Mid Range (MR) definition, comparisons and reach objective

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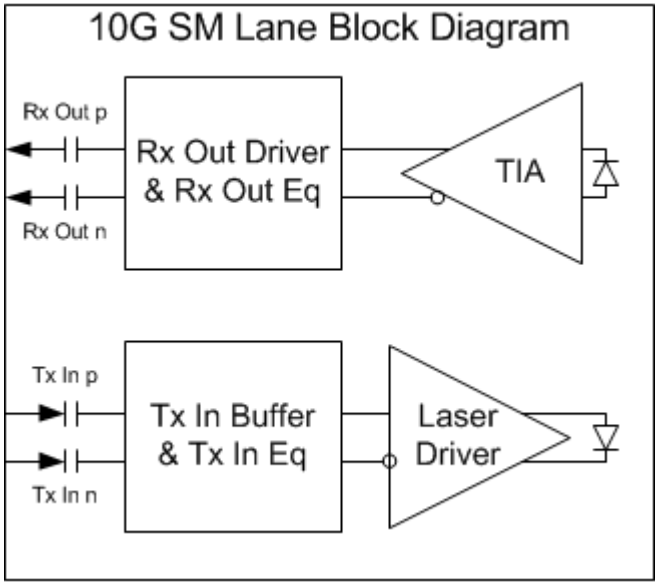
Presentation Overview

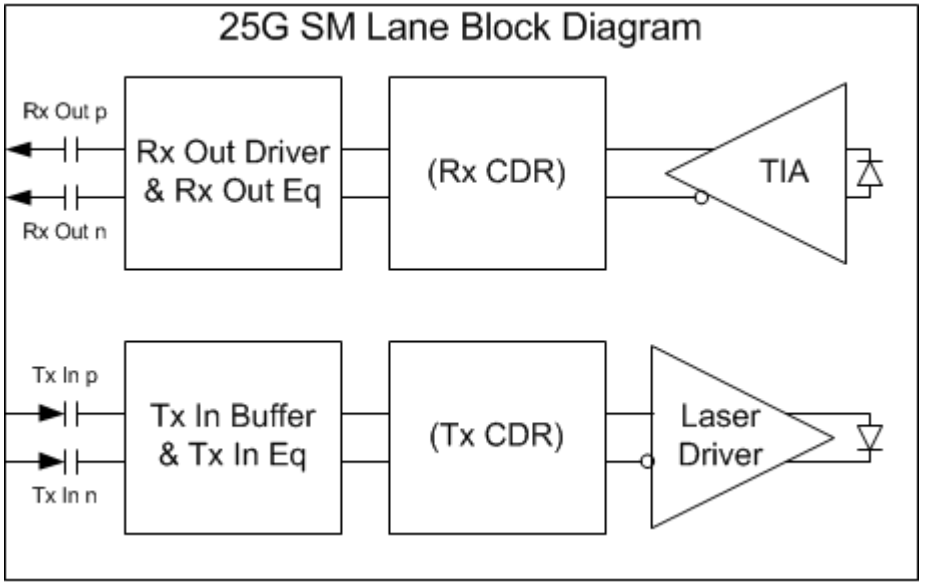
- From CFI-consensus-presentation, potential areas for SM study includes, “Study alternate PMD technologies to determine if there is significant opportunity for additional size, power and cost reduction”
- From, “ Objectives for Next Generation 100GbE Optical Interfaces”, “a possible objective could be: Define a 100 Gb/s PHY for operation over at least Zkm of SMF”
- This presentation defines a 100 Gb/s (4 lane) PMD capable of operation over 2 km of multi-lane SM fiber (G.652) with BER < 10^{-12} based on 1310 nm lasers, NRZ modulation and 64b/66b encoding, provides power, size and cost comparisons to 100G SR10 and SR4 variants and reviews Ethernet criteria for a new objective. While technically capable of supporting a 2 km reach, a 1 km objective is proposed for economic considerations.
- MR is used as an abbreviation for Mid Range denoting a reach up to 1 km.

