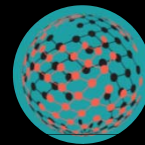




25GbE SMF 40km Technical Feasibility Review And Approach To Specification

Kohichi Tamura, Oclaro



Supporters/Contributors

- Peter Stasser, Huawei
- Kiyo Hiramoto, Oclaro
- Eiji Yoshida, NEL

Background / Outline:

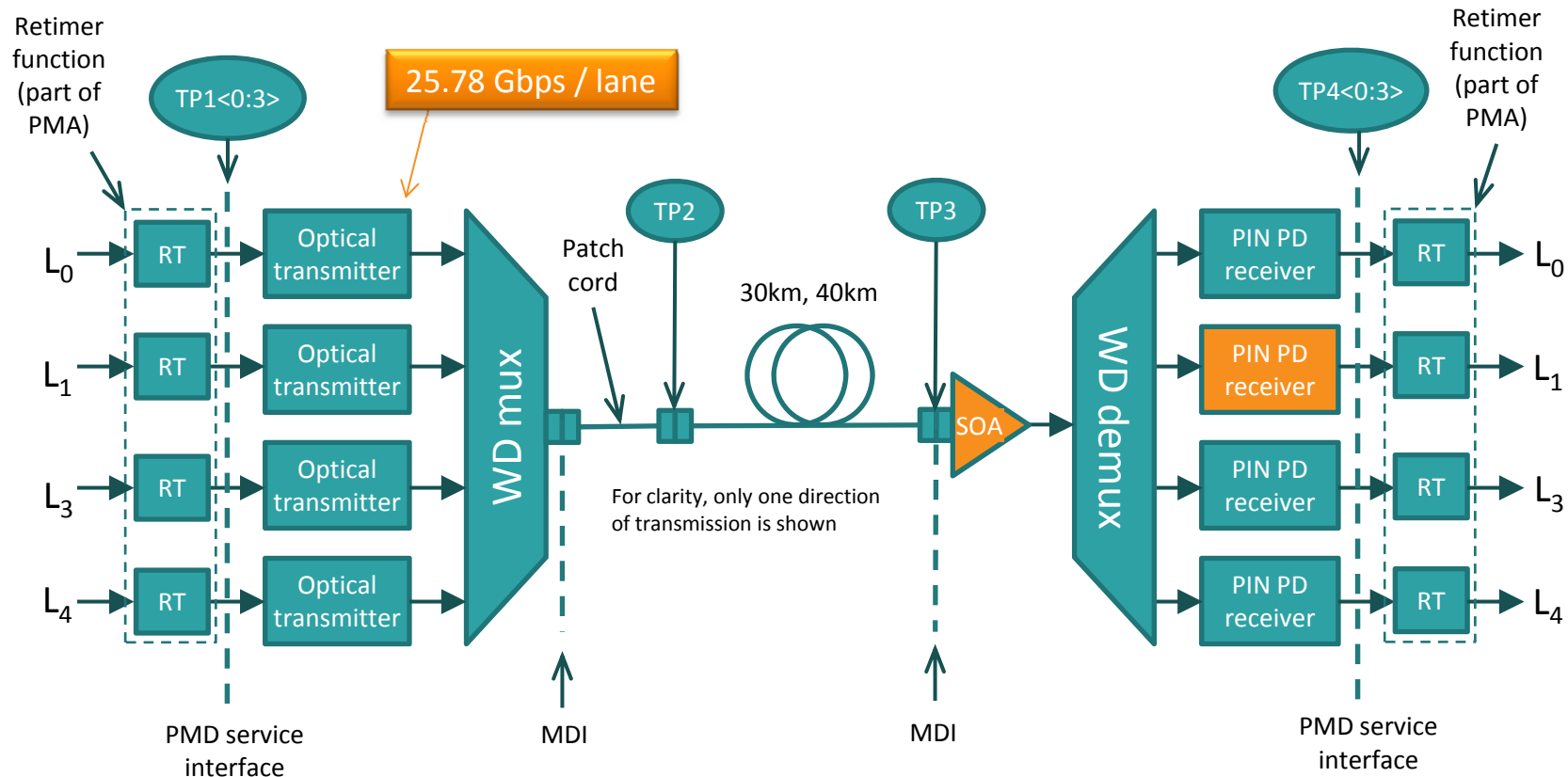
- Background:

