Proposed IEEE 802.3cz PMD, MDI and Media Baseline Text for 10G and 25G O-band

Ichiro Ogura, PETRA
Kazuhiko Kurata, AIO Core
Richard Pitwon, Resolute Photonics

IEEE 802.3cz Multigigabit Optical Automotive Ethernet Interim Task Force

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Supporters

- Shigeru Kobayashi, AIO Core
- Hideki Isono, Fujitsu Optical Components
- Takeo Masuda, OITDA/PETRA
- Hiroshi Sawano, OITDA
- Satoshi Takahashi, POF Promotion
- Mabud Choudhury, OFS
- Tomohiro Kikuta, Adamant Namiki Precision Jewel
- Yasuhiro Hyakutake, Adamant Namiki Precision Jewel
- Masayuki Iwase, Furukawa Electric
- Keisuke Kawahara, Furukawa Electric
- Masato Shiino, Furukawa Electric

Contributions on silicon photonics in 802.3cz TF

Ref #	Date	Title
[1]	**November 2019**	Introduction of SI Photonics transceiver technology with high temperature operation capability and MMF transmission
[2]	**January 2020**	A study for highly-reliable optical transceiver based on Si Photonics technology
[3]	**January 2021**	Thoughts on PMD baseline proposal for automobile based on Si-Photonics
[4]	**March 2021**	A proposal of Si-photonics for automobile
[5]	**March 2021**	Photonics for Automotive - Response to Proposal Assumptions
[6]	**April 2021**	Thoughts on interoperable PMD
[7]	**June 2021**	Status of silicon photonics reliability test
[8]	**July 2021**	Status of silicon photonics link budget

Relevant publications

Scientific papers

i. Kurata, K. et al., “Short reach, low-cost silicon photonic micro-transceivers for embedded and co-packaged system integration,” Proc. SPIE 11286, Optical Interconnects XX, 112860R (28 February 2020); https://doi.org/10.1117/12.2546626

ii. Pitwon, R. et al., "Hyperscale Integrated Optical and Photonic Interconnect Platform," 2020 IEEE Photonics Conference (IPC), Vancouver, BC, Canada, 2020, pp. 1-2, doi: 10.1109/IPC47351.2020.9252246.

iii. Nakamura, T. et al., “Fingertip-Size Optical Module, “Optical I/O Core”, and Its Application in FPGA” IEICE TRANSACTIONS on Electronics, Vol.E102-C, No.4, pp.333-339

iv. Mogami, T. et al., "1.2 Tbps/cm2 Enabling Silicon Photonics IC Technology Based on 40-nm Generation Platform," J. Lightwave Technol. 36, 4701-4712 (2018)

v. K. Kurata, I. Ogura, K. Yashiki and Y. Suzuki, "Chip-scale si-photonics optical transceiverfor a photonics-electronics convergence system (invited paper)," 2016 Tenth IEEE/ACM International Symposium on Networks-on-Chip (NOCS), Nara, Japan, 2016, pp. 1-6, doi: 10.1109/NOCS.2016.7579338.

Market Research Reports

vi. Yole Developpement report Silicon Photonics 2021

vii. LightCounting Integrated Optical Devices Report (May 2021)

Overview

- This contribution is a baseline proposal for the PMD and MDI for 10 Gb/s and 25 Gb/s consistent with contributions [1] – [8]

- The format and text has been adapted from the PMD/MDI/Media baseline text provided by Steven Swanson to ensure full compatibility and ease of insertion into a single baseline text (swanson_3cz_02c_0803_AUTO_MDI_Baseline.pdf)

