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

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www.kdpof.com

Speakers

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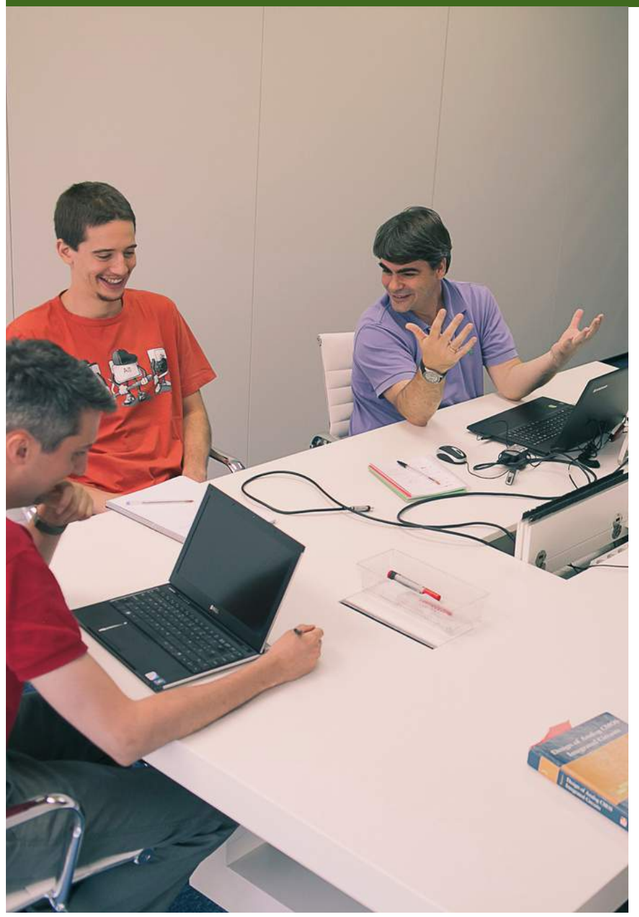
Optics & Photonics Engineer

About KDPOF

Who we are



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

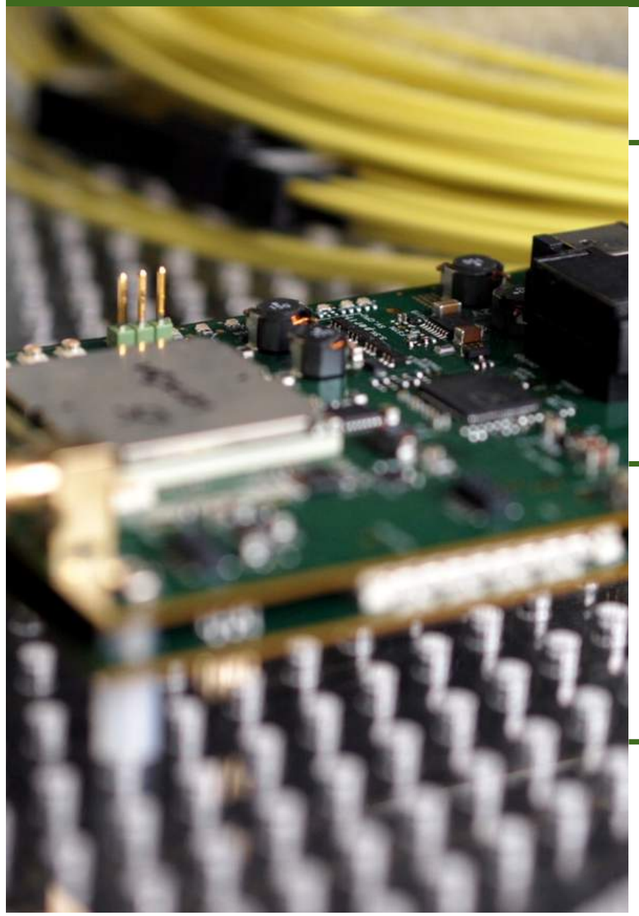
Our core

- 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).

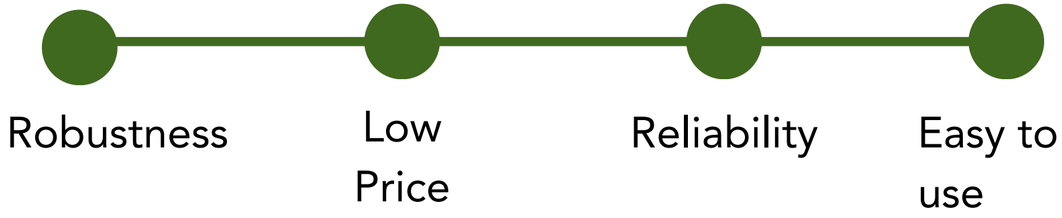
- We have people working from different places in Spain and other countries like:

- 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



New IEEE 802.3cz BASE-AU

How to increase data rate and reach? Strategies used in IEEE 802.3

Increase number of lanes

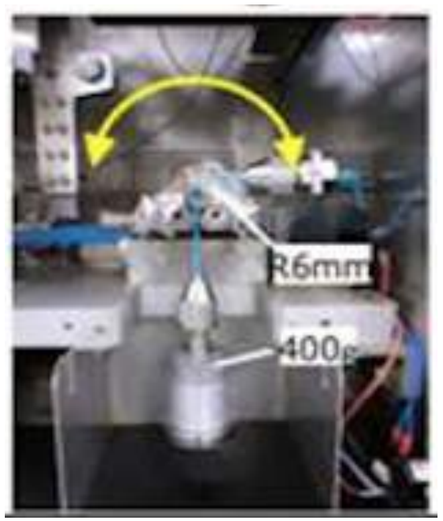
Increase DSP complexity

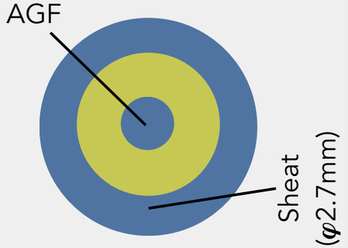
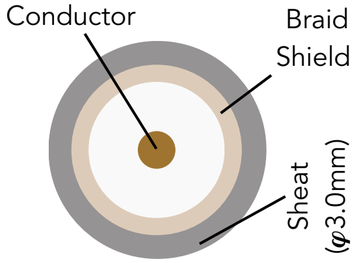
- Higher density constellations (3PAM, 4PAM, 8PAM, 16PAM, QPSK, 16QAM…)
- Multiplexing using other physical dimensions
  - Wavelength (WDM)
  - Frequency (OFDM)
  - Polarization (I/Q dimensions in optical constellations)
- Echo cancelling
  - Used for single-pair reuse for full-duplex communications
- Forward Error Correction algorithms
  - Reed Solomon, LDPC codes, …
- Equalization

