

OFC 2025

Theater III Session

Tuesday April 1st 11:00 ~12:00pm

Optical Solutions for Open Cloud RAN with 6G

Leveraging LPO for MOPA Fronthaul Blueprints Beyond 5G

Ryan Latchman, MACOM

Agenda

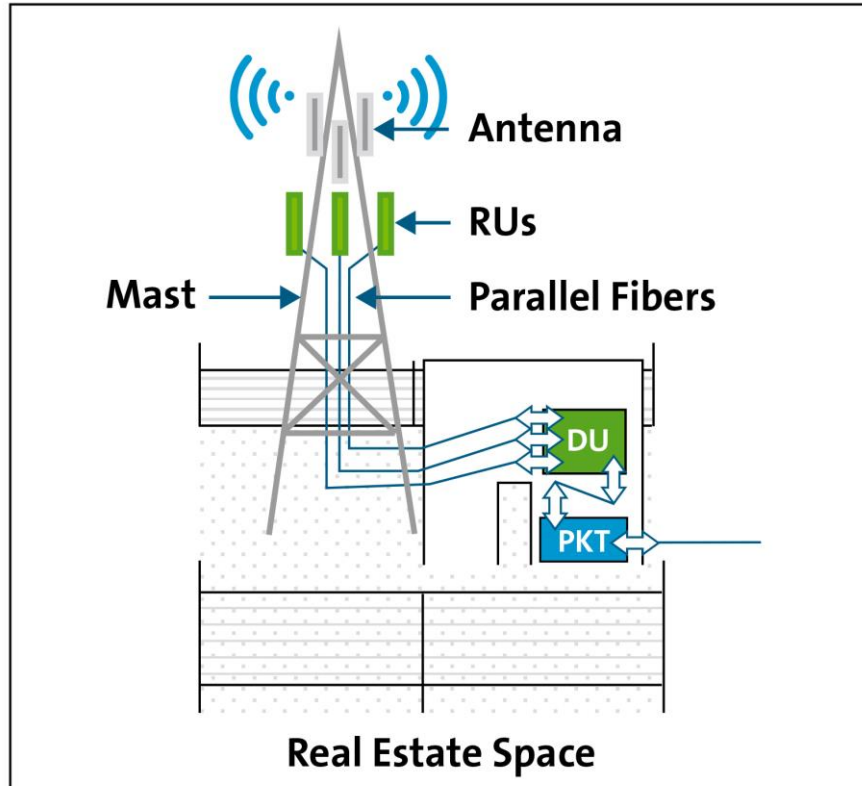
Mobile Optical Networks Connectivity

Linear Pluggable Optics (LPO)

Leveraging LPO In SFP56, SFP112, and Beyond

Conclusion

Optical Interconnect In Fronthaul:



Cell Site illustration for the DRAN Fiber Abundance Case.

