Proposal of new 400GbE signaling formats with 4λ x 100G configuration

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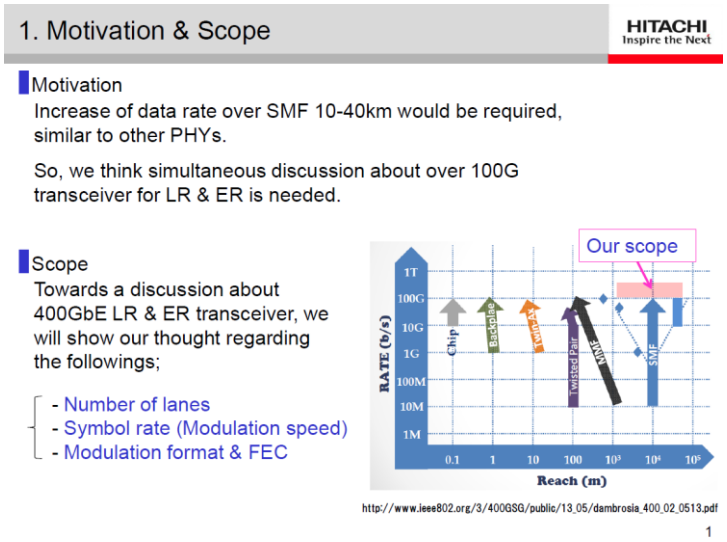
1. Background

Previous contribution

At Geneva meeting in July 2013,
we submitted a contribution as follows.

- 400GbE PMD is desired to cover wide range of SMF (100m~40km), in terms of cost, needs, and etc..

- 4λ x 100G configuration has several merits, in terms of number of lanes, size and etc..



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Merits of 4λ x 100G configuration compared with 8λ x 50G(NRZ)

- Compatible with 100Gbase-LR4 wavelength allocation

⇨ Easy to control wavelength, Low insertion loss of WDM filter , etc.

- Less Tx/Rx component counts

⇨ Good yield, Smaller size, etc.

⋮

2. 400GbE PMD requirement & our proposal

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Required features of 400GbE PMD

1) Simple Tx/Rx configuration … IM/DD is desirable

2) Common signaling format for wide application range
ex.) 100 m – 10 km (possibly beyond 10km?) over SMF

Our proposal

In this presentation, we will propose new candidates of 400GbE signaling formats with 4λ x 100G configuration, realizing 100-m~10-km SMF transmission with single polarization IM/DD.

Nyquist-SCM(Subcarrier modulation) with 16~36-level (<25 Gbaud) *

Nyquist-PAM4~8 (<50 Gbaud)

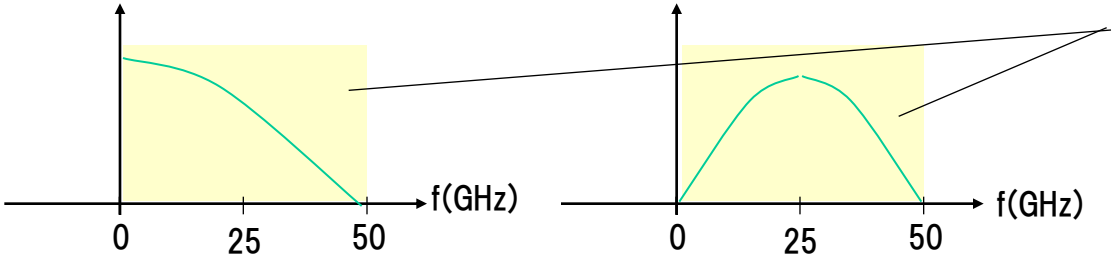
*Reference (but dual-pol. implementation): J C Cartledge, et al., ECOC2013 We.4.C.3.

3. Motivation

Principle of Nyquist modulation

1) Electrical spectrum of 100G/λ signal with IM/DD

- 50 Gbaud with 4-level (Baseband modulation)
- 25 Gbaud with 16-level (Subcarrier Modulation)

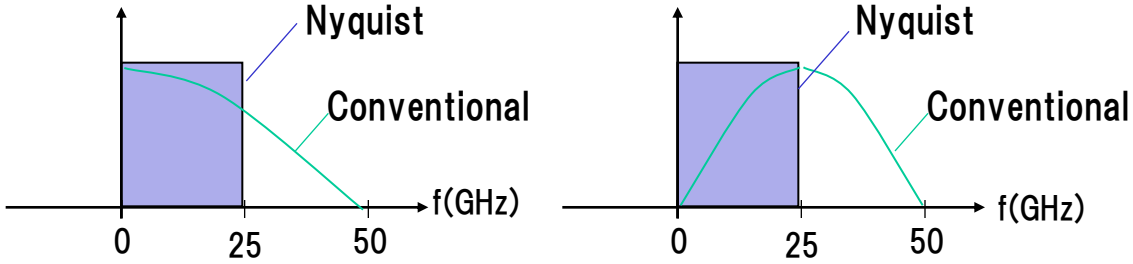


Baseband modulation　　Subcarrier modulation(SCM)

Require ≥100-GSa/s ADC/DACs to cover 50-GHz frequency range

*Narrow spectrum is also achieved by higher order modulation, however it will severely degrade Rx sensitivity.

