



10GBASE-LRM Interoperability & Technical Feasibility Report

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Interoperability / Technical Feasibility Goals

- To confirm experimentally the feasibility of the 10GBASE-LRM 1310nm serial PMD using multiple vendor's implementations
- Demonstration of compliance / path to compliance to 10GBASE-LRM clause 68 specifications
 - Parameter measurements and limits based on IEEE P802.3aq D2.3 specification (unless otherwise noted)
- An interoperability test using 10GBASE-LRM implementations with $2^{31}-1$ PRBS data
- Provide the Task Force data to support response to Motion #3 from November 2004 meeting:
 - *Move that IEEE 802.3aq demonstrate a 10^{-12} BER over the rated distance on a specified channel (TBD) and show interoperability between PMD's of at least three vendors for 10GBASE-LRM to support technical feasibility prior to sponsor ballot.*

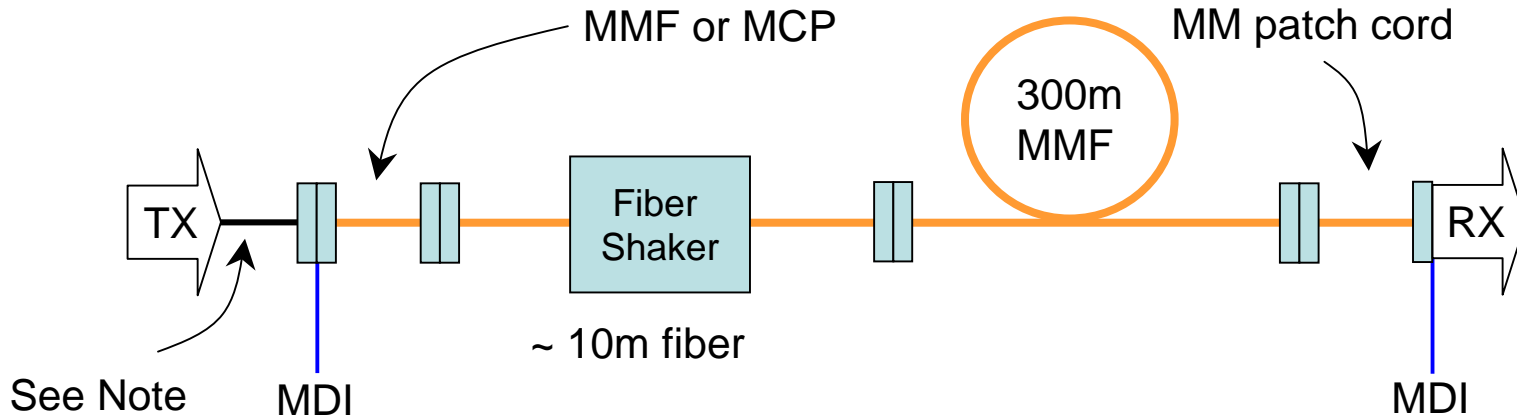
Interoperability Test Description

- Four independent 10GBASE-LRM PMA/PMD implementations
- Vendor A, B, C and D MDI's connected over a range of 50um and 62.5um fiber types operating at the 10GBASE-R rate
 - The LRM specification is for 220m length with minimum OFL BW of 500MHz·km for OM1 and OM2
 - The test fibers identified below are all 300m in length
 - The rated bandwidth distance product of 500 MHz·km at the 220m specification lengths is equivalent to 682 MHz·km for 300m fibers. The selected fibers have less than this bandwidth.

Fiber Type	Cable Name	Length Tested	OFL BW, MHz·km
OM1	1Green	300m	585
OM1	2Orange	300m	433
OM2	4Orange	300m	654
OM3	Orange - Red	300m	574

- OM1 & OM2 fibers from FO2-2 12/96 BW Modal Launch Test Cable
- OM3 fibers from TIA FO4.2.1 10GbE Demo Cables
 - OM3 Fibers provided courtesy of Corning, Inc.