Presentation Summary

- MR4 transceivers are defined in comparison with 100GBASE-SR10, 100GBASE-LR4 and proposed 100G SR4 transceivers
- Power consumption, density and cost comparisons are made relative to 100G SR10 and SR4 transceivers.
- Ethernet criteria are reviewed.
- Conclusion:
  - 100G MR4 offers cost advantages for the reach between that supported by 100GBASE-SR10 (and/or the proposed 100G SR4, petrilla_01_0112) and up to 1 km.

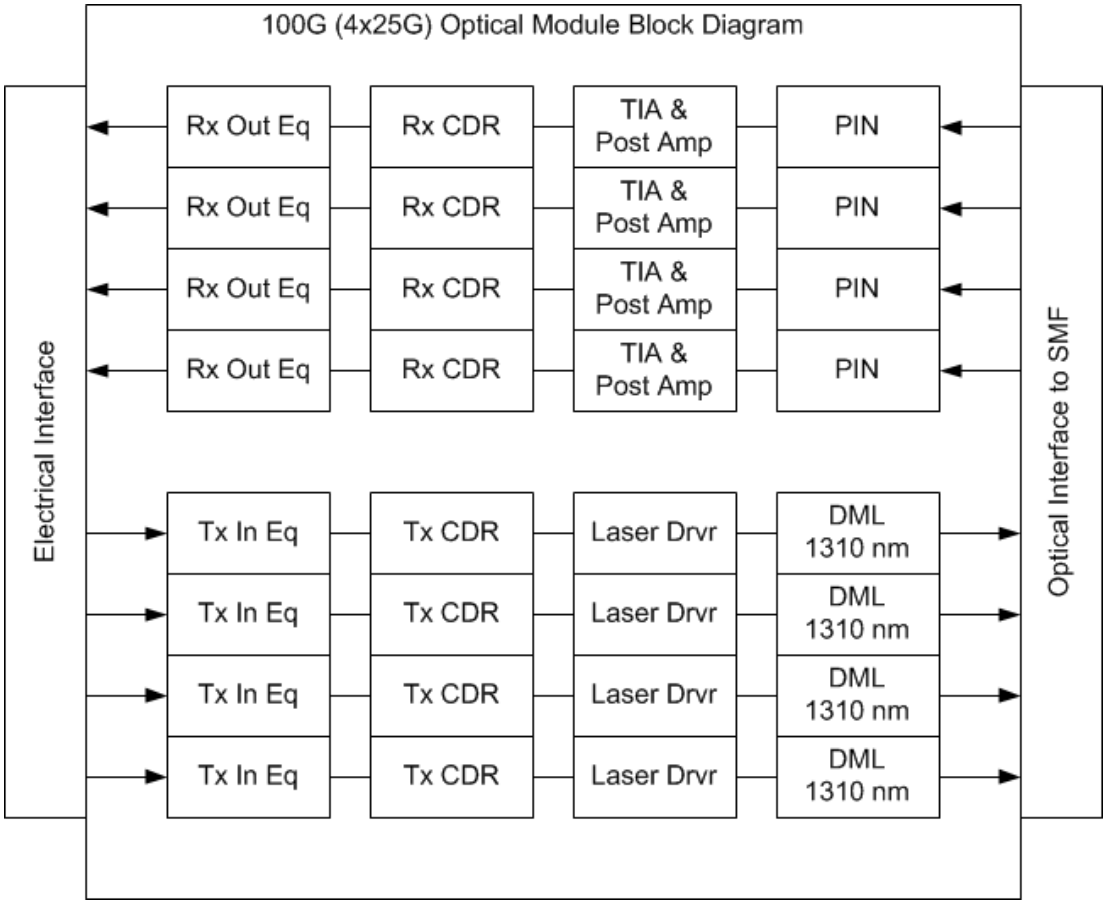
100G 25G/Lane Parallel SM Transceiver: Description [1/3]





- 10G Lane and 25G Lane block diagrams shown above for comparison
- NRZ modulation and 64b/66b encoding are assumed for both electrical and optical signals.
- At 10G simple Tx input equalization and/or Rx output equalization (de-emphasis) may appear.
- At 25G electrical interfaces are expected to require equalization and, at least initially, retiming.
- At 25G while some level of equalization is expected for MMF optical channel elements, this is not foreseen for SMF optical channel elements.

