



PSM4 Broad Market Potential

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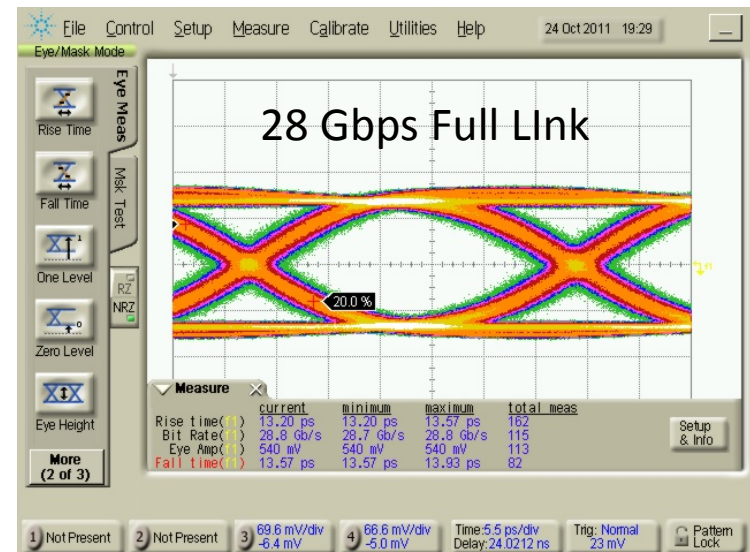
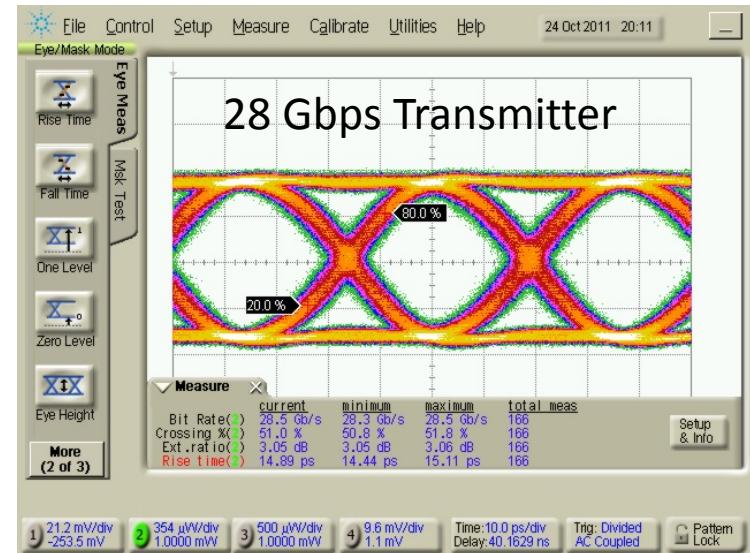
PSM4 Broad Market Potential

- What is 'Broad Market Potential'?
- A composite of:
 - Performance
 - Size/Power
 - Cost
 - Supply Chain

Performance

Performance

- From the Straw Polls:
 - January Technical Feasibility:
 - Yes: 66
 - No: 0
 - March Technical Feasibility
 - Yes: 59
 - No: 0
- Unanimous view that PSM4 is technically feasible.



Size and Power Consumption

Size and Power

- QSFP28 is the anticipated form factor for 100G-Base SR4
 - QSFP requires a sub 3.5 W solution
- Without a QSFP compliant SMF solution, system QSFP ports will be limited to 105 m (vs. 500 m)
 - 40G-LR4 supports 10km reach in QSFP form factor
 - Approximately 99% reduction in reach at 100G per QSFP port
- How important is QSFP to the industry
 - What is the cost of supporting different module form factors for different reaches?
 - Or will everything move to CFP4?

