Optical Fiber for Multi-Gig Auto

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

Motivation for this contribution

- IEEE 802.3cz has received contributions suggesting support for both glass optical fiber and plastic optical fiber (POF) for the automotive application

- POF has been specified in standards before, e.g. 802.3bv
  - In 802.3bv, a 1 mm step-index plastic fiber was specified
    - Large core (980 µm) allowed advantages in connectorization
    - But results in high attenuation (180 dB/km) and low bandwidth (5 MHz•km) at 650 nm

- **Step-index plastic optical fiber is typically limited to applications ≤ 1Gb/s**

- Higher bandwidth applications are now driving the need for graded-index plastic optical fiber
  - See https://grouper.ieee.org/groups/802/3/cz/public/9_feb_2021/watanabe_3cz_01_090221_gipof.pdf
  - Lower attenuation (e.g. ≤ 100 dB/km @850 nm) and higher bandwidth (e.g. ≥ 200 MHz·km @ 850nm) are possible

- But advantages in connectorization are lost because of smaller core diameter (e.g., 55 um)

- **Graded-index plastic optical fiber is typically limited to applications ≤ 10Gb/s**

Problem statement

- **Plastic optical fiber cannot support the adopted objectives for Multi-gig Auto**
  - A 40 meter channel length with 4 inline connections cannot be supported at 25Gb/s
  - A 15 meter channel length with 2 inline connections cannot be supported at 50Gb/s
- Multiple media complicates the standard and fragments the market
- OEMs have noted the importance of using the same physical medium from 5Gb/s to 50Gb/s
  - See https://grouper.ieee.org/groups/802/3/OMEGA/public/jan_2020/eek_OMEGA_01_0120.pdf
- OM3 glass optical fiber can support all of the adopted objectives
- **There is no advantage for specifying POF in the multi-gigabit automotive application**

POF cannot support the defined Objectives in IEEE 802.3cz[1]

Characteristic	2.5G	5G	10G	25G	50G
Link length	40m	40m	40m	40m[2]	15m
Number of in-line connectors	4	4	4	4	2
Glass optical fiber capability	🟢	🟢	🟢	🟢	🟢
Plastic optical fiber capability	🟢	🟢	🟢	🔴	🔴

[1] See https://grouper.ieee.org/groups/802/3/cz/public/9_feb_2021/perezaranda_3cz_01_090221_gipof_linkbudget.pdf

[2] POF has negative margin at 25G even if the link length is reduced to 15m

Characteristics of A4 fiber (from IEC 60793-2-40 ed5_86A1943CDV_A4)

Sub-category	A4a		A4b	A4c	A4d	A4e	A4f	A4g	A4h	A4i
	A4a.1	A4a.2								
Core diameter (µm)	See Note 1		See Note 1	See Note 1	See Note 1	≥ 500	See Note 3	120	62,5	55
Cladding diameter (µm)	1 000		750	500	1 000	750	See Note 3	490	245 Note 4	490
Numerical aperture Na_{ff} Note 5	0,50	0.53	0,50	0,50	0,30	0,25	See Note 3	0,190	0,190	0.24
Operating wave-length (s) (nm)	650 See Note 2		650	650	650	650	See Note 3	650 850 1 300	850 1 300	850
Applica-tions	Digital audio interface, automobile, industrial, sensor and data transmis-sion		Indus-trial and sen-sor	Sen-sor	Digital audiovisual interface and data transmission	Digital audiovisual interface and data transmission	See Note 3	Data transmission	Data transmission; primarily used in ribbon structures	Industrial Data transmission

The performance of glass is better for most attributes

Attribute	Glass optical fiber		Plastic optical fiber	
Core/Clad (µm)	50/125		55/490 µm	
Wavelength of operation (nm)	850	980	850	980
EMB (MHz•km)	2000	950	200	200
Attenuation (dB/km)	3	2	100	85
Support for IEEE 802.3cz Objectives	Yes		No	
Industry Support	High		Low	
Eye-Safe	Yes		Yes	
Robustness at high temperature	Sustainable		Not sustainable	
EMI resistance	High		High	

Safety concerns with glass fibers are largely unfounded

- While care needs to be observed when working with glass fiber, there are few concerns with safety
  - Glass disposal may be required but with proper training this is an easy task that has been proven over many years
- Despite being new to automotive, optical fiber just celebrated 50 years since it was developed – it is not a new technology
  - Fiber optic cables have been successfully spliced and terminated for over 40 years and deployed systems continue to operate reliably
- 100's million connectors have been deployed in optical networks worldwide
- 10's million field installable connectors have been deployed in optical networks worldwide
- Fiber manufacturers produce cables with more than 8000 fibers in a single sheath that are spliced in the field
- Connectors have been standardized that support the termination of 32 fibers at one time
- Standardized connectors have been terminated and deployed in a variety of harsh environments

Is there a strong rationale for supporting multiple media?

- Adding multiple media could delay the standard development
  - Specifying multiple media will negatively impact the 802.3cz project timeline
  - Specifying multiple media adds complexity to an already complex project
- We need to develop a baseline proposal
  - It has always been the practice of IEEE 802.3 to adopt baseline proposals as the means to select technical proposals for inclusion a draft standard
- Baselines should
  - Be consistent with our objectives
  - Be consistent with our PAR and CSD (e.g., economically and technically feasible)
  - Baselines need to be complete enough for an editor to create text, figures and tables for the draft

Summary

- OEMs have noted the importance of using the same physical medium from 5Gb/s to 50Gb/s
  - See https://grouper.ieee.org/groups/802/3/OMEGA/public/jan_2020/eek_OMEGA_01_0120.pdf
- Including multiple media types complicates the standard and fragments the market
- Glass optical fiber can support all of the adopted objectives for Multi-gig Auto
- **Plastic optical fiber cannot support all of the adopted objectives for Multi-gig Auto**
  - A 40 meter channel length with 4 inline connections cannot be supported at 25Gb/s
  - A 15 meter channel length with 2 inline connections cannot be supported at 50Gb/s
- **There is no known advantage for specifying POF in the multi-gigabit automotive application**

Recommendation

- We need to develop a baseline proposal
  - Selection of the supported media can accelerate this process
  - Selection of baseline drives work to resolve TBDs
  - Work is often not pursued seriously unless a baseline is adopted

- IEEE 802.3cz should proceed with the development of a standard based on glass optical fiber
  - Complexity is reduced
  - Minimizes delay in standard development

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