100G 25G/Lane Parallel SM Transceiver: Description [2/3]



<u>100GBASE-LR4 Comparison</u>

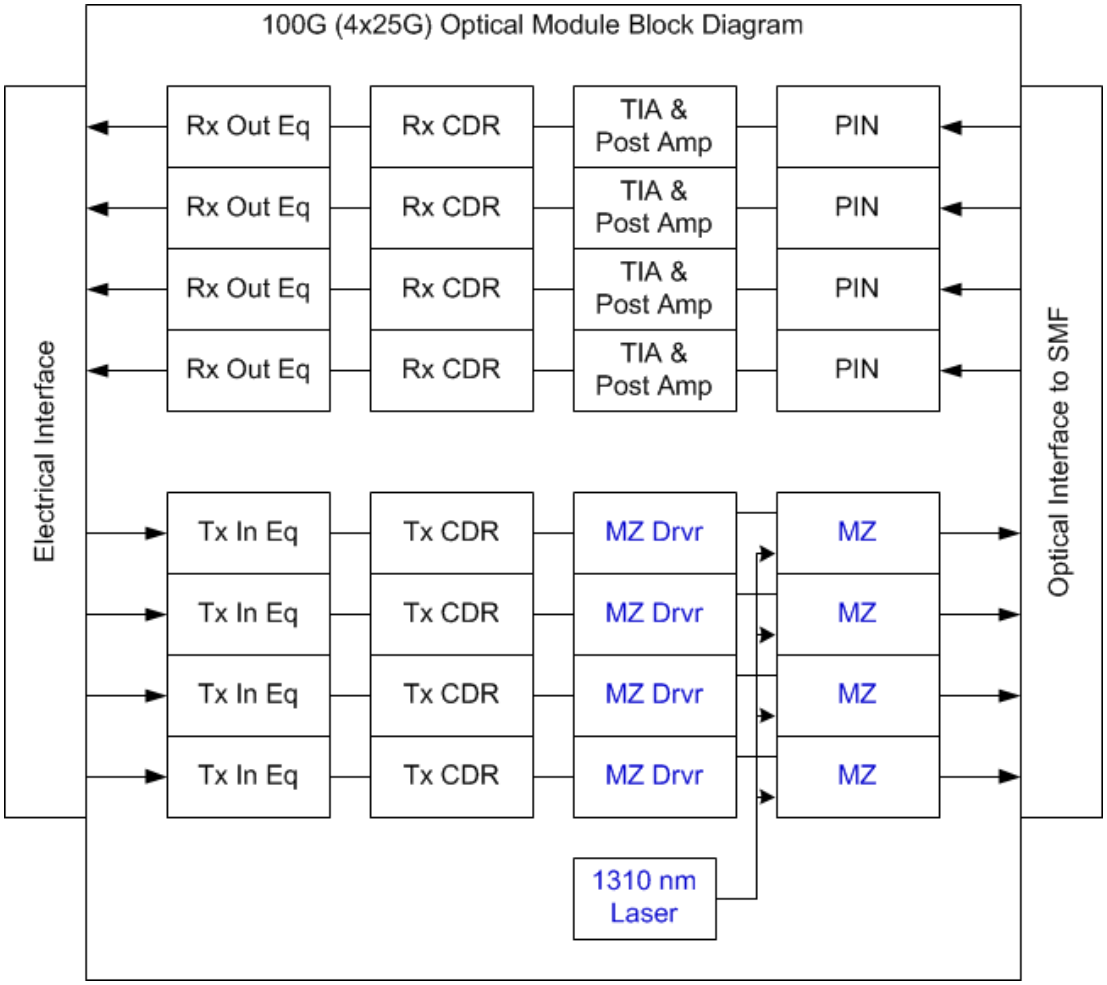
- No optical MUX
- No optical DMUX
- No tight wavelength requirements
- No TEC

Since this device can be viewed as a simplified and/or reduced cost 100GBASE-LR4 for a reduced reach, technical feasibility has been demonstrated.

MPO connectors are assumed for the optical interfaces.

NRZ modulation and 64b/66b encoding expected for both electrical and optical signals.

