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Plastic Optical Fiber for Automobile

Yuji Watanabe , AGC Inc.

IEEE P802.3cz Multi-Gigabit Optical Automotive Ethernet Task Force
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Introduction

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Transmission capability at 25Gbps of GI-POF was reported at Ad Hoc teleconference (Sep. 29, 2020)

Environmental and mechanical evaluation results for automobile grade GI-POF are presented at this meeting

Merits of GI-POF for automobile industry is introduced from point of view of assembling and handling

Finally, link margin re-calculation based on contribution "Link budget analysis of 25 and 10 Gb/s using GI-POF" by Rubén Pérez-Aranda, KDPOF, is studied

Evaluation results

Test results

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Test	Condition	Result
Dry heat	105˚C x 2000 hrs	No degradation
Damp heat	85˚C 85%RH x 2000hrs	No degradation
Cold storage	-40˚C x 2000 hrs	No degradation
Bending loss	R=5 mm U turn	<0.1 dB
Cyclic flex	R=5 mm x 500K cycles	<0.1 dB
Compression load	L = 100 mm 1000N	<0.1 dB

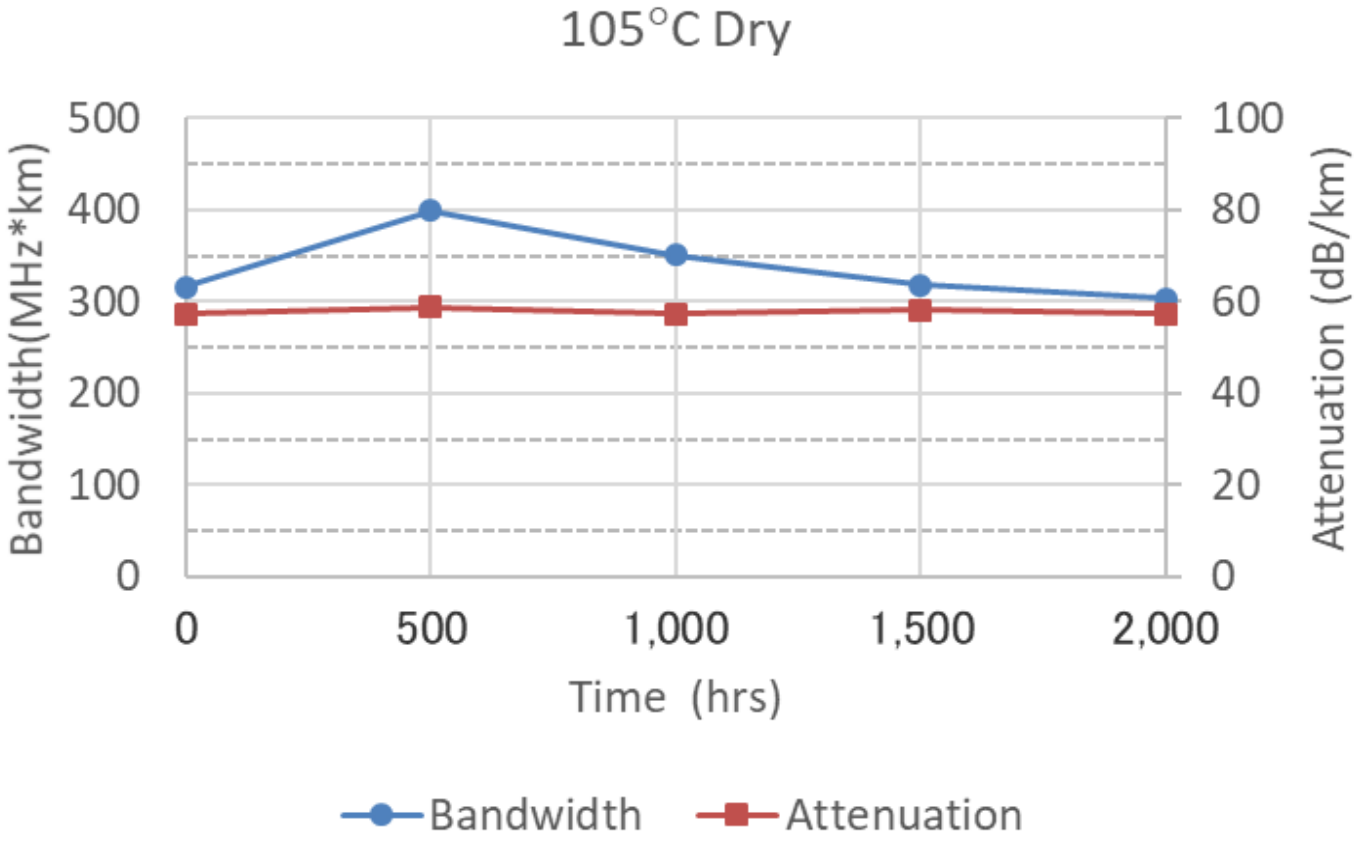
Environmental test

- No critical issue in 105˚C, damp heat at 85˚C 85%RH, and -40 ˚C

Mechanical test

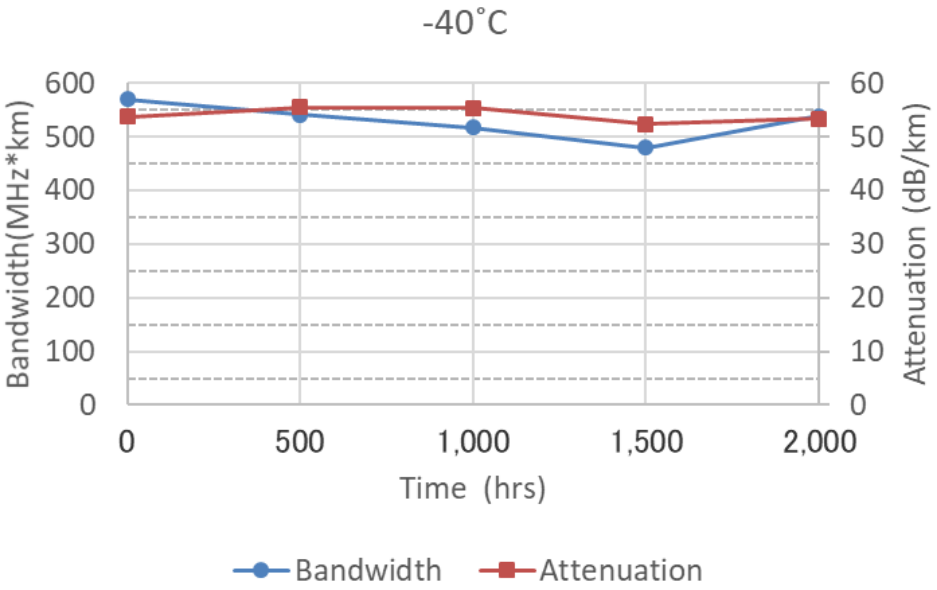
- No degradation

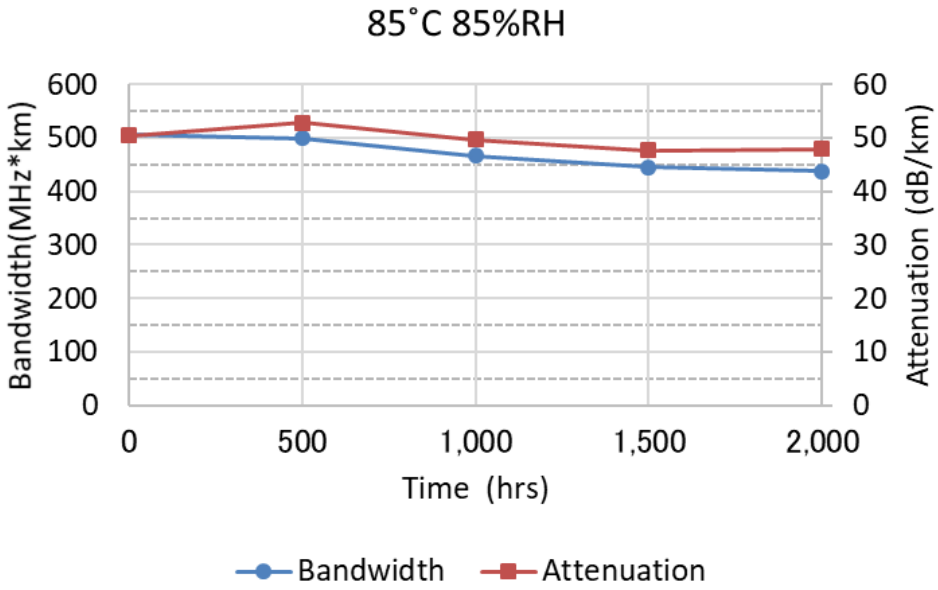
Environmental test results



Keep original bandwidth and attenuation after 2,000hrs at 105˚C

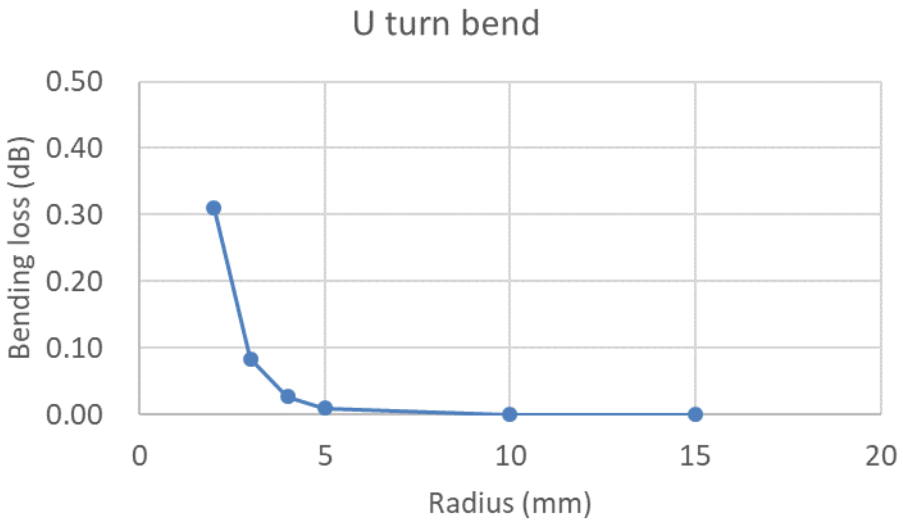
Environmental test results 2

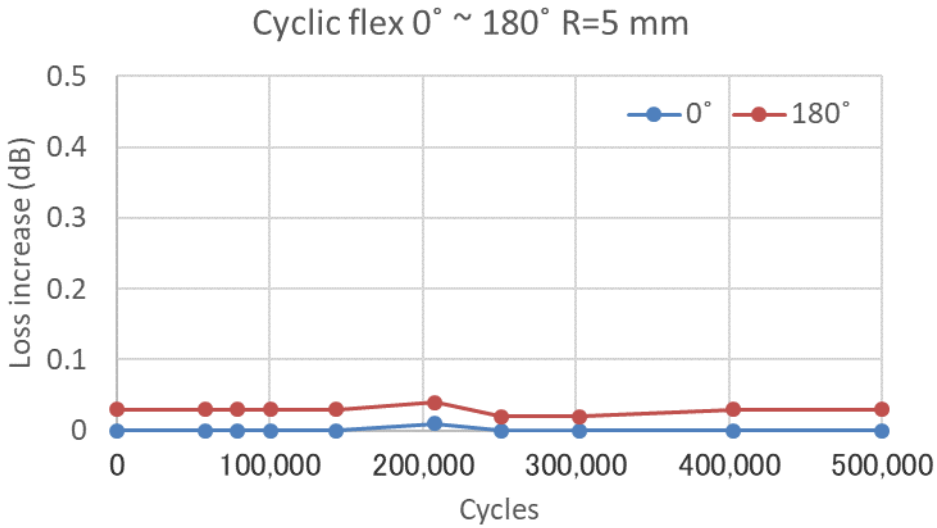


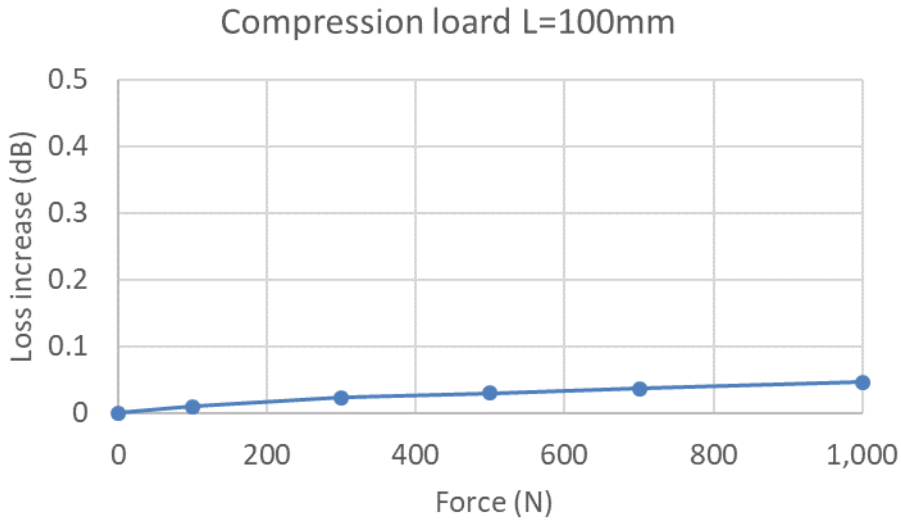