Power Consumption

CAUI-4 Interface

- CTLE ~ 25mW per lane
- CDR
 - Gen 1: 100-125 mW per lane
 - Gen 2: 50-75 mW per lane
- Output Driver ~ 25 mW per lane
- CAUI-4 Total
 - Gen 1: 1,000 – 1,200 mW
 - Gen 2: 600 – 800 mW

PSM4 Power Consumption:

- Gen 1 ~ 1.84 – 3.76 W
- Gen 2 ~ 1.44 – 3.36 W

Optics

- Silicon Photonics[†]
 - Transmitter ~ 160 mW per lane (including laser)
 - Receiver ~ 50 mW per lane
 - Total ~ 840 mW
- DFB[‡]
 - Transmitter ~ 485 mW per lane
 - Receiver ~ 155 mW per lane
 - Total ~ 2,560 mW
- Lisel[£]
 - Total < 2,00 mW

[†] *welch_01_0313_optx*

[‡] *petrilla_03a_0113_optx*

[£] *anderson_01_0111_NG100GOPTX*

Link Cost Analyses: PSM4, LR4, and SR10

Full Link Cost

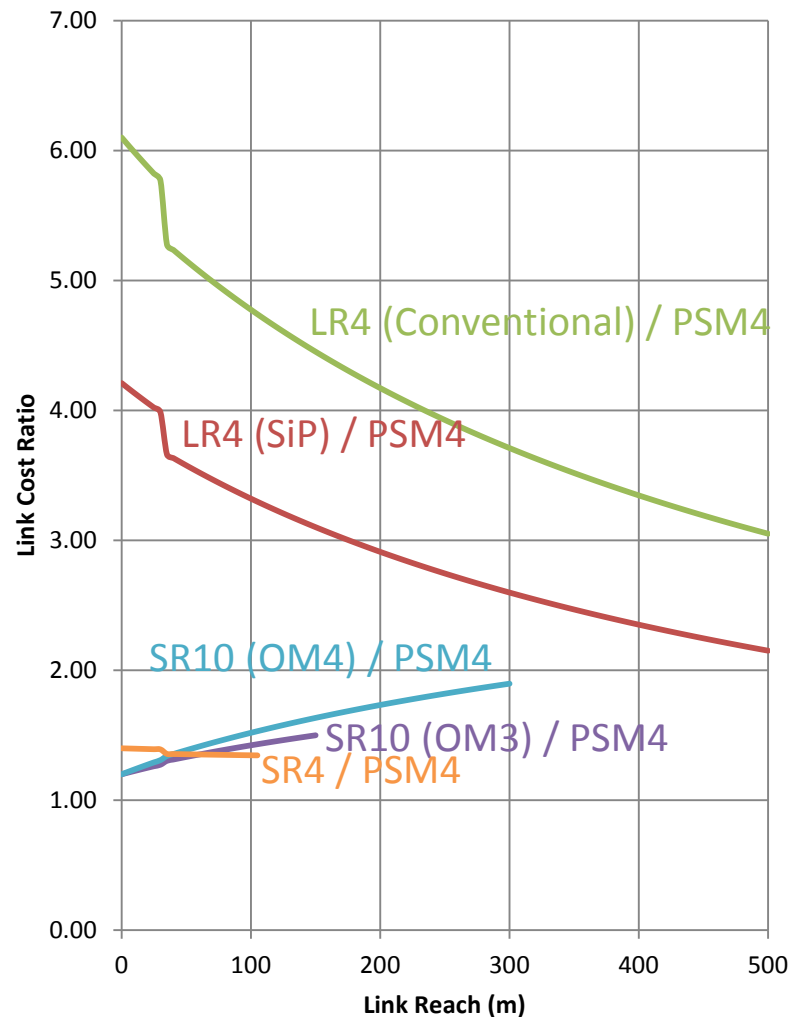
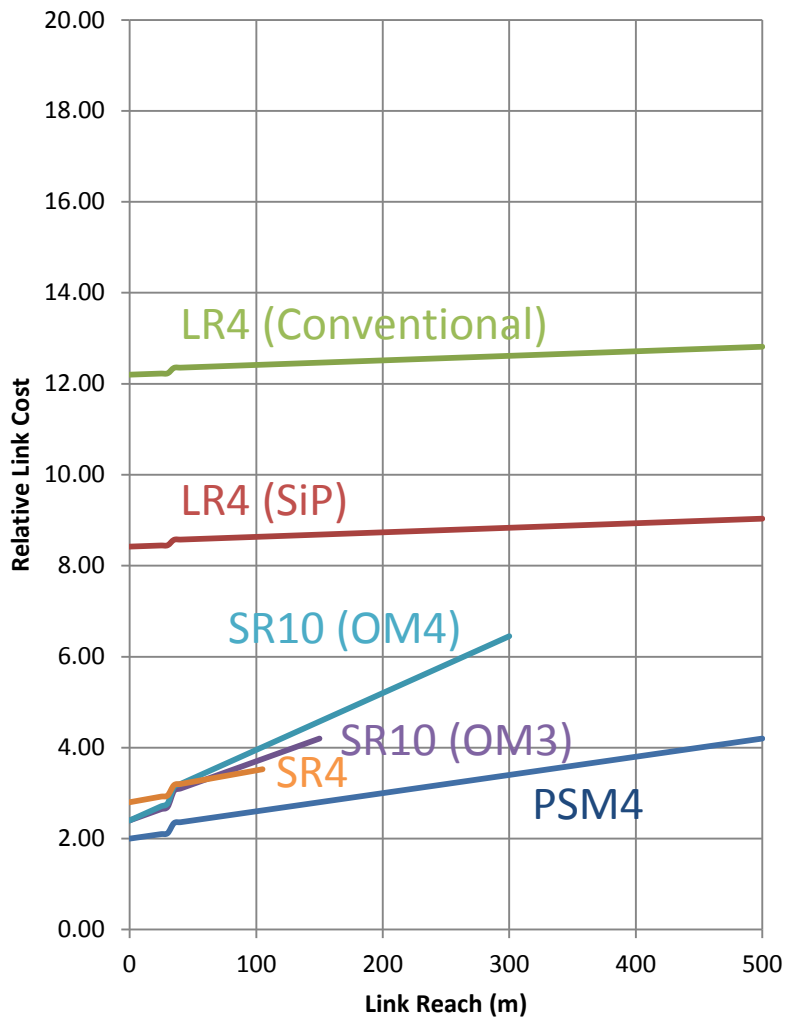
- Using module cost comparison from welch_01b_0113_optx, models full link costs.
 - Fiber & Connector costs are at the same level in the supply chain
- Compares PSM4, LR4 (using Silicon Photonics and conventional technologies) and SR10 (using both OM3 and OM4) link costs.
- Assumes links 30m or less are point to point (no patch panels)
- Above 30m assumes the fiber plant configurations show in kolesar_01_0213_smf
- Three Skews: Nominal Module + Fiber, Nominal Module + High Fiber (+50%) , High Module (+50%) + Nominal Fiber