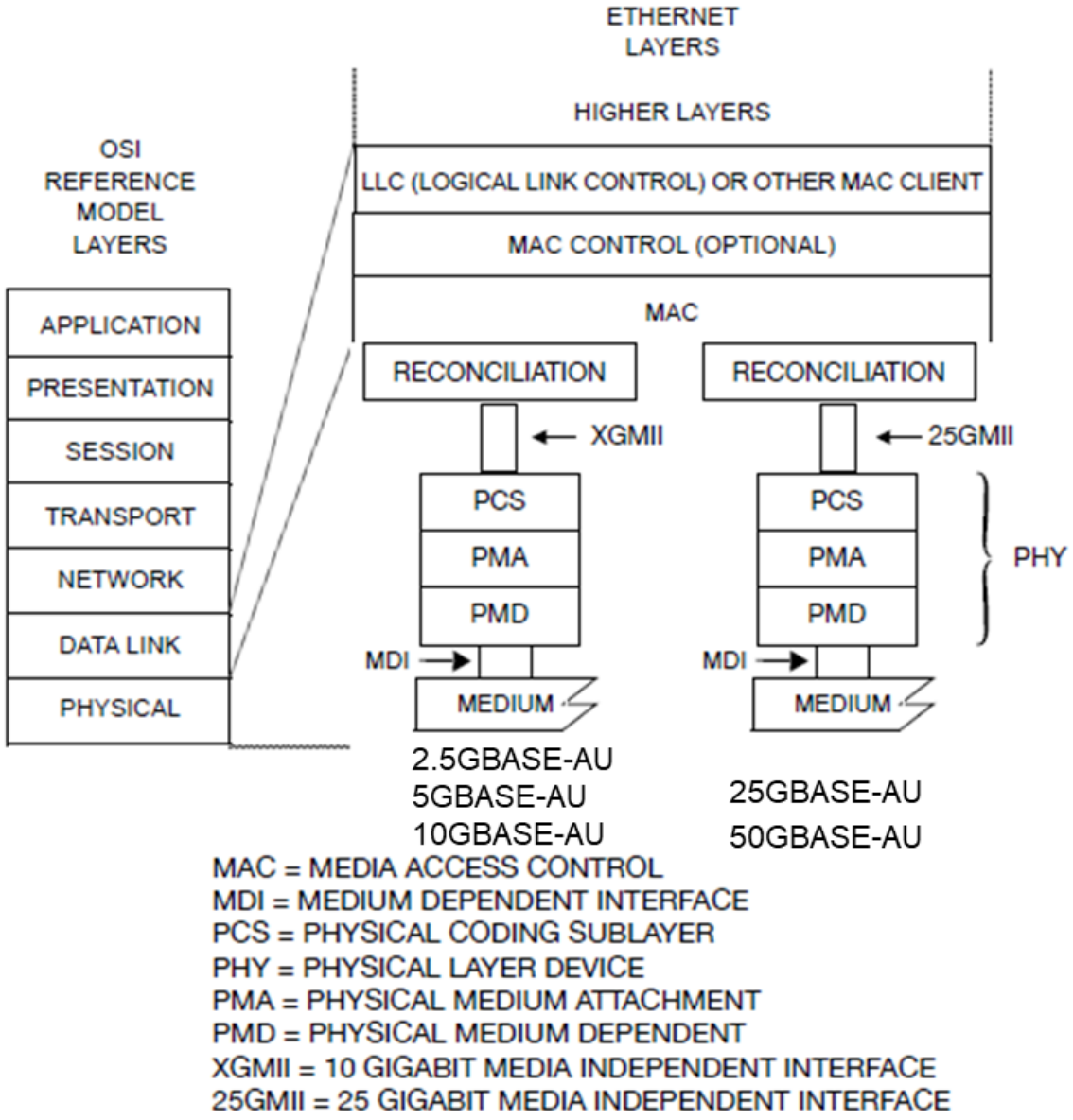
- Proposed PMD designations: **10GBASE AUO** and **25GBASE AUO** ('O' refers to O-band)

Physical layer specification objectives

- Define the performance characteristics of an automotive link segment and an optical PHY to **support 10 Gb/s** point-to-point operation over this link segment supporting up to **4 inline connectors for at least 40 m** on at least one type of automotive optical cabling
- Define the performance characteristics of an automotive link segment and an optical PHY to **support 25 Gb/s** point-to-point operation over this link segment supporting up to **4 inline connectors for at least 40 m** on at least one type of automotive optical cabling