1. For 25GbE SMF 10km objective, Fibre Channel specification suitable for SFP exists for 28Gbps over 10km with RS-FEC (32GFC) → Can use as basis for 25GbE SMF 10km specification with RS-FEC
2. For 25GbE SMF 40km objective, useful to review existing or proposed 100G (4x25G) 40km specifications to verify technical feasibility
3. 25GbE SMF modules should work in same SFP28 ports as 25GBASE-SR defined in 802.3by (Clause 112) → Require RS-FEC
 1. RS-FEC defined in 802.3by (Clause 108)
 2. BER requirement is $<5 \times 10^{-5}$ for 25GBASE-SR (Clause 112.1.1)

- Outline:

1. Review existing (proposed) optical specifications for 100G (4x25G) at 40km.
2. Review technical feasibility data of 100G (4x25G) at 40km taken with APD receiver.

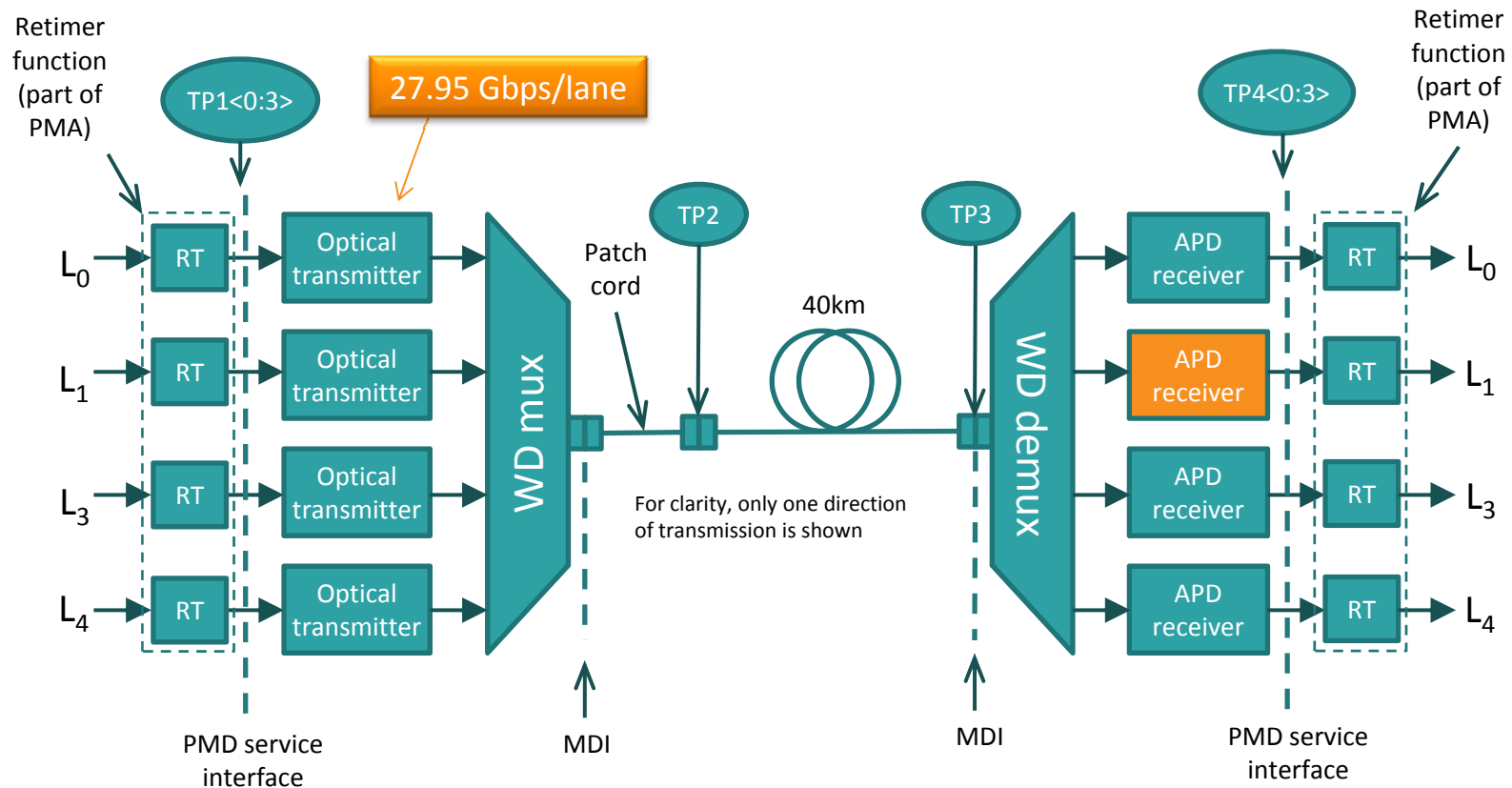
100G 40km Ethernet Specification (100GBASE-ER4)



