

In Support of a 500m objective for 200G Ethernet: Part I

Technical and Economic Feasibility

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Caveats and Disclaimers

- The materials presented within assume a 200G-DR4/PSM4 type solution for a 500m reach

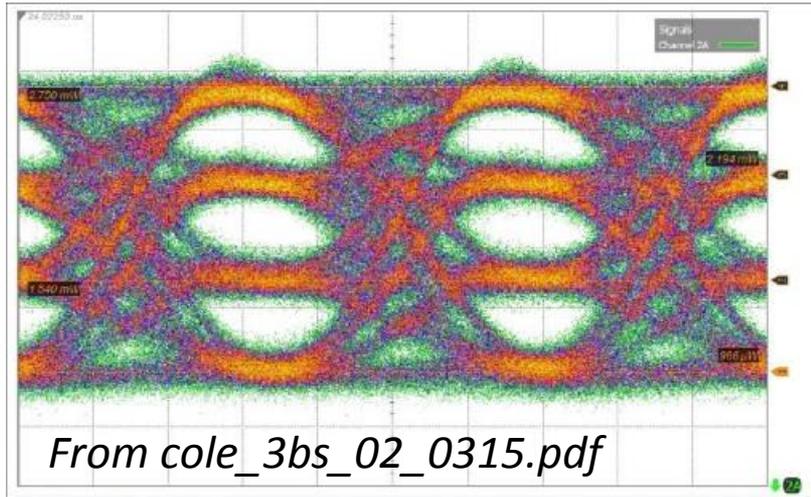
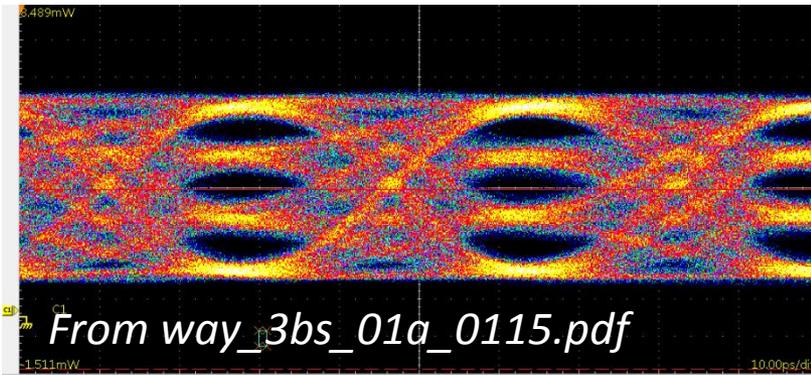
Technical Feasibility

Technical Feasibility

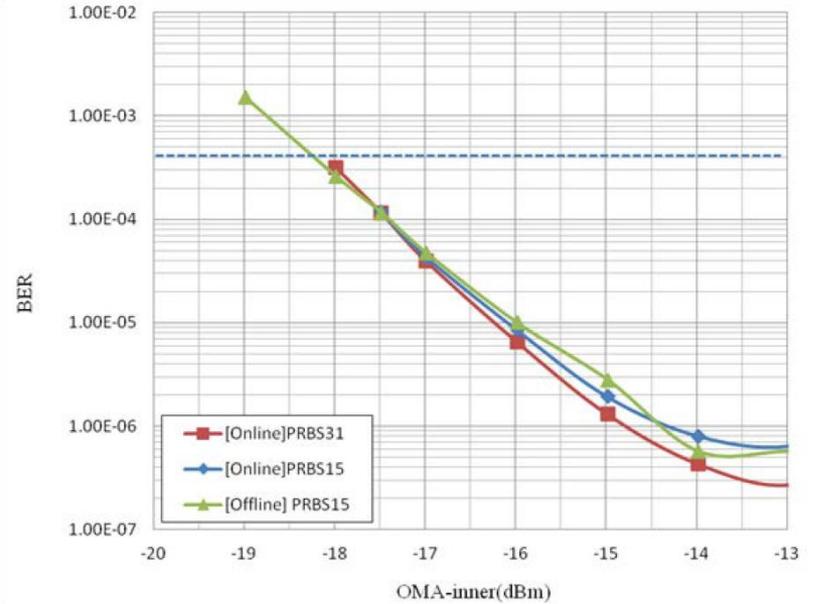
- Assuming a 26.5625 GBd-PAM4 modulation type per lane
 - Same per lane modulation type as adopted for 400G-FR8/LR8 baseline proposals
 - Same per lane modulation type as presented in support of 50GE 2km and 10km reach objectives
 - Same per lane modulation type as presented in support of 200GE 2km and 10km reach objectives
 - Same modulation type as adopted for per lane 50Gbps electrical interconnects as part of CDAUI-8 interface specifications
- Considerable presentation on 26.5625 GBD-PAM4 modulation type in 802.3bs project
 - Over 20 presentations through eight meeting cycles from May 2014 - July 2015
 - Additional presentations as part of the 50G/NGOATH study group