From welch_01b_0113_optx	Module Cost (Mean)†	Renormalized
PSM4	1.17	1
LR4 (Silicon Photonics)	4.93	4.21
LR4 (Conventional)	7.1	6.07
SR10	1.42	1.21
SR4		1.4‡

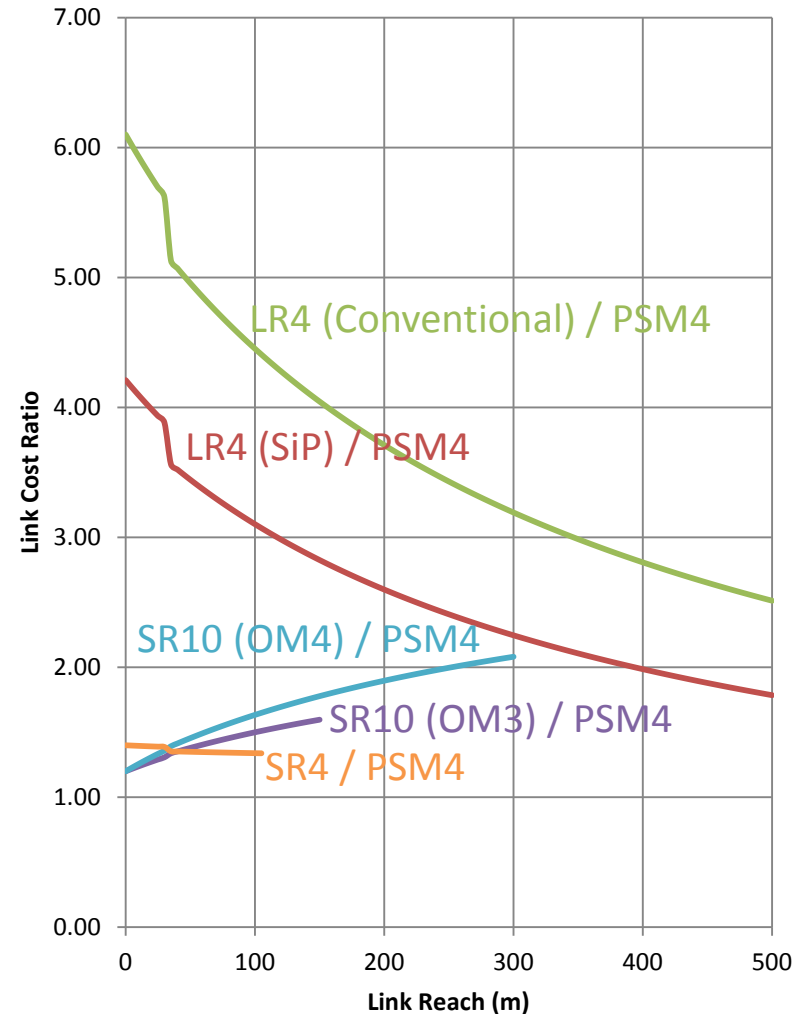
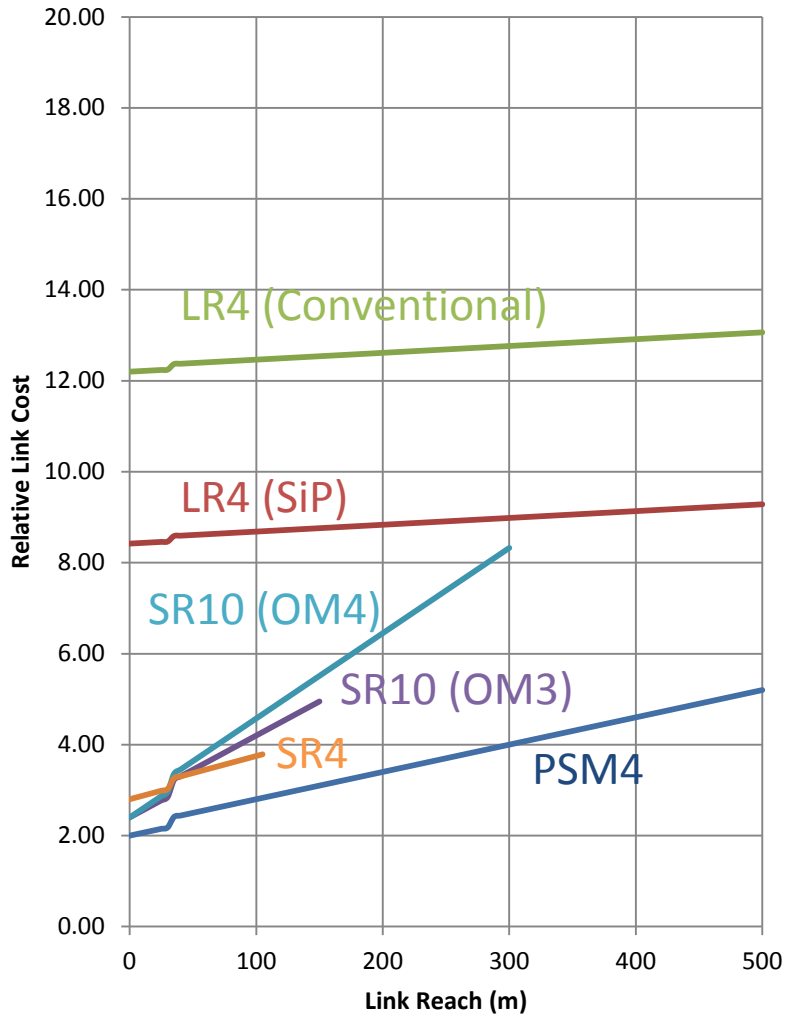
† Assumes all solutions at a mature cost point.