Change the media/cable

- Also related with the number of lanes

Mechanical Robustness



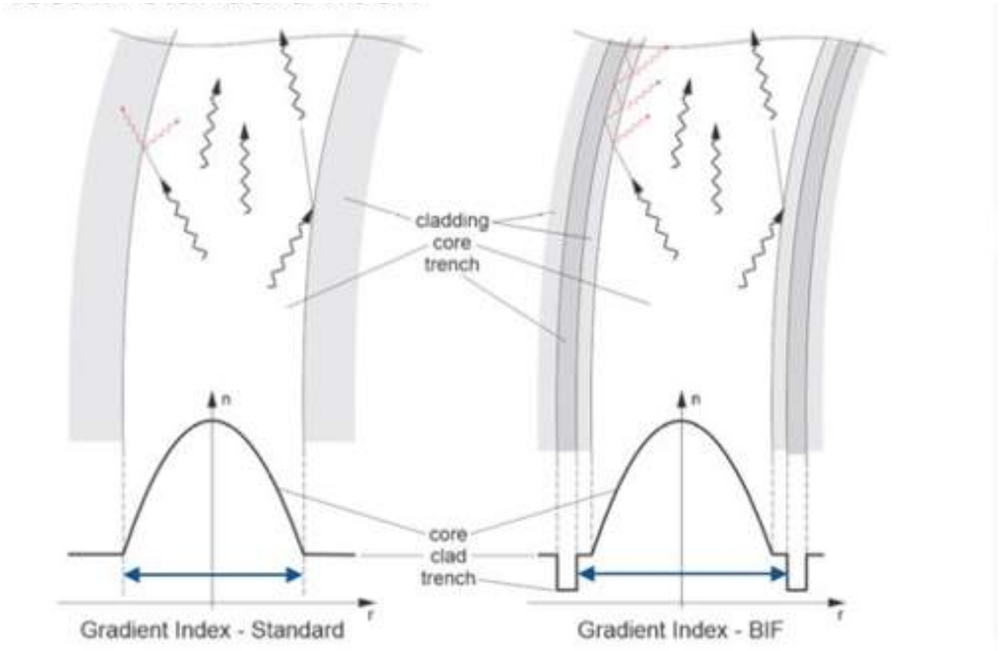
	CABLE	CYCLES	RESULT
Optical cable		1,000,000	
Co-axial Cable		10,000	

No failure

Disconnection of braid shield and conductor

CR- CORNING

Bend Insensitive



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

Automotive requirements

- 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

Available at https://standards.ieee.org/ieee/802.3cz/10918/

KD7251 and Use Cases

Automotive requirements for the KD7251

Reliability

- +15 years of lifetime, +30 kh 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

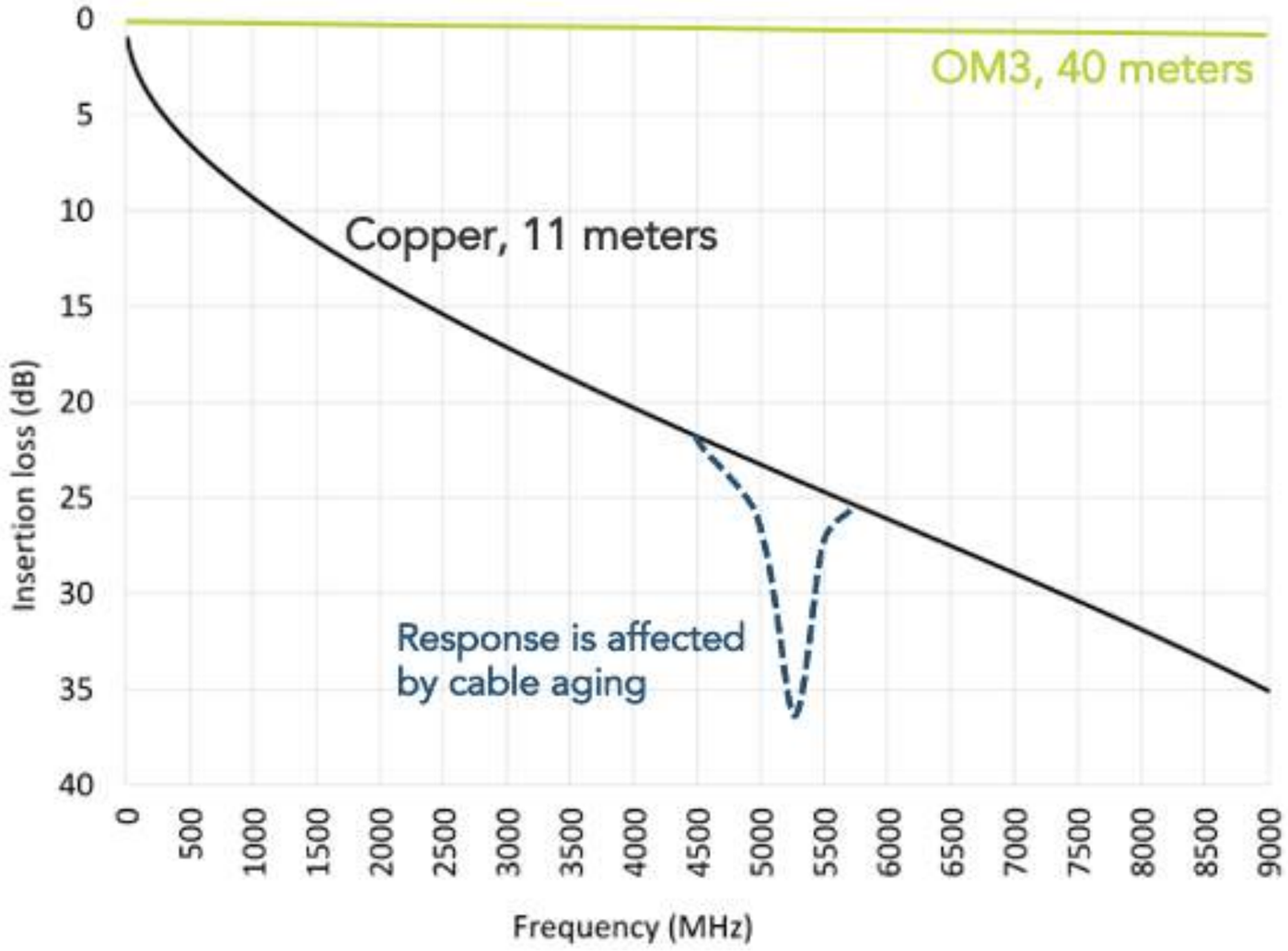
Cable and connector performance

- Bending: permanent, instant, dynamic, micro-bending
- Vibration
- Shock test
- Chemical loads