Selected Demonstrations of 50G Optical Lanes

Eye Diagrams



BER vs. OMA



From stassar_3bs_01a_0315.pdf

Comparison of prospective specifications

	200G-PSM4/DR4 [†]	50G-FR	200G-FR4	400G-FR8
OMA – Pre Mux	-2.5	-2	0.8	3
OMA	-2.5	-2	-1.2	0
RX Sensitivity	-11.6	-11.8	-11	-10
RX Sensitivity – Post Mux	-11.6	-11.8	-13.3	-13.3

Prospective solution for 200G-PSM4/DR4 has relaxed OMA and RX sensitivity specs when compared to other 50G/lane optical specifications and proposals

- OMA (Pre Mux) 5.5 dB lower than 400G-FR8
- RX Sensitivity (Post Mux) 1.7 dB less stringent than 400G-FR8

† from welch_50GE_NGOATH_01_0316.pdf

Power Consumption

PMA

- Assuming comparable power/throughput as CAUI-4
 - Advanced CAUI-4 PMA typically around 500-800mW (per 100G)
 - 5-8 mW/Gbps
- 200G electrical PMA expected to be around 1-1.6W

PMD

- 25GBD-PAM4 Optical Transmitter ~ 145 mW per lane
- 25GBD-PAM4 TIA/Receiver ~ 95 mW per lane
- PAM4 Decoder ~ 200mW per Lane
- 200G-PSM4/DR4 Total ~ 1.8 W

Module Total = PMA + PMD + Overhead (~100mW) \approx 2.9 – 3.5 W

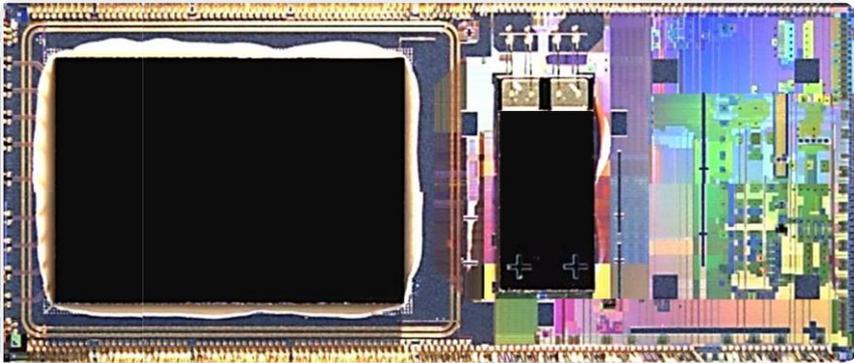
Economic Feasibility

Module Cost

- Comparison of a prospective 200G-PSM4/DR4 solution with a prospective 200G-FR4 solution
 - Assumes both done in a QSFP (or similar) form factor
- Cost modeling uses the methodology first employed in [welch_01b_0113_opts.pdf](#)
 - COGS build up from silicon photonics chipset
 - Compares amount of silicon area and light sources used
- Methodology does not consider parametric yield effects
 - Assembly yield is considered though
- Assumes both solutions manufactured in similar volumes
- Comparison done in a silicon photonics technology