Also no degradation is found after 2,000 hrs at 85 ˚C 85%RH and -40 ˚C

Mechanical test results as Φ2 cable







- Low bending loss: <0.1dB R=5 mm
- No degradation after 500K flex cycles with R=5mm and 1000N loading with 100 mm width (assuming stepping on cable by a person who has 100 kg weight).

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POF in mobility

Application of POF in mobility

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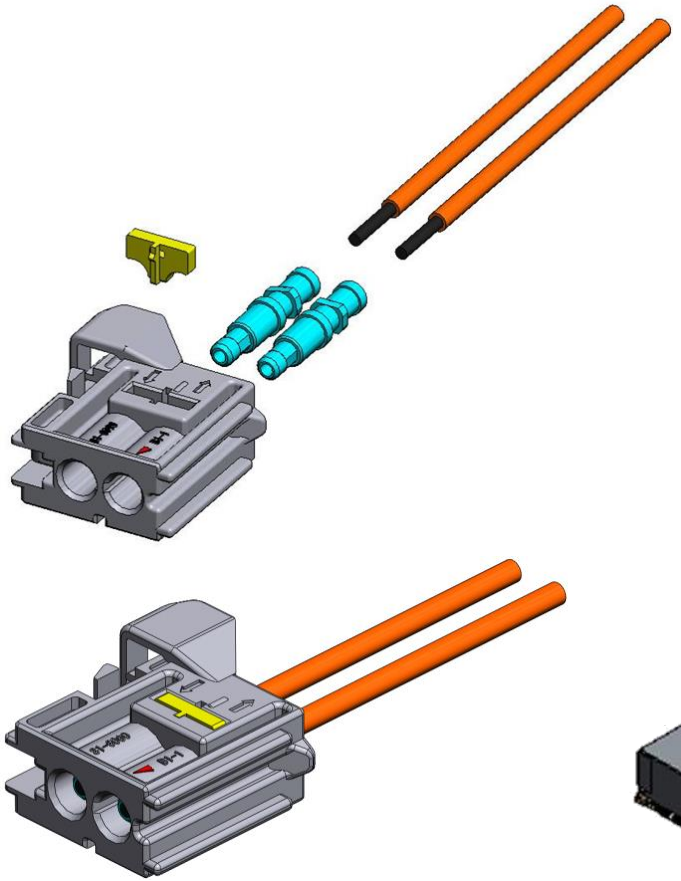
MOST COOPERATION