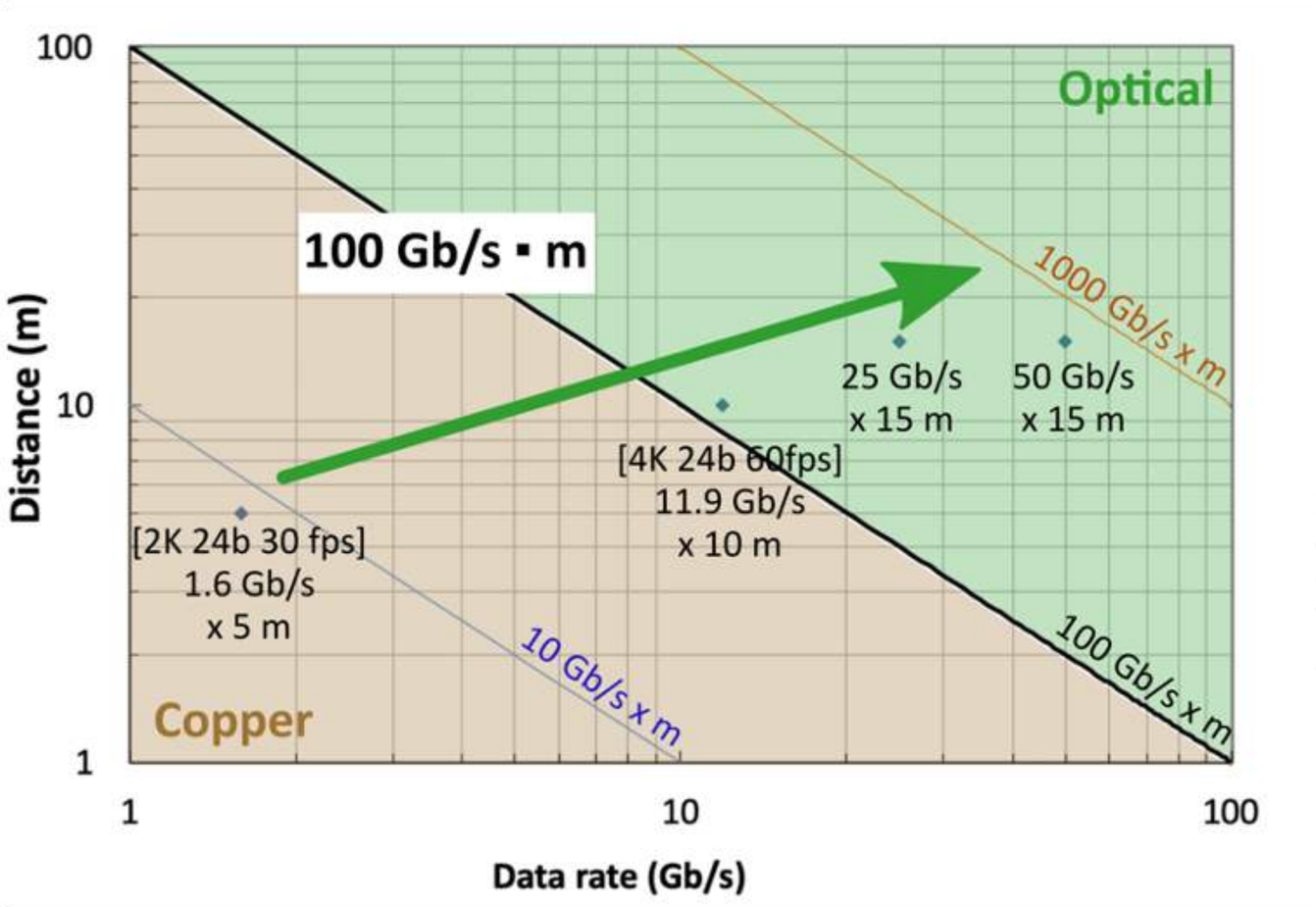
Link budget

- Optical parameters (emission profile, wavelength, spectral width, OAM and ER…)
- Signal integrity, power integrity, EMC

