A Comprehensive WAN, LAN, and Very Short Reach (VSR) PMD solution

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10GbE PMD Rationale

- 10GEA recommended PMDs.
  - 1550nm Serial
  - 1310nm Serial
  - 1310nm WDM
- Above PMDs primarily address WAN and LAN backbone.
- OEMs support proprietary links for distances <100m
- Standardizing VSR PMDs guarantees Interoperability.

10GbE PMD OPTIMIZATION

	<1m		100m		300m		40km
	INTERNAL		**EXTERNAL**				
Application	• Chip-chip • Backplane connections		• Rack-Rack • Intra-rack • Equipment room		• LAN Backbone		• MAN • WAN
PMD Type	• 20” copper on FR-4		**Standard solutions** • 10GFC VSR–850nm • 10GFC copper **Proprietary** • Ad Hoc industry consortia: - OIF - Infiniband		1310 WDM 1310 Serial		1550nm Serial

VSR 10Gb/s Applications

- OEM rack-to-rack switch connections.
- Server point-to-point connections.
- Network storage attachments.
- Backplane link extensions.
- Central office cross-connect.

VSR PMD Alternatives

FACT: 850nm has highest attenuation of the three proposed wavelengths.

- **Therefore, low cost VSR optical PMDs center on the 850nm wavelength.**
  - **850nm Serial**
  - **850nm Parallel**
  - **850nm WDM**

Eschew Proprietary PMDs

- Eliminate proprietary barriers which minimize customer alternatives.
- Reliance on proprietary solutions raises interoperability issue.
- Ad hoc industry consortia such as Infiniband, OIF may not be referenced by IEEE 802.3

Parallel VSR Objectives

- To propose a low cost 10G parallel transmission technical solution.
- To create a focus for providers of parallel transmission and standardize specifications.
- To answer needs of OEMs and system integrators for a standard short reach parallel transmission capability.

Multi Protocol Capability

- 10G Ethernet
  - Supports 64/66B encoding.
  - Optional XAUI interface.
- Fibre Channel 10G
  - Supports 8B/10B encoding.
  - Byte or word striping.
- ATM OC-48 (x4) cross connect
  - Scrambled data (PRBS 2^{31}-1).
- Infiniband®
  - 4x2.5Gb/s parallel data.

Parallel VSR Interface

- Supports bi-directional 4x2.5Gb/s on Multimode Fiber.
- Protocol Independent
  - 8B/10B block coded serial Baud rate of 3.125GBaud (each fiber).
  - 64/66B block coded serial Baud rate of 2.51GBaud (each fiber).
- Connector Independent
  - Array Connector (AC).
  - Ribbon Fiber Connector (RFC).

850nm Parallel 10Gb/s Link Performance

- >100m over installed base of 160MHz-km 62/125µm fiber.
- >200m over 400MHz-km 50/125µm ribbon fiber.
- >1km over new 2000MHz-km 50/125µm ribbon fiber.
  - Distance may be limited by skew compensation.

850nm Transmitter Characteristics

Description	Unit	50µm MMF	62.5µm MMF
Type		850nm Laser	
Nominal Signaling Speed	GBaud	3.125	
Rate Tolerance	ppm	±100	
Wavelength range (λ)	nm	840-860	
RMS Spectral Width	nm	0.85	
Average Launch Power (max)	dBm	-4	
Average Launch Power (min)	dBm	-10	
Rise/Fall, max (20%-80%)	ps	105	
Optical Modulation Amplitude (OMA), min	mW	0.196	
RIN_{12} (OMA), max	dB/Hz	-117	

Note: assumes 8B/10B encoded data

850nm Receiver Characteristics

Description	Unit	50µm MMF	62.5µm MMF
Nominal Signaling Speed	Gbaud	3.125	
Wavelength range (λ)	nm	830-860	
Average Receive Power, max.	dBm	0	
Optical Modulation Amplitude,min	mW	0.039	
Stressed Receiver Sensitivity (OMA), min.	mW	0.096	0.109
Receiver electrical 3dB upper cutoff frequency, max.	GHz	2.5	
Stressed Receiver ISI test, min.	dB	1.26	2.03
Return Loss, min.	dB/Hz	12	

Jitter (pk-pk), max.

	Unit	α_T	δ_T	γ_T	γ_R	δ_R	α_R
Deterministic (DJ)	UI	0,13	0,14	0,26	0,28	0,39	0,40
Total (TJ)	UI	0,25	0,26	0,44	0,48	0,64	0,65

VSR PMD Economics

- 850nm Serial lowest cost as IC prices decline.
- 850nm Parallel leverages existing technology, manufacturing base.
- 850nm WDM answers a primary 10GbE objective (100m over existing MMF).

850nm Parallel Relative Cost

- **Cost Unit (CU) Definition:**
  - **2m standard MMF = 1 Cost Unit (CU)**
- **Standard single fiber MMF cost (.5 CU/meter).**
- **Four fiber ribbon cost (1.5CU/meter).**
- **Additional connector cost for FAC or RFC (+10CU).**

850nm WDM Relative Cost

- 25 percent the volume of each wavelength laser (+15CU).
- Four optical filters (+20CU).
- Four position optical combiner (+25CU).
- Four position optical splitter (+25CU).
- Assembly/Test (+10CU).

850nm Parallel / WDM cost tradeoffs

- Cost parity achieved at approximately 85 - 100m depending on assumptions made.
- Assumes high volume 850nm WDM link manufacturing.
- 850nm WDM may offer more manageable skew budget at distance limits.

Cooperative Coexistence

- Historical precedent for Ethernet building on Fibre Channel standard.
- 10GFC has adopted two VSR PMDs.
  - 850nm serial
  - 850nm parallel
- Recommend future inclusion of VSR PMDs in 10GbE standard.
- Reference completed 10GFC VSR standard in 10GbE appendix /annex.

Comprehensive PMD Proposal

- The 10GEA approved 3 PMD set plus future inclusion of an informative annex referencing a completed 10GFC VSR PMD standard.
- Appoint a 10GFC liaison officer to coordinate VSR PMD activities.

Conclusion

- We have established a rationale for including a reference to 850nm VSR PMDs standardized by 10G Fibre Channel.
- We have demonstrated technical and economic feasibility for a VSR 10Gb/s four fiber parallel transmission array.
- We have proposed a PMD solution set which includes all necessary variants and distributes responsibilities to the appropriate standard.
- This multi-standard VSR PMD will answer the needs of OEMs and integrators of 10GbE, 10GFC, and Infiniband® network systems.