Source: MOST Cooperation

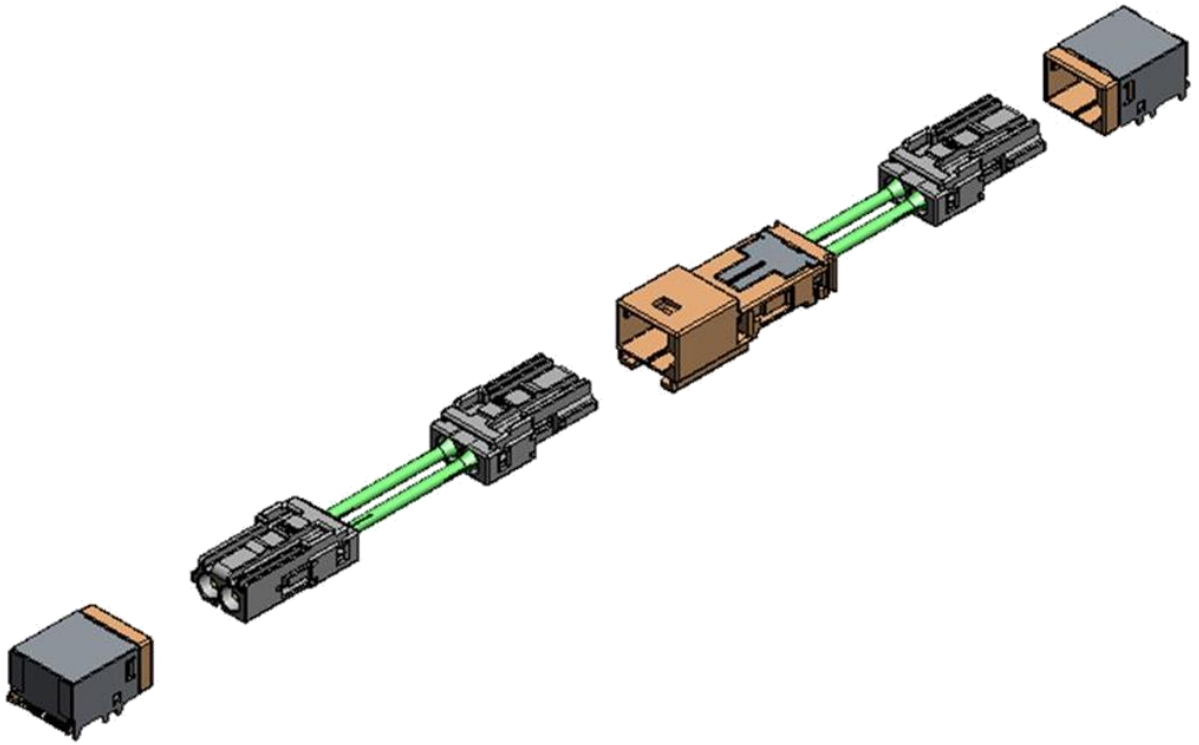
ARINC 629 in Boeing 777X

Besides bandwidth and EMI, easy termination and mechanical robustness are key motivation to apply POF in mobility.

Connectors



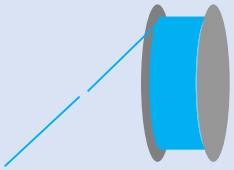
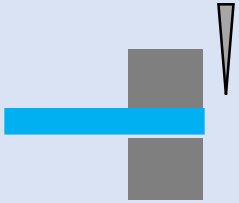
MOST Connector



Connector for GEPOF and GI-POF

- **>100M MOST nodes have been shipped for about 150 car models Similar design is applied to GEPOF and GI-POF**

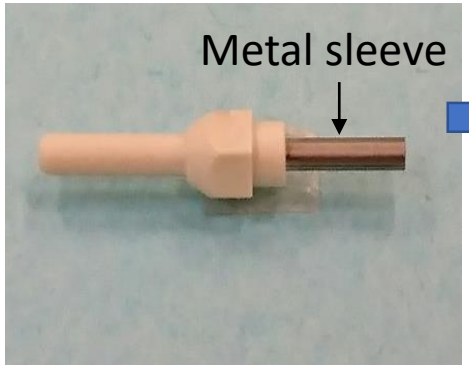
Assembling process for POF

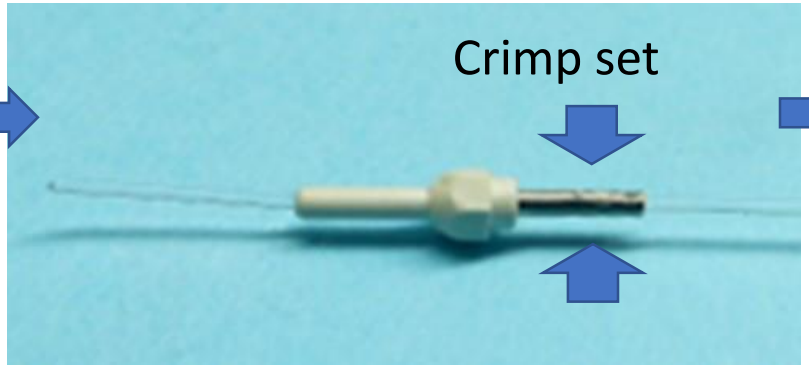
Process	1. Cable cut	2. Coating removal	3. Fiber insertion	4. Fixation	5. Fiber end processing
POF		No need			
	No risk generating sharp debris	Reduce process time	Special care is not needed (Fast)	Mechanical fixation (Fast)	Simple termination by milling etc. (Low cost)

- **No risk generating sharp debris during fiber cut (Occupational safety)**
- **Reducing process time (No coating removal, no risk of fiber break, mechanical fixation, fiber termination)**
- **No investment for expensive equipment such as laser cleaver**

Example of easy termination

- **Application: 1.25 Gbps industrial Ethernet (LC interface)**
- **Low cost plastic mold ferrule**
- **Mechanical fiber fixation (Crimp set without glue)**
- **No polishing, just milling fiber end face in a second**