Reference model

Relationship of 802.3cz PMDs to the ISO/IEC OSI reference model and the IEEE 802.3 Ethernet Model



PMD to MDI optical specifications

166.7 PMD to MDI optical specifications for 25GBASE-AUO

The operating range for the 25GBASE-AUO PMD is defined in Table 166–7. A compliant PMD operates on 50/125 µm multimode fibers, type A1-OM3 according to the specifications defined in Table 166–14. A PMD that exceeds the operating range requirement while meeting all other optical specifications is considered compliant (e.g., a 25GBASE-AUO PMD operating at 60 m meets the operating range requirement of 0.5 m to 40 m).

Table 166-7 Operating range

PMD	Required operating range
2.5GBASE-AU 5GBASE-AU 10GBASE-AU 10GBASE-AUO 25GBASE-AU 25GBASE-AUO 50GBASE-AU	0.5- 40m

Illustrative power budget

166.7.1 Illustrative link power budget

The illustrative power budget and penalties for 10GBASE-AUO and 25GBASE-AUO channels are shown in Table 166-10.

Table 166-10 Illustrative link power budget

Parameter	BASE-AU					BASE-AUO		Units
Data rate	2.5G	5G	10G	25G	50G	10G	25G	bps
Effective modal bandwidth			950			800		MHz▪km
Power budget	17.30	14.30	10.80	8.70	5.10	9.0	8.0	dB
Operating distance			40			40		m
Channel insertion loss [a]	10.28	10.28	10.28	8.28	4.28	8.28	6.28	dB
Allocation for penalties [b]	0.35	0.35	0.35	0.30	0.70	0.3	1.42	dB
Additional insertion loss allowed	6.67	3.67	0.17	0.12	0.12	0.42	0.3	dB

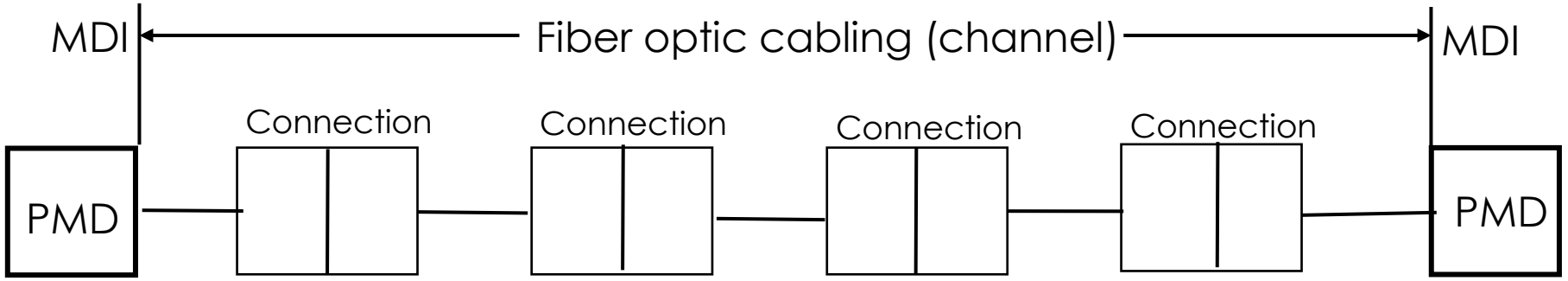
Cabling model

166.8 Fiber optic cabling model

The fiber optic cabling (channel) contains 1 optical fiber for each direction to support 2.5GBASE-AU, 5GBASE-AU, 10GBASE-AU, 10GBASE-AUO, 25GBASE-AU, 25GBASE-AUO and 50GBASE-AU, respectively. The fiber optic cabling interconnects the transmitter(s) at the MDI on one end of the channel to the receiver(s) at the MDI on the other end of the channel.

166.8.1 Fiber optic cabling model

The fiber optic cabling model is shown in Figure 166–5.