Test Set-up Diagram



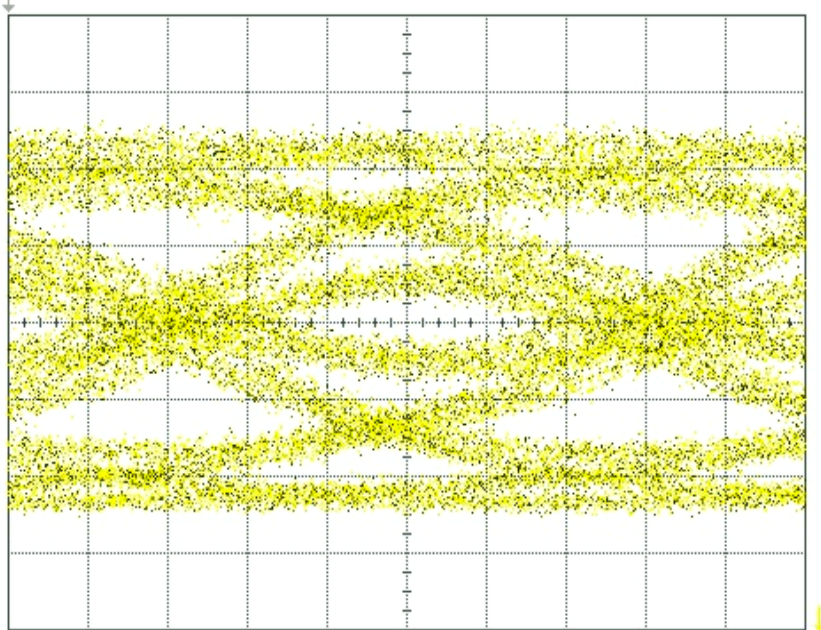
Note: At the request of some vendors, all vendors included a SMF and optionally an optical attenuator between their MDI and the MDI defined for these interoperation tests. This was to ensure that their receivers received a compliant optical power level but avoided receiver overload.

- Test Pattern: PRBS $2^{31}-1$
(Rx under test looped back to Transmitter to verify PRBS)
- Fiber Shaker
 - 2 separate fiber shakers used for the test (50um & 62.5um)
 - 3 figure 8's coiled on the apparatus

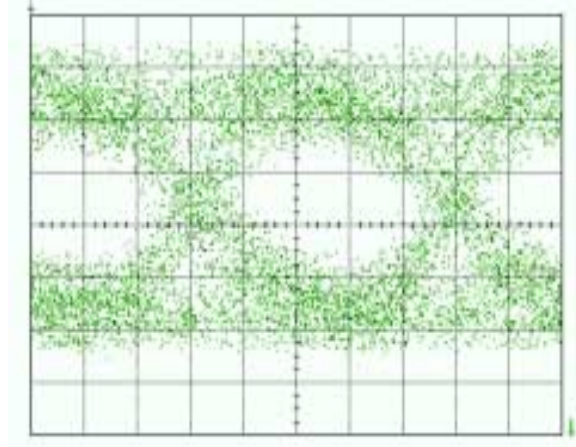


TIA 12-96 Fiber Set – OM1 Eye Diagram

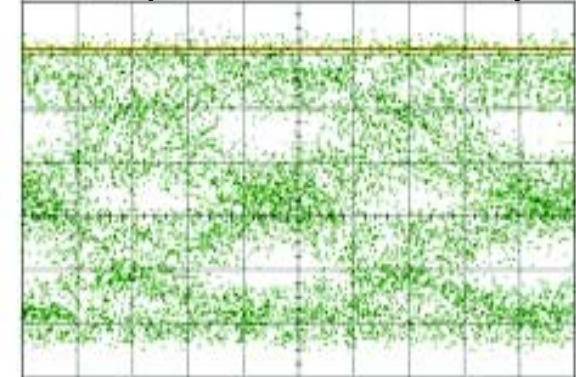
1Green
Mode Conditioning Patch Cord (MCP)