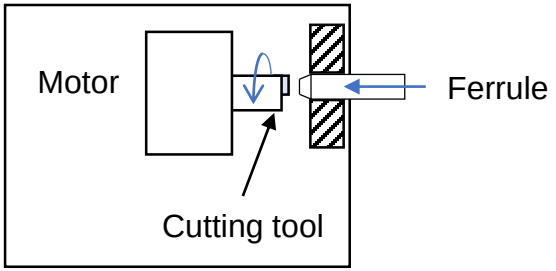




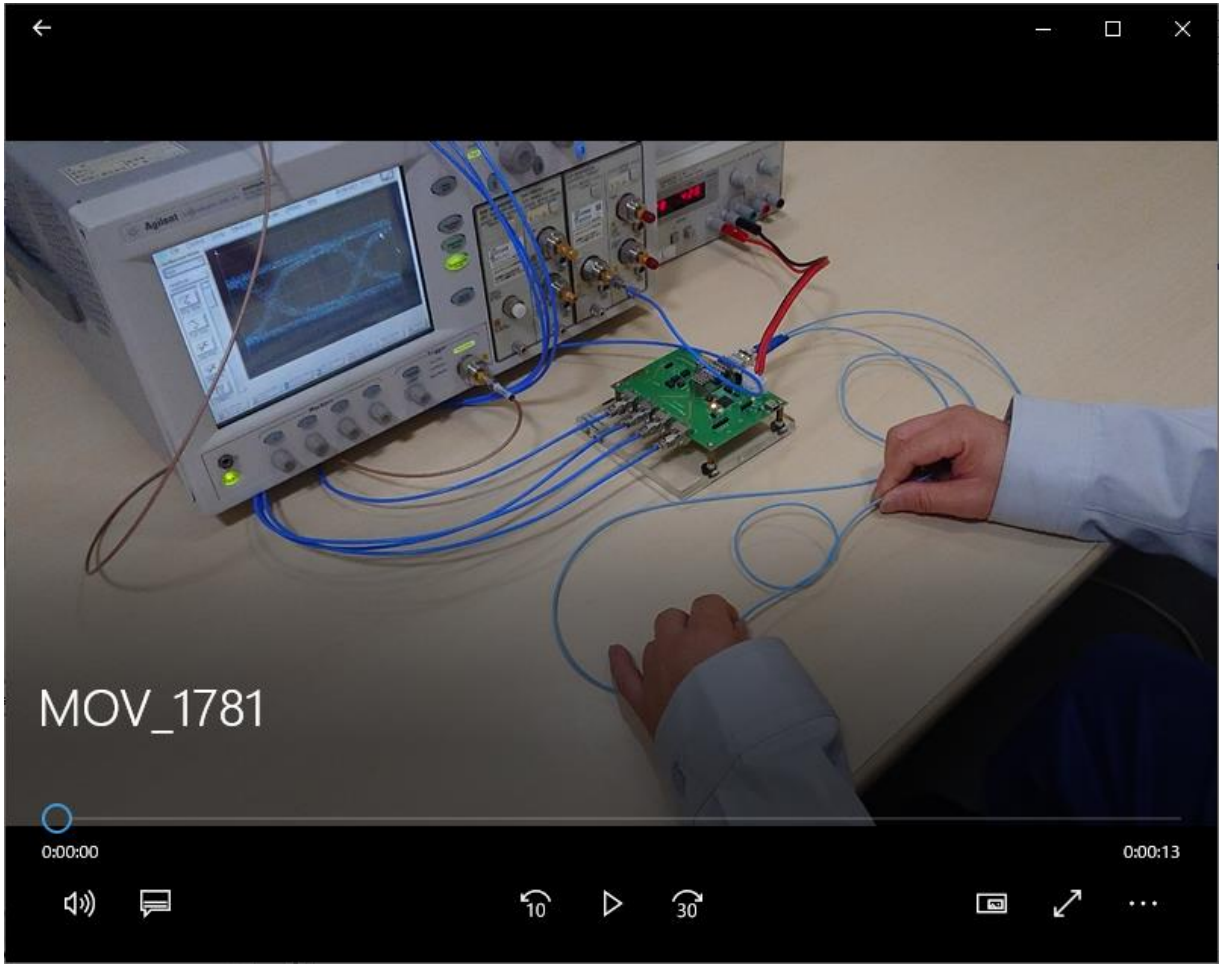
Plastic LC ferrule with metal sleeve

Crimp set (Mechanical fixation)

