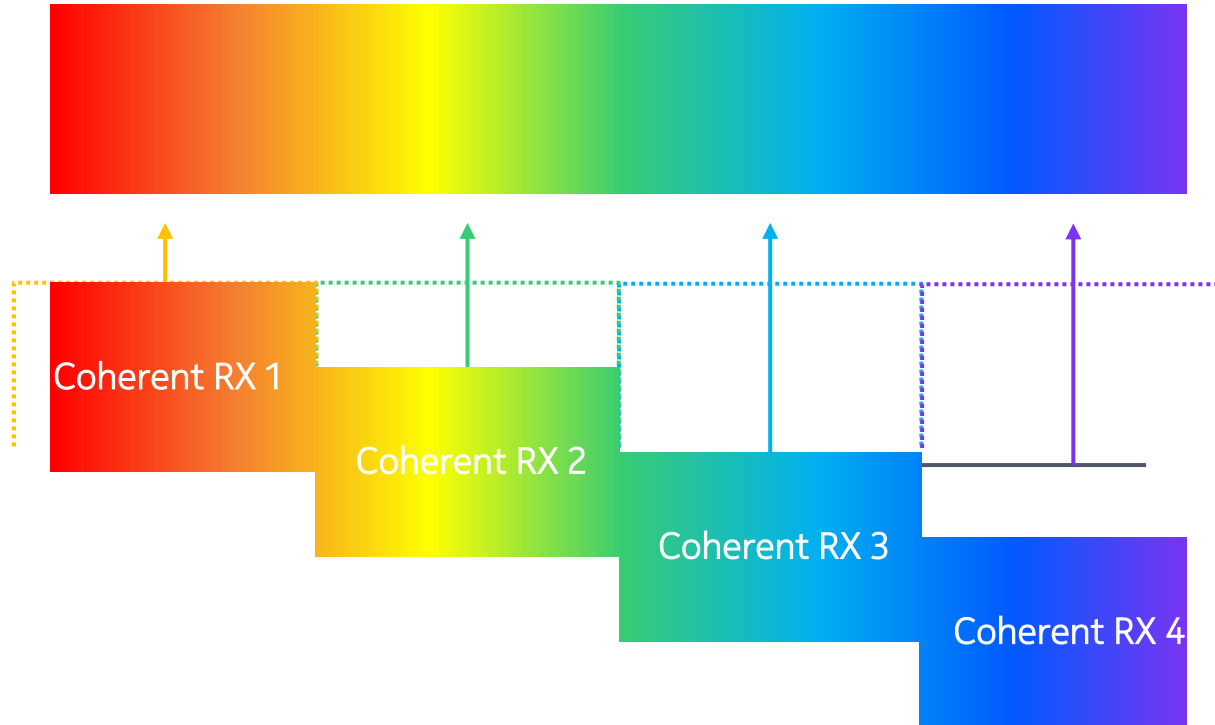
314-Gbaud Optical Transmitter



- ASK symbol mapping
 - RRC (0.005 roll-off factor) pulse shaping
 - Separation of DBI bands (L, M, and H bands)
 - Intermediate frequency conversion (for M and H bands)
 - Down-sampling (to the sampling rate of physical DACs)
 - Linear frequency-response pre-equalization (per band)
 - Amplitude/delay corrections among L, M and H bands
- DSP for DBI



Optical arbitrary waveform measurement (OAWM)

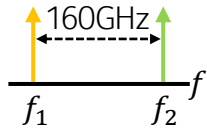
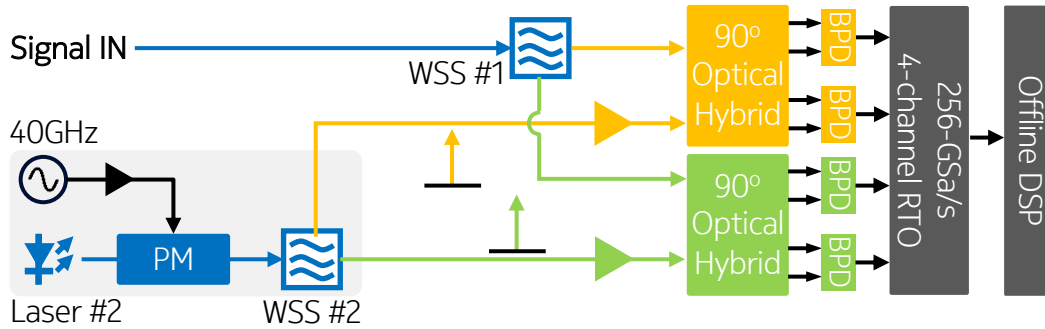


[1] N. K. Fontaine et al., "Real-time full-field arbitrary optical waveform measurement," Nature Photonics 4, 248-254, 2010.

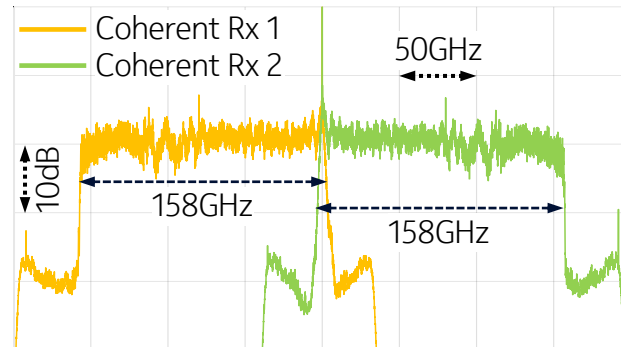
[2] D. Drayss et al., "Non-sliced optical arbitrary waveform measurement (OAWM) using soliton microcombs," Optica 10, 888-896, 2023.