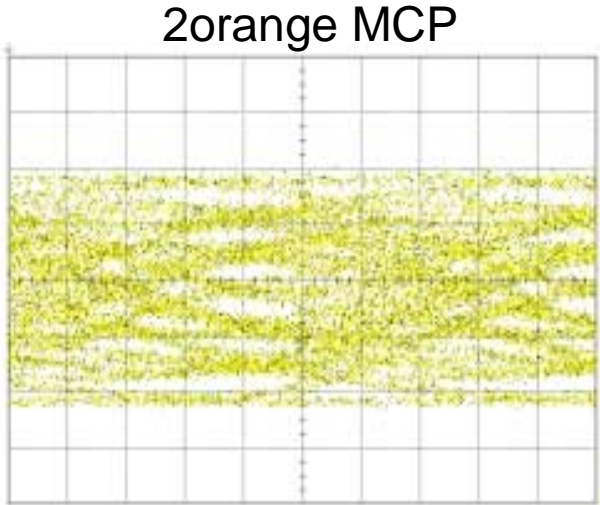
1Green Center Launch (CL)
(1st snapshot of shaker cycle)



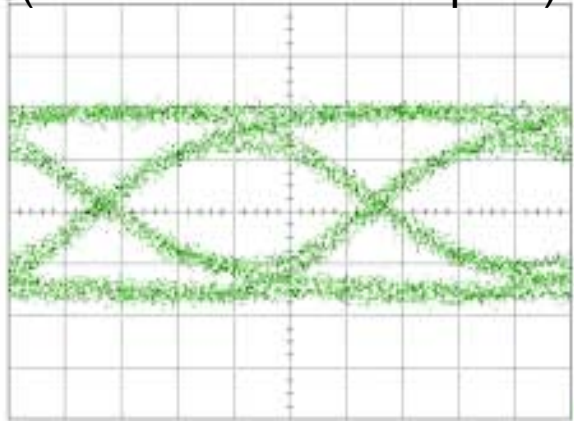
1Green CL
(2nd snapshot of shaker cycle)



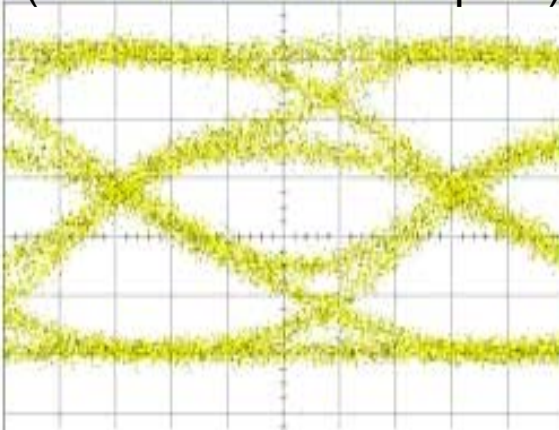
TIA 12-96 Fiber Set – OM1 Eye Diagram



2orange CL
(Transmitter & Set-up #1)

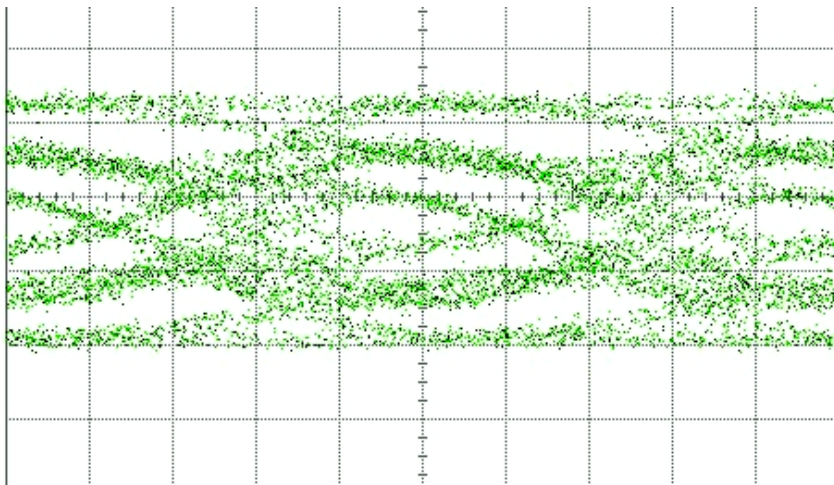


2orange CL
(Transmitter & Set-up #2)