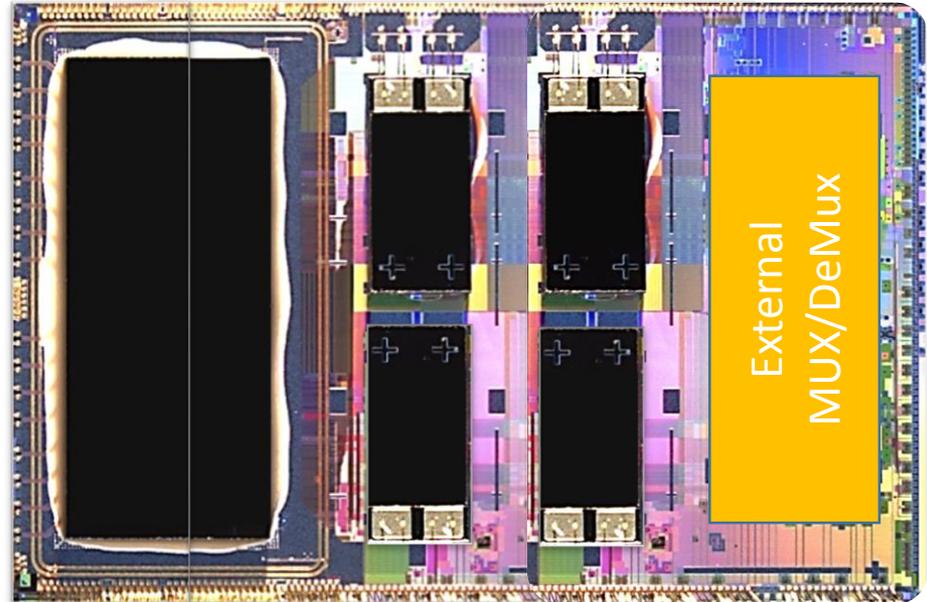
Chipset Comparisons

200G-PSM4/DR4



Conceptual – Not an Actual Die Photo

200G-FR4



Conceptual – Not an Actual Die Photo

Electronics IC	~ 21 mm ²
Photonics IC	~ 80 mm ²
Light Source(s)	1

Electronics IC	~ 21 mm ²
Photonics IC	~ 120 mm ²
Light Source(s)	4

Module Comparisons

200G-PSM4/DR4



CMOS	~ 100mm ²
Light Source(s)	1
Discrete MUX/DEMUX	0
Optical Attaches	2
Yield per Attach	95%
Net Yield	90%
Module COGS (Normalized)	1

200G-FR4

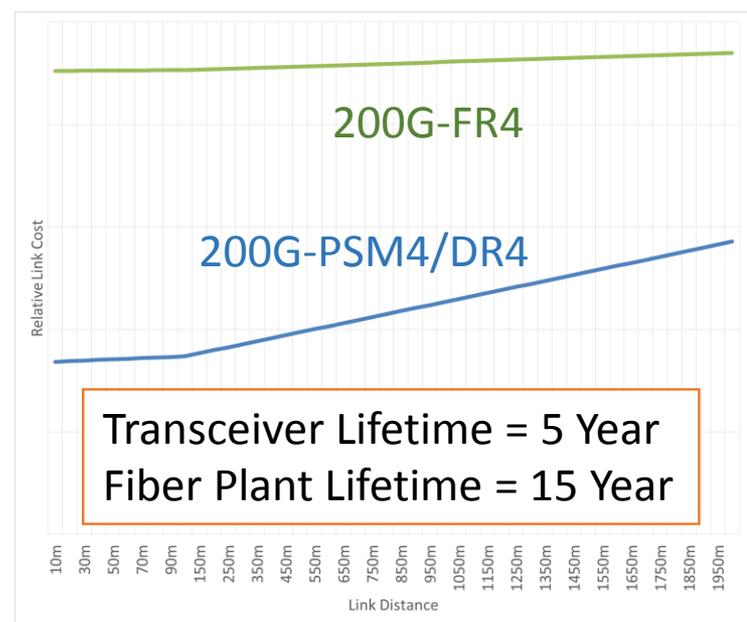
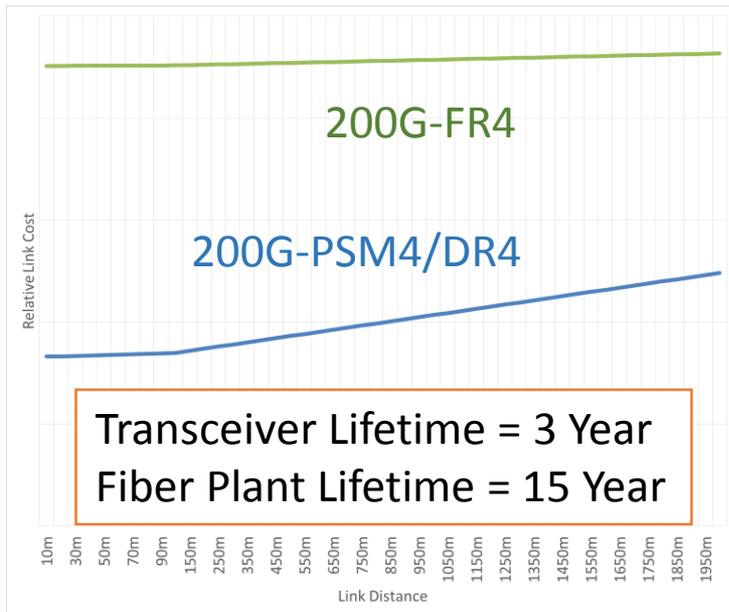
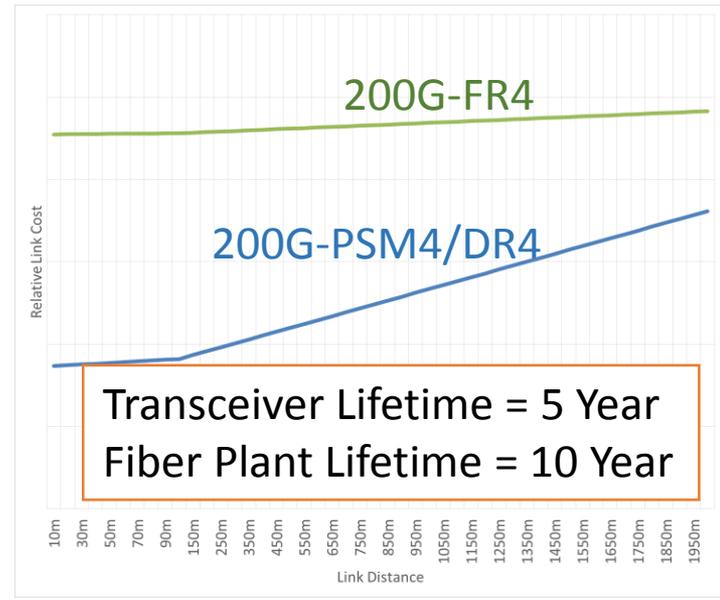
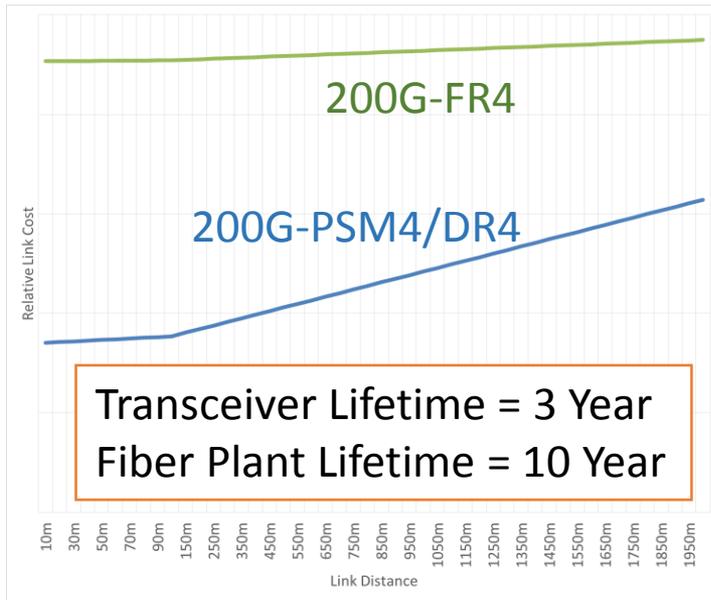