[3] C. Deakin et al., "2.4-THz Bandwidth Optical Coherent Receiver Based on a Photonic Crystal Microcomb," ECOC'2024.

Dual Coherent Receivers with OAWM Spectral Stitching



Recovered digital spectra for spectral stitching



Receiver frontend corrections (I/Q skew, frequency response)

Upsampling to 512 GSa/s

Frequency offset compensation (for each spectral slice)

Amplitude and phase matching between 2 spectral slices

Combining 2 spectral slices

Resampling to 628 GSa/s (2 sps)

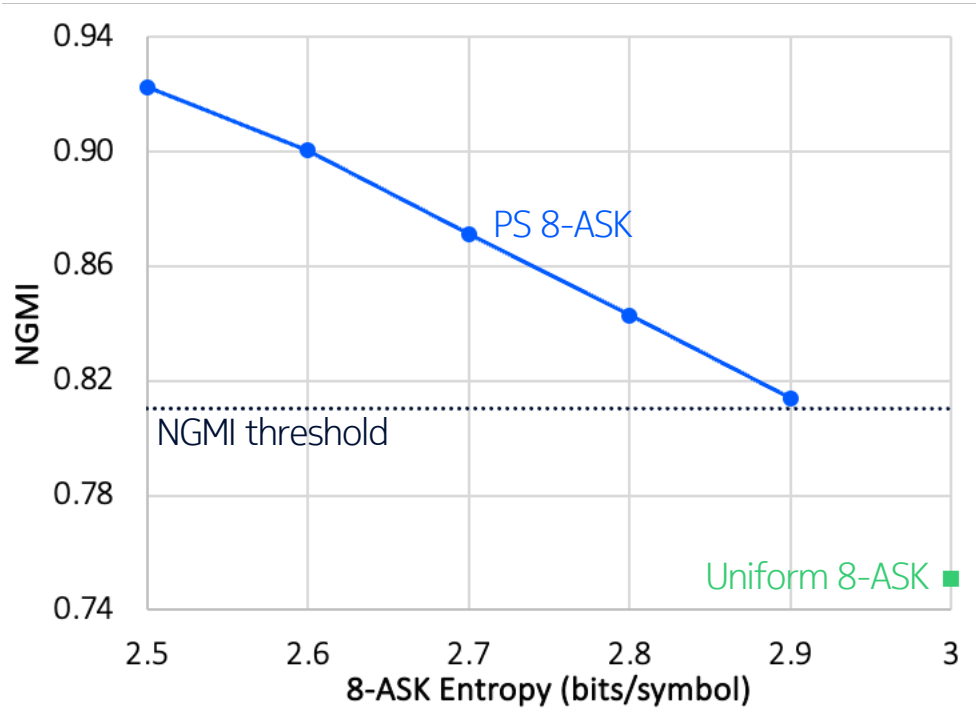
Frame sync. & matched filtering

LMS equalization (5-ns time duration, digital PLL embedded)

Performance evaluation (NGMI)

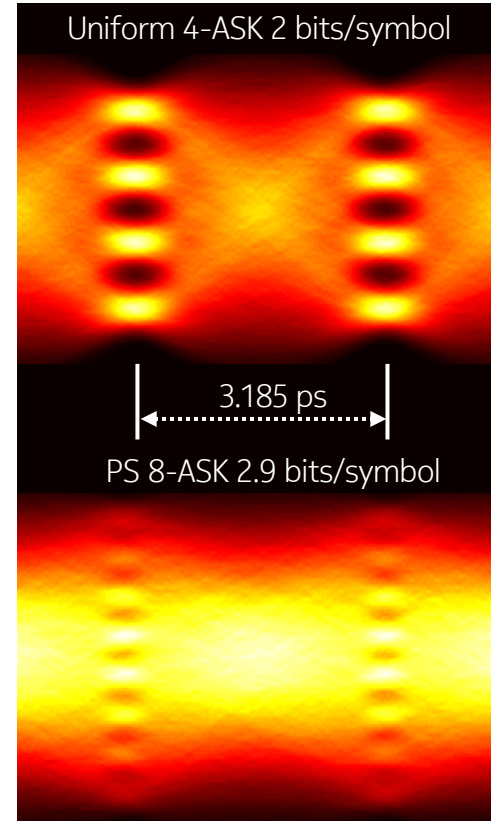
Spectral stitching

Experimental Results



$$314 \times (2.9 - (1 - 0.7436) \log_2 8) = 669.07 \text{ (Gb/s)}$$

Symbol rate Entropy FEC code rate



Conclusions

Single-wavelength signaling at 300+ Gbaud

- All-electronic 314-Gbaud signals (up to 8-ASK)
- 669 Gb/s (1-D, potentially 2.68 Tb/s 4-D)
- Flat spectrum without optical equalization

Can electronics drive optics again?

- A reliable platform to support the next-Gen development of 240+ Gbaud Optics
- A sustainable candidate for higher-speed D/A and A/D converters beyond the CMOS limit

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