Block diagram of transmit / receive paths assumed in specification
(modification of Figure 88-2 of IEEE Standard for Ethernet)

Specification assumes SOA (high power, high cost) → Not suitable for 25GbE 40km in SFP

100G 40km With APD Receiver (Proposed To ITU)



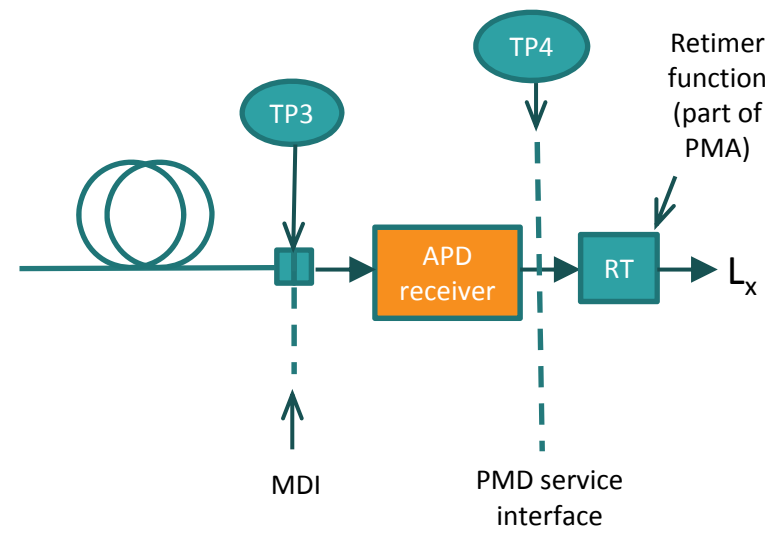
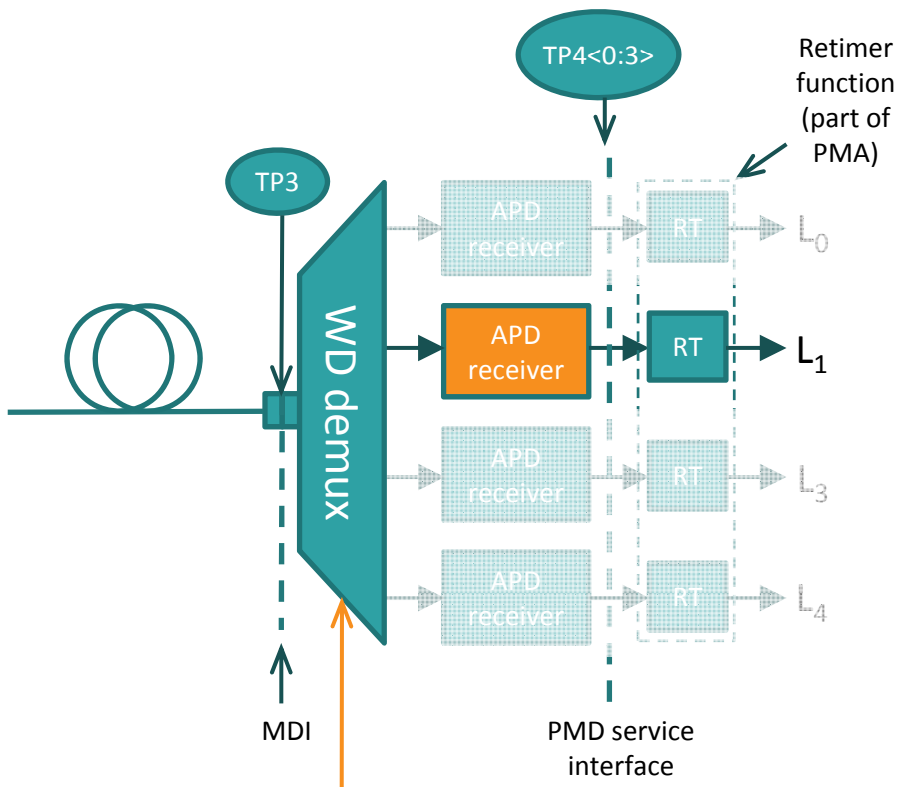
Block diagram of transmit / receive paths assumed in specification
 (modification of Figure 88-2 of IEEE Standard for Ethernet)