Optical is a must

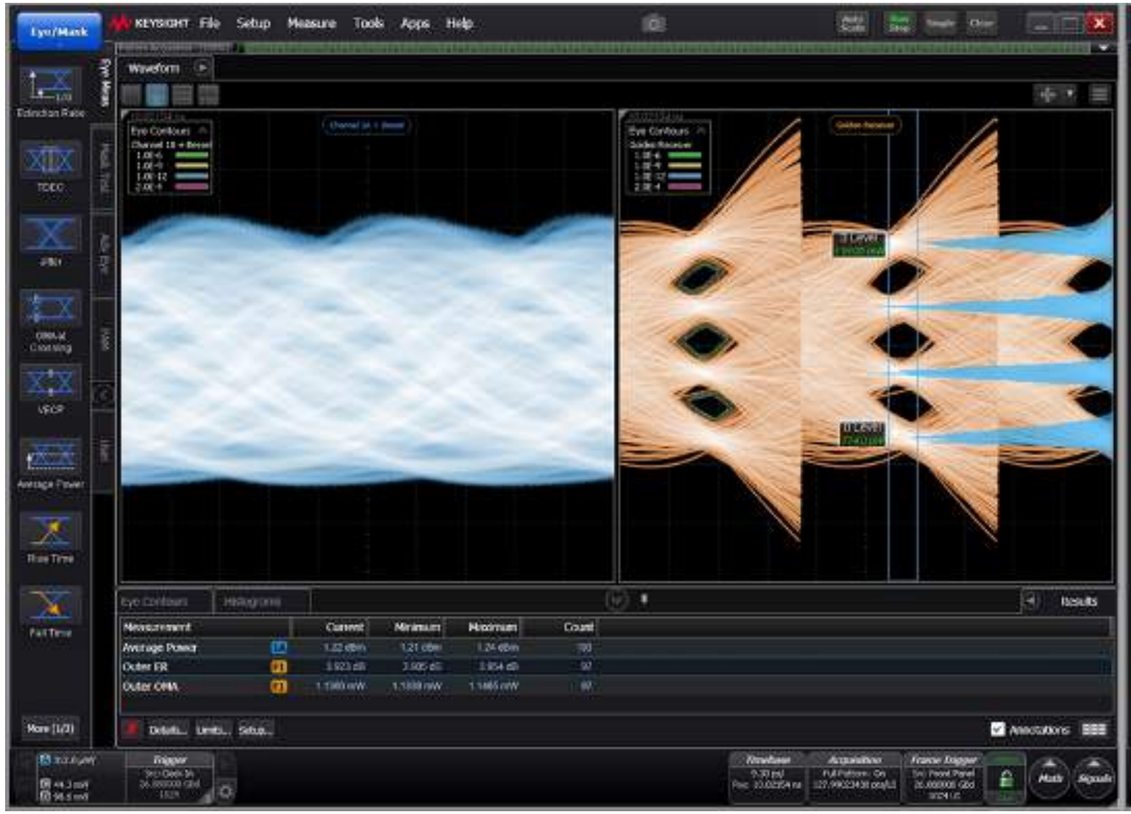


KDPOF view: Copper & Optical as speeds grow

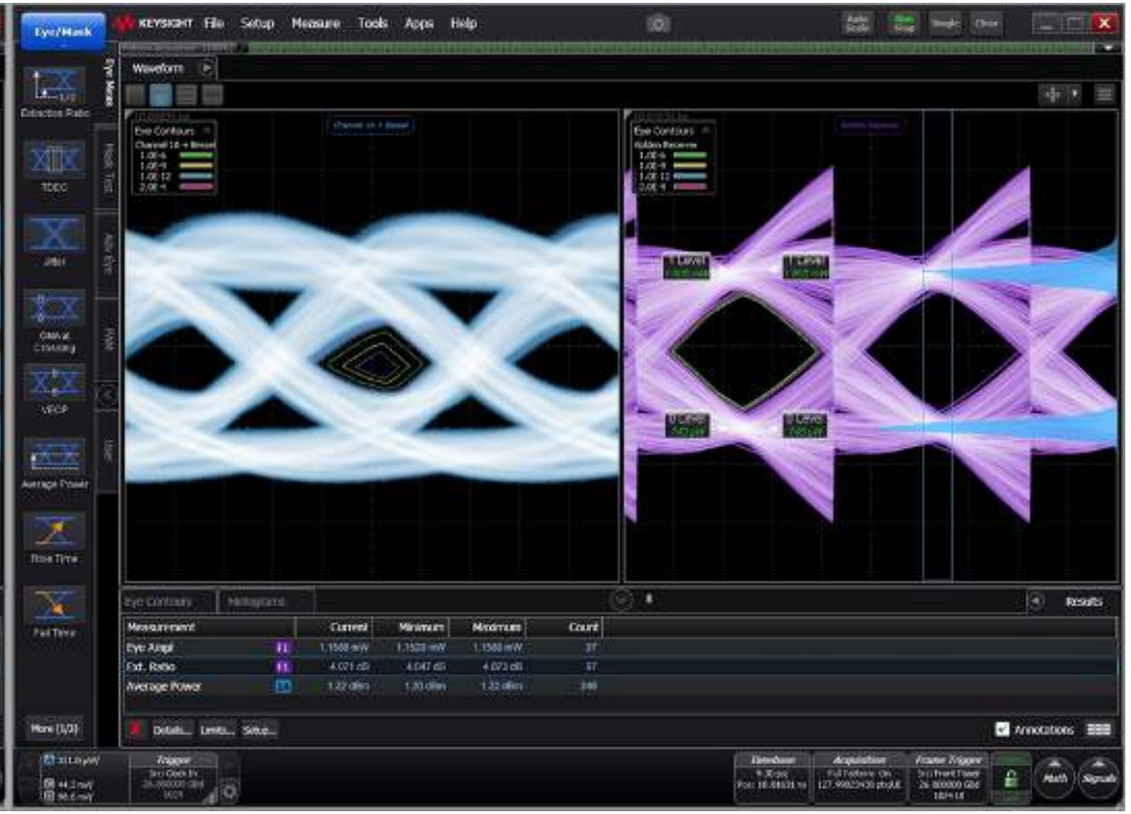


Elaborated from : A. V. Krishnamoorthy et al., "Progress in Low-Power Switched Optical Interconnects," IEEE J. Select. Topics Quantum Electron., vol. 17, no. 2, pp. 357–376, Mar. 2011