100G 25G/Lane Parallel SM Transceiver: Description [3/3]

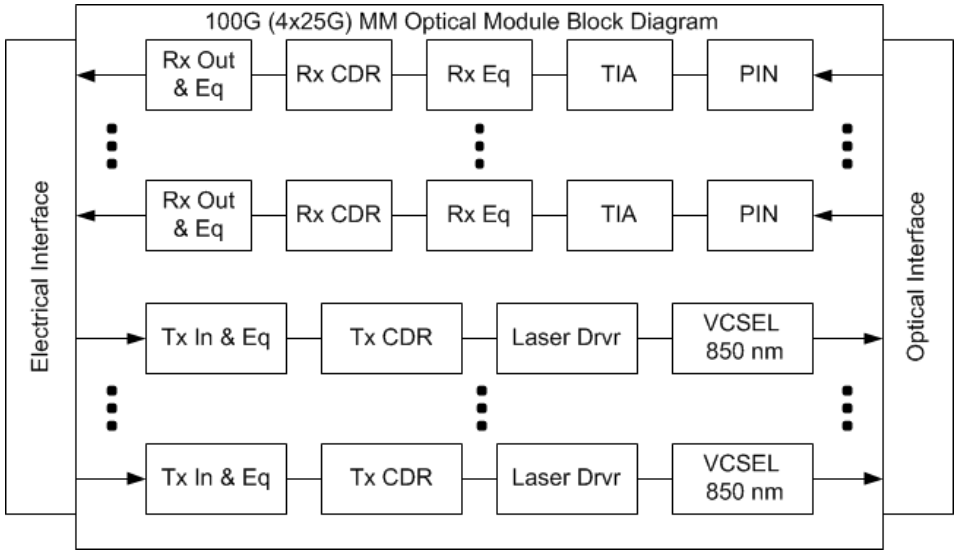


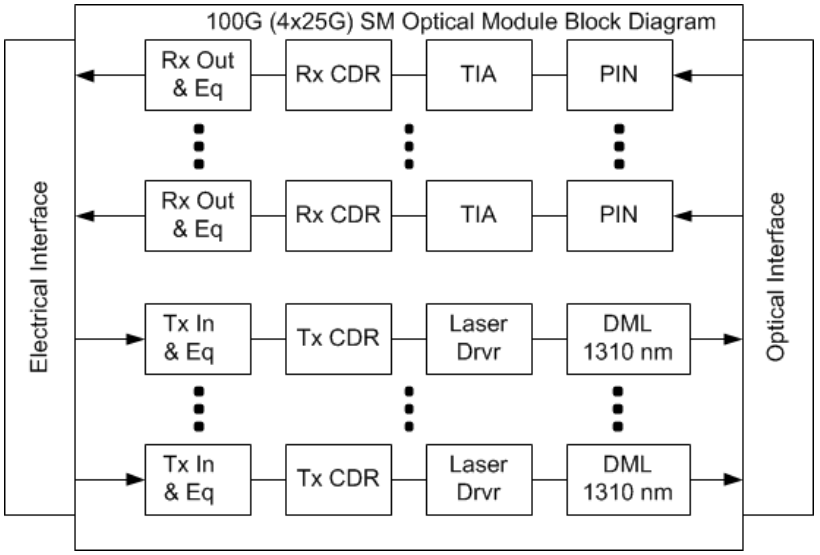
- Alternative block diagrams are possible, e.g. single CW laser and optical modulators combination.

MPO connectors are assumed for the optical interfaces.

NRZ modulation and 64b/66b encoding expected for both electrical and optical signals.

100G Parallel SM & MM Transceivers Comparison





- 100G SR4 (for MMF)and MR4 (for SMF) block diagrams are shown above for comparison.
- QSFP+ or CFP4, depending on power consumption and thermal management, are the assumed form factors for 100G SR4 and MR4 transceivers.
- Relative to 100G SR4 transceivers, for an MR Rx optical element equalization is not expected, while for an MR Tx higher laser bias currents are expected. Higher costs for lasers, optical isolators and alignment are expected.
- Alternative SM block diagrams (not shown) are possible, e.g. transmitter using a single CW laser and optical modulators combination.