Note – The 50GBASE-AU power budget is based on 2 in-line connectors at 2.0 dB/connection. 4 in-line connections may be supported with lower loss connections.

Figure 166-5 Fiber optic cabling model

Cabling model (continued)

166.8 Fiber optic cabling model

The maximum channel insertion loss is given in Table 166–14. A channel may contain additional connectors as long as the optical characteristics of the channel (such as attenuation, modal dispersion, reflections and losses of all connectors and splices) meet the specifications.

Table 166-14 Channel Insertion Loss

Description	BASE-AU					BASE-AUO		Units
Data rate	2.5G	5G	10G	25G	50G	10G	25G	
Nominal wavelength	980					1310		nm
Operating distance (max.)	40					40		m
Channel insertion loss (max.)	10.28	10.28	10.28	8.28	4.28	8.28	6.28	dB

Characteristics of the fiber optic cabling

166.8.2 Characteristics of the fiber optic cabling (channel)

The fiber optic cabling shall meet the specifications defined in Table 166-14. The fiber optic cabling consists of one or more sections of fiber optic cable and any intermediate connections required to connect sections together.

166.8.2.1 Optical fiber and cable

The fiber shall meet the requirements of IEC 60793-2-10 or the requirements of Table 166-15 where they differ for fiber subcategories A1-OM3 (50/125 µm multimode).

Table 166-15

Description	BASE-AU	BASE-AUO	Units
Fiber sub-category	50 µm A1-OM3	50 µm A1-OM3	
Nominal wavelength	980	1310	nm
Cabled optical attenuation (max.)	2.0	2.0	dB/km
Modal bandwidth	950	800	MHz·km
Zero dispersion wavelength λ_0	1328		nm
Dispersion slope (max.) S_0	.093477		ps/nm^2·km

Optical fiber connection

166.8.2.2 Optical fiber connection

An optical fiber connection, as shown in Figure 166-5, consists of a mated pair of optical connectors.

166.8.2.2.1 Connection insertion loss

The insertion loss is specified for a connection, which consists of a mated pair of optical connectors.

The maximum link distances for multimode fiber are calculated based on an allocation of 4.0 dB total connection loss for 50GBASE-AU, 8.0 dB total connection loss for 25GBASE-AU operation, 5GBASE-AU and 2.5GBASE-AU, and **6.0 dB for 25GBASE-AUO** and **8.0 dB for 10GBASE-AUO**.

For example, this allocation for **10GBASE-AUO / 25GBASE-AUO** supports four connections with a maximum insertion loss equal to **2 dB / 1.5 dB** per connection, or two connections with an insertion loss of **4.0 dB / 3.0 dB** per connection respectively.

Connections with different loss characteristics may be used provided the requirements of Table 166-14 are met.

Medium Dependent Interface (MDI) requirements

166.8.3 Medium Dependent Interface (MDI) requirements

The PMD is coupled to the fiber optic cabling at the MDI.

The MDI is the interface between the PMD and the "fiber optic cabling" (as shown in Figure 166–5).

Examples of an MDI include the following:

a) PMD with a connectorized fiber pigtail plugged into an adapter;

b) PMD receptacle

Note —Compliance testing is performed at TP2 and TP3 as defined in 166.5.1, not at the MDI.

Q&A

Power budget calculation

	Ruben		25GBASE-AUO
Insertion loss per inline connection, ILIC max (dB)	2	F	1.5
Number of inline connections (NIC)	4	G 4	4
Fiber attenuation (dB/km)	2	K	2
Channel attenuation, ILTP2-to-TP3 , max (dB)	8.28	L = (F × G) + J + (40/1000 × K)	6.28
OMATP2 min (dBm)	−2	O = N − D	0
OMATP3 max (dBm)	−13.3	Q = P + E	−8
Power budget (dB)	11.3	R = O − Q	8
Allocation for modal noise (dB)	0.3	S	1.42
Unallocated margin (dB)	2.72	T = R − L − S 0.12	0.3