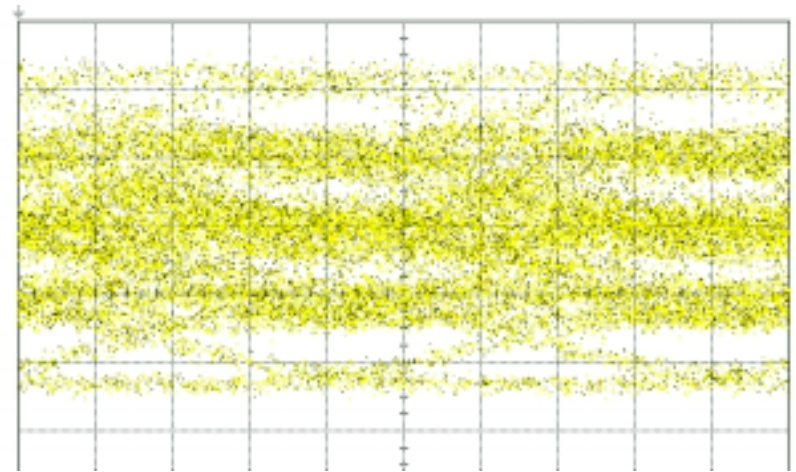


TIA 12-96 Fiber Set – OM2 Eye Diagram

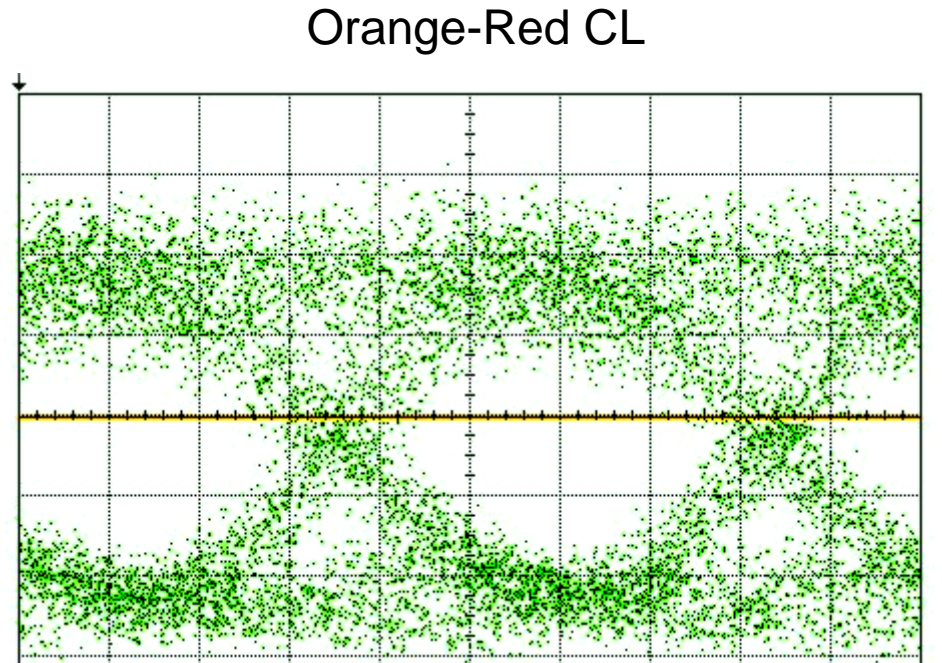
4orange MCP



4orange CL



TIA FO4.2.1 Fiber Set – OM3 Eye Diagram



Vendor Interoperability TIA Round Robin Fibers

OM1 1-Green 300m				
	A RX	B RX	C RX	D RX
A TX		PASS	PASS	PASS
B TX	PASS		PASS	PASS
C TX	PASS	PASS		PASS
D TX	PASS	PASS	PASS	
OM1 2-Orange 300m				
	A RX	B RX	C RX	D RX
A TX		PASS	PASS	PASS
B TX	PASS		PASS	PASS
C TX	PASS	PASS		PASS
D TX	PASS	PASS	PASS	
OM2 4-Orange 300m				
	A RX	B RX	C RX	D RX
A TX		PASS	PASS	PASS
B TX	PASS		PASS	PASS
C TX	PASS	PASS		PASS
D TX	PASS	PASS	PASS	
OM3 Orange/Red 300m				
	A RX	B RX	C RX	D RX
A TX		PASS	PASS	PASS
B TX	PASS		PASS	PASS
C TX	PASS	PASS		PASS
D TX	PASS	PASS	PASS	

