Economic feasibility of Multi-Fiber PMDs

Tom Palkert

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Requested by Economic feasibility ad hoc

What are the requirements for multi-fiber economic feasibility?

- Multi-fiber 400G solutions must meet relative cost objectives when compared to:
  - 100G-Base-SR10 for 100m lengths
  - 100G-Base-LR4 for 500m lengths

Module building blocks to examine

- Lasers
- Modulators
- Retimers/Gearbox

Infrastructure

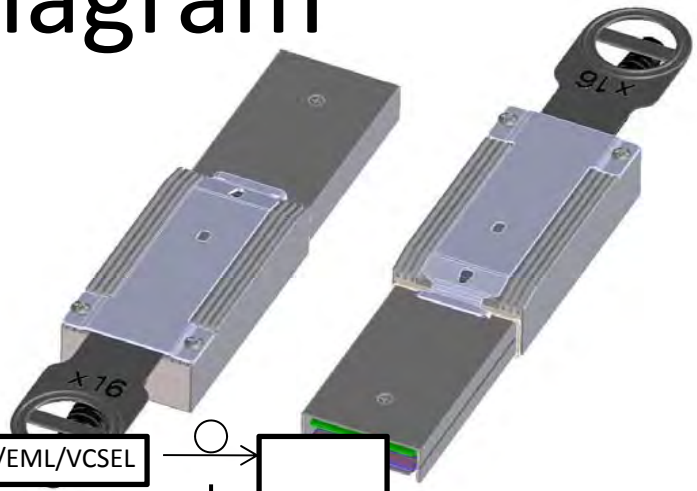
- Ribbon fiber
- Multi-lane connectors

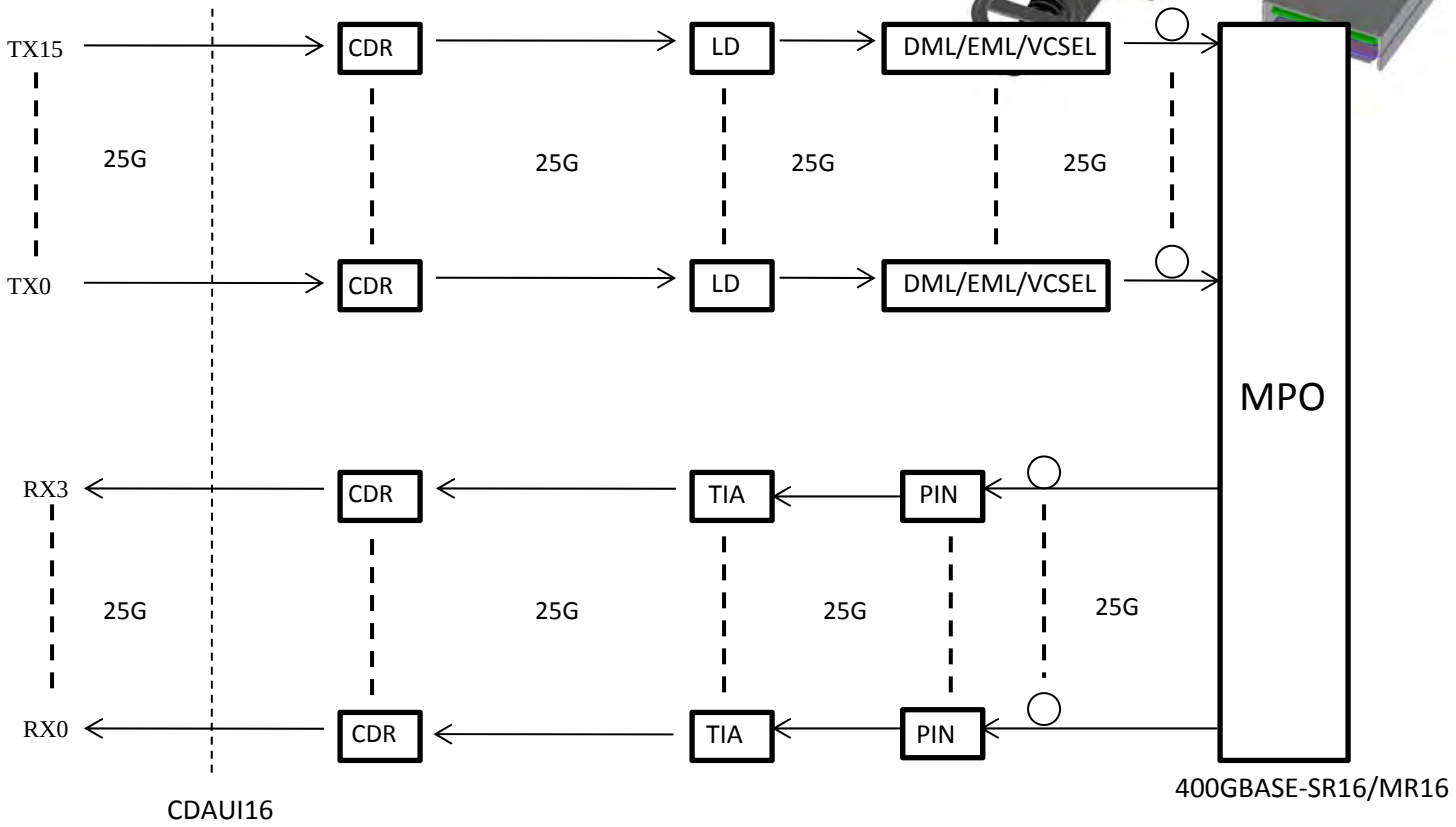
Possible 400G Module options for 100m and 500m objectives