APD-based receiver eliminates SOA → Suitable for 25GbE 40km in SFP

Receiver Comparison For 100G And 25G At 40km

100G

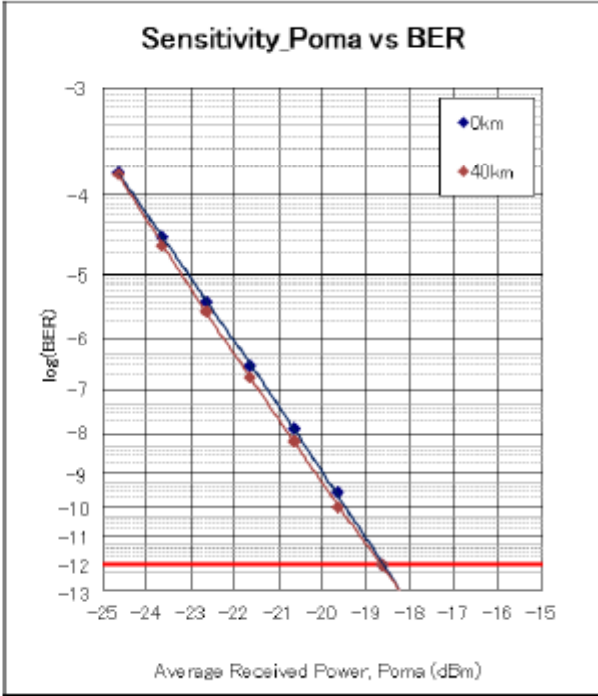
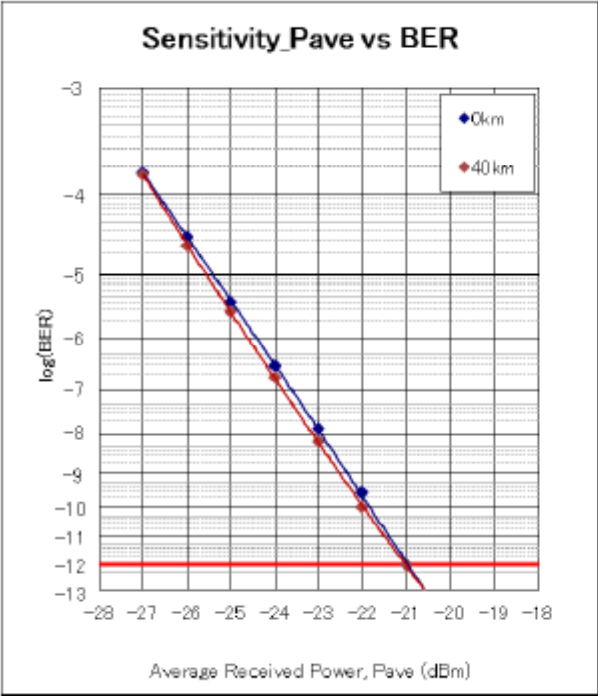
25G