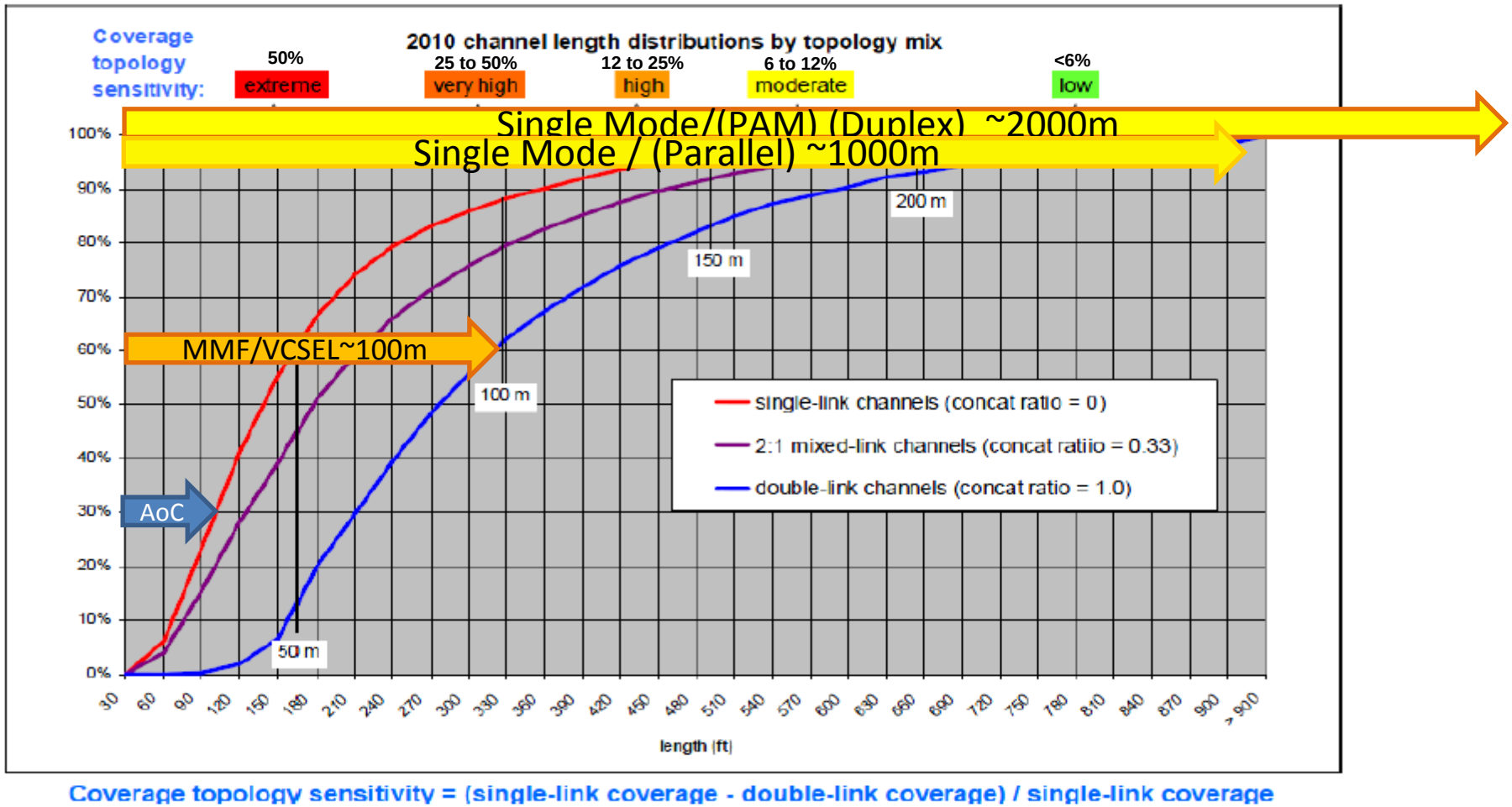
100G: SR10 - SR4 - MR4 Comparisons

	100G SR10	100G SR4	100G MR4 Palkert	100G MR4 Anderson	100G MR4 Petrilla	Comments
Lane Count	10	4	4	4	4	
Signal Rate/Lane	10.31 GBd	25.78 GBd	25.78 GBd	25.78 GBd	25.78 GBd	
XCVR Power Consumption	300 mW/lane	345 mW/lane	350 mW/lane	350 mW/lane	645 mW/lane	For block diagram elements in SR10
Laser bias current	1x	1.15x	7x	7x	7x	
CDR	Not Req'd	+345 mW/lane	+345 mW/lane	+345 mW/lane	+345 mW/lane	
CTLE Rx Eq	Not Req'd	+50 mW/lane	Not Req'd	Not Req'd	Not Req'd	For SR4 OM4 reach of ~90 m
XCVR Total	300 mW/lane	740 mW/lane	695 mW/lane	695 mW/lane	990 mW/lane	
Density						
Form Factor	CXP	QSFP+	QSFP+	QSFP+	QSFP+	QSFP+ for power consumption < 3 W
		CFP4	CFP4	CFP4	CFP4	CFP4 for power consumption > 4 W
Cable Plant / XCVR	2x10 (MMF)	1x8 (MMF)	1x8 (SMF)	1x8 (SMF)	1x8 (SMF)	
Host Routing lanes/channel	2x10	2x4	2x4	2x4	2x4	
Relative XCVR Cost	1x	1.2x	1.2x	3x to 4x	3x to 4x	

Why MR4?

- 100GbE used primarily for switch-switch links through 2020
- Switch-to-switch links are longer than server-switch links
- Estimate that ~ 20% of 100G links will be > 100m reach

