Update on 100GBASE-FR1 and 100GBASE-LR1 Wavelength Range Relaxation

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Initial comments from September 15 interim meeting

- At the September 15 interim meeting, we proposed to change the wavelength of 100GBASE-FR1 and 100GBASE-LR1 from “1304.5 to 1317.5” to “1300 to 1320” nm for enabling the uncooled DFB laser operation over the industrial temperature. The Task Force requested to review the presentation and include an assessment of the overall impact to the document.
- Can the same TDECQ and Tx OMA be used with the extended wavelength range? Review the impact on optical link budget for the propose wavelength range again considering dispersion penalty and the differential group delay (DGD)-induced penalty.
- It was also commented that the photodetector is not the only component in the optical receiver. Some implementations such as grating coupler may have larger wavelength-dependence in the receiver, so the broader wavelength range may lead to excess insertion loss and potential interoperability issue with the deployed units designed for the narrower wavelength range.

Dispersion Penalty

In this proposal, the specifications of TDECQ and |TDECQ-TECQ| are not changed to ensure the link budgets and interoperability with previously deployed spec, e.g. 100GBASE-DR and 400GBASE-DR4. This proposed broader wavelength range may impact dispersion penalty depends on the specific implementation, yet the studies below covering various implementations show it is still quite feasible to achieve the original specification of |TDECQ-TECQ|<=2.5 dB with margin.

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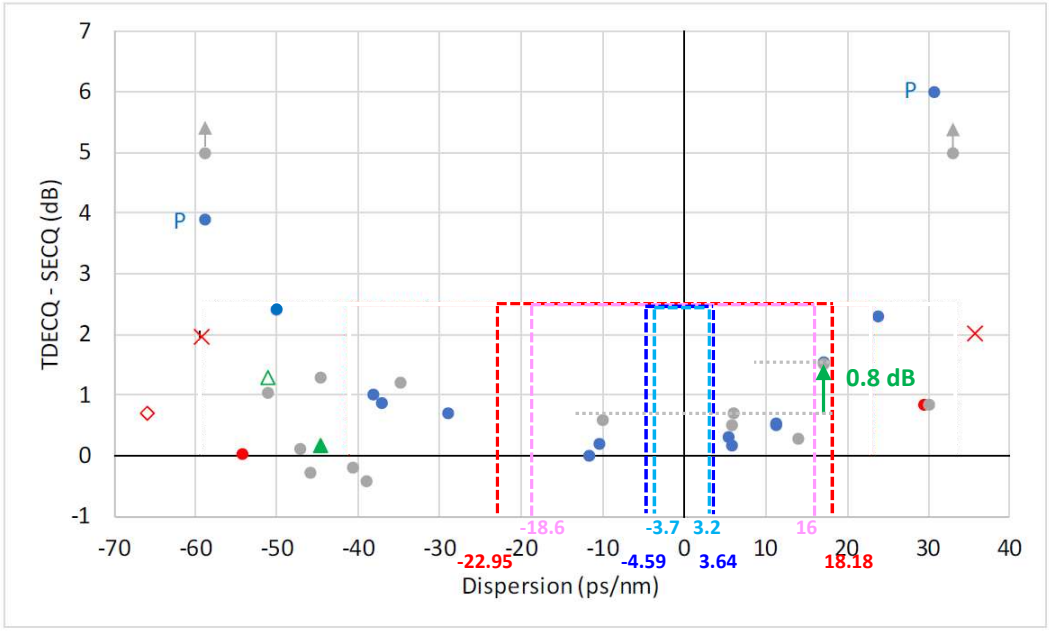

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- lewis_cu_adhoc_041719
- schube_3cu_01_0519 Si Ph (CD pen)
- mazzini_3cu_adhoc_082119 Si Ph
- 100G Lambda MSA
- 100G Lambda MSA excessive
- 100GBASE-FR1 802.3cu D3p0
- Proposed 100GBASE-FR1
- 100GBASE-LR1 802.3cu D3p0
- Proposed 100GBASE-LR1

DGD Penalty Study in 802.3cu Project

The differential group delay (DGD) penalty caused by polarization mode dispersion was reviewed in 802.3cu project last May.
http://www.ieee802.org/3/cu/public/cu_adhoc/cu_archive/shuai_3cu_adhoc_050119.pdf
http://www.ieee802.org/3/cu/public/cu_adhoc/cu_archive/lewis_3cu_adhoc_051519.pdf
http://www.ieee802.org/3/cu/public/cu_adhoc/cu_archive/anslow_3cu_adhoc_051519.pdf

The same DGD_max calculation is applied for different 100G per wavelength IEEE specifications with different wavelengths (1271/1291/1311/1331 nm) and distances (2/6/10 km), and the DGD_max estimation is essentially independent of wavelength, so there should be no impact to DGD_max from the wavelength relaxation.