2) Spectrum compression by Nyquist pulse shaping



Baseband modulation

Subcarrier modulation(SCM)
with a subcarrier freq. of half the symbol rate

- reduce analogue signal bandwidth
- reduce sampling rate (~ 50 GSa/s)

4. Key technologies

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1) Single polarization IM/DD

- Simple configuration

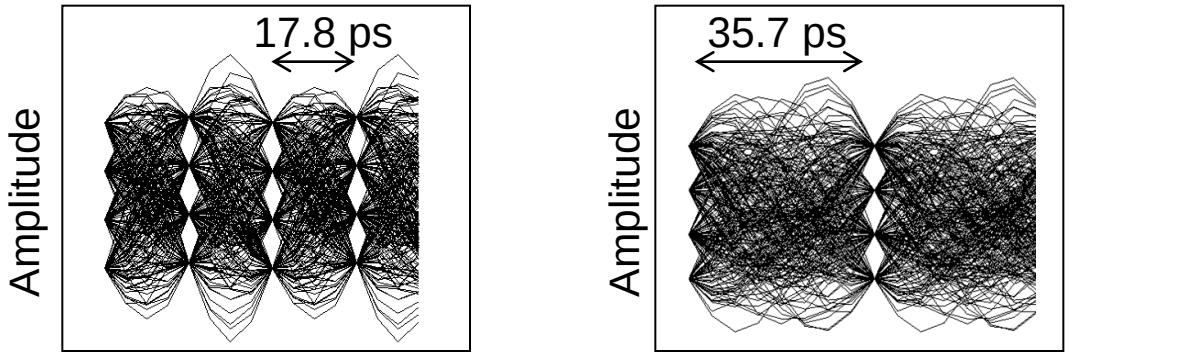
ex.)
- Short reach version(≤ SMF 2 km): 1.3-μm EAM-DFB + PD
- Long reach version(≥ SMF 2 km): 1.3-μm DFB + IQM + (SOA) +PD

2) Digital signal processing (DSP)

- High CD tolerance by digital predistortion for long reach ver.
- High Rx sensitivity by adaptive equalization

3) Nyquist pulse shaping

- Narrow signal spectrum by Nyquist filtering



56-Gbaud Nyquist PAM4　28-Gbaud Nyquist SCM 16-level

Optical waveform (Simulation)

5. Configuration of 400G Tx/Rx

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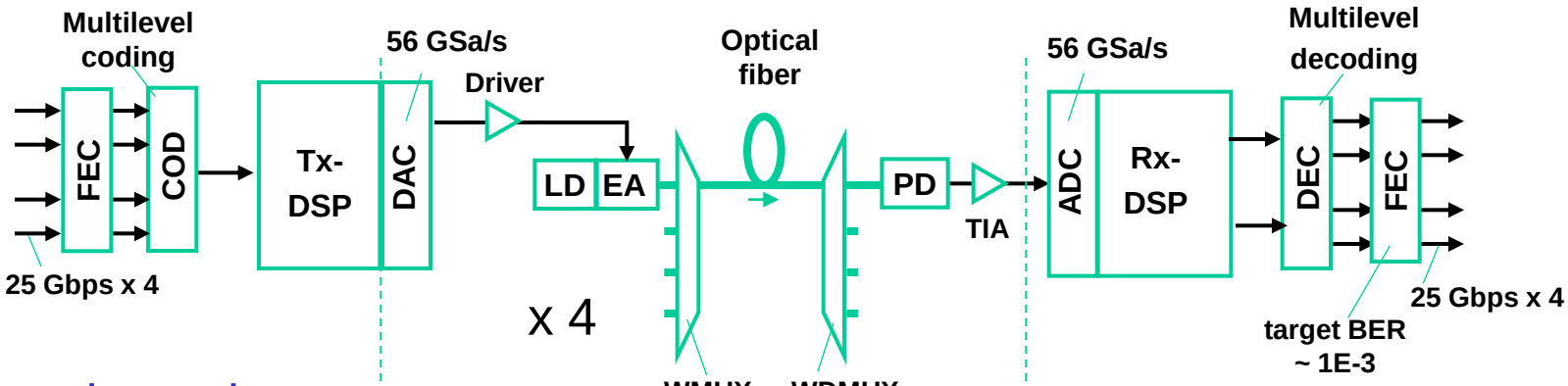
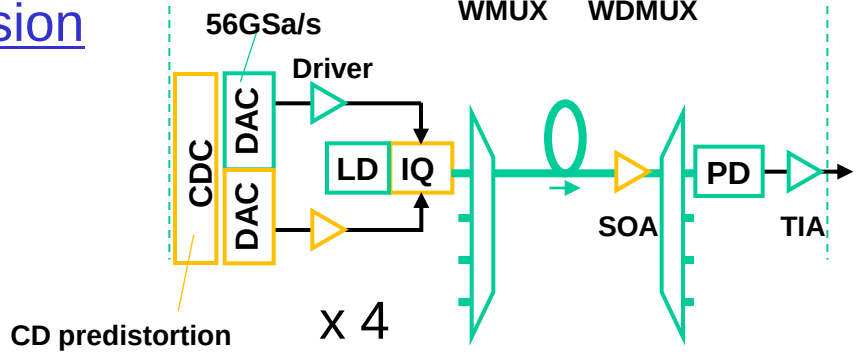
Short reach version



Long reach version



- Some parts are different between both versions.
- CD predistortion and SOA are added for long reach transmission.
- Subcarrier modulation/demodulation is realized by simple DSP.

6. Summary

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- ✓ We propose new candidates of signaling format with 4λ x100G configuration for wide application range (100m – 10/40 km over SMF)
- ✓ Simple Tx/Rx configuration (Single modulator + Single PD)
- ✓ High CD tolerance with Digital predistortion
- ✓ Simple DSP

Thank you