  => *A cost-effective solution for medium reach is essential!*

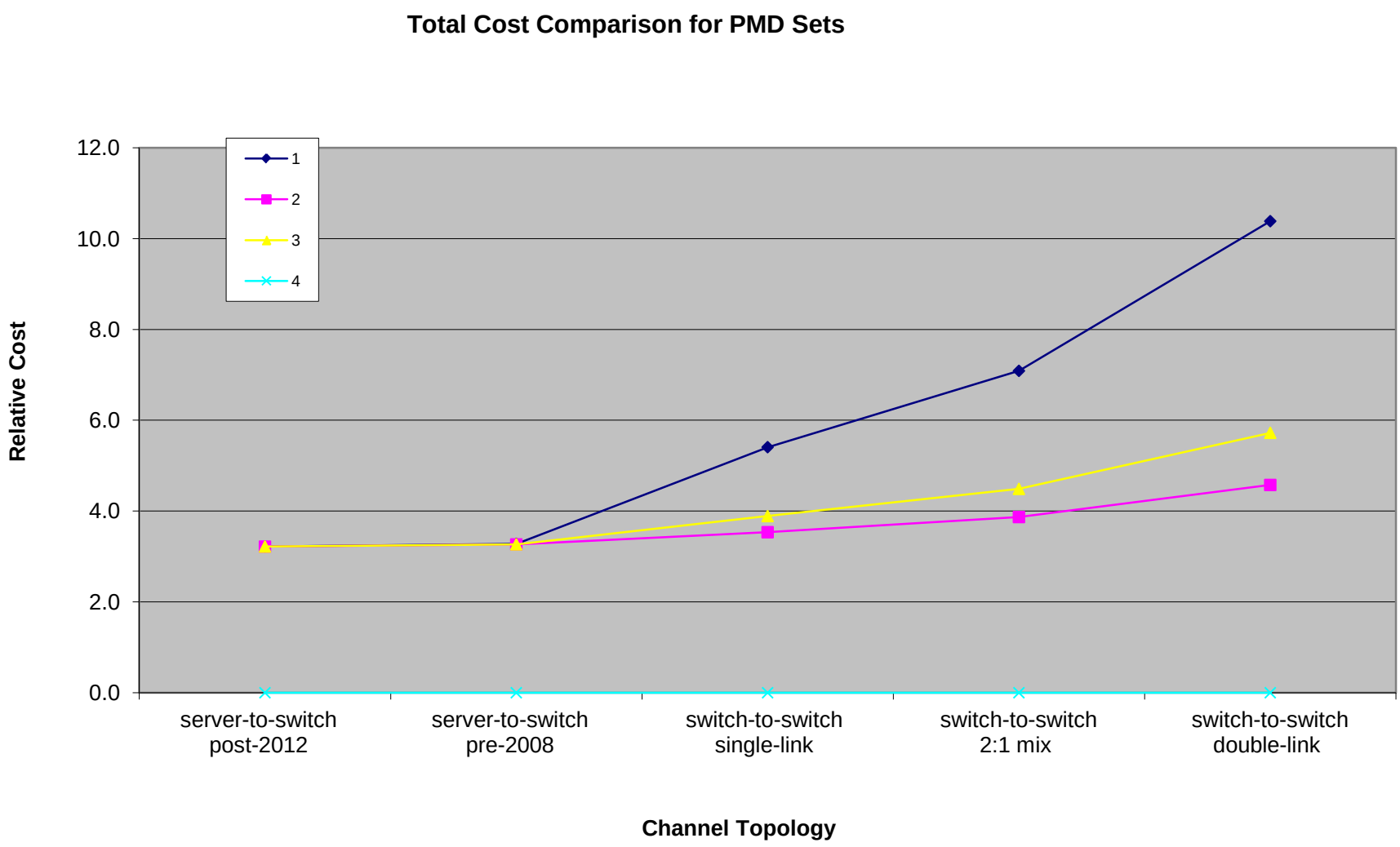


Coverage topology sensitivity = (single-link coverage - double-link coverage) / single-link coverage

Kolesar spreadsheet results

PMD set number	PMD description (ordered by increasing reach)	comparison metric (relative values)	PMD reach capability (m)	(ft)	PMD coverage for server-to-switch channels: server-to-switch post-2012	server-to-switch pre-2008	PMD coverage for switch-to-switch channels: switch-to-switch single-link	switch-to-switch 2:1 mix	switch-to-switch double-link
1				0.0	0.0%	0.0%	0.0%	0.0%	0.0%
				0.0	0.0%	0.0%	0.0%	0.0%	0.0%
	SR4	**1.2**	**100**	328.1	100.0%	99.9%	88.2%	79.3%	61.7%