Loss budget of ~2 dB → Could use as margin in 25GbE SMF 40km specification

25G APD Demonstration Over 40km SMF

There is no degradation after 40 km transmission



Measuring Condition
Tx: EML, Ex 11dB
25.78Gbps, 1309nm, PRBS=2³¹-1, Vapd=21.2V, RT

Courtesy: NTT Electronics

Example Of 112G 40km Specification With APD Receiver

Parameters	Unit	Proposed to ITU In 4L1-9D1F* (One Lane)	
		Low ER	High ER
T_x OMA (min)	dBm	1.85	1.85
T_x P_{avg} (min)	dBm	2.5	0.6
T_x ER (min)	dB	4	7
R_x OMA (min)	dBm	-16.1	-16.1
R_x P_{avg} (min)	dBm	-15.5	-17.4
R_x Sens OMA (max)	dBm	-17.6	-17.6
R_x Sens P_{avg} (max)	dBm	-17.0	-18.9
Penalties	dB	1.5	1.5
Loss Budget	dB	18	18

* With G.709 FEC

Could use same OMA specifications
(green) for 25GbE over 40km

Red bold: Explicit spec.

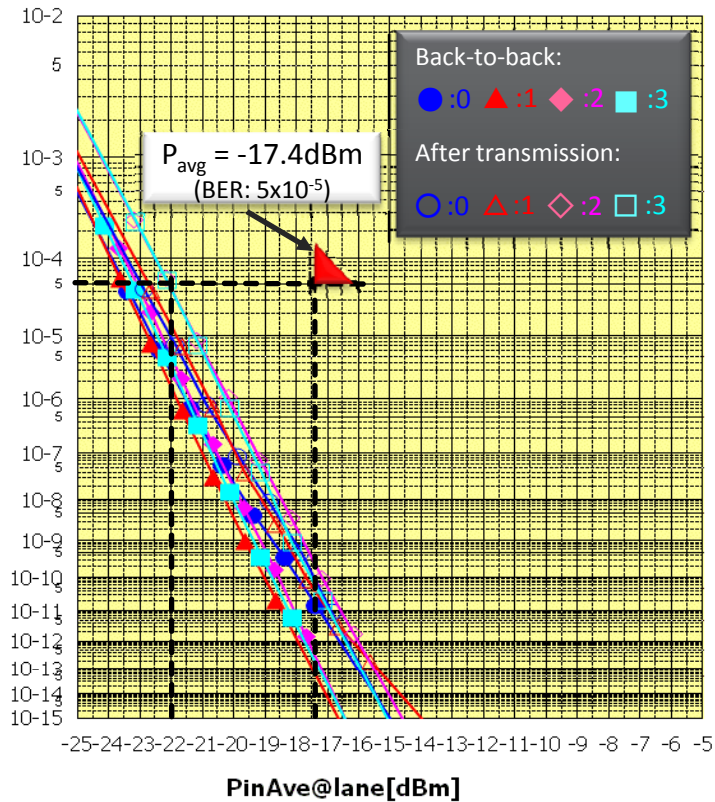
Black: Inferred spec.

Note: ITU spec not finalized.