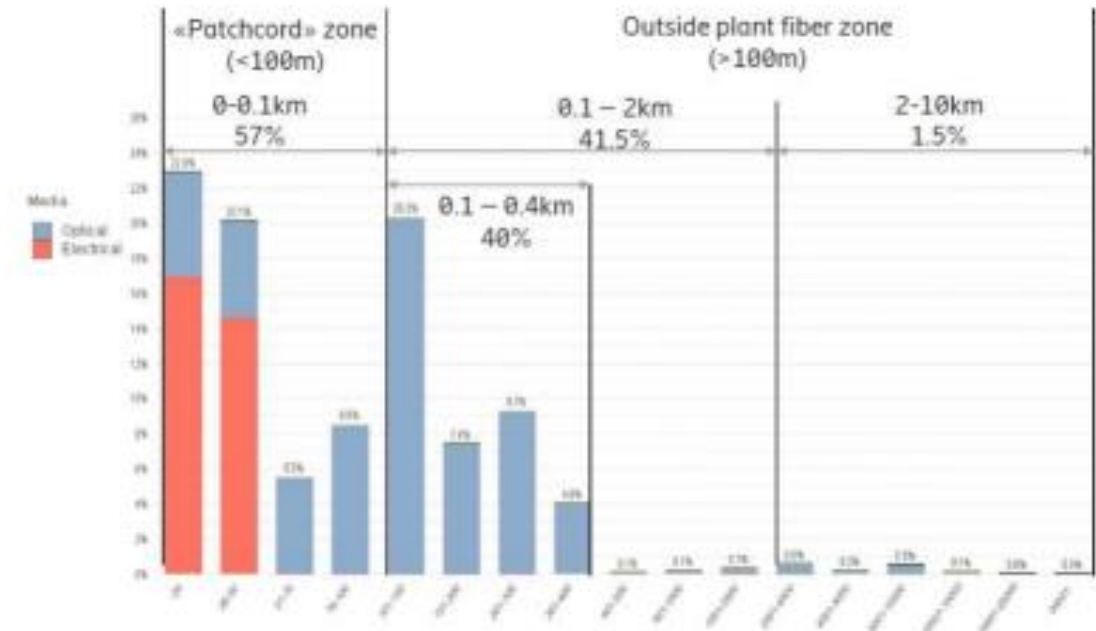
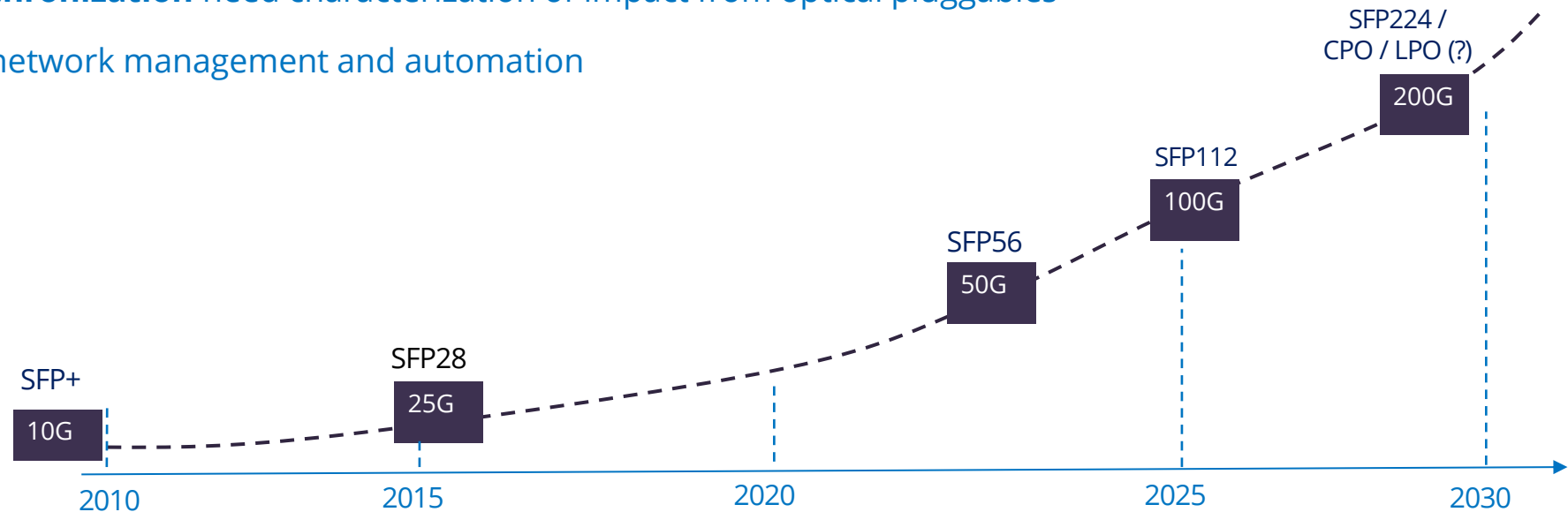


Figure 10: LLS link length distribution.

(source: Ericsson, by characterizing millions of LLS links in live networks).