	LR4	**10**	**10000**	32810.0	0.0%	0.1%	11.8%	20.7%	38.3%
				coverage check:	100.0%	100.0%	100.0%	100.0%	100.0%
				Figures of Merit:	1.20	1.21	2.24	3.02	4.57
2				0.0	0.0%	0.0%	0.0%	0.0%	0.0%
	SR4	**1.2**	**100**	328.1	100.0%	99.9%	88.2%	79.3%	61.7%
	MR4	**1.5**	**1000**	3281.0	0.0%	0.1%	11.8%	20.7%	38.3%
	LR4	**10**	**10000**	32810.0	0.0%	0.0%	0.0%	0.0%	0.0%
				coverage check:	100.0%	100.0%	100.0%	100.0%	100.0%
				Figures of Merit:	1.20	1.20	1.24	1.26	1.31
3				0.0	0.0%	0.0%	0.0%	0.0%	0.0%
	SR4	**1.2**	**100**	328.1	100.0%	99.9%	88.2%	79.3%	61.7%
	MR4	**3**	**1000**	3281.0	0.0%	0.1%	11.8%	20.7%	38.3%
	LR4	**10**	**10000**	32810.0	0.0%	0.0%	0.0%	0.0%	0.0%
				coverage check:	100.0%	100.0%	100.0%	100.0%	100.0%
				Figures of Merit:	1.20	1.20	1.41	1.57	1.89