- 16x25G-PSM16 –CDFP module
  - 16x25G retimers
  - 16 laser array or channel sharing of lasers
  - 32 fiber ribbon
  - 2x16 multi-fiber connector
- 4x PAM4-PSM4 – CFP2 or CDFP module
  - 8x50G to 4xPAM4 retimers
  - 4 laser array or channel sharing of laser
  - 8/12 fiber ribbon
  - SMF only?
- 8x50G-PSM8 –? module
  - 8 laser array or channel sharing of laser
  - 16 fiber ribbon
  - 1x16 multi-fiber connector

PSM16 block diagram

Uses existing 25G electrical I/F
Requires 32 fiber ribbon
X16 laser array or shared lasers





Economic feasibility of 16x25G module

- Relative costs compared to 100G-Base-SR10:

	100G-Base-SR10	400G-Base-SR16	Relative cost
Retimers	10	16	3x
Laser	10	16	2x
Fiber	24	32	1.2x
Connector	24	32	1.2x

25GX16 VCSEL array reliability (Relative to 10Gx10)

- 25G VCSELs are substantially different from 10G VCSELs. Wearout lifetimes will be driven by current density (size and operating current), and stability of the active layer. FIT rates are likely comparable, since the 1.6X larger number of lasers may be compensated by the smaller aperture areas (fewer defects in apertures). (Jack Jewell)

Economic feasibility of 16x25G 500m module using 16 lasers

- Relative costs compared to 100G-Base-LR4:

	100G-Base-LR4	400G-Base-SR16	Relative cost
Retimers	10:4 Gearbox	16	.5x
Laser	4 WDM	16	2x
Fiber	2	32	8x
Connector	2	32	5x
Optical coupling	WDM	Direct	.5x

25Gx16 laser DFB/DM laser array reliability

- Soliciting input

Economic feasibility of 16x25G 500m module using 8 channels/laser

- Relative costs compared to 100G-Base-LR4:

	100G-Base-LR4	400G-Base-SR16	Relative cost
Retimers	10:4 Gearbox	16	.5x
Laser	4 WDM	2	.3x
Fiber	2	32	8x
Connector	2	32	5x
Optical coupling	WDM	Direct	.5x

Reliability Example – Silicon Photonics

Reliability of Silicon Devices:

- Inherently reliable (diodes and passives)
- Wear-out conditions are orders of magnitude away from operational conditions

Light Source:

- Reliability proven, off-the-shelf InP laser diodes
- Efficient burn-in procedure

Reliability Qualifications:

- Silicon Photonics Wafer Process per JEDEC
- Silicon Photonics ICs qualified per JEDEC standard (e.g. HTOL)
- Photonic devices, light source and packaged products per Telcordia GR-468-CORE (with JEDEC sample sizes)