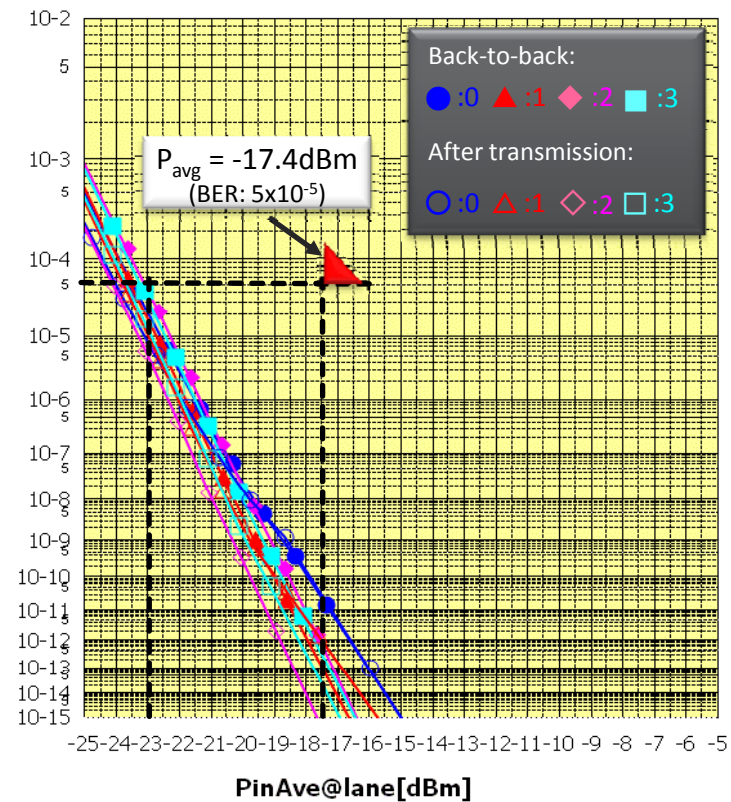
Technical Feasibility Of 40km With EML + APD

- Data under review in ITU-T SG15 for 4L1-9D1F in G.959.1

Positive Dispersion Limit



Negative Dispersion Limit



25GBASE-SR BER (Clause 112.1.1): $< 5 \times 10^{-5}$

100GBASE-ER4 Channel Characteristics

Description	100GBASE-ER4		Unit
Operating distance (max)	30	40	km
Channel insertion loss ^{a,b} (max)	18	18	dB
Channel insertion loss (min)	0		dB
Positive dispersion ^b (max)	28	36	ps/nm
Negative dispersion ^b (min)	-85	-114	ps/nm
DGD_max	10.3	10.3	ps
Optical return loss (min)	21	21	dB

Channel insertion loss and dispersion values in Ethernet are similar to ITU.

^aChannel insertion loss includes cables, connectors, and splices

^bOver the wavelength range of 1294.53 nm to 1310.19 nm

Channel insertion loss assumptions:

- Fiber loss: 0.43 dB/km at 1295nm
 - 0.43 dB/km x 30 km = 12.9 dB
 - 0.43 dB/km x 40 km = 17.2 dB
- Connector/splice loss: 2dB total (average of 0.5dB/connection)
- 40 km is engineered link i.e. same power budget as 30 km

Summary / Conclusion

1. 25GbE over 40km in SFP is technically feasible using APD receiver
2. Specification could be based on one lane of 112G (4x28G) 40km specification proposed in ITU (4L1-9D1F)

Comparison of 100G 40km Specifications

Parameters	Unit	Proposed to ITU In 4L1-9D1F*		100GBASE- ER4**
		Low ER	High ER	
T _X OMA (min)	dBm	1.85	1.85	0.1
T _X P _{avg} (min)	dBm	2.5	0.6	-2.9
T _X ER (min)	dB	4	7	8
R _X P _{avg} (max)	dBm	-3	-4.1	4.5
R _X OMA (min)	dBm	-16.1	-16.1	-17.9
R _X P _{avg} (min)	dBm	-15.5	-17.4	-20.9
R _X Sens OMA (max)	dBm	-17.6	-17.6	-21.4
R _X Sens P _{avg} (max)	dBm	-17.0	-18.9	-
Penalties	dB	1.5	1.5	3.5
Loss Budget	dB	18	18	18

* With G.709 FEC

** Clause 88: BER of 10⁻¹²

Could use same OMA specifications (green) for 25GbE over 40km

Red bold: Explicit spec.

Black: Inferred spec.

Note: ITU spec not finalized.