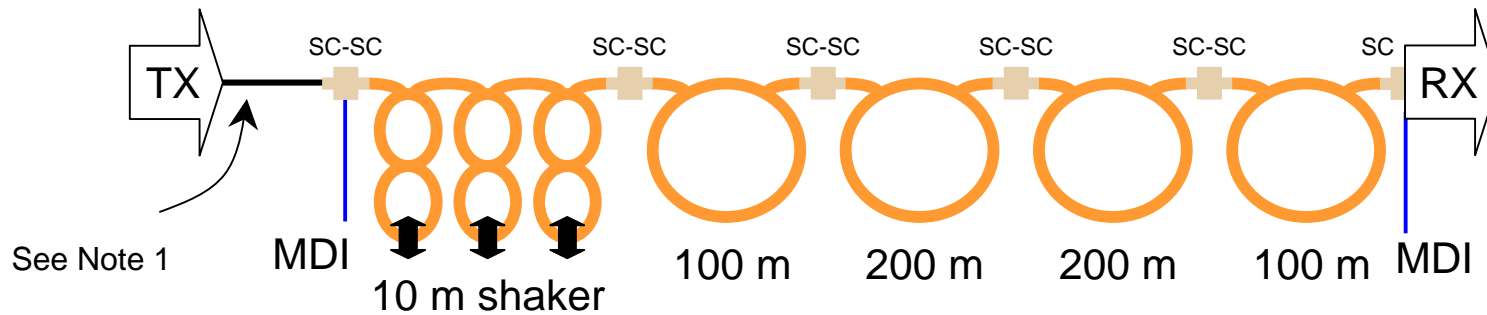
Pass = no errors in 5 minutes (>95%confidence of BER <10⁻¹²)

Additional Test Results & Details

- **Link Tests Were Conducted With Both Launches for OM1 and OM2**
 - **Success on Either Launch Is Reported As a Pass**
 - **On Some Fibers the Preferred Launch Always Succeeded, On Others The Alternate Launch Always Succeeded**
- **Fiber Shaker Had Surprisingly Little Influence on Results**
- **Qualitative Link Performance Was Found to Be Sensitive to Connectors**
 - **Manipulation of Connectors Affected Performance in Marginal Cases**
- **Overload Considerations Were Found To Be Practical Issues With Some Present Implementations**

Vendor Interoperability Nominal OM1 Fiber

OM1 Nominal 600 meters (100m, 200m, 200m, 100m)				
	A RX	B RX	C RX	D RX
A TX		not tested	not tested	not tested
B TX	not tested		Pass	Pass
C TX	not tested	Pass		Pass
D TX	not tested	Pass	Pass	



- To provide a data point for comparison to earlier 10GE interop testing, combined 4 segments of 'nominal' OM1 fiber totaling 600m. Nominal fiber = random purchase early 2004; did not specify any special characteristics.
- Testing was performed at the end of the interop period, and the matrix was not completed due to lack of time.
- Note 1: At the request of some vendors, all vendors included a SMF and optionally an optical attenuator between their MDI and the MDI defined for these interoperation tests. This was to ensure that their receivers received a compliant optical power level but avoided receiver overload.
- Note 2: This is not meant in any way to imply that LRM PMD's are suitable for 600m use, but that with nominal links, there is margin to the 220m distance specification.