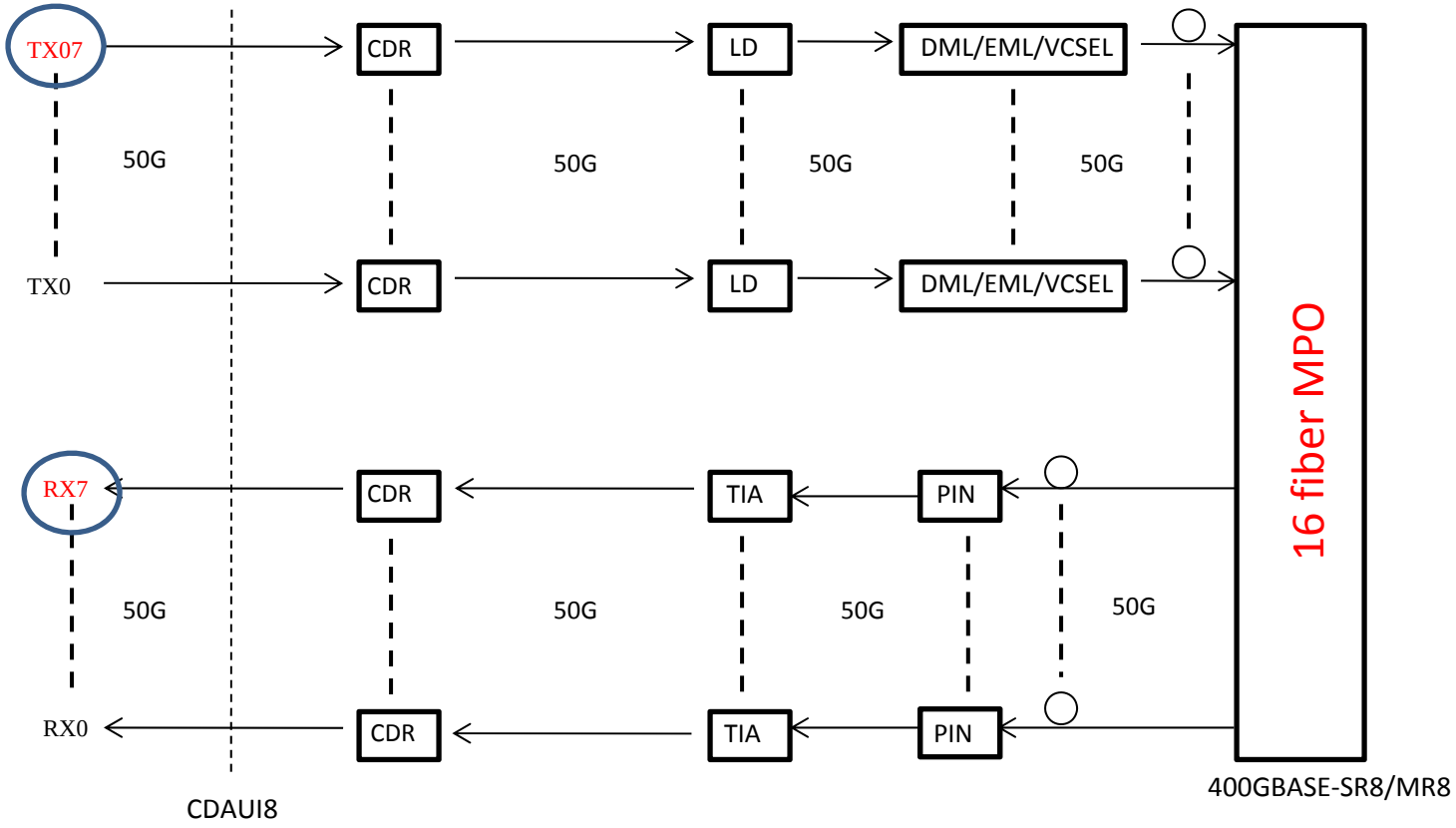
Random failure rate estimate: Example using 40G-PSM solution

- Packaged 4x10 Gbps transceiver (QSFP form factor)
- >524 M failure free operating hours
- < 1.75 FIT (60% confidence)