Polarization Mode Dispersion

Description	Symbol	Value	Unit	Note
Maximum PMD,Q for G.652.B	PMD,Q	0.2	(ps/√km)	made up of 20 cable sections
Maximum PMD for G.652.B	PMD,max	0.426	(ps/√km)	for 1 cable
Ratio of DGD_max to Mean DGD	r	3.75		
Distance	L		km	

DGD_max Calculation

Distance (km)	Mean DGD (ps)	DGD_max (ps)
2	0.60	2.26
6	1.04	3.91
10	1.35	5.05

DGD_max Specifications in IEEE Standard

Distance (km)	PMD	DGD_max (ps)
2	100GBASE-FR1 and 400GBASE-FR4	2.3
6	400GBASE-LR4-6	4
10	100GBASE-LR1	5

DGD_max = r * Mean DGD
= r * (PMD,max * √L)

Interop between 100GBASE-FR1/LR1 Tx and 100GBASE-DR/400GBASE-DR4 Rx

For the concern on receiver using grating coupler in some Si photonics implementations, we did a survey to understand the BW of various such implementation and found all of them have 1dB bandwidth larger than 20nm as illustrated in the chart below, so the excess insertion loss comparing the responsivity for 20nm range to 13nm range should be less than 0.5dB.

Considering the interoperability between 100GBASE-FR1/LR1 Tx and the deployed 100GBASE-DR/400GBASE-DR4 Rx for DR compliant link distances, as the Tx power for FR1 and LR1 is 0.7dB and 1.9dB higher than DR respectively, it is sufficient to compensate for the excess loss in the Rx due to the wavelength range relaxation.

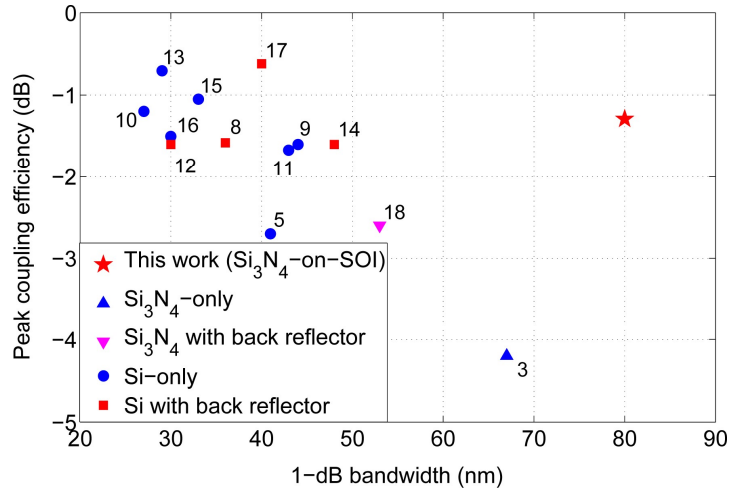

Fig. 1

Wesley D. Sacher, Ying Huang, Liang Ding, Benjamin J. F. Taylor, Hasitha Jayatilleka, Guo-Qiang Lo, Joyce K. S. Poon, "Wide bandwidth and high coupling efficiency Si3N4-on-SOI dual-level grating coupler," Opt. Express **22,** 10938-10947 (2014); https://www.osapublishing.org/oe/abstract.cfm?uri=oe-22-9-10938

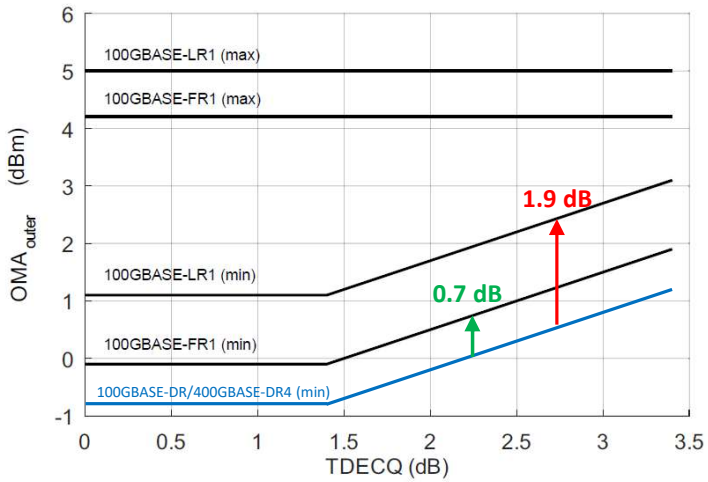

Figure 140–2a—OMAouter (max) and OMAouter (min) versus TDECQ for 100GBASE-FR1 and 100GBASE-LR1

Conclusions

- After further studies considering the comments from the September 15 interim meeting, we remain the same view on the needed changes to the document that are depicted in slide #2 and #3.
- The interoperability between the proposed wavelength range specification and the 100G DR and 400G DR4 specification especially in the presence of excess loss from grating coupler used in Rx implementation is analyzed which shows no impact to link budget.