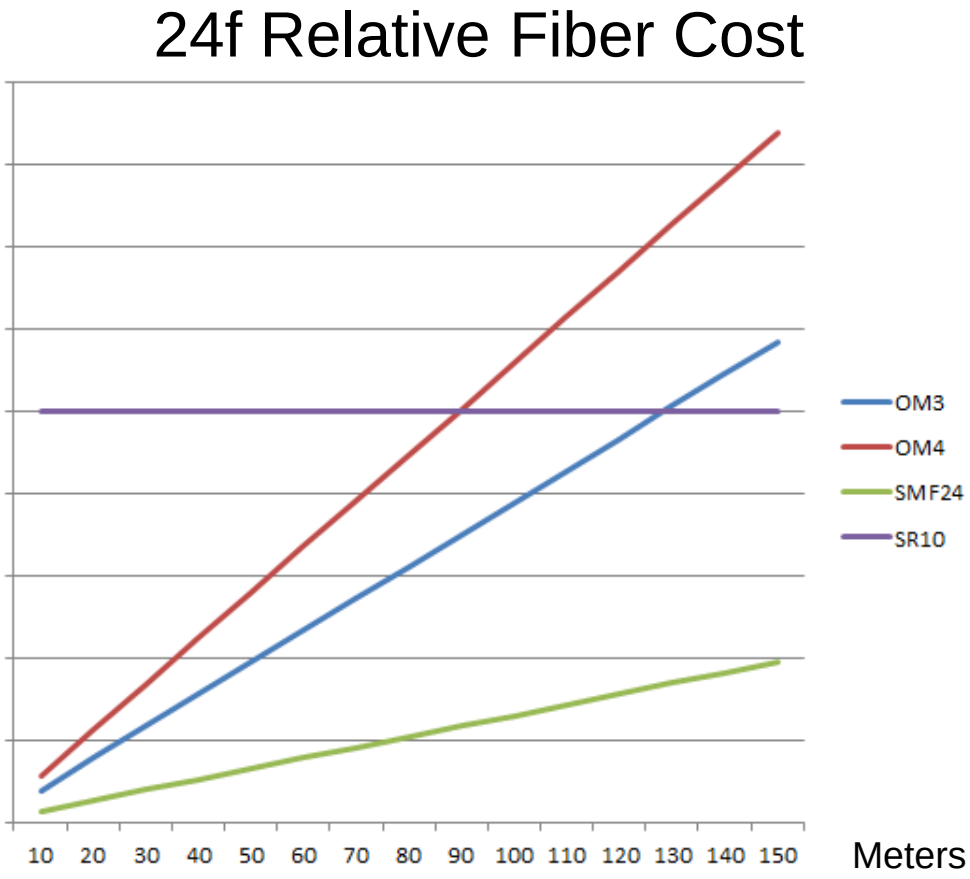
Kolesar Figure of Merit



Fiber Cost Comparison

Density	Fiber Type	Relative Cost
24f	OM3	3.0
24f	OM4	4.3
24f	SMF	1
Duplex	SMF	2.0*

Source: Jan 2012 quote from cable vendor
LC or MTP Termination costs not included.
* Cost to derive 12 - duplex pairs



24-Fiber SMF cable is half the cost of 12 duplex SMF cables, 1/3 the cost of 24f OM3 and 1/4 the cost of 24f OM4

Fiber + Module Cost Comparison @ 100m

Density	Fiber Type	Cable Cost(*)	Module Type	Module Cost	Total Cost
24f	OM3	3.0	SR4	4.5X	7.5X
24f	OM4	4.3	SR4	4.5X	7.8X
24f	SMF	1	MR4	4.5X-16X	5.5X-17X
Duplex	SMF	0.2	LR4	50X	50.2X

*Note: 8 fibers out of 24 used for SR4 and MR4, 2 fibers for LR4

Including the fiber cable, even at 100m MR4 is potentially the lowest cost overall solution.

This cost advantage increases with longer reach.

100G Next Gen Single Mode Optics: Criteria

- Broad Market Appeal: Several contributions speak to the interest in a mid range (MR) reach including ghiasi_01_911_NG100GOPTX, kolesar_01_0911_NG100GOPTX, & kipp_01_0112_NG100GOPTX
- Compatibility: Changes are confined to the MR PMD and no compatibility issues exist.
- Distinct Identity: The MR PMD will result in a new 802.3 clause making it straightforward for the reader to identify the relevant information. The PMD will be uniquely identified by fiber, wavelength, signal rate and reach.
- Technical Feasibility: This contribution, anderson_01_1111_NG100GOPTX, anderson_01_0112_NG100GOPTX, palkert_01_1111_NG100GOPTX & petrilla_01_1111_NG100GOPTX as well as the existence of 100GBASE-LR4 speak to the technical feasibility.
- Economic Feasibility: This contribution, anderson_01_1111_NG100GOPTX, anderson_01_0112_NG100GOPTX, kipp_01_0112_NG100GOPTX and nowell_01_1111_NG100GOPTX speak to economic feasibility.

100G Next Gen Single Mode Optics: Next Steps

Motion:

Move that the study group adopt as an objective:

Define a 100 Gb/s (4 lane) PMD that will operate over, at least, 1 km of multi-lane SM fiber (G.652) with BER < 10^{-12} based on 1310 nm lasers, NRZ modulation and 64b/66b encoding.