Challenges for future mobile networks

- **RUs need SFPx form factor** with
 - Low power consumption
 - High(er) temperatures - I-temp (and higher)
 - Long life span - 15 years
- **Increased data rates**
 - LLS (fronthaul) RU and DU gray → 50G, 100G
- Increasingly **tight timing synchronization** need characterization of impact from optical pluggables
- Easier operations with better network management and automation



MOPA v3.1 Blueprint Targets

SFP56 Power Class: 1.5W

>Same as prior form factors

Cost Targets

>Similar to prior form factors

What can we expect for 100G?

>Similar cost & power targets to prior form factors

2 km RU-DU Parallel Fibers Blueprint			
Typical UC	DRAN DU to RU; Du to cell site router intra-site; Du and/or cell site router to microwave element intra-site. Up to 2 km. The BiDi use cases, which are high volume, are covered by 10 km optics (see 7.2.2. blueprint)		
Distance	Typ Min 0 km; Typ. Max: 2 km		
Channel IL	208 dB O-Band (For typ. max distance)		
Mode, Nr, ch., WL	Dual Fiber: O-Band 1310 nm		
Temp. Range/Class	I-temp, VHT cases are also exist		
Lifespan	15 Years		
Data Rates	10 Gb/s	25 Gb/s	50 Gb/s
Form Factor	SFP+	SFP28	SFP56
FEC, Mod. Format	No, NRZ	Yes, NRZ	Yes, PAM4
Power Class	PC2 (1.5 W)	PC2 (1.5 W)	PC2 (1.5 W)
Pluggables Codes	10G-2 km-O-G-1-2-SFP+		
Key Technologies	–	Low-cost 25G DFB (e.g., reuse 10G 10 km). New low-cost tech like 25G FP	TBD
Standards	IEEE 802.3, Clause 52	IEEE 802.3, Clause 114	IEEE 802.3, Clause 139
Market Status and Outlook (*)	Mature	Mature	Introduced

Table 6: 2 km RU-DU direct parallel fibers Blueprint. Following Figure 10, distances up to 2 km are expected to cover a large majority of the deployments.

