New IEEE 802.3cz Standard: multi-gigabit links for automotive

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www.kdpofof.com
Speakers

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Who we are

- Fables semiconductor company incorporated in Madrid in 2010
- Team of 40 FTE (Including 15 IC designers) led by the co-founders.

Our core
- Excellence
- Transparency
- Horizontal Management
- Innovation

Our markets
- Automotive
- Home and SOHO
- Industrial
What we do

- We work in optical high-speed connectivity for complex environments such as automotive and industrial matters, to be integrated in SoCs (System on Chips).

- We have people working from different places in Spain and other countries like:

- Also, we have many partners in some countries around the world:
How we do it

- Make simpler and more robust products implementing
- Approaching Shannon's limit
- Customer centric

LEADING BY

Robustness  Low Price  Reliability  Easy to use
New IEEE 802.3cz BASE-AU
How to increase data rate and reach? Strategies used in IEEE 802.3

- Increase number of lanes
- Increase DSP complexity
  - Higher density constellations (3PAM, 4PAM, 8PAM, 16PAM, QPSK, 16QAM...)
  - Multiplexing using other physical dimensions
    - Wavelength (WDM)
    - Frequency (OFDM)
    - Polarization (I/Q dimensions in optical constellations)
  - Echo cancelling
    - Used for single-pair reuse for full-duplex communications
  - Forward Error Correction algorithms
    - Reed Solomon, LDPC codes, ...
  - Equalization
- Change the media/cable
  - Also related with the number of lanes
# Mechanical Robustness

<table>
<thead>
<tr>
<th>CABLE</th>
<th>CYCLES</th>
<th>RESULT</th>
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</thead>
<tbody>
<tr>
<td>AGF</td>
<td>1,000,000</td>
<td><img src="image" alt="Image" /></td>
</tr>
<tr>
<td>Sheath (⌀2.7mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-axial Cable</td>
<td>10,000</td>
<td><img src="image" alt="Image" /></td>
</tr>
<tr>
<td>Conductor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Braid Shield</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheath (⌀3.0mm)</td>
<td></td>
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</tbody>
</table>

- **No failure**
- **Disconnection of braid shield and conductor**

CR- CORNING
Bend Insensitive Fibers (FIB) add a layer in the cladding with a lower index of refraction to provide an addition reflection. This guides the light. That would be lost in standard fiber.
The IEEE P802.3cz Standard

- EMC
- Operation temperature range (-40° – 125°C)
- Reliability / Durability (15 years of operation, less than 10 FIT)
- Inline connectors / reach 40 m + 4 inline connectors (cars, buses, trucks)
- Data rates: 2.5, 5, 10, 25 and 50 Gb/s, single lane
- Cost-effective
- Dependability/ link management/diagnosis
- Future proven
- Low weight harness
How 802.3cz covers Automotive requirements?

- The use of vanilla-flavoured fiber cabling (OM3) eliminates electromagnetic compatibility problems in cabling, has a reduced cost and achieves the data rate goal using a single lane.

- Moderate to low DSP complexity (no echo cancelling) allows for high loss / lower cost inline connectors, accommodates IC production yield, and lower power consumption.

- The light source (IR VCSEL) has been specially selected for its reliability and performance in the designated temperature range.

- The operation, Administration, and Management (OAM) side channel has been designed for dependability, advanced diagnosis and link management.

- EEE support allows big power saving in low traffic conditions and asymmetric rate use cases.
802.3cz: A multi-gigabit Optical Ethernet Standard

IEEE Standard for Ethernet Amendment 7: Physical Layer Specifications and Management Parameters for Multi-Gigabit Glass Optical Fiber Automotive Ethernet

Available at https://standards.ieee.org/ieee/802.3cz/10918/
KD7251 and Use Cases
Automotive requirements for the KD7251

Reliability
- +15 years of lifetime, +30kh operation time, -40°C ~ +105°C ECU ambient temperature (up to +125°C substrate temperature)

FuSa
- Functional safety according to ISO 26262, ASIL B

Qualification plan
- According to the new AEC-Q102-003 standard, considering all relevant AEC-Q100 and AEC-Q102 tests and advance reliability assessment approach of SAE-J1879

Feedback from Tier1
- IC (package, pitch, SMD...)
- Connector housing (two-step assembly, waterproof, environmental...)
- Connector-IC mating (manufacture & assembly tolerances)
- Functional requirements: data interfaces, test capabilities, safety, security, etc.
Automotive requirements for the KD7251

- **Cable and connector performance**
  - Bending: permanent, instant, dynamic, micro-bending
  - Vibration
  - Shock test
  - Chemical loads

- **Link budget**
  - Optical parameters (emission profile, wavelength, spectral width, OAM and ER...)
  - Signal integrity, power integrity, EMC
Optical is a must

- OM3, 40 meters
- Copper, 11 meters
- Response is affected by cable aging
KDPOF view: Copper & Optical as speeds grow

Transceiver feasibility: 980nm, ER 4dB, 125°C, 40m OM3

53.76 Gb/s PAM4

26.88 Gb/s NRZ
CSI-2 Connectivity: Satellite Radar

- 2 or 4 FMCW radar transceivers per sensor ECU (e.g. AWR2243)
- 4-lane CSI-2 port per transceiver, 600 Mb/s per lane
- Data-rates:
  - 2 x 4 x 600 = 4800 Mb/s (rear sensors and front corners)
  - 4 x 4 x 600 = 9600 Mb/s (front sensor)
- Radar application is intensive in number of lanes and ports to get aggregated rate
• Up to 10 cameras in high-end platforms with raw-data transmission

• Most of the cameras are ~3 Gb/s, some of them are ~8 Gb/s

• # CSI-2 ports per SOC limited, max 4 (e.g. Xavier, Renesas): virtual CSI-2 channels over single CSI-2 port are used
  - Dual and quad deserializers are currently used with coax and PHY

• However, camera application is intensive in rate per lane with low number of lanes and ports
Displays Connectivity

- DSI over D-PHY
- eDP (Embedded DisplayPort)
- Ethernet-based zonal architecture
- HPC/VCU backbone
- Sensor fusion
Smart Antenna

- Avoid noise from smart antenna module link to ECU
  - It will reduce antenna reception sensitivity
- Use of optical link to enhance antenna performance
- New plastic/crystal roofs don't shield antenna from car noise
Connectors and light sources
Automotive Optical Ethernet Harness

- Optical connector End
- Bundling Optical Harness to Separation Keeping R15mm
- Bundling Optical Harness to Copper Binding
- Dust Protection Cap to all Connector Ends

Most common optical connectors

Fiber Optic In-Line connector

https://community.fs.com/blog/fiber-optic-adaptec-coupler-tutorial.html
Automotive Industry Requires Kojiri Protection

- Kojiri protection and dust covers protect connectors against dust and damage
  - Some solutions include lens systems to facilitate the design of Kojiri protection

- New connectors for Glass Optical Fiber are under development
  - POF connectors with Kojiri protection are available in the market
Reflow Soldering

Typical reflow soldering profile (SMT = Surface Mount Technology)

- 0.8 degC/sec
- 1 degC/sec
- 260 degC

* Depending on location on PCB, design of lens, potential heat shielding etc.

https://www.raypcb.com/what-is-reflow-soldering-and-wave-soldering/
The Particularly Demanding Application in the Automotive Sector

• Compared to data centers, automotive applications require not only a much wider range of operating temperatures, ranging from minus 40 °C up to 125 °C back-side temperature, but also an interconnect length of even less than 40 meters.

• Long-term studies have already proven that 980nm VCSELs can operate at much higher temperatures while maintaining excellent reliability.
  ◦ TRUMPF has demonstrated a test ran at 170 °C showed no failures with test time exceeding 4,000 h
  ◦ Under the same conditions, 850nm VCSELs showed 50 % failures after few 100 h

• The benefit can be used in different ways:
  ◦ Higher operation temperature is favored by higher environment temperature use like 980nm for automotive and co-packaged optics.
  ◦ Higher wavelength material more robust to operate at higher current densities which enable higher bandwidths, therefore better for 100G interconnect
Thank you!

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