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

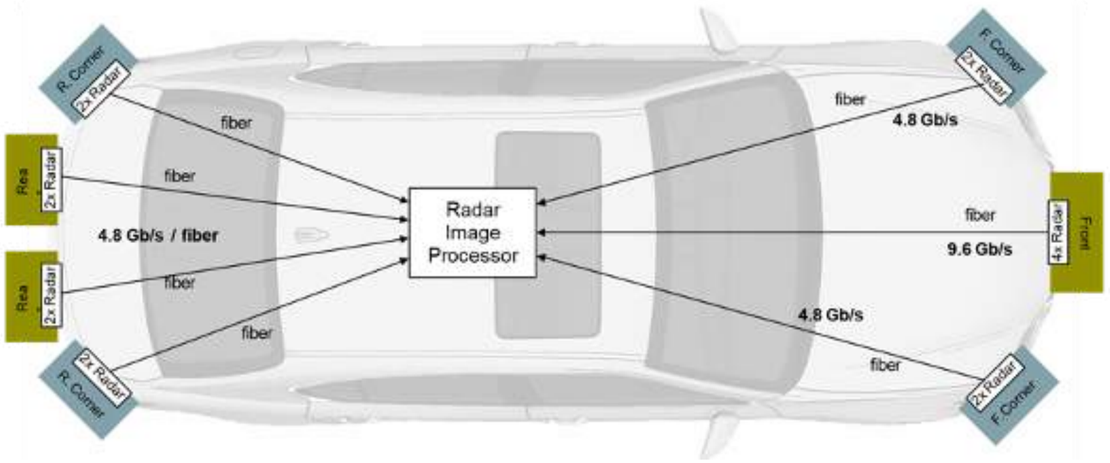


53.76 Gb/s PAM4



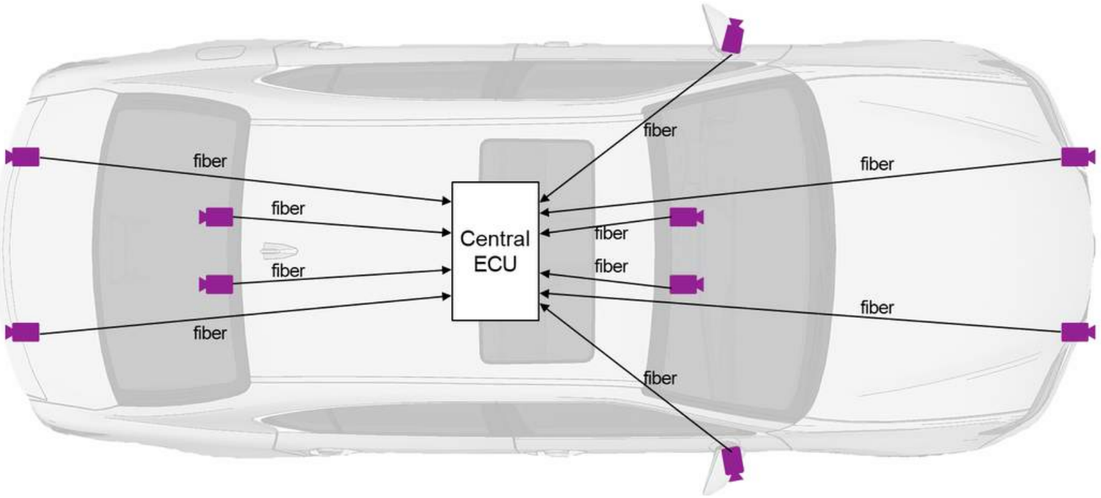
26.88 Gb/s NRZ

CSI-2 Connectivity: Satellite Radar



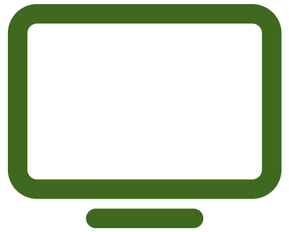
- 2 or 4 FMCW radar transceivers per sensor ECU (e.g. AWR2243)
- 4-lane CSI-2 port per transceiver, 600 Mb/s per lane
- Data-rates:
  - 2 x 4 x 600 = 4800 Mb/s (rear sensors and front corners)
  - 4 x 4 x 600 = 9600 Mb/s (front sensor)
- Radar application is intensive in number of lanes and ports to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

CSI-2 Connectivity: Camera Sensors



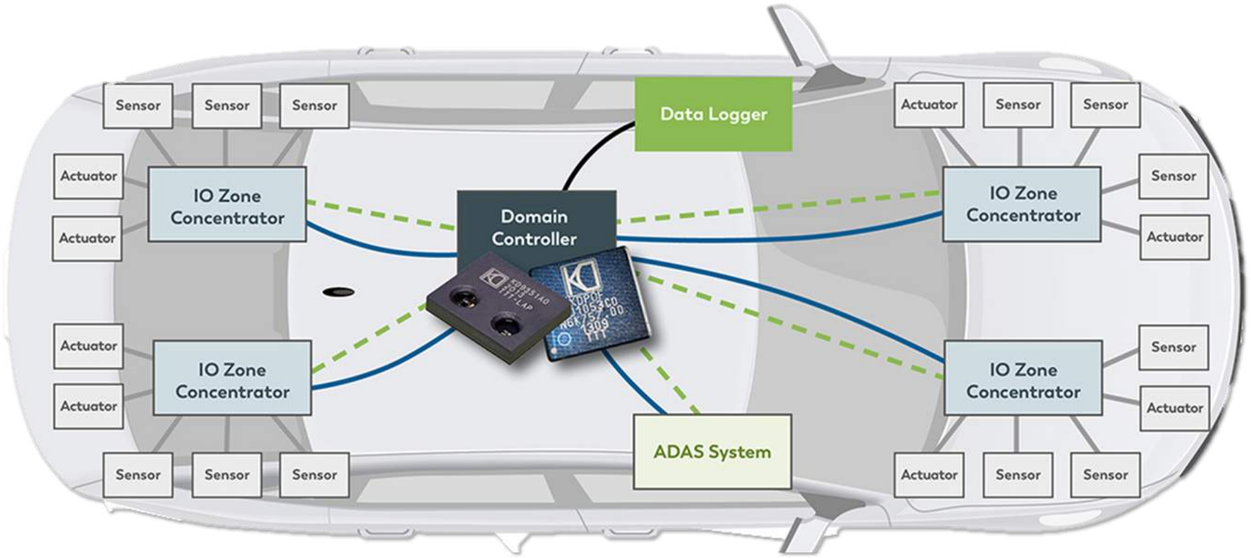
- Up to 10 cameras in high-end platforms with raw-data transmission
- Most of the cameras are ~3 Gb/s, some of them are ~8 Gb/s
- # CSI-2 ports per SOC limited, max 4 (e.g. Xavier, Renesas): virtual CSI-2 channels over single CSI-2 port are used
  - Dual and quad deserializers are currently used with coax and PHY
- However, camera application is intensive in rate per lane with low number of lanes and ports

Displays Connectivity



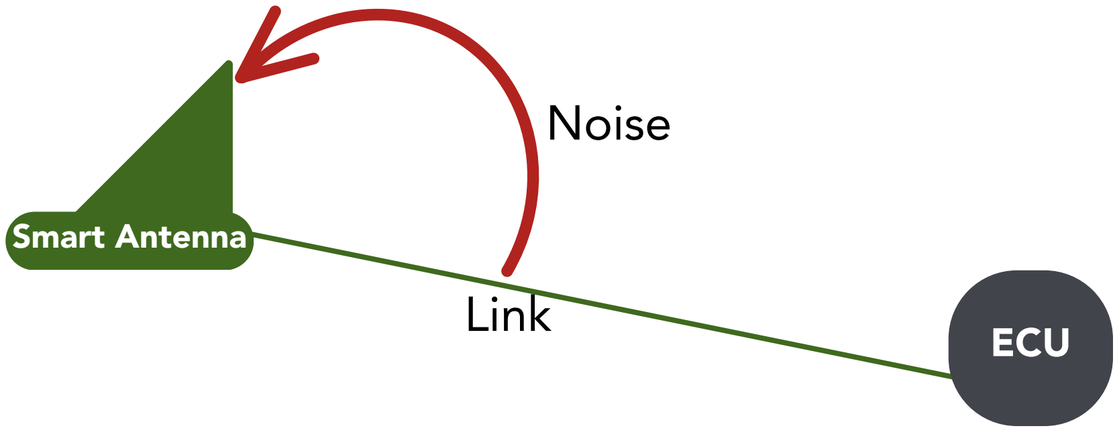
- DSI over D-PHY
- eDP (Embedded DisplayPort)