CMOS	~ 140mm ²
Light Source(s)	4
Discrete MUX/DEMUX	1
Optical Attaches	6
Yield per Attach	95%
Net Yield	74%
Module COGS (Normalized)	2.8

Link Costs

- Uses module costs previously calculated
- Uses depreciation model for fiber plant as first presented in [welch_400_01_1113.pdf](#)
 - Uses MACRs depreciation to model different fiber plant lifetimes
 - Modeling 10 and 15 year SMF fiber plant (depreciation) lifetimes
 - Modeling 3 and 5 years SMF transceiver lifetimes
- Uses double link fiber plant from [kolesar_02_0313_optx.pdf](#)
- Link cost vs. reach shown (up to 2 km)

Link Costs



Summary and Observations

- 50Gbps per lane signaling using 25GBD-PAM4 signaling is technically feasible
 - Broad consensus shown for that through it's adoption in multiple other standards
- Solutions optimized for 500m likely to fit into QSFP (or similar) form factors
 - Not expected to have power/thermal limitations
- 200G-DR4/PSM4 type solutions for 500m are economically feasible
 - Lower transceiver and link cost expected than with duplex solutions

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Thank You

Reference: MACRS Tables

Recovery Year	3	5	7	10	15	20
0	0.333	0.200	0.143	0.100	0.050	0.038
1	0.445	0.320	0.245	0.180	0.095	0.072
2	0.148	0.192	0.175	0.144	0.086	0.067
3	0.074	0.115	0.125	0.115	0.077	0.062
4	0.000	0.115	0.089	0.092	0.069	0.057
5	0.000	0.058	0.089	0.074	0.062	0.053
6	0.000	0.000	0.089	0.066	0.059	0.049
7	0.000	0.000	0.045	0.066	0.059	0.045
8	0.000	0.000	0.000	0.066	0.059	0.045
9	0.000	0.000	0.000	0.066	0.059	0.045
10	0.000	0.000	0.000	0.033	0.059	0.045
11	0.000	0.000	0.000	0.000	0.059	0.045
12	0.000	0.000	0.000	0.000	0.059	0.045
13	0.000	0.000	0.000	0.000	0.059	0.045
14	0.000	0.000	0.000	0.000	0.059	0.045
15	0.000	0.000	0.000	0.000	0.030	0.045
16	0.000	0.000	0.000	0.000	0.000	0.045
17	0.000	0.000	0.000	0.000	0.000	0.045
18	0.000	0.000	0.000	0.000	0.000	0.045
19	0.000	0.000	0.000	0.000	0.000	0.045
20	0.000	0.000	0.000	0.000	0.000	0.022