Milling fiber end with rotating cutting tool



Robustness



Knot test @10.3125Gbps

Merits of POF

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- **Easy termination: High production through put**
- **Simple fiber end face processing: No need to invest expensive equipment such as laser cleaver**
- **Robustness: Low risk of fiber break in assembling, installation and in service**
- **Safer for workers: No need to pay attention to fiber debris**
- **Possibility of BiDi : Reduce cable counts and weight (preferable for EV)**

Link margin analysis

Based on the contribution “Link budget analysis of 25 and 10 Gb/s using GI-POF” by Rubén Pérez-Aranda, KDPOF, Link margin is re-calculated with different fiber attenuation and connection loss

Worst-case spec. of GI-POF

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Type		Perfluorinated GI-POF
Operation temperature range (°C)		-40 ~ 105
Core dia.(μm)		55
Fiber dia.(μm)		490
NA		0.22
Attenuation (dB/km)	at 850 nm	≤ 100
	at 980 nm	≤ 85
Bandwidth (EMBc) (MHz*km)	At 850 and 980 nm	≥ 200

Same transceiver can be applicable to GOF and POF, because POF has;

- Similar core diameter and NA as GOF
- Same operation wavelength (850 nm and 980 nm)

Link budget re-calculation

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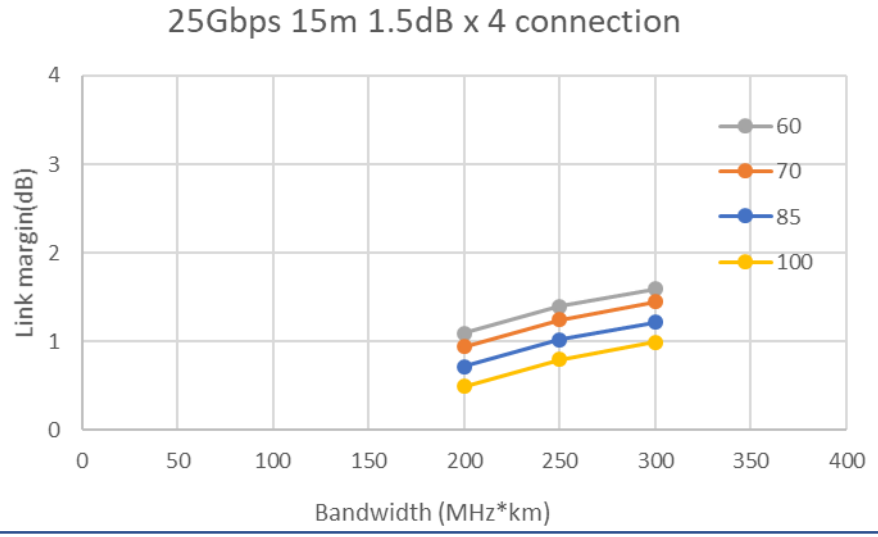