Backbone

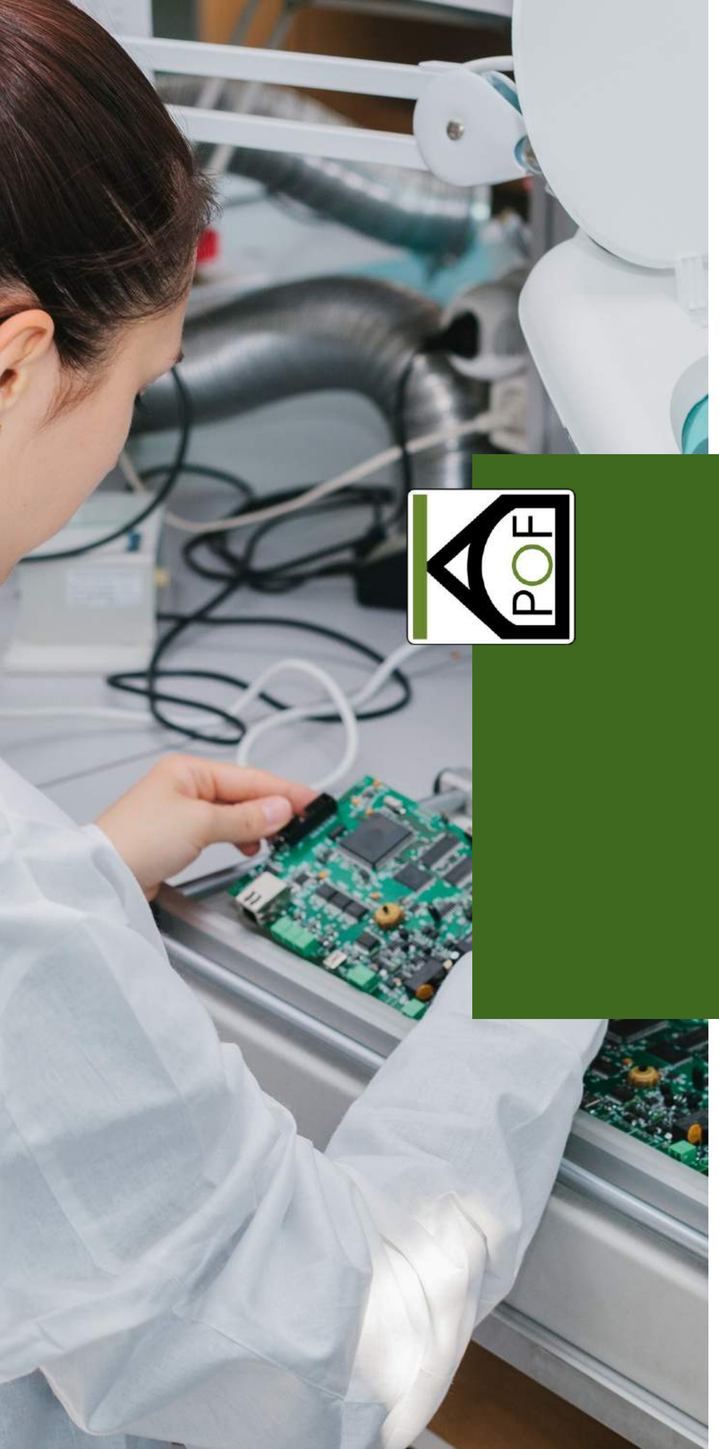


- Ethernet-based zonal architecture
- HPC/VCU backbone
- Sensor fusion

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



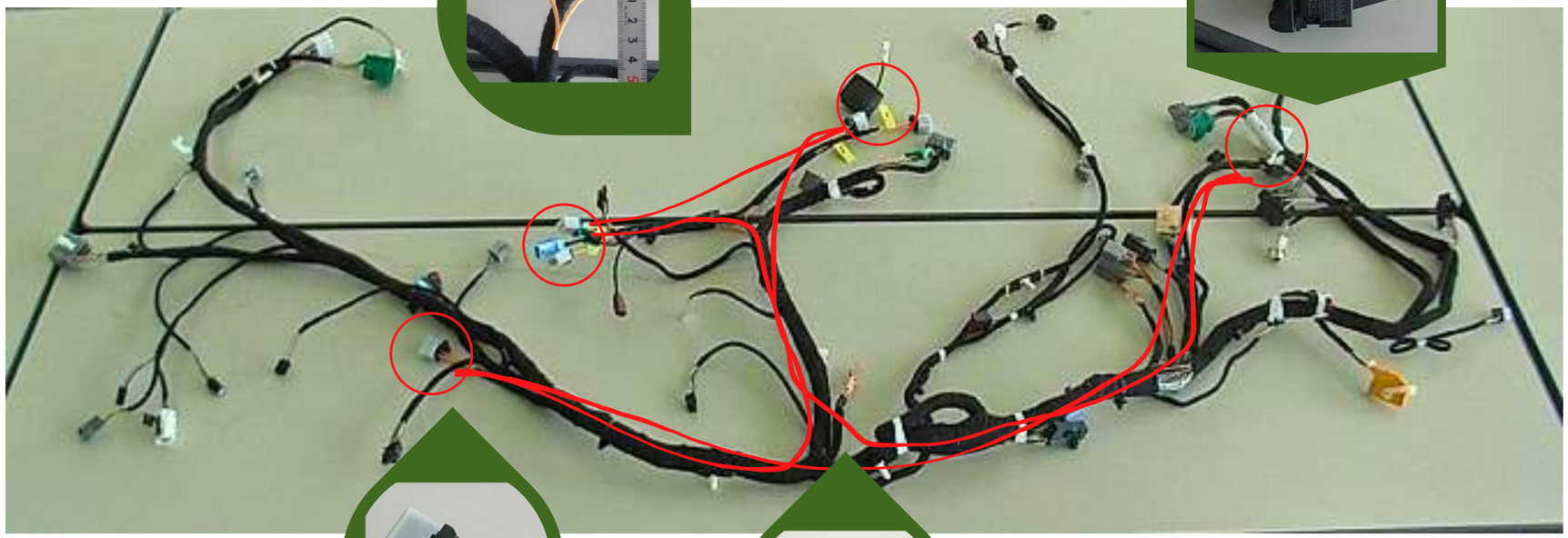
Connectors and light sources

Automotive Optical Ethernet Harness

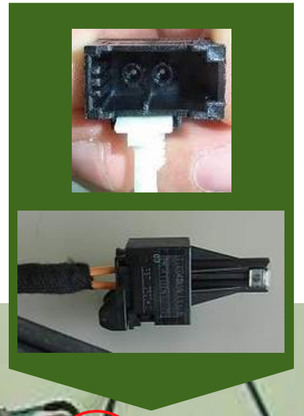
Optical connector End

Routing

https://www.mouser.es/new/hirose/hirose-hvh-280-automotive-connectors/



Bundling Optical Harness to Separation Keeping R15mm