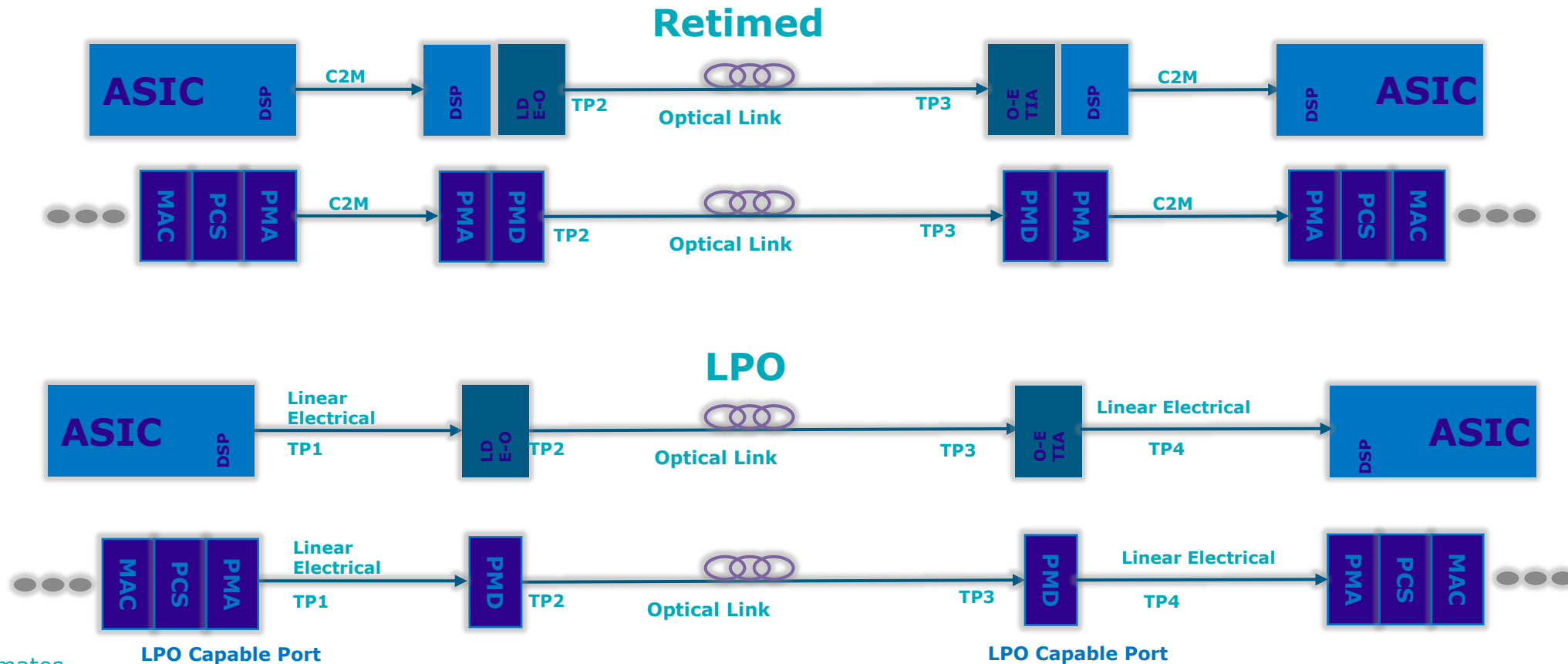
Key Technology for SFP56 & SFP112: LPO

Removing DSP saves 50% Power and 30% BOM at 112G*

Improves Latency & Reliability

Rate Agile Optical Module

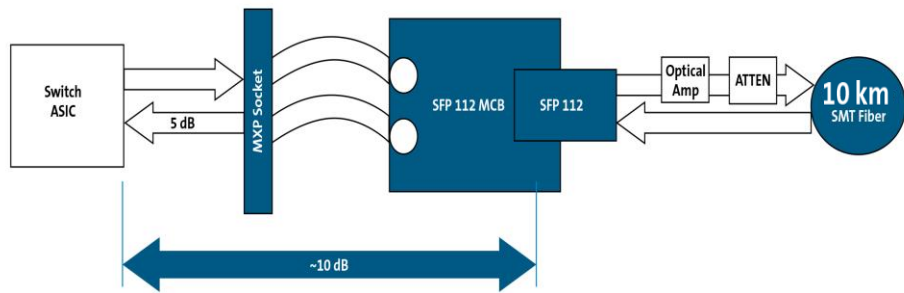
ASIC DSP Capability MUCH BETTER than reference receivers in sub-links



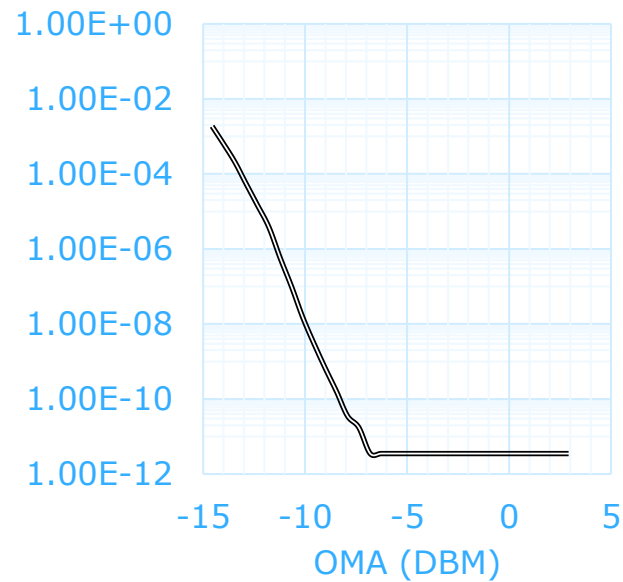
* MACOM estimates

Linear SFP56 vs DSP SFP56

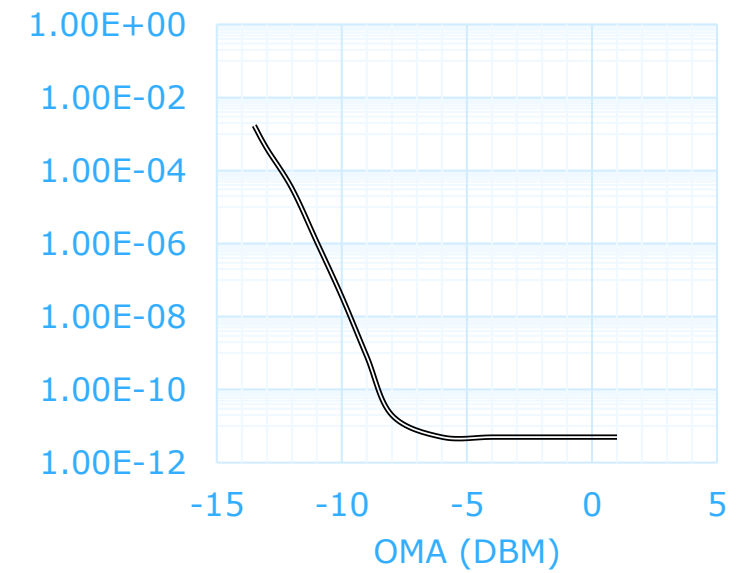
	Linear SFP56 (EML Cooled)	DSP SFP56 (DML Uncooled)
Power Consumption	1.26 W Typical (1.5W Max, I-temp)	1.8 W Typical (2.5W Max)
TDECQ	0.7 dB	0.7 dB
Sensitivity (at 2.4E-4 Pre-FEC)	-13 dBm	-13 dBm
Error Floor (Pre-FEC)	Better than E-12	Better than E-12
SFP56 Latency	~0.05 ns	100 ns



Linear Setup



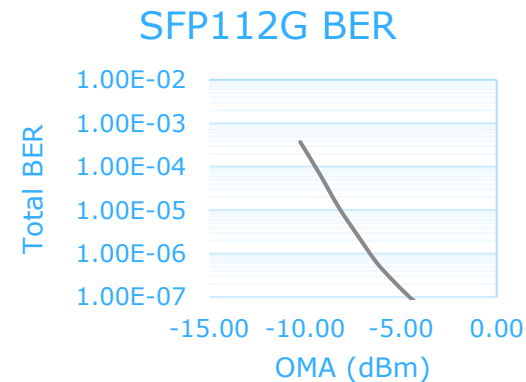
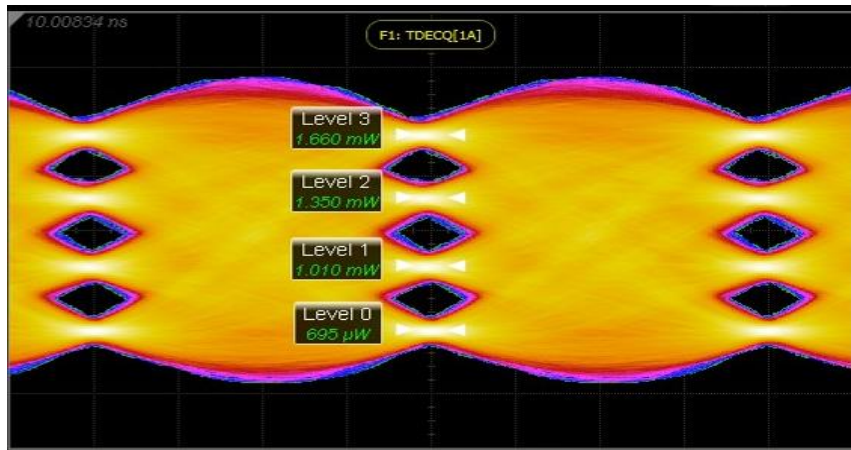
— 10km SMF



— Point Blank

Linear SFP112 (and Beyond)

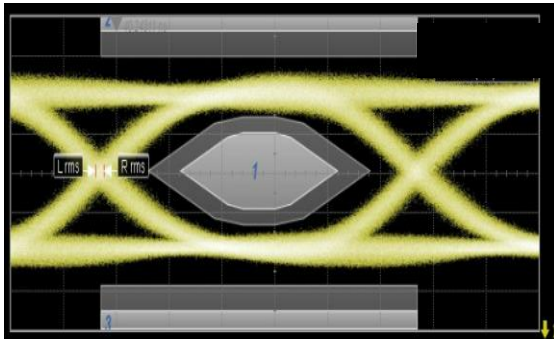
	Linear SFP112 (EML Cooled)	Linear SFP224* (EML Cooled)
Power Consumption	<1.5W Max, I-temp	<1.5W
TDECQ	2dB	~802.3dj
Sensitivity (at 2.4E-4 Pre-FEC)	-10dBm	~802.3dj
Error Floor (Pre-FEC)	Better than E-8	Similar
SFP112 Latency	~0.05ns	Similar



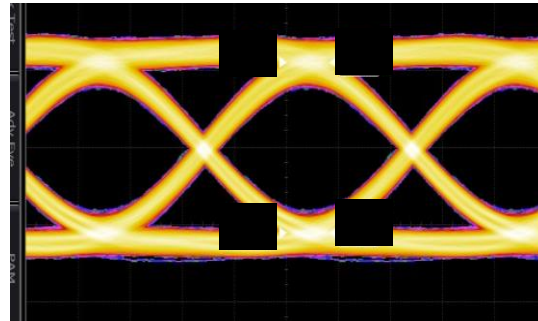
SFP112 Rate Agility & Delay Accuracy

Multi-rate operation is more straight forward without retiming

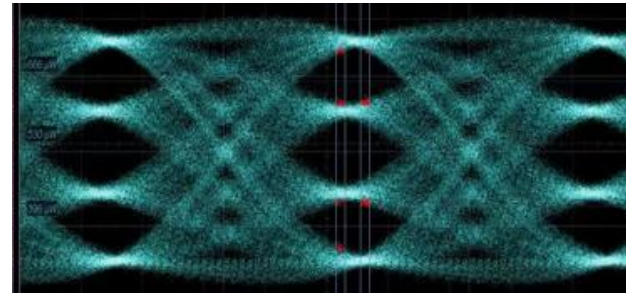
Latency through module $\ll 0.1\text{ns}$, meeting most stringent timing error budgets



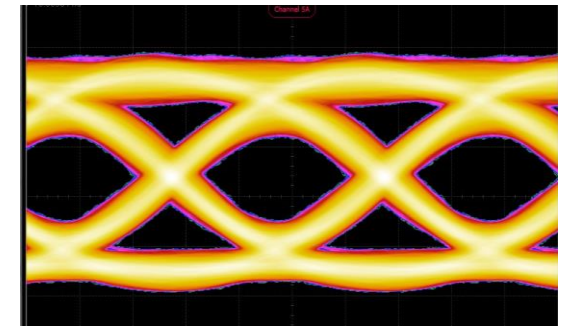
SFP112G Module Operating at 10G



SFP112G Module Operating at 26G



SFP112G Module Operating at 26GBAUD PAM 4



SFP112G Module Operating at 50G NRZ

	Class A.10	Class A.20	Class B.10	Class B.20	Class C.2	Class C.10
Max constant time error budget allocated to one pluggable	+/- 5 ns ✓	+/- 10 ns ✓	+/- 2 ns ✓	+/- 4 ns ✓	+/- 0.2 ns ✓	+/- 1 ns ✓
	$\Delta T_{max} = +/- 5\text{ns}$	$\Delta T_{max} = +/- 10\text{ns}$	$\Delta T_{max} = +/- 2\text{ns}$	$\Delta T_{max} = +/- 5\text{ns}$	$\Delta T_{max} = +/- 0.2\text{ns}$	$\Delta T_{max} = +/- 1\text{ns}$
	$\Delta r_{max} = +/- 5\text{ns}$	$\Delta r_{max} = +/- 10\text{ns}$	$\Delta r_{max} = +/- 2\text{ns}$	$\Delta r_{max} = +/- 5\text{ns}$	$\Delta r_{max} = +/- 0.2\text{ns}$	$\Delta r_{max} = +/- 1\text{ns}$

Table APB.2: Proposed optical pluggable classes.

Source: https://mopa-alliance.org/wp-content/uploads/2024/03/MOPA_Tight-Sync_Paper-v1.0.pdf

LPO-MSA Diagnostic White Paper

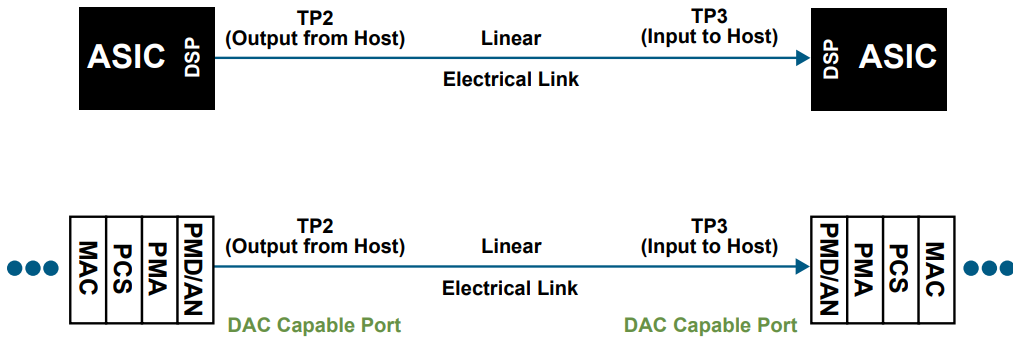


Figure 2: Passive Copper (DAC) Link

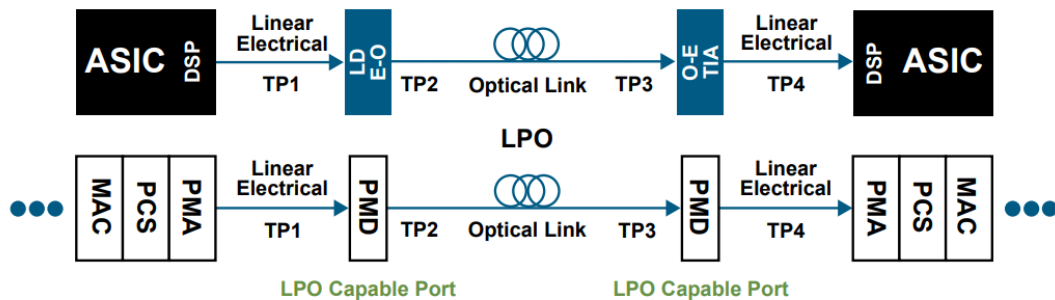


Figure 1b. LPO Link

LPO MSA Diagnostics Overview

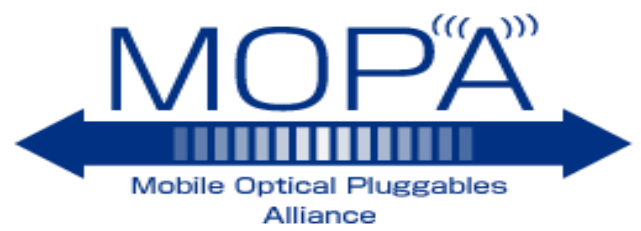
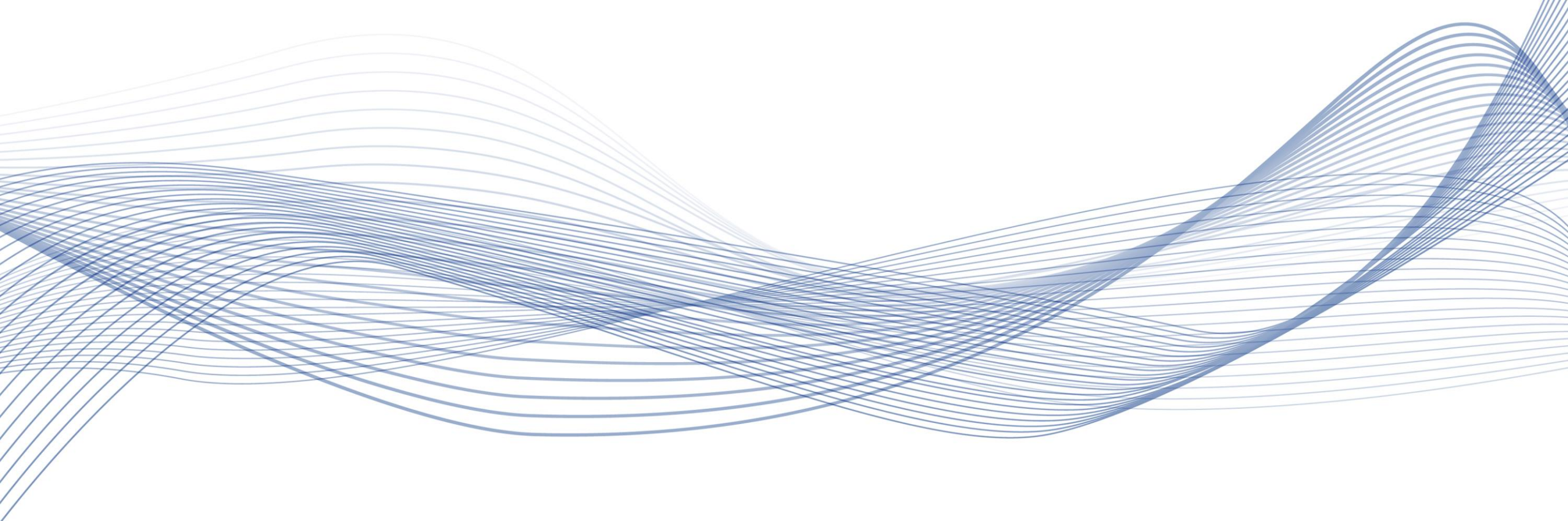


Diagnostic Feature	DAC	LPO	Retimed (DSP)
Tx LOS	N/A	Yes	Yes
Tx Output Disable	Yes, via Host ASIC	Yes	Yes
Tx Optical Output	N/A	Yes	Yes
Laser Bias Flags	N/A	Yes	Yes
Rx LOS	Yes, via Host ASIC	Yes	Yes
Rx Optical Input	N/A	Yes	Yes
Module Temp / Voltage	N/A	Yes	Yes
Tx & Rx LOL	N/A	N/A (no retiming in Module)	Yes (retimers have LOL events)
Segmented SNR / FEC Statistics	No	No	Yes
End-End Link SNR/FEC/S21 Statistics	Yes	Yes	No
Media SNR	Yes, via Host ASIC	Yes, from Host ASIC	Yes, Segmented
Media FEC Statistics	Yes, via Host ASIC	Yes, from Host ASIC	Yes, Segmented
MPI Detection (Optical Reflections)	N/A	Yes, from Host ASIC	Yes, Segmented
Signal Loopback	No	No	Yes
PRBS Gen/Check	Yes, via Host ASIC	Yes, from Host ASIC	Yes, Segmented

Source: <https://www.lpo-msa.org/home/specifications-and-white-papers.html>

Conclusion

**MOPA Community has a long history of optimizing interconnect
LPO represents an important opportunity for minimizing cost and power
Mobile Access community can re-purpose technology developed for DC / AI to
offer next generation connectivity**



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