‡ From cole_02c_0413_smf.pdf

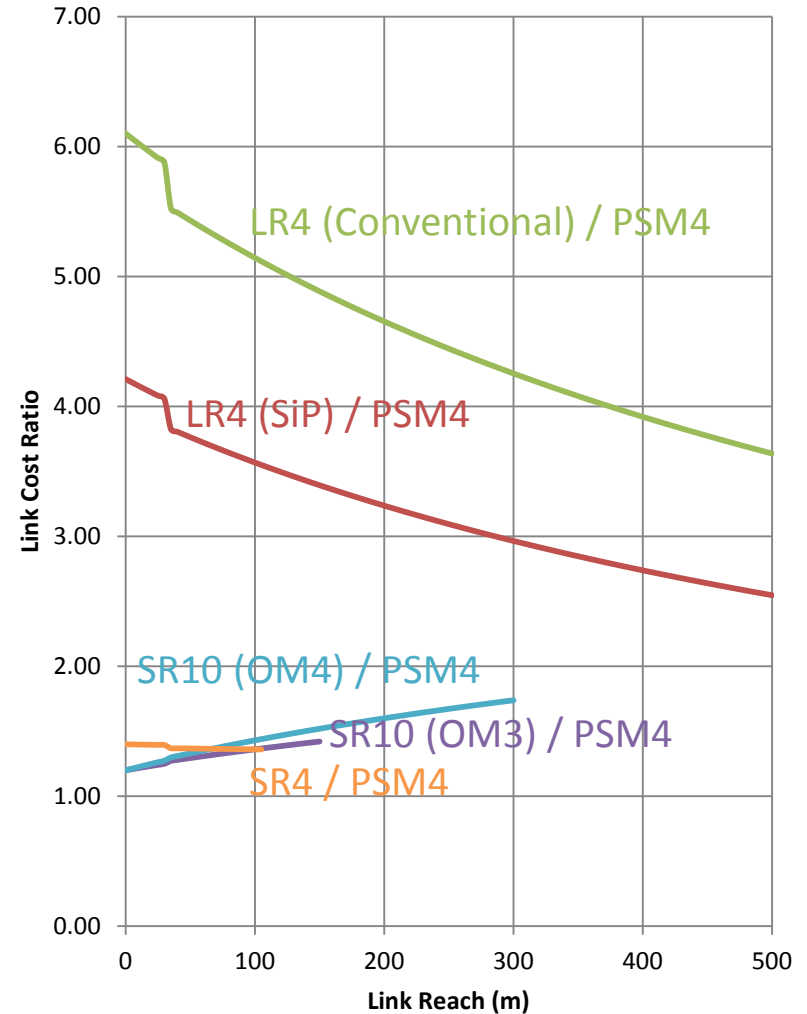
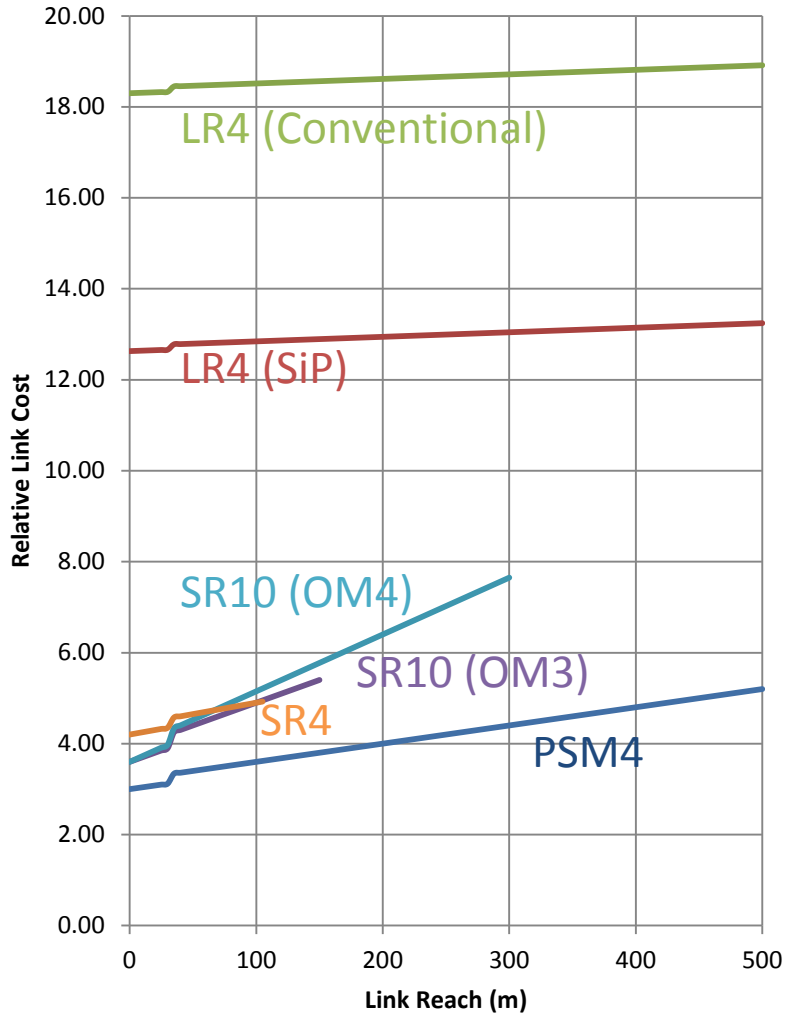
1) Nominal Module + Nominal Fiber