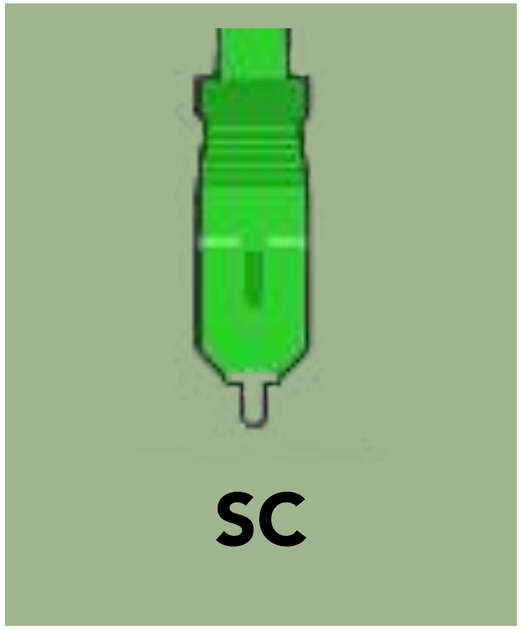


Loopback (for Diagnostics) Connector with Clamp

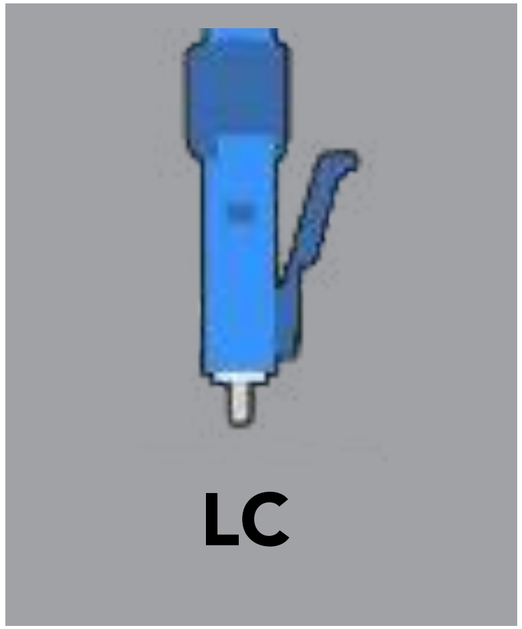
Dust Protection Cap to all Connector Ends

Bundling Optical Harness to Copper Binding

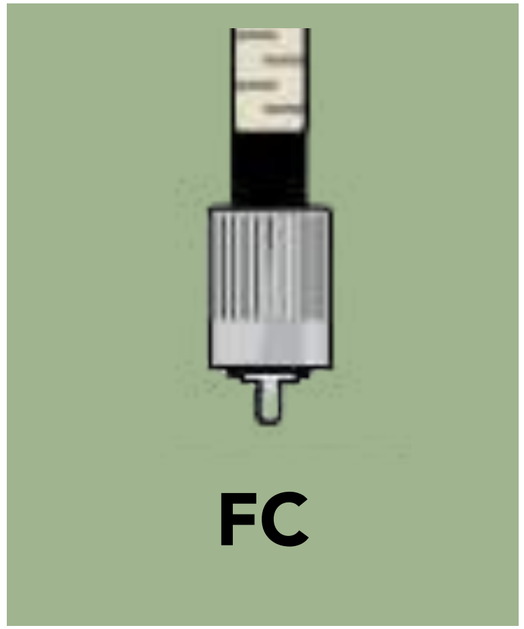
Most common optical connectors



SC



LC



FC

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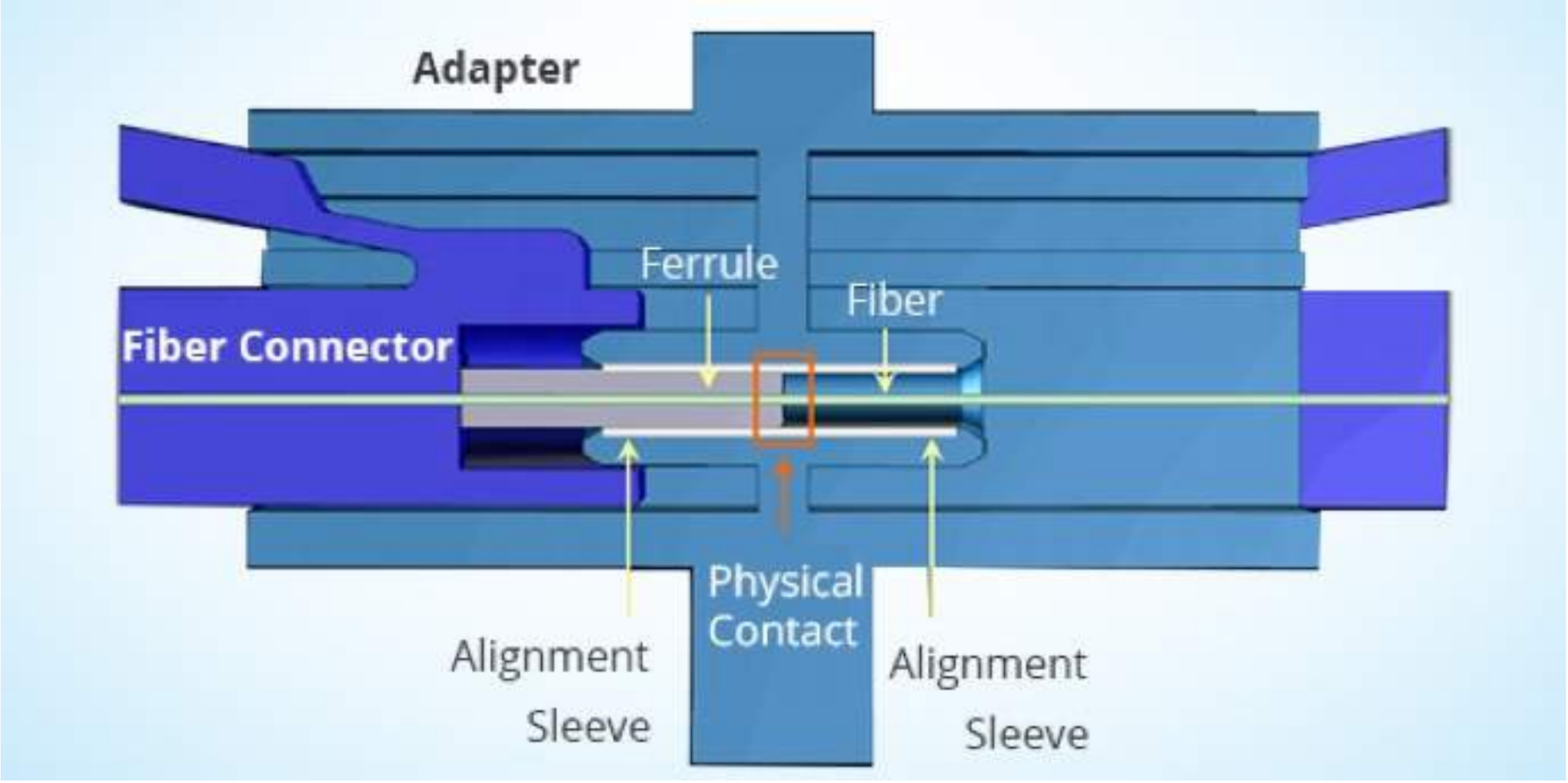
https://www.promaxelectronics.com/ing/news/578/optical-fiber-connector-types-an-easy-guide/

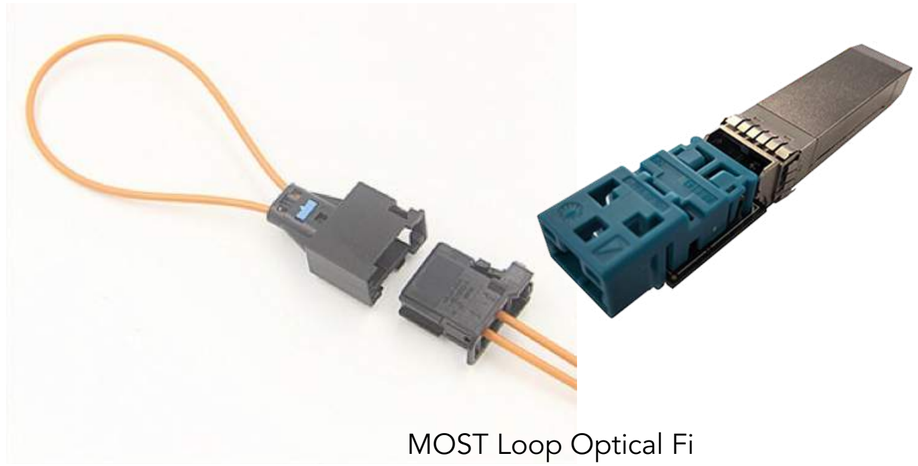
Fiber Optic In-Line connector



https://community.fs.com/blog/fiber-optic-adaptercoupler-tutorial.html

Automotive Industry Requires Kojiri Protection

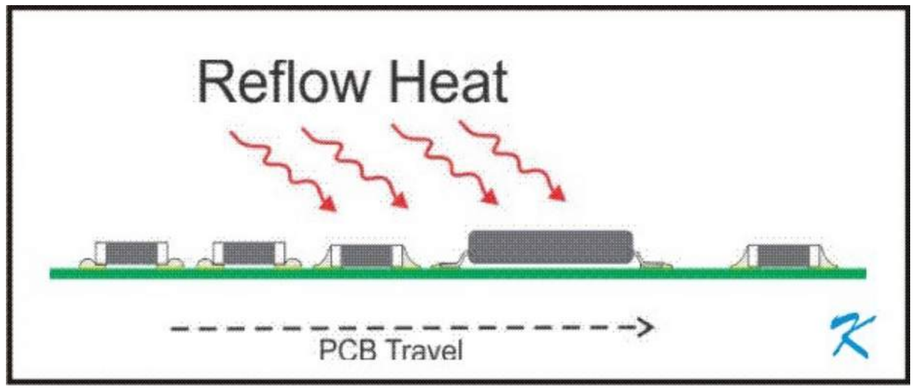
IEEE 802.3 CFI July 2019: Automotive Optical Multi-Gig PHY

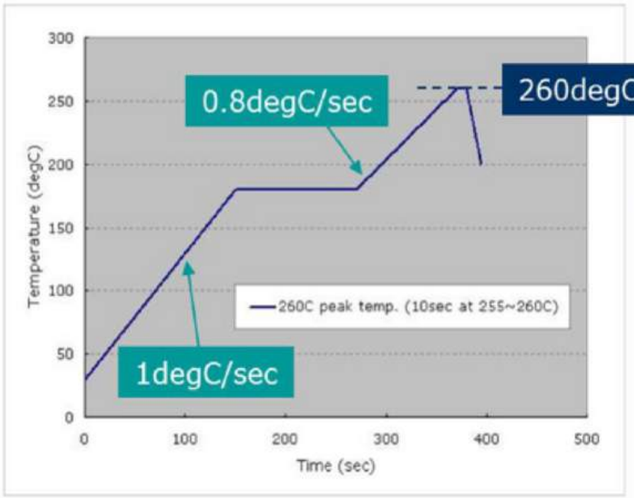


MOST Loop Optical Fi

- 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

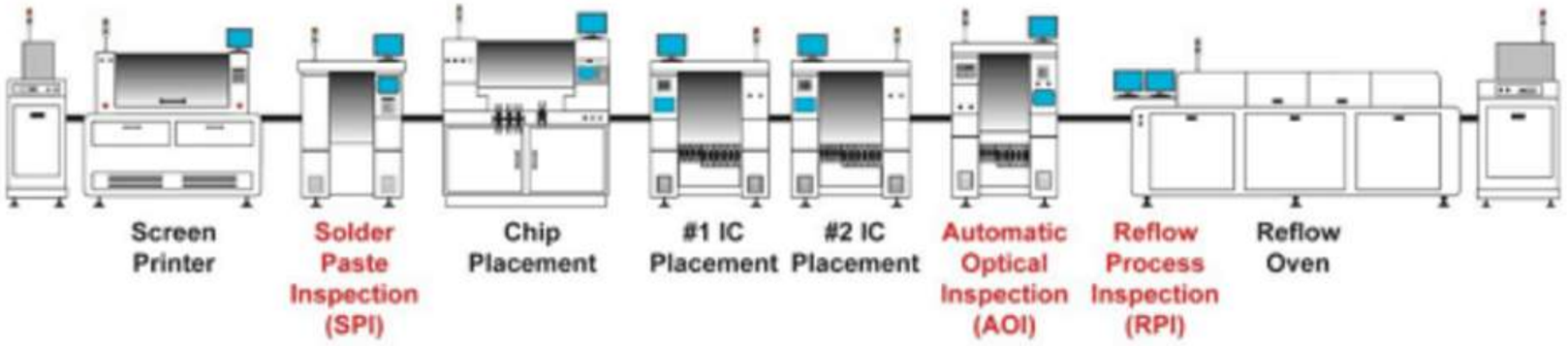
Reflow Soldering





Typical reflow soldering profile (SMT = Surface Mount Technology)

* 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

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Thank you!

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