Economic feasibility for PSM8

Narrower electrical and optical interface

- Requires 50G electrical I/F
- Requires only 16 fibers

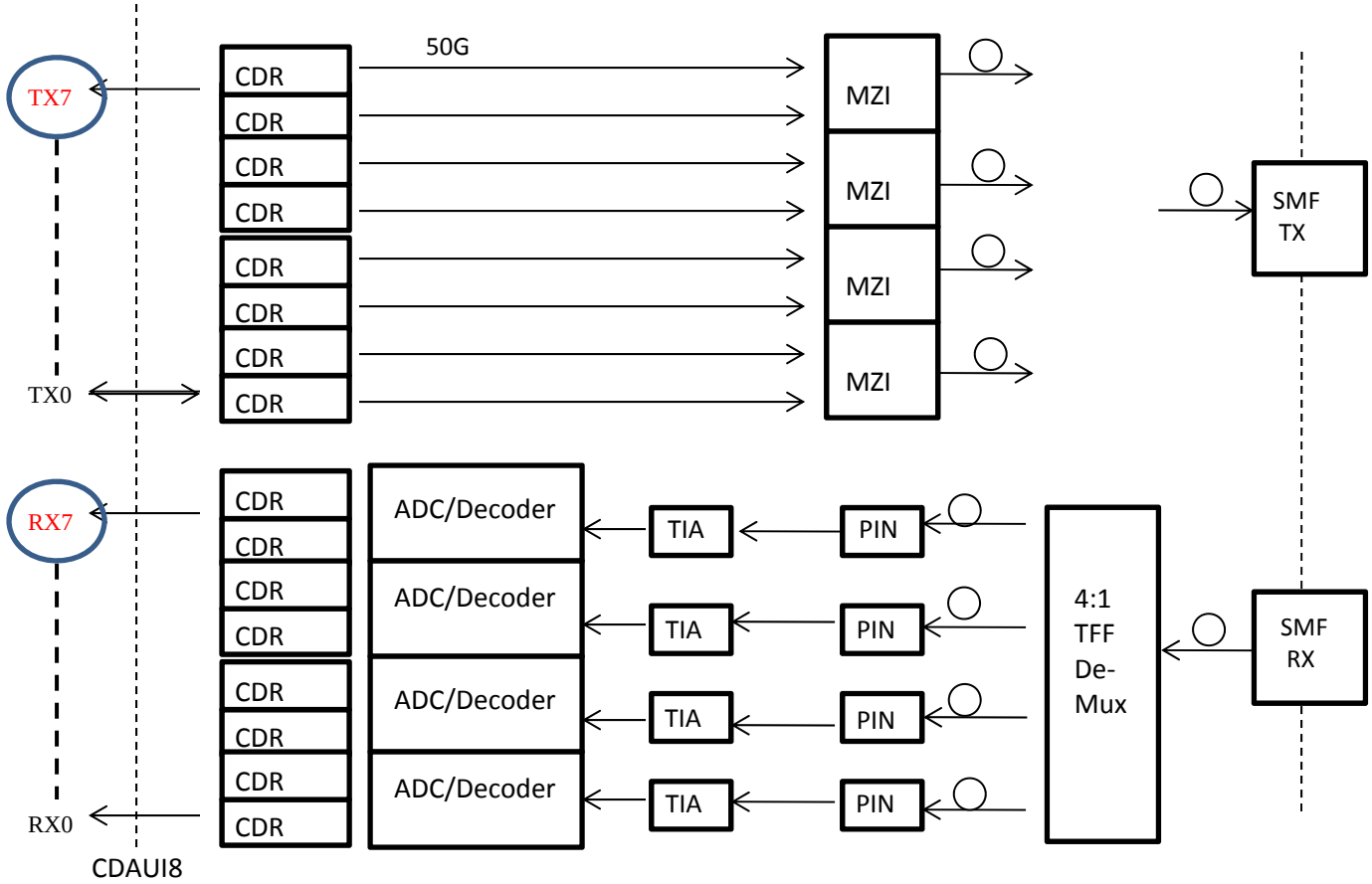


Summary for PSM8

- Narrower interface provides direct cost savings in connector and fiber count
- Retimers and lasers at 40G have been demonstrated but realistic cost comparisons would require additional effort

PSM4 (4x PAM4)

Narrower electrical I/F enables higher density modules
Optical I/F stays the same (8 fiber ribbon)



Summary for PSM4

- Narrower interface provides direct cost savings in connector and fiber count
- PAM4 modulation and ADC integration would be required to realize economic feasibility

Summary

- Economic feasibility for multi-lane 100m and 500m PMDs has been demonstrated :
  - Reliable Laser arrays
  - Common module form factors
  - Multi-fiber connectors
  - Ribbon fiber