Vendor Compliance Data

802.3aq Draft 2.3

Transmit Characteristics per Table 68-3

Pass ■ Fail ■ Not Tested









































































Description	Type	Value	Unit	A	B	C	D
Signaling speed	nom	10.3125	GBd				
Signaling speed variation from nominal	max	± 100	ppm				
Center wavelength	range	1260 to 1355	nm				
RMS spectral width at 1260 nm	max	2.4	nm				
RMS spectral width between 1260 nm and 1300 nm	max	See Figure 68-3	nm				
RMS spectral width between 1300 nm and 1355 nm	max	4	nm				
Launch power in OMA	max	1.5	dBm				
Launch power in OMA	min	-4.5	dBm				
Average launch power	max	0.5	dBm				
Average launch power	min	-6.5	dBm				
Average launch power of OFF transmitter	max	-30	dBm				
Extinction ratio	min	3.5	dB				
Peak launch power	max	3	dBm				
RIN ₂₀ OMA	max	-128	dB/Hz				
Eye mask parameters {X1, X2, X3, Y1, Y2, Y3}		{0.25, 0.40, 0.45, 0.25, 0.28, 0.80}					
Transmitter waveform and dispersion penalty (TWDP)	max	4.7	dB				
Uncorrelated jitter (rms)	max	0.033	UI				
Optical launch for OM1 and 160/500, 62.5 μm fiber:							
Preferred:		62.5 μm mode-conditioning patch cord, see 68.9.3					
Encircled flux for alternative launch per D2.2	min min	30 % in 5 μm radius 86 % in 11 μm radius					
Optical launch for OM2 and 400/400, 50 μm fiber:							
Preferred:		50 μm mode-conditioning patch cord, see 68.9.3					
Encircled flux for alternative launch per D2.2	min min	30 % in 5 μm radius 86 % in 11 μm radius					
Optical launch for OM3 50 μm fiber:							
Encircled flux per D2.2	min min	30 % in 5 μm radius 86 % in 11 μm radius					
Optical return loss tolerance	min	20	dB				
Transmitter reflectance	max	-12	dB				

Receiver Characteristics per Table 68-5

Pass 

Fail 

Not Tested 

Description	Type	Value	Unit	A	B	C	D
Signaling speed	nom	10.3125	GBd				
Signaling speed variation from nominal	max	± 100	ppm				
Center wavelength	range	1260 to 1355	nm				
Stressed sensitivity in OMA at BER 10 ⁻¹²	-	-6.5	dBm				
Overload in OMA at BER 10 ⁻¹²	-	1.5	dBm				
Conditions of comprehensive stressed receiver tests:							
Bandwidth of Gaussian white noise source	min	10	GHz				
Test transmitter signal to noise ratio, Q _{eq}							
For sensitivity tests	-	22.5					
For overload tests	-	28.8					
Tap Spacing, Δt, of ISI generator	-	0.75	UI				
Pre-cursor tap weights {A1,A2,A3,A4}		{0.158, 0.176, 0.499, 0.167}					
Symmetrical tap weights {A1,A2,A3,A4}		{0.00, 0.513, 0.00, 0.487}					
Post-cursor tap weights {A1,A2,A3,A4}		{0.254, 0.453, 0.155, 0.138}					
Conditions of simple stressed receiver test:							
Signal rise and fall times (20% to 80%)	-	115	ps				
Conditions of receiver jitter tolerance test:							
Jitter frequency and peak to peak amplitude	-	(40, 5)	KHz, UI				
Jitter frequency and peak to peak amplitude	-	(200, 1)	KHz, UI				
Received average power for damage	-	2.5	dBm				
Receiver reflectance	max	-12	dB				

Summary

- Successfully interoperated LRM links between four vendors' independent 10GBASE-LRM implementations across a range of fiber types at or above the specification maximum fiber distance
- Vendors' independent implementations met nearly all TP2/3 interface parameter requirements of the present D2.3 document.
- Multiple vendors creating products for 10GBASE-LRM PMD with different EDC & optical components

Motion

- Move to accept this report as fulfillment of the requirements of the motion quoted below from the November 2004 10GBASE-LRM meeting as a prerequisite to Sponsor Ballot;
 - Motion # 3 Move that IEEE 802.3aq demonstrate a 10^{-12} BER over the rated distance on a specified channel (TBD) and show interoperability between PMD's of at least three vendors for 10GBASE-LRM to support technical feasibility prior to sponsor ballot.
- Moved:
- Seconded:
- Results: