Optical Ethernet in Automotive

A Reality

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### Optical Automotive Communication Systems

<table>
<thead>
<tr>
<th>Speed (Mbps)</th>
<th>Application</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Digital audio</td>
<td>1998</td>
</tr>
<tr>
<td>25, 150</td>
<td>Infotainment</td>
<td>2001-2008</td>
</tr>
<tr>
<td>10</td>
<td>Safety-critical</td>
<td>2001</td>
</tr>
<tr>
<td>400</td>
<td>Infotainment</td>
<td>2004</td>
</tr>
<tr>
<td>10</td>
<td>SRS</td>
<td>2006</td>
</tr>
<tr>
<td>100</td>
<td>Industrial networks</td>
<td>1992</td>
</tr>
</tbody>
</table>

 Optical Communication is well established in the automotive field.

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The MOST story… Lessons Learnt

• Success: > 200 mio. nodes  > 200 vehicle models
  → POF established as reputable automotive media

• Till 2016 “de facto” proprietary technology

• Value chain was not oriented to optimize cost
  “Margin stacking” undermined the value proposition:

  • # Network Interface Controller: 1
  • # FOT suppliers: 2
  • # Header connector suppliers: 3
  • # Harness suppliers: 4

Open specification → Competitive value chain → Cost optimization

Gigabit Optical should be fairly SPECIFIED to foster a competitive value chain
Gigabit POF Standardization

ISO TC22 SC31 (WG3)
- Complements IEEE 802.3bv 1000BASE-RHC

ISO TC22 SC32 (WG10)
- Addresses physical harness components (fiber and connectors)

Publishing 1Q. 2017

Publishing 1Q. 2019

Gigabit POF currently being standardized

P802.3bv Timeline
Gigabit POF Ecosystem

PCS/PMA

FOT (PMD, MDI)

Cable harness

Kit and evaluation boards (switch, MC) available
Gigabit POF  Zoom into components

Specifications of basic properties:
- Application Temp.: -40 to 105[deg.C]
- Storage condition: -40 to 105[deg.C]
- Soldering condition: Flow / Reflow soldering (Peak Temp.: 260[deg.C])

The SMD connector interface is completely the same as that of the THD.

Header connector portfolio to accommodate any board and interconnection topology
Gigabit POF Seamless hybrid connector integration

Feature & Advantages
- MOST small header connector can be used as SMD-Pigtail
  Height: 20mm (standard component) vs. 10mm (small component)
- Useful for display unit interface, such as strongly requested thinner devices

Seamless integration of POF in hybrid electrical/optical connectors

Equipped with dual, plastic (typically orange), fiber-optic lines connected to the radio or amplifier (not necessarily this connector).
Harness and Assembly process

Floor W/H

- Inline Connector Yellow: Dust Protection Cap
- White: Clamp
- No Protection for Optical Fiber inside Protector
- Winding and Clamping similarly to Copper Cable
- Protector Exit; Similarly treated to Copper Cable
- Fixing Inline Connector to Protector

Instrument Panel W/H

- Bundling Optical Harness to Separation (Keeping R10mm)
- Dust Protection Cap to all Connector Ends
- Loopback (for Diagnostics) Connector with Clamp
- Bundling Optical Harness to Copper Binding

Optical Connector End - Routing

Seamless integration of POF with W/H at manufacturing and installation
### Reference scenario

- Total length: 23.03 m
- Total connectors: 10
- Total in-line connectors: 4

**Excluding final assembly as well as investment costs**

### Cable Type

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>STP (e.g. KROCAR 64995781)</th>
<th>Jacketed TP (e.g. LEONI DACAR 676)</th>
<th>POF (e.g. PM 4Y 1,0/1,51/2,3 Gebauer &amp; Griller)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Price Savings of cables [%]</td>
<td>as base value</td>
<td>66,3</td>
<td>78,5</td>
</tr>
<tr>
<td>Estimated Price Savings of harness [%]</td>
<td>as base value</td>
<td>15,8</td>
<td><strong>23,1</strong></td>
</tr>
</tbody>
</table>

### Costs are favorable

- Costs are favorable

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**Total weight of wires [ kg ]**
- STP: 0.6679 kg
- Jacketed TP: 0.2990 kg
- POF: 0.2303 kg

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**Estimated Price Savings of cables [%]**
- STP: 66.3%
- Jacketed TP: 78.5%
- POF: 78.5%

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**Estimated Price Savings of harness [%]**
- STP: 15.8%
- Jacketed TP: 23.1%
- POF: 23.1%
Use cases 1 Gbps / 100 Mbps Optical links

- **BMS**
  - Galvanic Isolation

- **Backbone**
  - Autonomous driving safety redundancy

- **Smart Antenna modules**
  - ADAS cameras interconnection

- **100 Mbps links**
  - EMC-tight

**ADAS ECU**

**Switch ECU**

**ADAS cameras**

**Interconnection**

**Galvanic Isolation**

**Autonomous driving safety redundancy**

**100 Mbps links**

**EMC-tight**
Optical Ethernet is the Future

<table>
<thead>
<tr>
<th>100 Mbps</th>
<th>1 Gbps</th>
<th>10 Gbps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper: JTP</td>
<td>Copper: STP?</td>
<td>Copper: STP: Cat 7?</td>
</tr>
<tr>
<td>Optical: SI-POF</td>
<td>Optical: SI-POF</td>
<td>Optical: PCS, GI-POF</td>
</tr>
</tbody>
</table>

**Cost**
- Copper beats Optical
- Copper loses Optical
- Copper loses Optical

**Weight**
- Copper ties Optical
- Copper loses Optical
- Copper loses Optical

**EMC noise/susceptibility**
- Copper loses Optical
- Copper loses Optical
- Copper loses Optical

Optical Ethernet is the natural path to higher speed.
The future of Optical Multi Gbps Ethernet speed

- MII, RMII, 100BASE-X
- RGMII, SGMII, 1000BASE-X
- xGBASE-X

Components for higher speed

- SI-POF 1mm RED-LED Si Pin Diode 15m + 4
- SI-POF 1mm Green-LED Si Pin Diode 10m + 1
- GI-POF? PCS? IR-VCSEL GaAs Pin Diode 15m + 4
- GI-POF? IR-VCSEL GaAs Pin Diode 15m + 4

WOULD YOU LIKE TO PARTICIPATE?
Value Proposition

• EMC problem free
  • Yazaki EMC measurements demonstrates EMS/EMI performance
  • Problem free integration, no EMC adoption R&D costs per derivative etc.

• Galvanic isolation
  Advantage for high voltage systems

• Very reliable
  Compared with GOF, COAX and STP

• Predictable / competitive price
  Compared with COAX in big volumes

• Good bending
  Radius down to 10 mm

• Availability
  Early products available

• Automotive qualified
  POF is an approved media

• Temperature Range
  New standard -40°C to 105°C

• Seamless integration
  Harness manufacturing and installation

• Future Proven
  Multi-Giga under development

EMC CISPR-25 class 5
In summary….

Gigabit POF is available and standardized in a solid and competitive Ecosystem

Gigabit POF has a compelling value proposition: EMC, COST and SEAMLESS INTEGRATION

Gigabit POF is the first step to an indisputable automotive future-proven MULTI GIGA optical world

… Do you have any reasonable argument why not to use Gigabit POF?

… Contact César Esteban cesar.esteban@kdpofo.com
Thank you

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