2) Nominal Module + High Fiber



3) High Module + Nominal Fiber



Link Cost Ratios – 8f & 20f

150 m	Module (Nom) + Fiber (Nom)	Module (Nom) + Fiber (High)	Module (High) + Fiber (Nom)
LR4 (Conventional) / PSM4	4.3	3.8	4.7
LR4 (SiP) / PSM4	2.9	2.7	3.3
SR10 (OM4) / PSM4	1.6	1.8	1.5
SR10 (OM3) / PSM4	1.5	1.6	1.4
<i>SR4 / PSM4 @ 105m</i>	<i>1.35</i>	<i>1.34</i>	<i>1.36</i>

300 m	Module (Nom) + Fiber (Nom)	Module (Nom) + Fiber (High)	Module (High) + Fiber (Nom)
LR4 (Conventional) / PSM4	3.5	3.1	4.1
LR4 (SiP) / PSM4	2.5	2.2	2.9
SR10 (OM4) / PSM4	1.9	2.1	1.7

500 m	Module (Nom) + Fiber (Nom)	Module (Nom) + Fiber (High)	Module (High) + Fiber (Nom)
LR4 (Conventional) / PSM4	2.9	2.4	3.5
LR4 (SiP) / PSM4	2.1	1.7	2.5

Link Cost Ratios – 12f & 24f

150 m	Module (Nom) + Fiber (Nom)	Module (Nom) + Fiber (High)	Module (High) + Fiber (Nom)
LR4 (Conventional) / PSM4	4.0	3.5	4.5
LR4 (SiP) / PSM4	2.8	2.4	3.1
SR10 (OM4) / PSM4	1.6	1.7	1.5
SR10 (OM3) / PSM4	1.5	1.5	1.4
<i>SR4 / PSM4 @ 105m</i>	<i>1.34</i>	<i>1.33</i>	<i>1.35</i>

300 m	Module (Nom) + Fiber (Nom)	Module (Nom) + Fiber (High)	Module (High) + Fiber (Nom)
LR4 (Conventional) / PSM4	3.1	2.6	3.7
LR4 (SiP) / PSM4	2.2	1.8	2.6
SR10 (OM4) / PSM4	1.8	1.9	1.7

500 m	Module (Nom) + Fiber (Nom)	Module (Nom) + Fiber (High)	Module (High) + Fiber (Nom)
LR4 (Conventional) / PSM4	2.4	1.9	3.0
LR4 (SiP) / PSM4	1.7	1.4	2.1

Supply Chain

Supply Chain

- A key value of PSM4 is that it enables a diverse module supply chain.
 - Does not require a specific technology to implement.
- Three different approaches pursued in creating the specification:
 - Silicon Photonics
 - DFB
 - Lisel
- Key tradeoffs enabled through specification to allow for cost optimization of the module provider.
 - ie, Transmitter OMA, Wavelength, and TDP
- Also, with the large number of QSFP ports being deployed, it is more likely that the necessary investments would flow into cost optimization of QSFP transceivers (vs. CFP).
 - Approximately 6 Million QSFP ports shipped last year

Summary

- PSM4 has the performance necessary to satisfy the 500m objective.
- PSM4 fits within a QSFP thermal envelope for all but the most conservative Gen1 predictions
- PSM4 satisfies the cost ambitions of the 500m objective.
 - Cost floor at least $1/3^{\text{th}}$ that of LR4 solutions for 150 m links (500m cost centroid)
 - At least $1/4^{\text{th}}$ that of contemporary cost projections of LR4 links.

Closing Question

- If 100GBase-SR4 could have supported 500m of fiber, would you have voted to do so?