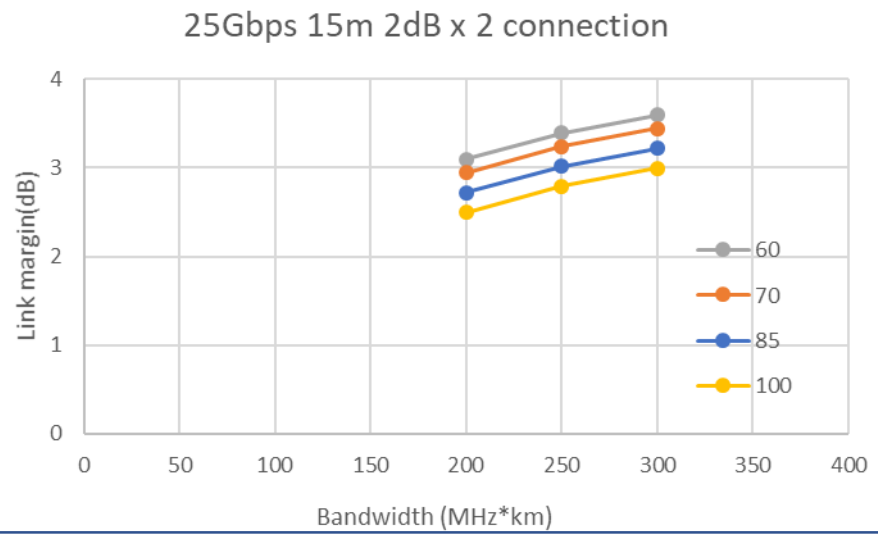

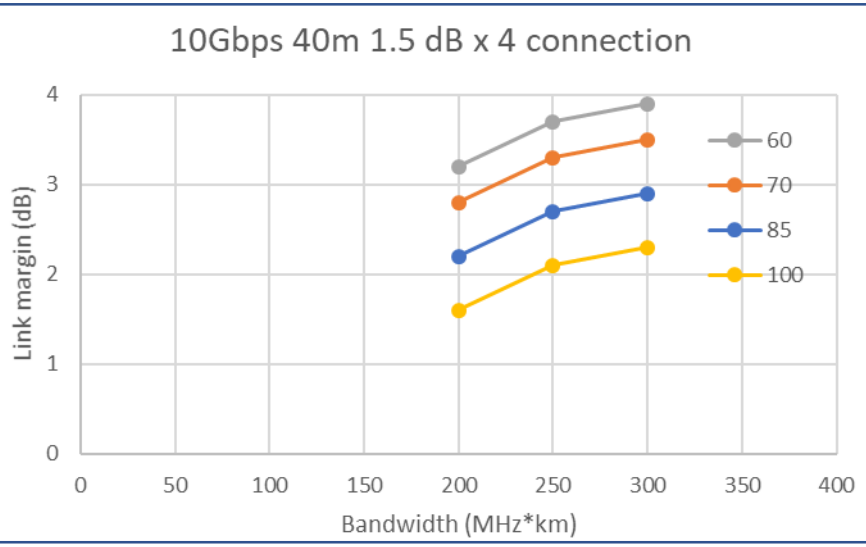

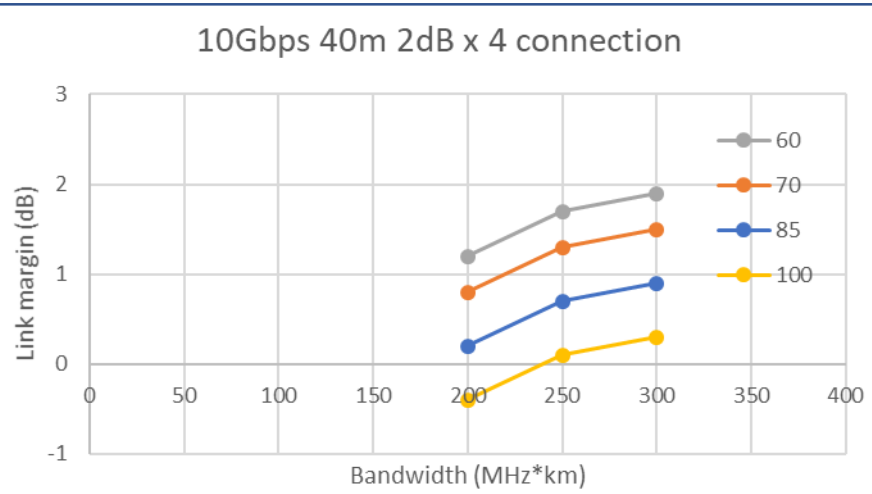

Summary of link budget analysis

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10Gbps

- **Even though worst-case fiber attenuation and bandwidth, it can support 10Gbps over 40m transmission with four connections**

25Gbps

- **40m transmission with four connections is not feasible due to higher attenuation of GI-POF, but 15m transmission is feasible with two or four connections (depends on loss per connection)**
- **15m is practical length for a car**

Considering merits of POF (assembling easiness in harness production and robustness in installation and in service etc.), we recommend GI-POF as one of optical fiber media for OMEGA

Proposal

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- **To define max channel insertion loss including in-line connections for each data rate irrespective of fiber medium as Table 115-16 802.3bv adopted**

Parameter	2.5G	5G	10G	25G	Unit
Power budget	11.80*1			8.90*1	dB
Max channel insertion loss	TBD			TBD	dB
Fiber medium	GOF/POF				-

*1 https://www.ieee802.org/3/cz/public/22_dec_2020/perezaranda_3cz_02a_221220_reliability_linkbdget.pdf

Table 115–16—Worst case link power budget

Parameter	Units	RHA	RHB	RHC	
		Fiber optic channel			
		Type I	Type I	Type II	Type III
Link power budget (min)	dB	11	10	8	9.5
Channel insertion loss without in-line connections (max)	dB	9.5	9.5	8	3
Unallocated link margin (min)[a]	dB	1.5	0.5	0	6.5

[a] Unallocated link margin may be used for in-line connections (connectors). Maximum 1.5 dB insertion loss per in-line connection is assumed.

Thank you for your attention.

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